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Irish Aid Climate and Development Learning Platform

Zambia Case Study Final Report

Climate Resilient Agriculture in Northern Province, Zambia: Integrating Considerations of Climate into Cropping Strategies of Smallholder Farmers

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Executive Summary

Agriculture remains the productive base for rural communities in Least Developed Countries (LDCs) and Lower-Middle Income Countries (LMIC) in Sub-Saharan Africa. Zambia's population remains predominantly rural and agriculture based, and thus has acute exposure and sensitivity to climate variability and change. High inter-annual rainfall variability, especially in relation to onset and cessation, are weighing on the development of smallholder farmers, and contributing to vulnerability and food insecurity.

The Irish Aid Climate Change and Development Learning Platform seeks to improve resilience through climate risk management in development programming. In the case reported here this was attempted through institutional and farmer learning on climate risk management mainstreaming. This case study for the Zambian Mission facilitated experiential learning on climate risks faced by farmers and the support institutions in current development activities in Northern Province. The investigation uses existing farmer demonstration plots operated by Livelihood Enhancement Groups (LEGs), together with engagement from partners (Self-Help Africa and CGIAR consortium), to adjust business-as-usual cropping strategies for climate risk.

This final report details the stages of the exercise carried out between February 2016 and July 2017 – scoping, participatory risk assessment, farmer dialogue, crop planting, and harvest evaluation – and presents the findings of the action research. The first sections of the document set out the relevant literature and the development of a conceptual framework for climate risk management of smallholder farming. The second section outlines the participatory climate risk assessment exercise for participants in four LEGs. This established business-as-usual cropping strategies and practices of LEG participants, and calculated the climate risks to crops through a simple formula (risk = magnitude of crop losses x probability of occurrence). Section three sets out and applies a methodology to integrate findings from the risk assessment with seasonal forecast information, which are used to improve resilience by systematically adjusting business-as-usual cropping strategies. The performance of business-as-usual and risk adjusted crop strategies are then compared by planting the two strategies. Using monetary valuations of yields, the final sections document the relative performance of risk adjusted cropping strategies, in addition to the experiential learning of LEG farmers.

In the single season (2016-2017), the performance of risk adjusted cropping strategies are approximately even in monetary terms with the business-as-usual scenario. Though it is important to consider the approach of risk adjustment is designed to be an iterative process, minimizing climate risk to crops over multiple seasons with variable rainfall and temperature (perhaps between three and five seasons). Additionally, as a case study commissioned by the Irish Aid Climate Change and Development Learning Platform, the establishment of climate resilient cropping strategies with the pre-existing LEG system is primarily a learning process. Engagement and learning of LEG farmers and support institutions was of paramount importance, with the transference of the knowledge between support institutions and LEG farmers occurring over time.

Much has been learnt from the trialling of the approach in the case study in Northern Province. It is observed that Irish Aid will need to work with partners that have a permanent mandate of support to farmers e.g. providing resources to engage local government (particularly agriculture and met departments), and an interest in such work as a medium term learning exercise that focuses on knowledge transfer to LEG farmers.

Introduction

Despite urbanization and livelihood diversification, agriculture remains the productive base for rural communities in Least Developed Countries (LDCs) and Lower-Middle Income Countries (LMIC) in Sub-Saharan Africa. Smallholder farmers in the region are arguably the population most sensitive to climate, particularly due to the reliance in rain-fed production and low technological capacity (Bosello et al., 2014). As a stand-alone stressor, climate is estimated to contribute between 15% and 40% of the difference in Gross Domestic Product (GDP) between Sub-Saharan Africa and the rest of the world (Barrios et al., 2012). In these sensitive productive systems, even moderate future warming scenarios (≈2.5ºC rise over average temperatures) could reduce the Gross Domestic Product (GDP) of countries in Africa on average between -4.1% and -8.6% per annum (Plambeck and Hope, 1996).

Zambia has experienced significant warming – 1.3ºC since 1960 – compared to other countries in Sub-Saharan Africa (GoZ, 2015). The population remains predominantly rural (65%) and agriculture based (employing 67% of population) and as such is highly affected by severe weather and climate events (GoZ, 2016). Three ecological regions running approximately south-to-north and are mainly demarcated by rainfall performance [ranging between 600mm (Region 1) and 1000mm (Region 3). There is high inter-annual rainfall variability, especially in relation to onset and cessation, with consequences on the length of the growing season (Tadros et al, 2005). Though a LMIC, 59% of the Zambian population live in poverty and are highly dependent on agriculture and natural resources; the median age is 17, and life expectancy remains low at 38 years at birth (GoZ, 2010).

Many initiatives and projects are underway in Zambia to assist smallholder farmers address climate risk to agriculture. The largest is the Pilot Program for Climate Resilience in Zambia. This project strengthens the adaptive capacity of vulnerable rural communities through improvements to community decision-making around climate risk (World Bank, 2017). The Department for International Development (DfID) fund the Vuna project focusing on Climate Smart Agriculture, which uses climate information and extension staff to assist smallholder farmer's plan seasonal cropping. Conversely, Participatory Integrated Climate Services for Agriculture (PICSA) project aims to integrate climate information into decision-making, through the development of an index designed to inform livelihood choices. These initiatives are in addition to broader efforts on crop diversity (Cook and Boerwinkel, 2017), agricultural pests (Chiliufya, 2017), and the balance between agricultural production and natural resources (Jones and Franks, 2017).

Irish Aid have institutional objectives to reduce poverty and vulnerability (Irish Aid, 2016), and Ireland's policy on international developement connects reduced hunger with stronger resilience (Government of Ireland, 2013). The Irish Aid Climate and Development Learning Platform is designed to improve resilience of development programming via building institutional knowledge on climate mainstreaming [see Irish Aid (2017) for policy briefing on climate resilient agriculture]. The case study for the Zambian Mission is designed to facilitate experiential learning about climate change for farmers/supporting institutions. The research uses existing farmer demonstration plots with engagement from partners (Self-Help Africa and CGIAR consortium) operating the Irish Aid Local Development Programme (IALDP) in

Northern Province. More specifically, Livelihood Enhancement Groups (LEGs) – groups of approximately 30 farmers established under the IALDP – incorporate knowledge of climate risks with climate information products to develop cropping strategies that adjust business-as-usual cropping for climate risk [see Irish Aid (2017a) for technical note on climate resilient agriculture]. The case study research questions are as follows:

1. What are the historical, current and future climate risks to the agricultural strategies of the poor?

2. What changes to on-going agricultural development activities are necessary to address current and future climate risks?

This final report details the stages of the research and sets out the key findings. The sections proceed as follows: section one surveys the relevant literature; section two outlines the conceptual approach of climate risk management; section three outlines the methodology and findings from the climate risk assessment; section four details the approach taken to apply the climate risk assessment to cropping strategies of 4 LEG experiential learning plots; section five outlines the findings from the experiential learning plots and summarises responses to the survey of LEG farmers; section six offers conclusion and suggest next steps.

Literature Review

This section outlines the literature associated with the case study, and thus ties together framings of climate resilience and risk assessments. The first sub-section details the literature on climate resilience and climate mainstreaming, and explains the case study as a local level form of climate mainstreaming. The second summarizes the past work around the assessment of climate risk. The final sub-section draws together past research into climate farmer field schools, and explains the linkage with the case study working with LEGs in Northern Province.

Climate Resilience, and Climate Mainstreaming

Climate adaptation and resilience policy is designed to assist vulnerable populations to address climate risk (Wisner et al., 2004). Physical hazards – e.g. flooding, droughts and storm occurrences – combine with poor, marginalized and under-developed societies to create climate risk via variability and change (IPCC, 2001). Effective policy measures can protect social systems from adverse effects, and assist with the creation beneficial outcomes from new opportunities (see conceptual framework later in this section).

On a conceptual level, climate resilience is understood by academics as “the ability of a system to deal with, or respond to, a spectrum of (climate) shocks and perturbations, whilst retaining the same structure and function” (Adger et al., 2011, p. 697). Irish Aid’s working definition considers building resilience as: “empowering people, communities, institutions and countries to anticipate, absorb, adapt to, or transform, (while experiencing) shocks and stresses (Irish Aid, 2016). Central to all framings is the capacity of the people to learn, adapt and self-organise (Folke et al., 2002). This includes availing of opportunities when disturbances open up through changing structures and processes, system renewal, and emergence of new trajectories (Folke, 2006).

Climate change is having a detrimental effect on development, which is being addressed by re-designing Official Development Assistance (ODA) to improve climate resilience (Ayers and Huq, 2009; Am et al., 2013). The objective is often improving 'climate risk management' to achieve 'climate resilient development' – protecting/enhancing development practices and trajectories in times of emerging climate stress (Anderson, 2011). This often takes the form of 'mainstreaming' of climate into development planning and decision-making (Rockefeller Foundation, 2009; USAID, 2014), so knowledge/information of climate events, trends and projections are included in governance, management and organizational processes (Travis and Bates, 2014) addressing disaster risk management (Aldunce, 2014), community-based adaptation (NEF, 2013) and infrastructure (IEG, 2013).

Climate Risk Assessment

The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values (IPCC, 2014). A Community Climate Risk Assessment is one where community members, Non-Governmental Organizations (NGOs), Traditional Authorities (TA), development committees, and vulnerable groups assess and plan for climate risk. The climate risk assessment process focuses on the actual and potential climate changes in the locality and the impacts on livelihoods and production. Climate risk assessment estimates the likelihood of the impact due to a combination of hazard events interacting with vulnerable social or physical conditions; whilst considering vulnerability as proportional to the severity of the impacts of the hazard.

Climate risk assessments can be either top-down (e.g. national institutions) or bottom-up (e.g. community-based) tools to diagnose challenges of climate variability and change, and often prescribing measures that reduce risk (Jones and Preston, 2010). The climate risk assessment literature focuses on different scales and objectives, but most commonly identify socio-economically based exposures and sensitivities, whilst considering present and future likelihood of hazard occurrence (Willows et al., 2003; Van Aalst et al., 2007). Participatory and/or observation data collection can be used to determine these relationships, and the choice of which structures the type of findings possible. For instance, participatory data can include perceptions of vulnerable groups, whilst observational data provides a more standardized and systematic comparisons.

