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Climate-resilient seed systems & access and benefit-sharing in Zambia

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EXECUTIVE SUMMARY

Zambia, like any other country, has been experiencing the effects of climate change across all sectors of national development, including agricultural production. Changes in climate and weather patterns include unpredictable rains, a shifting and shortening of the growing season, increase in temperatures, and longer dry spells. The production of maize, which is a staple food crop in Zambia, is predicted to decrease by up to 20% in some places by 2050. The importance of developing new varieties and maximizing the use of existing diversity is paramount for responding to climate change, as one of the strategies for adaptation. Accessing this diversity for climate change adaptation will be a key to ensuring farmers and communities adapt to climate change.

This case study focuses on activities being implemented in relation to access and benefit sharing in the development of plant genetic resources for food and agriculture (PGRFA), and the availability of PGRFA for climate change adaptation. The study looked at the movement of PGRFA in and out of Zambia, and how international and national PGRFA developments have enhanced the resilience of Zambia's seed systems. Secondary data, obtained from the Genesys database[1] and the Secretariat of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), was analysed to show trends in flows of PGRFA in and out of the country and within the country. Primary data and information on germplasm exchange was collected from key informant surveys with people from various institutions involved in research, conservation and extension.

Using crop-climate suitability modelling, PGRFA that are potentially adaptable to present and future climate challenges were identified from national and international gene banks. A combination of climate and GIS modelling tools were used to match specific accessions to the climates of collection points, based on 19 bioclimatic variables.

The study also looks at the policy and regulatory implications for access and benefit sharing (ABS) in Zambia, identifying gaps and recommending changes that need to be made at a policy level in order to facilitate access to and exchange of genetic resources for the benefit of farmers. The fact that millions of seed samples representing different genetic resources have been secured globally, and are available for use through the Standard Material Transfer Agreement (SMTA) of the ITPGRFA, offers an opportunity towards developing new varieties to respond to climate change. Germplasm introductions from external sources outside the country continue to be a major feature of crop development and improvement programmes for major crops in the country.

The country now needs to ratify the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity (Nagoya Protocol/CBD), and to develop the necessary legislation, regulations and structures for its implementation. This will broaden access and benefit sharing to cover crops that are not currently included in the Multilateral System of Access and Benefit Sharing of the ITPGRFA (MLS). Consequently,

[1] Genesys is a global portal to information on plant genetic resources for food and agriculture, can be accessed at www.genesys-pgr.org, accessed 13 December 2016.

germplasm for all crops of interest to breeders will be available for exchange and use. But to achieve this, the Ministry of Lands, Natural Resources and Environmental Protection (MLNREP), which is responsible for the Nagoya Protocol, must work together with the Seed Control and Certification Institute (SCCI) and the National Plant Genetic Resources Centre (NPGRC) to develop guidelines for the implementation of the Nagoya Protocol.

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ACRONYMS

ABS	Access and benefit sharing
AEZ	Agro ecological zones
Africa RISING	Africa Research in Sustainable Intensification for the Next Generation
BCN	Biodiversity Community Network
BLA	Better Life Alliance
CASH	Commercial Agribusines for Sustainable Horticulture
CBD	Convention on Biological Diversity
CBO	Community-based organization
CDKN	Climate and Development Knowledge Network
CGRFA	Commission for Genetic Resources for Food and Agriculture
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
COMESA	Common Market for Eastern and Southern Africa
CPB	Cartagena Protocol on Biosafety to the Convention on Biological Diversity
CRS	Catholic Relief Services
CSB	Community seed bank
CTDT	Community Technology Development Trust, Zambia
DTMA	Drought-Tolerant Maize for Africa project
FAO	Food and Agriculture Organization of the United Nations
FISP	Farmer Input Support Programme
FSRP	Food Security Research Project III
GART	Golden Valley Agricultural Research Trust
GIS	Geographic information system
GRPI	Genetic Resources Policy Initiative
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
ISSD	Integrated seed sector development
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
MAFF	Ministry of Agriculture, Food and Fisheries
MAWA	Zambia Economic Resilience Program for Improved Food Security
MLNREP	Ministry of Lands, Natural Resources and Environmental Protection
MLS	Multilateral System of Access and Benefit Sharing of the ITPGRFA
MTA	Material transfer agreement
Nagoya Protocol	Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity
NAPA	National Adaptation Programme of Action
NARS	National Agricultural Research System
NGO	Non-governmental organization