Assessment methodologies are typically framed as steps. Table 1 outlines examples to illustrate. Approaches often assume some unit of focus, such as a community (Daze et al., 2009), or define units according to application (Willows et al., 2003; Wiggins et al., 2009). The next stage commonly involves observational data, and/or information on perceptions, to identify exposure, sensitivity, and likely future physical hazards.

Table 1: Approaches to Climate Risk Assessment

Name	Approach	Steps
Wiggins (2009) – Tearfund: Climate Change and Environmental Degradation Risk and Adaption Assessment	Climate Change and Environmental Degradation Risk and Adaptation Assessment	1. Identify Zones; 2. Identify Information Needed; 3. Compile Questions; 4. Collect Scientific Information; 5. Collect Community Knowledge
Daze et al. (2009) – Care: Climate Vulnerability and Capacity Analysis	Generic Step-by-Step Guidance	1. Community Hazard Mapping; 2. Seasonal Calendar; 3. Historical Hazards; 4. Vulnerability Matrix (Hazard Impact on Livelihood); 5. Institutional Access and Support
IISD (2012) - Community-Based Risk Screening Tool: Adaptation and Livelihoods	Project Planning Tool for Climate Adaptation	1. Establish Development Trends; 2. Act./Expected. Climate Context; 3. Impacts Associated Climate;
Willows et al. (2003) – (UKCIP's) Climate Adaptation: Risk Uncertainty	Using Thresholds and Endpoints for Climate Risk Assessment	1. Define Exposure Units; 2. Define Climate Variables; 3. Use Climate Projections; 4. Use Non-Climate Scenarios.
Van Aalst et al. (2007) – Climate Guide	Generic Step-by-Step Guidance	1. Develop an Initial Orientation; 2. Designate a Focal Point; 3. Assessment of Priorities: + Implications of Climate Change; + Look at Implications for Risk; + Prioritize Risks.

Climate Farmer Field Schools

Climate risks to African agriculture are highly contextualized and location-based (Sonwa et al., 2016). Climate farmer field schools are institutions for individual farmers to learn and gain experience about interactions between agriculture and climate processes – such as the effect of weather, climate change on conservation agriculture, organic agriculture, animal husbandry, and soil husbandry – resulting in the incorporation of new technologies (Boer et al., 2014). Farmers learn by doing – 'experiential learning' – from their fields where crop responses to weather and climate provide lessons for future strategies (FAO, 2010). The school teaches agricultural meteorology and crop management skills that enable farmers to make contextualized, critical and informed decisions in relation to farming practices (SUSTAINET EA, 2010), enabling practical solutions for climate risks to agriculture (Braun and Duveskog, 2008).

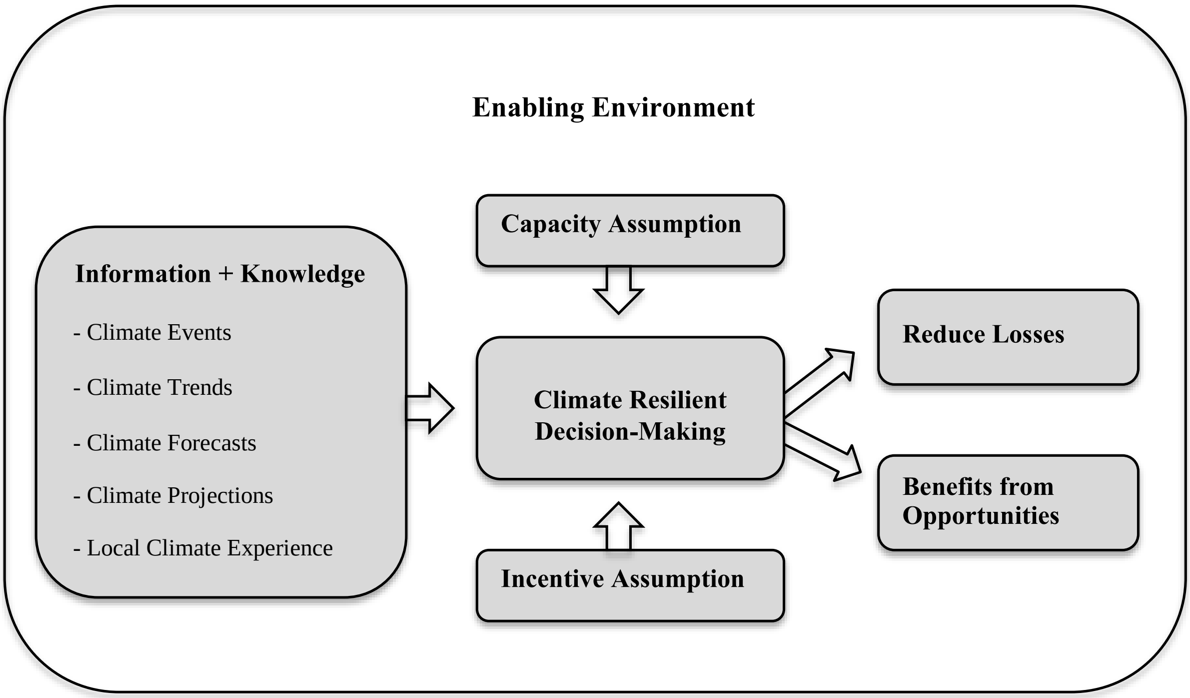
Climate farmer field schools take many forms. Siregar and Crane (2011) apply climate information to cropping strategies in Indonesia. They use the seasonal forecast to design rice and watermelon farming systems, but emphasize the need to also include social, ecological and technical factors into farmer decision-making. Christian Aid's (2009) methodology focuses instead on community knowledge and cropping strategies. They identify extreme weather events, and associated local responses and coping strategies. Conversely, Patt et al. (2005) use participatory approaches to incorporate seasonal forecast information into the cropping decisions for the coming season in several villages in Zimbabwe. The methodology directs implementers to ask farmers about previous seasonal rains, scientific/traditional forecasts, the success of farmer practices, present forecast probabilities for the coming season, and facilitate discussion over appropriate farmer strategies in light of seed availability. Finally, Ozor and Cynthia (2011) prioritise outcomes, and create a hierarchy of responses for climate change effects, current responses, and potential future roles of extension teams in facilitating climate change adaptation.

The study in Northern Province corresponds most closely with Patt et al. (2005) by incorporating climate information – in addition to knowledge from contextualized climate risk assessments – to develop risk management strategies that are trialed through experiential learning plots. The aim is to integrate climate information and knowledge into cropping strategies that can be replicated and improved through the collaboration of in-country partners and smallholders (Braun and Duveskog, 2008). The research fosters collaborative learning between smallholder farmers, implementing partners and researchers to iteratively build risk management strategies using present and projective climate information with detailed knowledge of past and present climate risks.

Conceptual framework

Figure 1 illustrates a conceptual framework for climate risk management (Travis and Bates, 2014). Climate risk management requires knowledge and information of climate events, trends, forecasts, and projections to be included into decision-making. Climate-informed decision-making reduces climate-related losses, or positive beneficial effects from availing of development opportunities regardless of climate stress. Nevertheless, the likelihood of engaging in climate-smart decision-making is itself constrained or facilitated by smallholder farmer capacity and the incentives to incorporate climate considerations.

Figure 1: Climate Risk Management Conceptual Framework



The case study combines knowledge from climate risk assessments, seasonal forecast information, with participatory techniques. The objective is for LEG participants and their supporting institutions to learn about climate risks smallholder farmers experience in Mbala and Lwingu districts, and assist them in applying this knowledge of risks and climate information to make decisions that improve climate risk management and climate resilience.

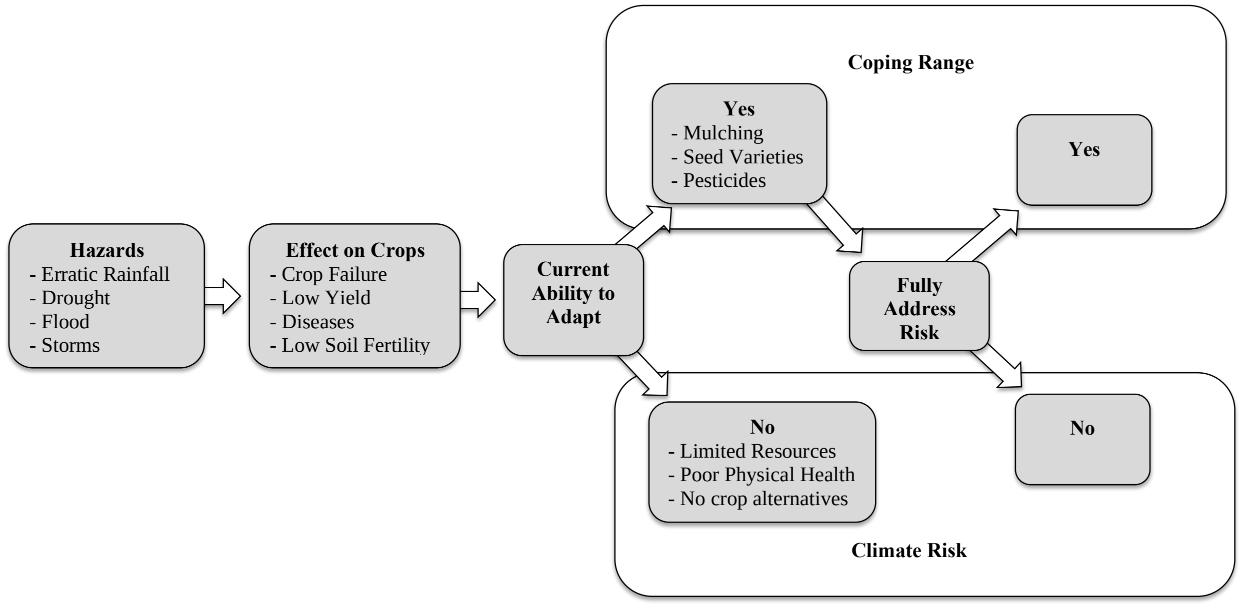
Developing Resilient Cropping Strategies with Climate Risk Assessment and Seasonal Forecast

This section outlines the design and application of the climate risk assessment. The first sub-section sets out aims and objectives. The second sub-section outlines the 3 step approach. The third sub-section explains the methodological application of the risk assessment and seasonal forecast to make decisions on cropping strategies. The fourth sub-section documents the findings.

Aims and Objectives

The objective is to design a participatory climate risk assessment tailored to inform the climate farmer field school in Mbala and Luwingu districts. What follows is adapted from Willows et al. (2003) and Ozor and Cynthia (2011) (see Figure 2) and frames climate risk in terms of hazards multiplied by crop losses. The assessment identifies specific climate risks of different crops by accounting for: a) hazards thresholds for crops; b) effects of hazards on crops (sensitivity component of vulnerability); and c) the current ability to adapt and associated success (representing adaptive capacity).

Figure 2: Climate Risk Assessment Adapted to inform Climate Farmer Field School



3 Step Approach

Step 1: Identify and define the nature and extent of the exposure units, receptors, and assessment period;

LEGs are the units of interest, made up of participating members. LEGs will aggregate climate risks of each participating member into the design and implementation of experiential learning plots (see Appendix A for survey design for households). Therefore, the climate risk to farming activity of participating LEG members will be assessed in terms of crop production, and reinforced by LEG focus group discussions. Finally, the assessment period will be the last five cropping seasons, and so the past five years.

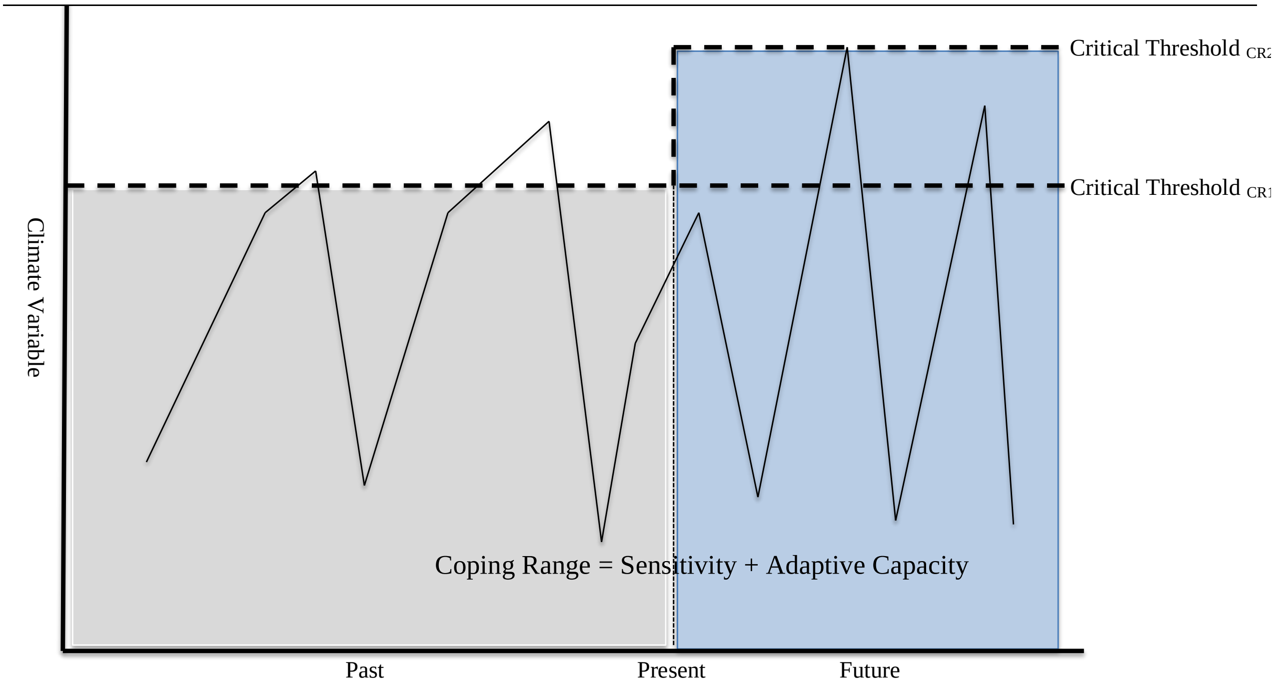
Step 2: Identify climate variables to which the exposure unit is sensitive and able/unable to adapt.

LEGs participants in Luwingu and Mbala will be surveyed on their experience with erratic rainfall, shorter seasonal rains, drought, dry spells and temperature rise (Smith, 2015). To understand sensitivity, assessors will: a) first document climate variables considered a hazard by each household; b) establish the 'coping range' for each crop type, in terms of identifying thresholds where crop production is adversely affected. The process of recording the range of values for climate variables (e.g. number of consecutive wet days per season, maximum temperature) in which crops are viable/not viable reveals socio-economic vulnerability of the farming system.

To understand adaptive capacity, the climate risk assessors will: a) document the presence/absence of adaptation/resilience measures designed to adapt to climate stresses on crops; b) if such measures are in place, gauge the degree of effectiveness in reducing risk. For example, too much rain can saturate maize crops, and raising the planting mound allows for tolerance of heavy rainfall. The important aspect is document how much rain such technologies can withstand; alternatively, to address shorter wet seasons, farmers may switch to early maturing varieties to circumnavigate this hazard. Again, precisely how short can a season become and a crop experiences no adverse effects. This facilitates an understanding of coping ranges for different crops.

Figure 3 illustrates climate variability for a single crop. The grey area is the coping range in the years before and at the time of the assessment, which simultaneously represents the extent of climate sensitivity and adaptive capacity of farmers. The blue area incorporates the projection data of the climate variable, and necessary changes to sensitivity and adaptive capacity needed to address emerging climate change.

Figure 3: Example of Climate Variable (e.g. rainfall level) and Coping Range



Adapted from Willows et al. (2003)

Step 3: Using climate-scenarios and risk assessment to determine climate risk.

Based on adverse climate impacts on crops in recent seasons, the objective is to aggregate knowledge on the extent and nature of the climate risks to crops likely over the season. The second objective is to establish the likelihood of experiencing climate hazards over the same time period. **This identifies changes in climate risk over time that are relevant to farming systems in Mbala and Luwingu as the primary output of the climate risk assessment: identifying the present and immediate future climate risk to different crops, given current levels of sensitivity and adaptive capacity**.

Decision-Making Methodology

The development of a climate risk management strategy for crops is highly contextual, requiring systematic integration of knowledge from the climate risk assessment, combined with climate information. The experience of smallholders and extension teams are already embedded within current strategies – including on-going adaptive measures – and the purpose of the climate farmer field school is for all LEG participants, SHA and other partners to assimilate their understanding of climate risk and uncertainty within each of the 4 LEGs.

The **first step** is to calculate climate risk using the following formula: **risk = probability of hazard occurrence x magnitude of loss**. Figure 4 shows that the probability of a hazard occurring in any year is the likelihood that normal variability in weather/climate gives way to hazardous conditions, and has adverse effects on crops. The magnitude of the loss represents the scale of the impact. For instance, this can be measured either in yield losses (e.g. Kg), the monetary value of yield losses (e.g. some currency value) or another standard metric. Figure 4 shows that if you have a 0.34 probability of a hazardous weather/climate event occurring within any one year, and with $50 loss typically associated with such an event, climate risk for that crop is $85, assuming a 5 year reference period. This value can be compared to those for other crops so as to inform decision-making under climate uncertainty.

Figure 4: Calculating Climate Risk Using Climate Knowledge and Information

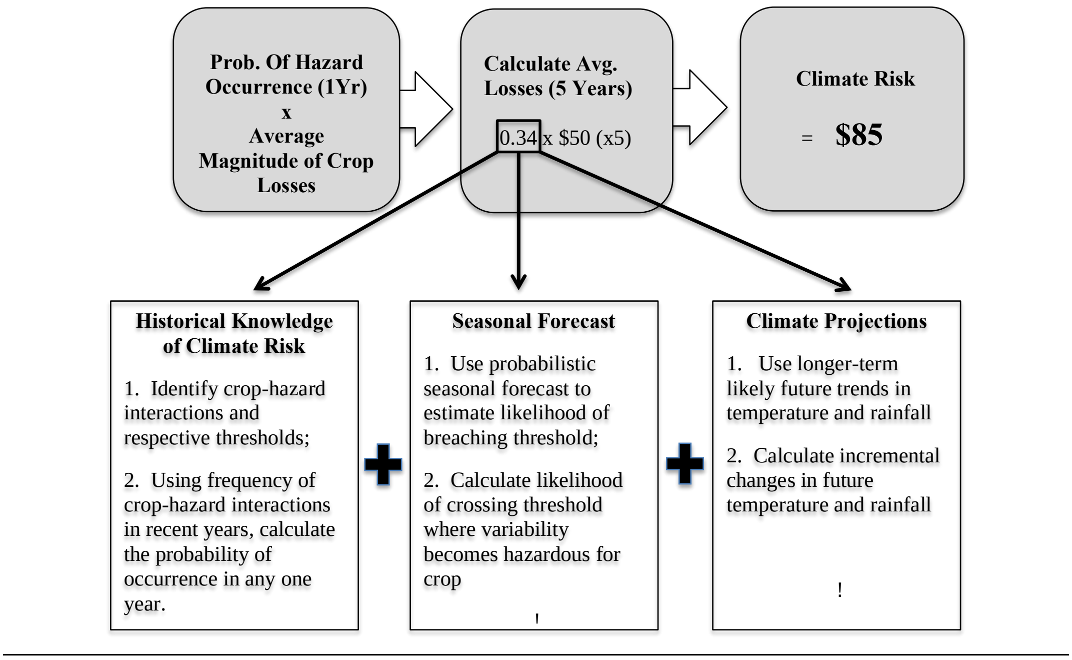
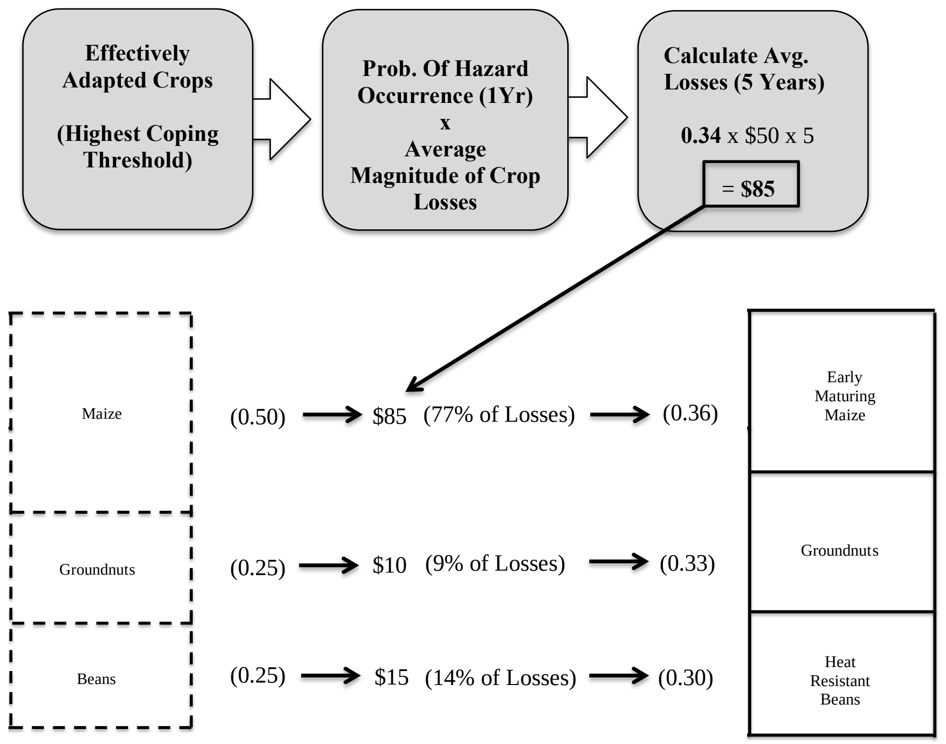