NPGRC	National Plant Genetic Resources Centre
OPV	Open-pollinated variety
PGR	Plant genetic resources
PGRFA	Plant genetic resources for food and agriculture
PLARD	Programme for Luapula Agricultural and Rural Development
PROFIT+	Production, Finance and Improved Technology Plus
QDS	Quality-declared seed
SADC	Southern African Development Community
SAVCA-CSA	Strengthening Agriculture Value Chains through Adoption of Climate-Smart Agriculture
SCCI	Seed Control and Certification Institute
SCRB	Soils and Crops Research Branch (MAFF)
SHA	Self Help Africa
SMIP	Sorghum and Millet Improvement Program
SMTA	Standard Material Transfer Agreement
TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights
UNDP	United Nations Development Programme
UNZA	University of Zambia
UPOV	International Union for the Protection of New Varieties of Plants
USAID	United States Agency for International Development
WIPO	World Intellectual Property Organization
WTO	World Trade Organization
ZARI	Zambia Agriculture Research Institute

1. INTRODUCTION

Zambia, like any other country, has been experiencing the effects of climate change across all sectors of national development including agricultural production. Farmers in most parts of Zambia have reported changes in climate and weather patterns, including unpredictable rains, shifting and shortening of the growing season, an increase in temperatures, and longer dry spells. According to the *Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC), southern Africa has been experiencing an increase in the annual mean temperature, and maximum and minimum temperatures, since the mid-twentieth century, with the most significant rises in temperature occurring over the last two decades. The report further notes that minimum temperatures have risen more rapidly compared to maximum temperatures over inland southern Africa (CDKN, 2014). In Zambia, where maize is the staple food crop, the production of maize is predicted to decrease by up to 20% in some places by 2050, under such temperature and precipitation scenarios (Schlenker and Lobell, 2010).

Perceptions of the effect of climate change in the country are very much in conformity with the 2013 global survey findings of the Food and Agriculture Organization of the United Nations (FAO), that climate change impacts on production, genetic resources for food and agriculture, and ecosystem services, and that there is a need in many cases to change species or varieties to respond to climate change (FAO, 2015). Ways of coping with increased climate stresses are needed, particularly with abiotic stresses such as heat, drought and flooding. The importance of developing new varieties is paramount for responding to the negative effects of climate change. The IPCC recognizes the use of existing diversity to adapt to climate change as one of the strategies for adaptation. Accessing this diversity for climate change adaptation will be key to ensuring farmers and communities adapt to climate change.

This case study focuses on access and benefit sharing in the utilization and development of plant genetic resources for food and agriculture (PGRFA), and, specifically, PGRFA for climate change adaptation. The study looks at the movement of PGRFA in and out of Zambia, and at how international and national PGRFA developments have enhanced the resilience of Zambia's seed systems. The future interdependence of two communities, due to climate change, is also used to illustrate how climate change will necessitate access to PGRFA for adaptation. Finally, the study examines the current access and benefit-sharing (ABS) regime in Zambia, and the ways in which it can be improved to make PGRFA accessible for climate change adaptation.

2. METHODOLOGY

The study uses various approaches to analyse the flows and exchange of genetic resources at different levels:

- *International to national exchange* between (i) national gene banks from different countries; (ii) CGIAR centres and national gene banks; (iii) foreign national gene banks and academic or research institutions; (iv) advanced research institutes abroad and local research institutes; and (v) local community gene banks and community gene banks in other countries.
- *National exchange* between different actors; for example, between (i) breeding programmes (ii) national gene banks and breeders, communities and other users; (iii) communities; and (iv) communities and the private sector.