Figure 5 outlines the knowledge and information components that together constitute the likelihood of hazard occurrence. **Knowledge** from the climate risk assessment indicates the thresholds where weather/climate variability becomes hazardous for particular crops within the context, and the effectiveness of adaptive measures in raising this threshold. **Information** is both short- and long-term, but is subject to availability. Short-term information (rainfall only) is available through the use of seasonal forecasts, which provide probabilistic signals for rainfall outcomes in the approaching season, and which further inform the likelihood of breaching crop-hazard thresholds identified during the climate risk assessment. Long-term information indicates systemic changes in rainfall and temperature over years.

The systematic integration of climate information with findings of the risk assessment is a challenge. Using the formula (risk = probability of occurrence x the magnitude of the hazard), the objective is to adjust the probability of occurrence (initially calculated from daily rainfall data) according to climate information that suggest a change in the likelihood of hazard occurrence previously identified in the risk assessment. For the seasonal forecast, standard calculations of probability of occurrence are adjusted by observing the likelihood of the same hazard occurring in years when forecasts are normal, below or above normal. For instance, the standard probability may be 0.35 for a 15 days dry spell in any one year, but in an above normal year, the same hazard may occur only once in 5 years (0.20). Therefore, the probability a 15 day threshold being breached in an above normal year will be 0.27 (0.35 + 0.20 / 2 = 0.27).

Figure 5: Using Climate Risk Calculation to Re-Configure Experiential Learning Plot from Business-as Usual Scenario



The **second step** operationalizes calculations to inform decision-making for the climate risk management strategy. Figure 6 demonstrates the method used in the design of experiential learning plots. The objective is to calculate proportions within the treatment section of the plot given each crop type, which minimises losses and maximise benefits, whilst also considering and building on the original cropping preferences of farmers. Using the probabilities of hazard occurrences in combination with the magnitude of losses provides a basis on which to make systematic comparisons across crop types, and which serves as the basis to make space allocations. The final stage is to compare values of likely losses with the original proportions allocated to crops in the business-as-usual scenario, and make upward/downward adjustments to the proportion of each crop in the treatment plot.

Figure 6: Example of Experiential Learning Plot

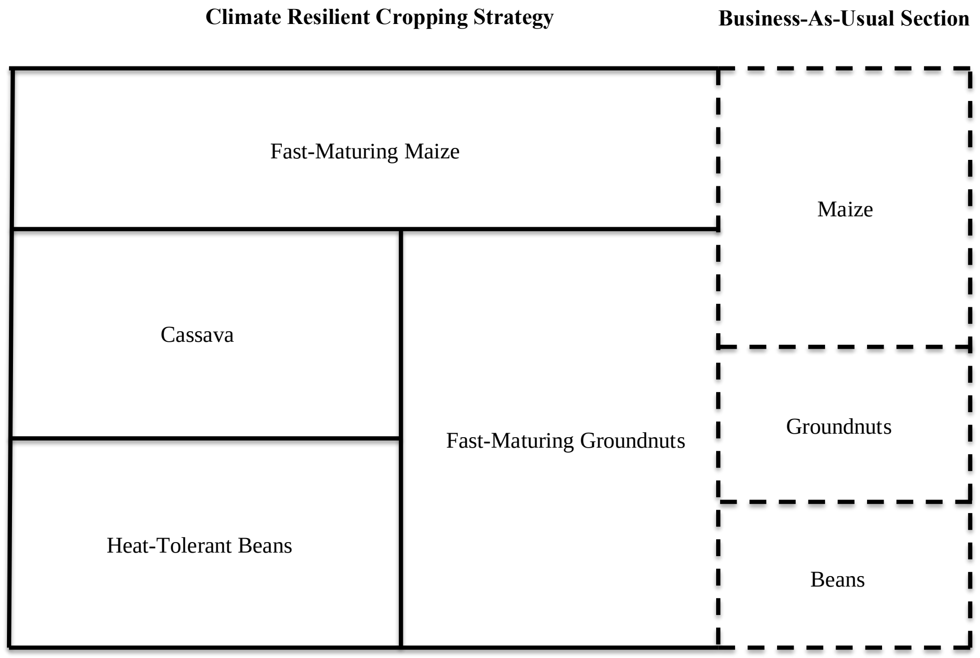


Figure 6 illustrates a hypothetical plot broadly applicable to farming systems in Mbala and Luwingu. The business-as-usual scenario developed from the aggregate standard cropping strategies of LEGs members suggest concentration on maize, with approximately the same proportion divided between beans and groundnuts. On the basis of the risk assessment and climate information, the climate resilient cropping strategy is more diverse and gives more area to certain crops over others.

Integrating Climate Risk Assessments and Seasonal Forecasts

This sub-section details the results from the climate risk assessments with the 4 LEGs in Northern Province. This involves 2 stages: the first is the conversion of survey data into a calculation of climate risk; the second uses figures of climate risk to adjustment the business-as-usual cropping strategy of the 4 LEGs. The result is a climate resilient cropping strategy that constitutes a treatment to compare to the control, or business-as-usual scenario. For a full set of diagrams showing the treatment and business-as-usual scenarios for each LEG, please see Annex C.

Calculation of Climate Risk

The top row of Table 2 shows calculations of relative climate risk for the Shimumbi LEG 113 (top row). These are based on the probability a hazard occurring (2nd column) multiplied by the magnitude of typical losses (interpreted through Zambia Kwacha as a standardisable measure). Groundnuts represent a significant proportion of climate risk to crops (60%) due to prolonged dry spells resulting in disproportionate losses, followed by maize (33.2%), and beans (6.7%), both of which also succumbed to dry spells, albeit with lower monetary consequences.

The second row of Table 2 sets out the calculation of relative climate risk for different crops within Mfungwe LEG 65 (second row). Maize is most susceptible with 62.7% of all climate risk due to protracted dry spells. Beans (21.2%) and groundnuts (16.1%) are also at risk. These findings allow for systematic comparison across crop types according to climate risk.

Table 2: Climate Risk Calculations – 4 LEGs

Crop Type	Ave. No. of Days (Prob. of Occ.**)	Value (kwa)	Climate Risk Calc. (Prob of Occ. x Value)
	Shimumbi		
Groundnuts	17 Days Dry Spell (0.73)	1628	1188 (60%)
Maize	16 Days Dry Spell (0.73)	903	659 (33.2%)
Beans	23 Days Dry Spell (0.1)	1338	133 (6.7%)
	Mfungwe		
Maize	14 Days Dry Spell (0.73)	2182	1592 (62.7%)
Beans	15 Days Dry Spell (0.73)	735	536 (21.2%)
Groundnuts	16 Days Dry Spell (0.73)	563	410 (16.1%)
	Zombe		
Beans	17 Day Dry Spell + 82mm Flooding (0.53)	2261	1198 (35.9%)
Maize	22 Days Dry Spell + 103mm Flooding (0.36)	4434	1596 (47.8%)
Groundnuts	21 Day Dry Spell (0.36)	1500	540 (16.2%)
	Chozi		
Beans	27 Days Dry Spell (0.1)	707	70.7 (4.1%)
Maize	26.3 Days Dry Spell + 103mm Flooding (0.36^{+})	1533	551 (32%)
Groundnuts	20 Days Dry Spell (0.26)	1170	304 (17.6%)
Cassava	94mm Flooding (0.53)	1500	795 (46.2%)

*Planting Period from 15th Nov. – 15th Apr. and Con. Dry Days >5mm + 2 >10mm
** Based on 5 Year Historical Record integrated with Seasonal Forecast

The third row of Table 2 sets out calculations of relative climate risk for crops within Zombe LEG 214 (third row). Once again, maize is highly susceptible to weather/climate, in the form of dry spells and flooding instances, with 47.8% of all risk. Beans (21.2%) also show susceptibility to dry spells and flooding. It should be noted that when crops are exposed to two different types of hazard, both the magnitude of the loss and the probability of occurrence rise. Finally, groundnuts have a relatively minor climate risk from dry spells alone (16.2%).

Finally, the bottom row of Table 2 shows the calculation of climate risk for crops in Chozi LEG 132 (bottom row). This is based on the probability a hazard will occur (2nd column) multiplied by the magnitude of mean losses. Cassava has the highest risk measure (46.2%), due to a flooding and saturation incident that ruined the crops. Maize is still highly sensitive to climate with 32% of the risk through both flooding and dry spells, followed by groundnuts (17.6%) and beans (4.1%) that both suffer from dry spells.

Adjusting Business-As-Usual Scenarios for Climate Risk

Table 3 calculates adjustments required to incorporate a climate risk management into the original cropping preferences of farmers. Column 1 and 2 show the level of climate risk and original farmer crop preferences respectively. Column 3 demonstrates the difference between the crop preferences and risk, either as minus values when risk is greater than preference (recommending reductions in space allocation), or positive values when risk is less than preference (suggesting an increase in space allocation).

In Shimumbi, the risk to maize and beans is not greatly different from farmer preferences (-1.1% and 6.7% respectively) and thus signals the need for small adjustments. Conversely, groundnuts have a climate risk measure considerably higher that the original farmer preference (56.8% risk and 17.4% original preference), meaning the removal of groundnuts from the plot is recommended from a risk management perspective.

The objective is to set out the proportions of a risk averse cropping strategy (see Column 5). The next step is to adjust original farmer preferences according to the difference between crop risk and original preference (see Column 5). As anticipated, this process had a small impact on beans (13.4% to 16%) and maize (32.1% to 24.7%), but reduces the proportion of the plot given to groundnuts to a minus figure. Climate risk is so high for groundnuts that the analysis suggests the crop should be removed and the space be distributed out amongst the remaining crops according to their space proportions. Millet and cassava are re-introduced into the analysis as having zero observable climate risk, and upward adjustments are made in proportion to their original preference – space allocation for millet rises from 11.7% to 18.7%, and cassava from 25.3% to 40.4% (compare Column 2 to Column 5).

For Mfungwe, Table 3 outlines the calculated adjustments necessary to establish the climate risk averse cropping strategy designed in terms of the original preferences of farmers (second row). The significant risk to maize outweighs the original crop preference (62.7% risk versus 19.6% preference) to the extent it is necessary to remove maize from a risk management perspective. With maize absorbing a considerable proportion of climate risk, the analysis suggests space should be increased with the remainder of crops, especially for crops with no risk (see Column 3). After adjusting original farmer preferences according to the difference between crop risk and original preference (see Column 4) and reconverting values into true percentages (Column 5), the following changes occurred in crop space allocations: beans were increased fractionally from 29.1% to 30.1%; followed by a small space increase for groundnuts from 24.4% to 26.6%, and with considerable rise in the area given to those with no observable climate risk - sweet potato (from 7.8% to 12.7%) and cassava (from 18.7% to 30.4%).

For Zombe, Table 3 sets out the calculated adjustments necessary to develop a risk averse cropping strategy from the original farmer preferences (third row). The significant risk to maize results in a reduction in size – from 31.8% of farmer preferences to 15.6% of the risk management cropping strategy. Beans are also reduced from 25% to 14% of space allocation. Conversely, the farming of groundnuts in Zombe has a relatively low exposure to climate hazards, and increases in the suggested area planted from 26% to 35.3%. Finally, the space allocated to cassava almost doubles in the risk management strategy from 17.7% to 34.9%.

Table 3: Adjusting Business-As-Usual Cropping According to Climate Risk – 4 LEGs

	(1)	(2)	(3)	(4)	(5)
Crop Type	Climate Risk (%)	Farmer Pref. (%)*	Diff. (%) Risk v Pref.	Adj. Farmer Preferences (%)	Risk Averse Crop Strategy (%)**
			Shimumbi		
Groundnuts	1302 (60%)	17.4%	-42.6%	-	-
Maize	722 (33.2%)	32.1%	-1.1%	31%	**24.7%**
Beans	267 (6.7%)	13.4%	6.7%	20.1%	**16%**
Millet	No Risk (0%)	11.7%	11.7%	23.4%	**18.7%**
Cassava	No Risk (0%)	25.3%	25.3%	50.6%	**40.4%**
			Mfungwe		
Maize	1592 (62.7%)	19.6%	-43.1%	-	**-**
Beans	536 (21.2%)	29.1%	7.9%	37%	**30.1%**
Groundnuts	410 (16.1%)	24.4%	8.3%	32.7%	**26.6%**
Sweet Pot.	No Risk (0%)	7.8%	7.8%	15.6%	**12.7%**
Cassava	No Risk (0%)	18.7%	18.7%	37.4%	**30.4%**
			Zombe		
Maize	1596 (47.8%)	31.8%	-16%	15.8%	**15.6%**
Beans	1198 (35.8%)	25%	-10.8%	14.2%	**14%**
Groundnuts	540 (16.2%)	26%	9.8%	35.8%	**35.3%**
Cassava	No Risk (0%)	17.7%	17.7%	35.4%	**34.9%**
			Chozi		
Cassava	795 (46.2%)	22.3%	-23.9%	-	**-**
Maize	551 (32%)	33%	-1%	32%	**32%**
Groundnuts	304 (17.6%)	14.3%	-3.3%	11%	**11%**
Beans	70.7 (4.1%)	16.5%	12.4%	28.9%	**28.9%**
Sweet Pot.	No Risk (0%)	14%	14%	28%	**28%**

* Original preferences are in absolute figures – now converted into **true percentage** (i.e. = 100);

** Risk-adjusted proportion calculations - now converted into **true percentage** (i.e. = 100);

For Chozi, Table 3 sets out the calculated adjustments necessary to develop a risk averse cropping strategy from the original farmer preferences (bottom row). This time cassava is removed from the analysis due to climate risk being higher than the original crop preference. Minor reductions are recorded from maize (from 33% to 32%) and groundnuts (14.3% to 11%), and the majority of the area gains are for beans and sweet potato. Beans have such a small risk relative to original preference that space allocation increases from 16.5% to 28.9%. As with all crops that have no observable risk, the space allocated for sweet potato rises considerably from 14% to 28%.

In summation, there are patterns to draw from the climate risk assessment. Maize is highly susceptible to dry spells and flooding in particular. When climate variability becomes hazardous, the associated losses are often significant. Similarly, groundnuts show climate sensitivity across all LEGs, and this particularly relates to prolonged dry spells. Beans have medium to low climate risk, with climate often becoming hazardous, but the values of losses are typically lower. The most resilient crops to climate are tubers, such as sweet potato and cassava, which appear susceptible only to prolonged water logging events.

Findings

This section details findings from the experiential learning plots in the 4 LEGs. It first explores how the findings from the climate risk assessment/seasonal forecast were developed with the LEG farmers through an open dialogue. The second section describes the planting process, and the engagement between SHA, LEG farmers, and other in Northern Province. The third section sets out the main findings in terms of harvest yields from treatment and control plots, and the monetary value of those yields.

From Risk Assessment/Seasonal Forecast to Planted Treatment Plots

A process of dialogue was opened between all interested parties – Self-Help Africa, local government, Met. Office and wider extension representatives/staff – over the findings of the climate risk assessment and the suggested treatment plots. The objective was to include the views of LEG farmers, and make the adjustments necessary to the planned cropping strategies. On one level, this was to ensure the proposed strategy was not outside the preferences of LEG farmers; on another, the process was to verify the approach taken to the specific human and physical capacities of the context.

The dialogue process involved detailed description with LEG farmers of the methods used to convert data on crop-hazard interactions into relative measures of climate risk for each crop, as well as the systematic decision-making procedure to adjust crop types, and space allocated.[1] The negotiated treatments were then be used for the experiential learning in each LEG using the one Lima plot. For detailed illustrations of changes made between the risk assessment/seasonal forecast and the finalized negotiated plots in each LEG, see Figure 8, 9, 10 and 11 in Appendix C.

Planting process in LEGs in Northern Province.

The planting of the 4 experiential plots happened between November and December 2016. A challenge was the late onset of rains in Northern Province in the time of the planned planting.

[1] The original objective was to incorporate effective technologies used in the past detailed in the survey, but during the negotiations and at the implementation stage, these factors were not considered.

As a consequence, SHA remained to lead the exercises on the planting with the LEG members.

There was also difference occurred between the size of land allocations for individual crops as negotiated with the LEG members, and the actual level of land allocated at planting stage (for detail on precise differences, please see the difference between 'negotiated cropping strategy' and 'planted cropping strategy' in Appendix C). This was partly to do with small errors, and partially to attributable to walkways not being included within the measurements. Results should be interpreted with these differences in mind.

Harvest Yields and Monetary Value

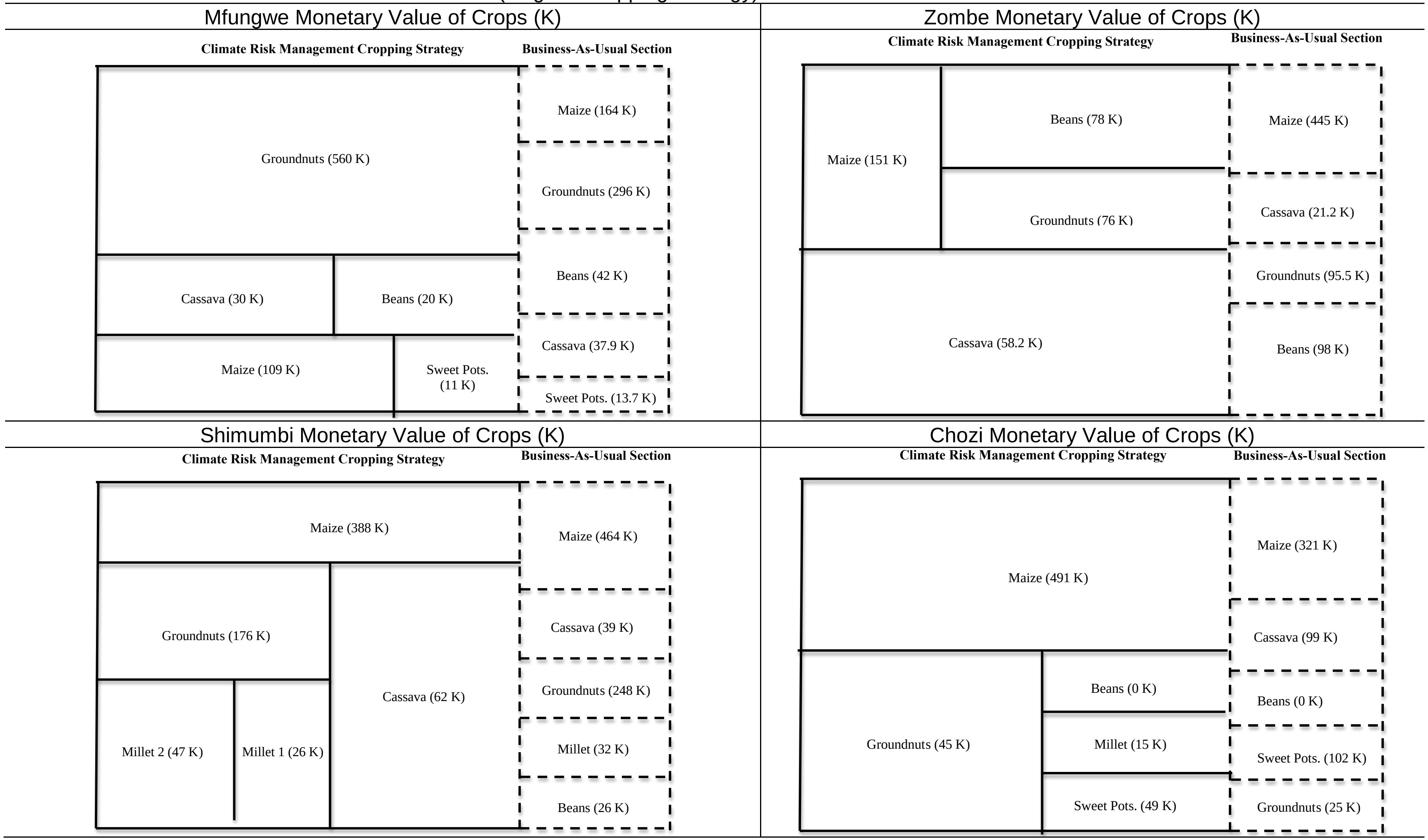
The objective of the evaluation was to record the performance of the experiential plot treatments, relative to the control, after the negotiation and planting process. The evaluation was conducted in June-July 2017. The full results are presented in box 4 [yield (kg)] of each LEGs diagrams in Appendix C, and the findings of crop yield are converted into monetary form in Figure 7. Overall, the results of the performance are even, with Mfungwe and Chozi (+177K and +53K respectively) performing better than the control, while Zombe and Shimumbi showing the opposite (-296K and -110K respectively).