Secondary data, obtained through the Genesys database[2] and the Secretariat of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), was analysed to show trends in PGRFA flows in and out of the country and within the country. Primary data and information on germplasm exchange were collected from key informant surveys with representatives of various institutions involved in research, conservation and extension.

The study also draws upon case studies on the exchange of genetic materials between communities, and looks at how climate change drives the interdependence and exchange of genetic resources. Two communities, namely Chikankata and Rufunsa, were chosen for the case studies. Each community selected a crop based on its importance for food security and climate change adaptation, and its contribution to livelihoods. Chikankata selected maize, while Rufunsa chose sorghum. PGRFA potentially adaptable for present and future climate challenges were identified from national gene banks and international gene banks, using a combination of climate and GIS modelling tools that matched specific accessions to the climate of the collection points based on 19 bioclimatic variables. Accessions were then selected based on their similarity to the present or predicted future (2050s) climate of the site. These accessions were then made available to farmers for trials. Potentially adaptable germplasm from the communities and community seed banks (CSBs) were also identified in collaboration with farmers through participatory varietal selection and ranking.

Finally, the study investigates the policy and regulatory implications for ABS in Zambia, identifying gaps and recommending changes that need to be implemented at policy level in order to facilitate access to and exchange of genetic resources for the benefit of farmers.

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[2] Genesys, a global portal to information on plant genetic resources for food and agriculture, can be accessed at www.genesys-pgr.org, accessed 13 December 2016.

3. RESULTS AND DISCUSSION

3.1 Climate change in Zambia and its impact on agriculture

Zambia is situated on a large plateau between 8° and 18° south of the equator. The climate is predominantly sub-tropical, with 95% of precipitation falling during the wet season (November to April). Rainfall varies according to latitude and agro-ecological region, with over 1,200 millimetres (mm) falling annually on average in the north and northwest (Region III), and less than 700 mm in the south (Region I). Region II, the central part of the country, receives between 800 and 1,200 mm of rain annually. Average temperatures peak in October, and the lowest average temperatures occur in July.

The past 40 years have experienced a slight reduction in annual precipitation, along with increased variability in rainfall year-to-year, and an increase in extreme precipitation events (Solomon et al., 2007; Kirtman et al., 2013). There have been more droughts and floods over the past 20 years, which have impacted significantly on crop production and crop diversity in particular. Both droughts and floods are believed to have led to some loss of crop diversity on farm (Mwila, Ng'uni and Phiri, 2008). Predicted impacts of climate change differ between the country's three agro-ecological zones, depending on rainfall. In the western and southern parts of the country, rainfall has been low, unpredictable and poorly distributed for the past 20 years, despite historically being considered a good cereal cropping area (Jain, 2007).

Since 1960, the mean annual precipitation countrywide has been decreasing by 1.9 mm per month per decade, most notably in the summer months, and the growing season has been shortening (McSweeney, New and Lizcano, 2010; Tadross, 2009). The climate, including its precipitation and temperature patterns, is expected to continue to change over the next five to 40 years. In the coming decades, the temperature across Zambia, along with the entire southern African region, is widely expected to increase by up to two degrees Celsius (°C) (Hulme et al., 2001; Tyson, 1991; Christensen et al., 2013). Total annual precipitation is expected to decrease slightly, although the frequency of extreme precipitation events (causing flash floods) will probably become greater. The intensity of rainfall events and the time between them may also increase. In other words, this reduction in the frequency of rainy days could lead to longer dry spells interspersed with more intense, heavy precipitation, all without greatly altering total annual precipitation (Gannon et al., 2014).