The choice to use market prices to standardise the results is by no means the only method, as others exist, such as establishing the calorific content, that provide an alternative perspective on the performance of different cropping strategies. In addition, choosing the monetary value of crops harvested will always give a greater emphasis on maize than other crops, because the yield weights are higher relative to all other crops. However, as seen in the climate risk assessment, **the probability of failure of maize can be high and costly, and so it is important to consider the work a multi-year exercise (at least over 3-5 years), when drier seasons are likely to significantly weigh on performance of high yielding crops such as maize, but then the overall risk be reduced through diversification with other crops.**

Mfungwe: the major treatment crop after negotiations and planting was groundnuts, which harvested an exceptionally high yield (140 kg) compared to other LEGs, and produced 76% of value from 52% of land. Cassava was decreased (18.7% 14.8%) and this appears to have been the right approach due to the crop producing only 4% of value from 14% of the land. Beans also underperformed, producing 2.7% of value. Finally, maize essentially broke even with 14.9% of value from 13% of land. The overall message is that under the favourable climate conditions (likely >650mm of rainfall), planting the majority of the plot with groundnuts and maize resulted in the higher performance relative to the control.

Zombe: the major treatment crop after negotiations and planting was cassava at 48.6%, which represented a significant increase from the business as usual scenario (17%). This did not work in this LEG plot, as seen through the low yield of 29kg, or 58 K (only 15.9% of total value). This was partially saved by a relatively high yield of maize (135kg) from only 10.8% of the land, which had a market value of 151K (41.5% of the value). Other components of the plot included beans (19.9% of land) and groundnuts (20.5%), which essentially broke even with a yield of 78 K and 76K respectively, and which corresponded to 21.4% and 20.9% of the value. Essentially, over-emphasis on cassava held the performance of the plot back in a season when the rainfall conditions (675mm) favoured maize.

Figure 7: Diagrams of Experiential Learning Plot for Mfungwe LEG. From Top-Left in Clockwise Direction, Risk Adjusted, Negotiated, Planted and Yield of LEG Treatments versus Business as Usual (Original Cropping Strategy)



Shimumbi: the major treatment crop after negotiations and planting was cassava at 39.9% (an increase from 25.3% in the business as usual scenario). This cassava crop performed exceptionally poorly, with the harvest representing only 62K (8.8% of treatment plot value). Maize was reduced from 32.1% to 26.8%, but represented 55.5% of yield value (388 K). Groundnuts were also reduced from 17.4% to 12.2% of land used, but which out-performed by yielding 25.1% of total value. Once again, too much emphasis was given to cassava in this one season, when the weather conditions (786mm) favoured maize and groundnuts.

Chozi: the major treatment crop after negotiations and planting was maize at 50.3% (an increase from 33% in the business as usual scenario). This maize crop out-performed the rest of the crops, through the 491 K generated representing 82% of total value for the treatment. While groundnuts were planted in 25.2% of the plot (up from 14.3% in the business as usual scenario), the 45 K generated only accounted for 7.5% of the total. Beans were reduced from 16.5% in the business as usual scenario, to 8.4%. This was a correct move overall, because the entire beans crop failed. Millet was a new crop brought in via the negotiations (10.4% of treatment land used), but which significantly under-performed (15 K) by only contributing 2.5% of the treatment value. Overall, a heavier emphasis on maize was the most important determinant in the treatment performing better than the control.

In summation, the treatments performed well when the focus on maize was maintained, and they performed poorly when cassava replaced maize. But cassava is the insurance against exceptionally dry seasons, which didn't materialise this season. The risk assessment signified that a disproportionate share of the risk was often attributable to maize, and to a lesser extent, groundnuts. To repeat from above, climate related losses to maize are typically associated with drier years, and the seasonal rainfall this season appeared to be sufficient in the areas of the LEGs. Therefore, to understand the performance of adjusting for climate risk, it will be necessary to evaluate the method used as an iterative process. The objective is for the methodology to enable farmers to perform better across all seasons, despite the likely increase in between year variability in rainfall.

Challenges and Next Steps

As a case study commissioned by the Irish Aid Climate Change and Development Learning Platform, the establishment of climate resilient cropping strategies with the pre-existing LEG system was first and foremost designed to be a learning process. Therefore, the crop yield results are secondary, and the engagement and shared learning with the LEG farmers and support institutions was of paramount importance. More specifically, the original concept note envisaged that personnel in the support institutions would learn most from the exercise and then transfer knowledge on to smallholder farmers over time through recurrent engagement.

This emphasis on learning and knowledge transfer means that the engagement by support institutions has to be high quality and constant. In this case, good early interest in the process dwindled over time.

Another challenge in this first year of the process was that the controls were not planted as had been planned. Instead, just the treatments were planted at the start of the season. All yield calculations of the control had to be developed from yield and area measurements of the treatment, and that of surrounding farms. This reduced the experiential smallholder farmer-learning component of the study. Additionally, instead of including the various different practices in the treatments and comparing these with the business-as-usual scenario in the control, the comparisons were just the changes in space allocations to crops. Changes in seed varieties, adaptation measures, such as ridging, using climate information to gauge planting time, and many other techniques discussed to circumnavigate climate hazards were not implemented as planned.

Next Steps

Much has been learnt from the trialling the approach in Northern Province. The case study was designed to be an iterative process, spanning multiple seasons and with consistent engagement from a committed team of participants keen to learn about addressing threats to cropping for smallholder farmers, particularly from variation in rainfall. To achieve this Irish Aid will need to work with agencies with more permanent mandates to smallholder farmer development. This might include providing resources to engage local government (particularly agriculture and met departments) directly in a collaborative team interested in the work as a medium term learning exercise. The institutional learning is key, but knowledge should passed on to smallholder farmers, who as the most vulnerable to emerging climate change, should always be the main focus of such exercises.

The case study in Northern Province put into practice an approach set out in the new Irish Aid technical note on climate resilient agriculture. As such, and as a means for Irish Aid to meeting institutional objectives of food security, vulnerability reduction, climate and development, the process of adjusting on-going development activity to climate risk will offer a guide to all future partner engagement relating to agriculture. Therefore, lessons learnt will be communicated around the Irish Aid Missions to ensure development programming for smallholder farming improves as a result of the case study, and any future uptake of the approach to climate resilient cropping can avail of past experiences.

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Appendix A

Zone Name: Interviewee's Name:

LEG Number:

HOUSEHOLD DEMOGRAPHY

a) Male/Female Headed Household (M/F)

b) Number of Adult Men ( ) and Women ( )

c) Number of Children ( )

d) Age and Education of Adults:

	Age	Education in Years
Adult 1	( )	( )
Adult 2	( )	( )
Adult 3	( )	( )
Adult 4	( )	( )
Adult 5	( )	( )
Adult 6	( )	( )
Adult 7	( )	( )
Adult 8	( )	( )

TYPICAL CROP STRATEGY

	Crop Type	**Specifications**	**Proportion**
1.	( )	( )	(%)
2.	( )	( )	(%)
3.	( )	( )	(%)
4.	( )	( )	(%)
5.	( )	( )	(%)
6.	( )	( )	(%)
7.	( )	( )	(%)
		Total	(%)

CROP-RELATED CLIMATE HAZARDS AND SENSITIVITY (PER CROP-HAZARD)

	Type	Crop/Variety	Threshold*	Prop Lost	Value
2015	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)

* **mm, days, °C, hale, wind speed (kph)**

	Type	Crop/Variety	Threshold*	Prop Lost	Value
2014	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
2013	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
2012	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
2011	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)
	( )	( )	( )	(%)	(Kwa)

*** mm, days, ºC, hale, wind speed (kph)**

REFLECTION ON MAIN CLIMATE HAZARDS AND SENSITIVITY
Please reflect on the main climate hazards affecting your crop-based livelihood activities (Record All Points)

MAIN ADAPTIVE MEASURES TO ADDRESS CROP-RELATED HAZARDS

Hazard-Crop Interaction **Adaptive Measure**

1. ( ) ( )

Change in Threshold From ( ) To ( )

Hazard-Crop Interaction **Adaptive Measure**

2. ( ) ( )

Change in Threshold From ( ) To ( )

Hazard-Crop Interaction **Adaptive Measure**

3. ( ) ( )

Change in Threshold From ( ) To ( )

Hazard-Crop Interaction **Adaptive Measure**

4. ( ) ( )

Change in Threshold From ( ) To ( )

Hazard-Crop Interaction **Adaptive Measure**

5. ( ) ( )

Change in Threshold From ( ) To ( )

* **mm, days, °C, hale, wind speed (kph)**

REFLECTION ON MAIN CLIMATE HAZARDS AND ADAPTIVE CAPACITY
Please reflect on the measures used to address your main climate hazards, and their effectiveness in lowering your risk (Record All Points)

Appendix B

Zone Name/LEG Number:

Focus Group Type: Women / Youth / Men

TYPICAL CROP STRATEGY			
	Crop Type	Specifications	Proportion of Strategy
1.	( )	( )	( )
2.	( )	( )	( )
3.	( )	( )	( )
4.	( )	( )	( )
5.	( )	( )	( )
6.	( )	( )	( )
7.	( )	( )	( )
8.	( )	( )	( )
9.	( )	( )	( )
10.	( )	( )	( )

CROP-RELATED CLIMATE HAZARDS AND SENSITIVITY
Describe and reflect on the type of crops commonly used, the hazardous climate effects, the specific level or threshold where the climate becomes hazardous, and describe the adverse impact on crops.

REFLECTION ON MAIN CLIMATE HAZARDS AND SENSITIVITY
What is the single most significant threat to any one crop from climate related hazards?
CROP-RELATED HAZARDS AND ADAPTIVE CAPACITY
Please describe measures used to adapt to each hazard for each crop. How effective is each adaptive measure in reducing the threat from the climate hazard?

Appendix C

Figure 8: Diagrams of Experiential Learning Plot for Mfungwe LEG. From Top-Left in Clockwise Direction, Risk Adjusted, Negotiated, Planted and Yield of LEG Treatments versus Business as Usual (Original Cropping Strategy)

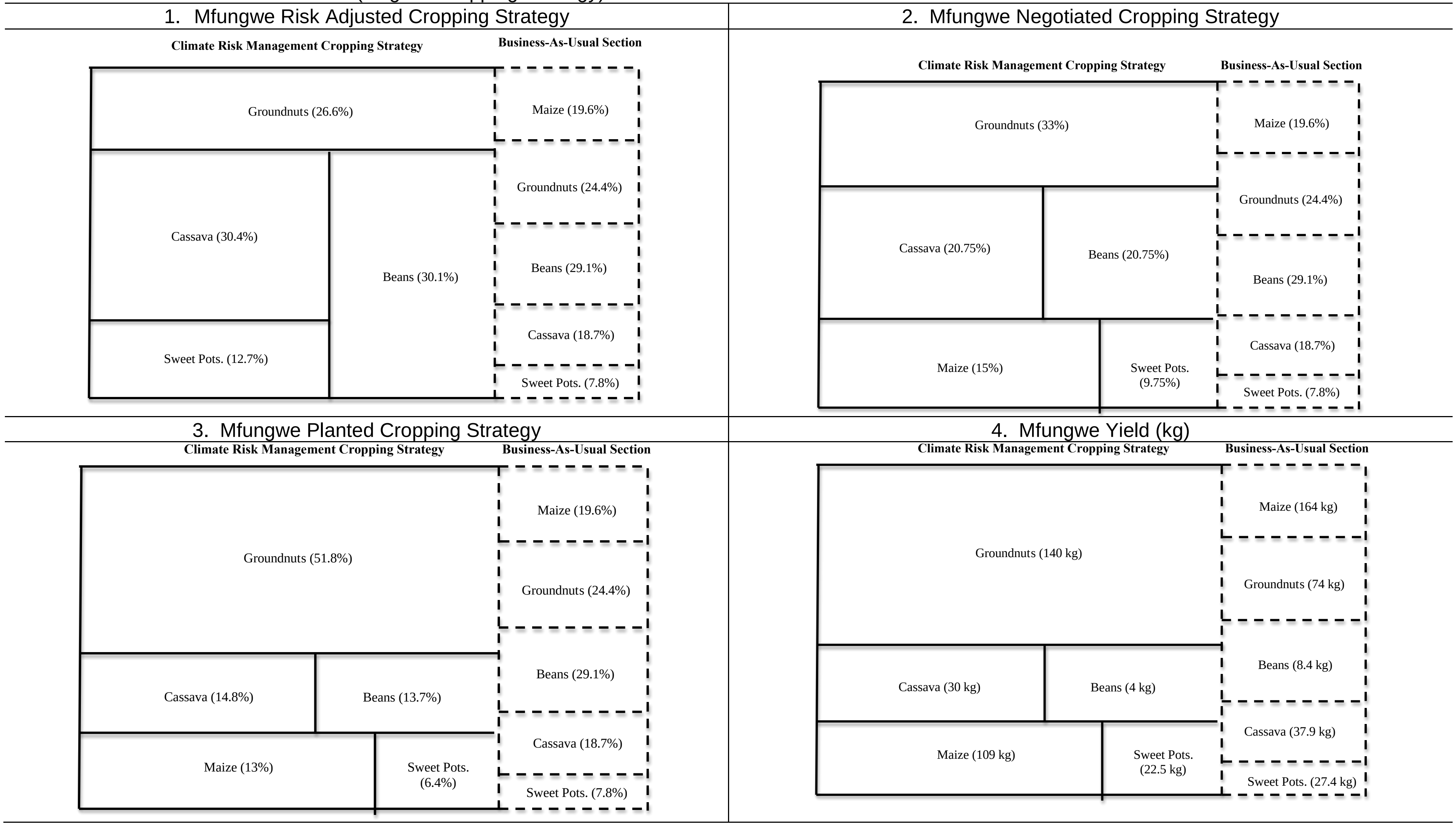
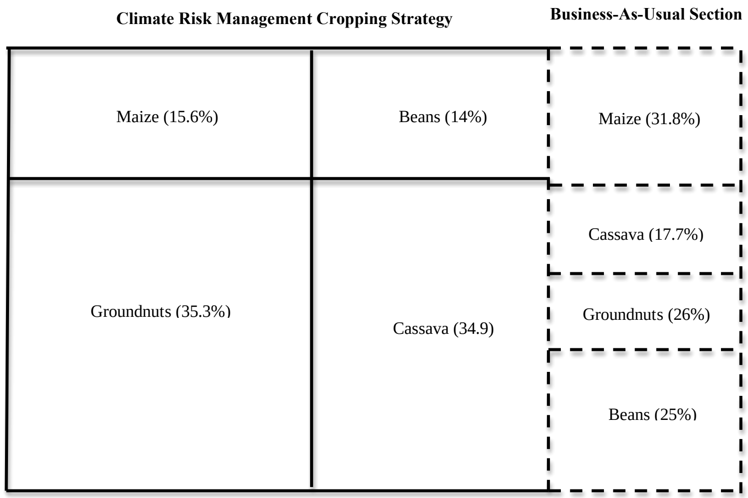
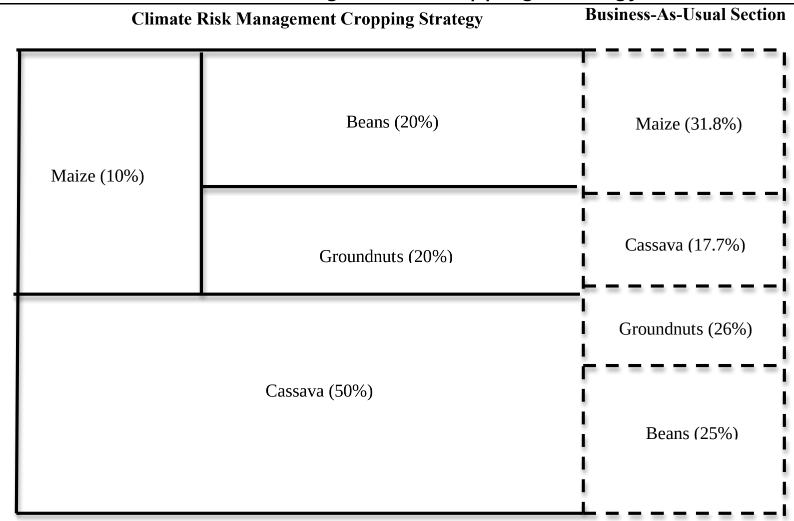


Figure 9: Diagrams of Experiential Learning Plot for Zombe LEG. From Top-Left in Clockwise Direction, Risk Adjusted, Negotiated, Planted and Yield of LEG Treatments versus Business as Usual (Original Cropping Strategy)

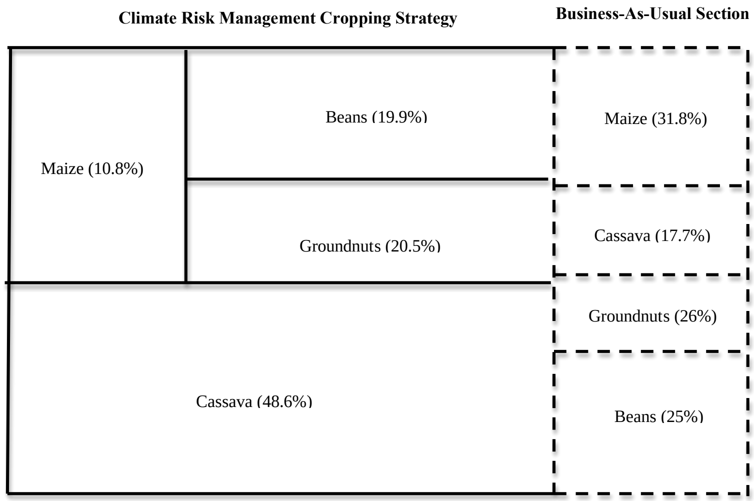
1. Zombe Risk Adjusted Cropping Strategy