The effects of climate change in Zambia are being felt most by farmers, through extreme weather events such as droughts, storms, floods and cold snaps; and gradual shifts in rainfall patterns and sometimes temperatures. These observations have been aptly summarized by FAO in Table 1. Longer or shorter rainy seasons in the northern or southern parts of the country, respectively, are the main changes perceived by farmers. This is confirmed by meteorological observation, which indicates that rainfall patterns in Zambia have changed significantly since the late 1980s. In the south, the critical threshold has almost been reached, with only 130 days left for planting maize. This is insufficient for many varieties except early-maturing varieties, which mainly have smaller yields. In the north, on the other hand, longer rainfalls often cause the maize crop to rot in the fields (Neubert et al., 2011). Planting varieties that mature within the duration of the season is therefore a major form of adaptation. In addition to shifts in varieties, crop species diversification is also necessary so that areas that are no longer suitable for maize can shift to sorghum and millets as well as cassava, which are more resilient.

The majority of Zambia's farmers lack the capacity, resources and financial assistance to adapt to and overcome worsening climatic conditions. The National Adaptation Programme of Action (NAPA) of Zambia highlights that Zambian communities are vulnerable to climatic hazards (such as drought, flooding, extreme temperatures and prolonged dry spells), which precipitate widespread crop failure, negatively impact food and water security and, ultimately, affect the sustainability of rural livelihoods (MTENR, 2007). Indeed, within the last 20 years, prolonged dry spells and shorter rainfall seasons have reduced maize yields to only 40% of the long-term average. Furthermore, based on the scenario in which carbon dioxide (CO^2) doubles in these regions, estimates predict a reduction in yield of approximately 66% under rain-fed conditions. The country therefore has to come up with strategies for adaptation to climate change not only at national level, but for specific communities in different agro-ecological zones (AEZs).

Table 1. Main effects of climate change

Climate change effect	
CO^2 fertilization	• Increased CO^2 availability for plant growth
Increase in global mean temperatures – **0.2 - 0.4 °C per decade** **2 - 4 °C by 2050**	• Increase in maximum temperatures on hot days • Increase in minimum temperatures on cold days • Increase in occurrence of hot days per year • Increase in intensity, duration and frequency of heat waves
Changes in precipitation	• Frequency, duration and intensity of dry spells and droughts • Changes in timing, location and amounts of rain • Shortening of the rainy/growing season
Increase in frequency and intensity of extreme weather events	• High winds • Storm surges • Flash floods
Greater weather variability	• Instability of seasonal weather patterns • Changes in start and end of growing seasons

Source: FAO (2015)

The dominance of rain-fed agriculture in Zambia means that climate change poses a considerable challenge. The yield during a severe drought in 1991-1992, for example, was less than half that of the preceding season. Droughts in 1993-1995, 2001-2002 and 2004-2005 similarly had a severe impact on yields and consequently on food security. Global climate models predict that temperatures will increase in southern Africa by 0.6 - 1.4 °C by 2030. Rainfall predictions are more ambiguous, with some models suggesting increased precipitation, and some suggesting reduced precipitation. Crop yields in the region are expected to suffer as a result, with maize yields predicted to fall by 30% and wheat by 15%, in the absence of adaptation measures (Lobell et al., 2008).

It should be noted that the impact of climate change on crop production is not limited to total rainfall and temperature effects: intra-seasonal rainfall variation is also important. A 'false start' to the rainy season due to erratic rainfall can be disastrous for crop establishment. Similarly, intra-seasonal dry spells may be more damaging to growth than low total rainfall (Kaczan, Arslan and Lipper, 2013).

Major crops that are grown in the country are maize, sorghum, millet, rice (paddy), wheat, cassava, groundnut, sunflower, cotton, soybean, beans and tobacco. Of these, maize, the staple food, is the most important, and also faces a significant threat from the impact of climate change on its production.

3.2 Development of programmes on climate-resilient seed varieties

In addition to the many adaptation programmes taking place in the country, there are also efforts to utilize so-called climate-smart varieties, which are considered to be adapted to the changed climate. There is indeed scope in finding or developing varieties that may withstand increased temperatures or reduced moisture during crop production. The fact that millions of seed samples, representing different genetic resources, have been secured globally, and are available for use through the Standard Material Transfer Agreement (SMTA) of the ITPGRFA, offers an opportunity towards developing new varieties to respond to climate change.

The FAO report on PGR and resilience to climate change (FAO, 2015), has outlined a number of technical adaptation actions that support adaptation and include the following:

- Actions involving change in species or varieties in production systems. The changes include direct selection of materials to meet changed conditions, and introduction of adapted materials (species and varieties).
- Diversification leading to increased diversity of crops or species, and use of trees in crop production systems.
- Improved and increased access to and availability of materials that can be used in adaptation. This has both policy and technical dimensions and is linked to capacity development.

The Integrated Seed Sector Development (ISSD) Africa programme, in its assessment of the Zambian seed sector, identified five seed systems in the country (Nakaponda, 2012):

- Informal or farmer-managed system, in which farmers exchange and sell seed of traditional varieties.
- Non-governmental organizations (NGOs) that provide support through their projects to farmers engaged in community-based and entrepreneurial forms of seed production of officially released varieties that are certified by the Seed Control and Certification Institute (SCCI).
- National seed companies, which depend mainly on the CGIAR for germplasm for breeding, and engage both commercial and small-scale farmers in seed production of the released varieties of mainly food crops.

- International seed companies, which are involved in breeding and seed production of mostly hybrid maize and some cash crops.
- The export commodities-driven seed system, which is based on an out-grower scheme arrangement between smallholders and commercial farmers for cash crops, where the company provides seed of cotton or tobacco.

The Drought-Tolerant Maize for Africa (DTMA) project is being jointly implemented by the International Maize and Wheat Improvement Center (CIMMYT) and the International Institute of Tropical Agriculture (IITA), and involves national agricultural research and extension systems, seed companies and NGOs. The project aims to develop and disseminate drought-tolerant, high-yielding, locally adapted maize varieties in sub-Saharan Africa. Using material developed through this project, 22 drought-tolerant maize varieties were released between 2007 and 2014 in Zambia by the Zambia Agriculture Research Institute (ZARI) and various seed companies. Details about these varieties are provided in Table 2 below.

Table 2. Drought-tolerant maize varieties released in Zambia between 2007 and 2014

Variety	Year of release	Hybrid/open-pollinated variety (OPV)	Producer
PGS 53	2007	Hybrid	Progeny Seeds
PGS 71	2007	Hybrid	Progeny Seeds
ZM 423	2007	OPV	ZARI
KAM 601	2008	Hybrid	Kamano Seed Company
KAM 602	2008	Hybrid	Kamano Seed Company
ZM 523	2008	OPV	ZARI
ZM 625	2008	OPV	ZARI
ZM 721	2008	OPV	ZARI
SC 721	2008	Hybrid	Zambia Seed Company Ltd
SC 727	2010	Hybrid	Zambia Seed Company Ltd
CAP 9001	2010	Hybrid	Capstone Seeds
ZMS 606	2010	Hybrid	Zambia Seed Company Ltd
Nelson's Choice	2010	OPV	Capstone Seeds
MMV 409	2011	OPV	ZARI

ZMS 623	2012	Hybrid	Zambia Seed Company Ltd
GV 628	2013	Hybrid	ZARI
GV 635	2013	Hybrid	ZARI
GV 638	2013	Hybrid	ZARI
GV 613	2014	Hybrid	ZARI
GV 637	2014	Hybrid	ZARI
GV 655	2014	Hybrid	ZARI
MMV 607	2014	OPV	ZARI

Source: CIMMYT (2015)

The involvement of ZARI, which is a public research institution, contributed to the inclusion of open-pollinated varieties (OPVs) that are more affordable and can be grown in more than one generation by small-scale farmers, while seed companies concentrated only on hybrids.