2. Zombe Negotiated Cropping Strategy



3. Zombe Planted Cropping Strategy



4. Zombe Yield (kg)

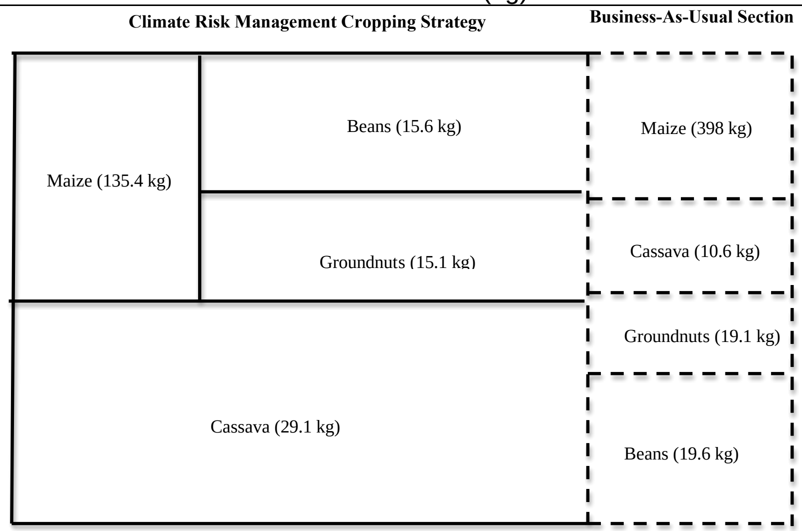
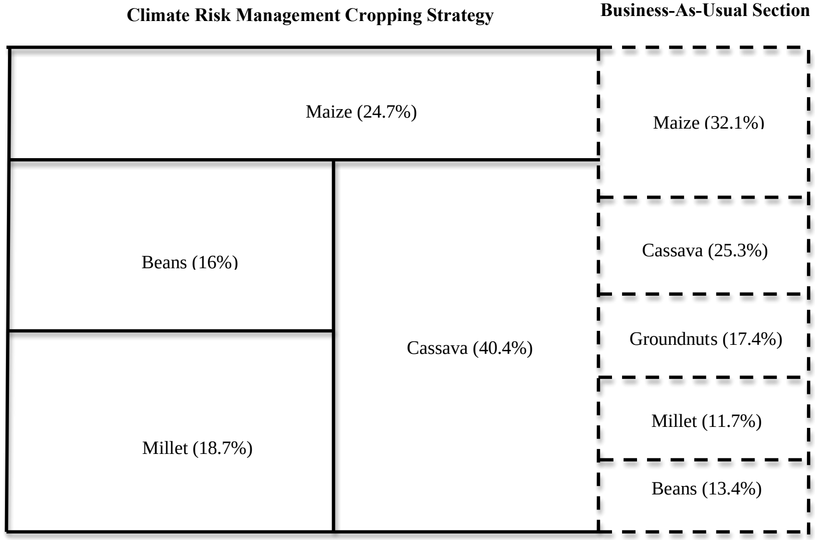
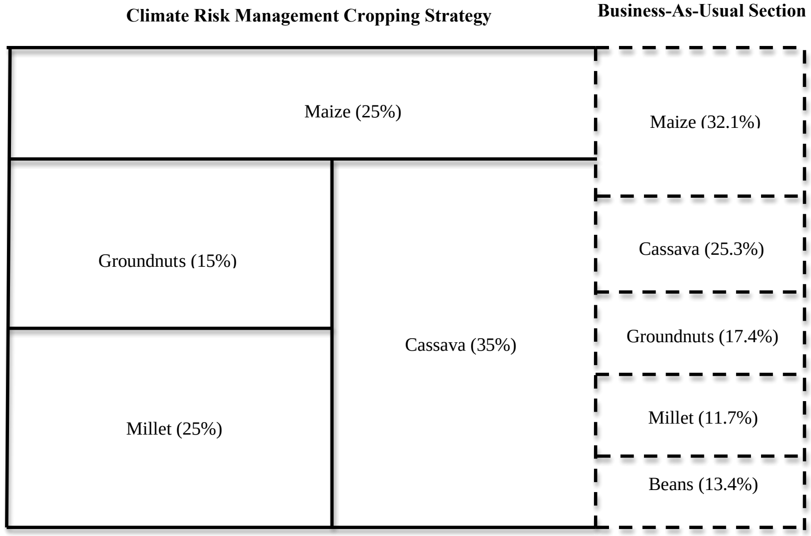


Figure 10: Diagrams of Experiential Learning Plot for Shimumbi LEG. From Top-Left in Clockwise Direction, Risk Adjusted, Negotiated, Planted and Yield of LEG Treatments versus Business as Usual (Original Cropping Strategy)

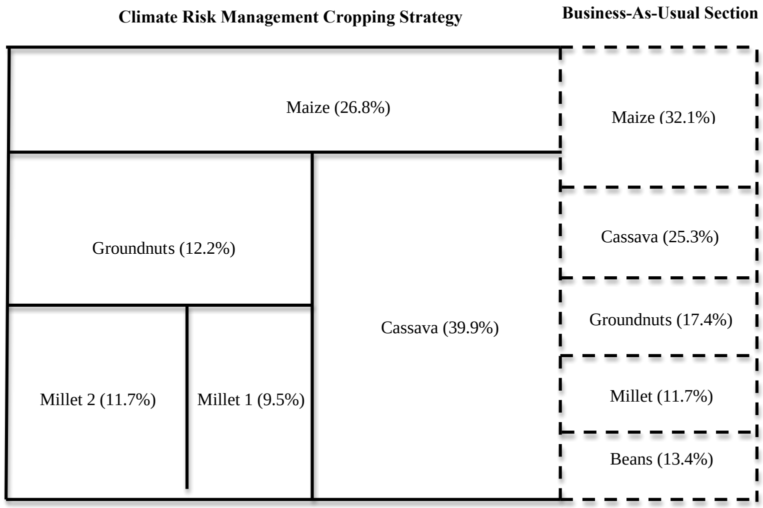
1. Shimumbi Risk Adjusted Cropping Strategy



2. Shimumbi Negotiated Cropping Strategy



3. Shimumbi Planted Cropping Strategy



4. Shimumbi Yield (kg)

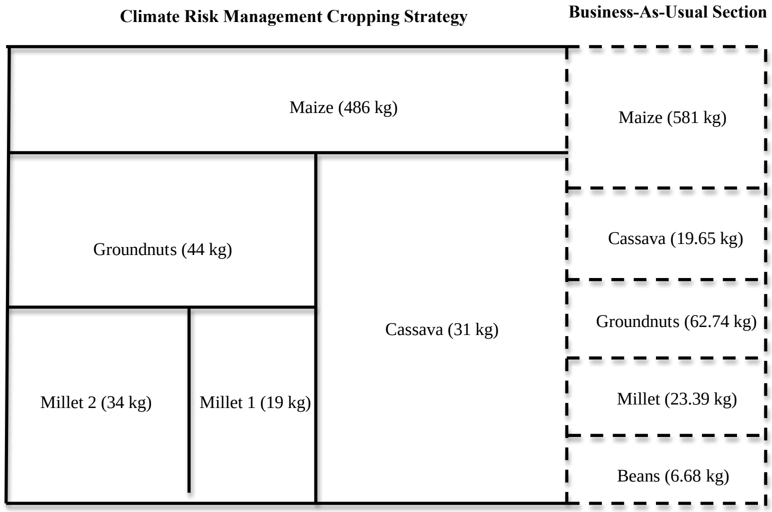
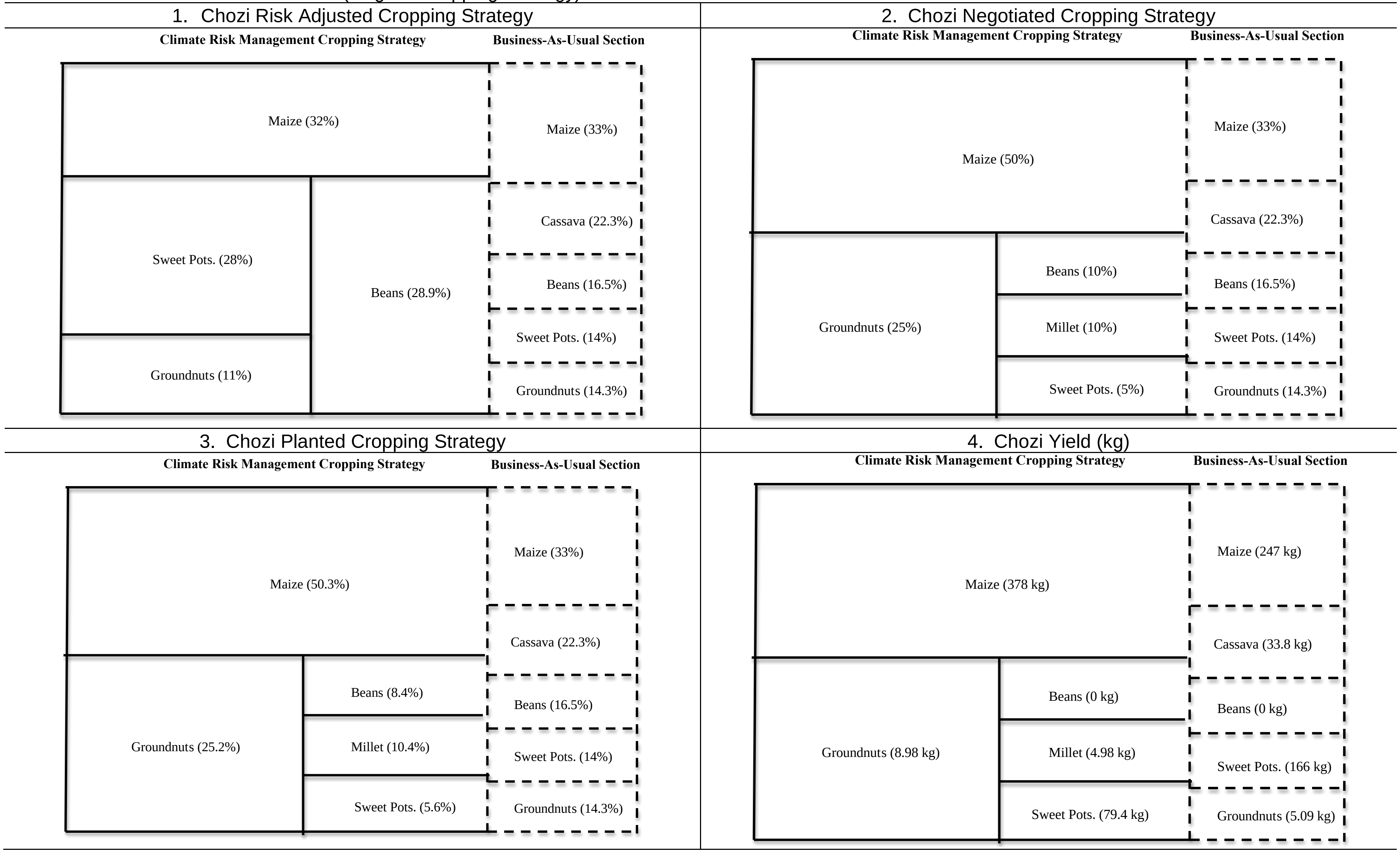


Figure 11: Diagrams of Experiential Learning Plot for Chozi LEG. From Top-Left in Clockwise Direction, Risk Adjusted, Negotiated, Planted and Yield of LEG Treatments versus Business as Usual (Original Cropping Strategy)



Policy is effective from this Thursday 19 October
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