3.3 Indigenous knowledge and its application for climate change adaptation

Most seed sown in the country is produced locally by farmers who manage their own seed production. This seed is used by the household, exchanged or bartered with neighbours, kin or other communities (Mulvany and Mpande, 2013). By and large, most seed is informally produced, except maize seed for which there are many improved varieties on the market. Much more breeding for climate change is required to boost agricultural production in the country. Local varieties often yield less than improved varieties, though they may be better adapted to diverse and location-specific low-input agricultural conditions. They are also a source of seed security in case the improved varieties fail. Yet the farmer-managed seed system continues to decline as new improved varieties, particularly hybrid maize, are promoted in the government-driven Farmer Input Support Programme (FISP), to the extent that the conservation and use of local varieties or local knowledge associated with these crops and varieties, and also the maintenance and seed production of those crops, is threatened. It is important that traditional varieties and associated indigenous knowledge are given prominence in the identification or development of varieties that address climate challenges.

Through community seed banking and custodian farmers, indigenous knowledge has been preserved in the communities. Currently, very few community seed banks (CSBs) exist in the country, though the term is also often erroneously used to describe seed stores for community seed producers who produce seed of commercial varieties in partnership with seed companies and NGOs. The role of a CSB is to provide a sustainable flow of local indigenous seed and associated knowledge, and to conserve local varieties. In Zambia, CSBs are also known to participate in the distribution of improved maize varieties; they act as intermediaries between seed companies and farmers because they are already organized and their seed networks are strong. Many CSBs are involved with seed companies such as Kamano and Steward Globe, as well as ZARI, to produce maize OPVs, legume seed of groundnut, beans and cowpea, and small cereals like finger millet.

Various NGOs have promoted community seed production of mostly open-pollinated improved varieties, which are released locally by research institutions, as shown in Table 3.

Table 3. Varieties multiplied by community seed producers using foundation seed provided by variety owners

Crop	Variety	Owner
Maize	Pool 16	Zambia Seed Company Ltd
	Pop 16	ZARI
	Obatampa	GTZ
	MMV 600	Zambia Seed Company Ltd
	MMV 400	Zambia Seed Company Ltd
	ZM 421	ZARI
	ZM 521	ZARI
	ZM 621	ZARI
Sorghum	Kuyuma	Zambia Seed Company Ltd
	Sima	Zambia Seed Company Ltd
Pearl millet	Lubasi	Zambia Seed Company Ltd
Finger millet	Nyika	Zambia Seed Company Ltd
Groundnut	MGV 4	Zambia Seed Company Ltd
	MGV 5	ZARI
	Chishango	ZARI
	Chalimbana	ZARI
Cowpea	Bubebe	Zambia Seed Company Ltd
	Lutembwe	Zambia Seed Company Ltd
Soybean	Lukanga	ZARI
	Magoye	Zambia Seed Company Ltd

Source: Nakaponda (2010)

It is important to pay attention to some seemingly illogical things that farmers do. Why are some varieties popular despite low yields? Understanding the decision-making process of the farmers can facilitate the development of varieties that are adapted to changing or unstable climates. Whenever a four-cell diversity analysis is conducted in a community, the cell with many households growing a particular variety in small areas generates a lot of useful indigenous knowledge, because this is the cell that will have varieties that may be overlooked commercially, but are very important to the community because of attributes that may not be related to yield or even marketing. Some of the reasons for growing these varieties may be linked to climatic factors, such as drought resistance or short growing season, food security, or taste and cooking properties. An example of a situation where farmers have applied local indigenous knowledge in the decision to plant, conserve and manage local maize diversity can be found in Chikankata where a four-cell analysis of maize varieties was carried out (see Box 1).

Box 1. Local indigenous knowledge in the management, use and conservation of local maize diversity in Chikankata

Participatory research carried out with farmers in Chikankata, revealed that farmers had been experiencing higher temperatures and shorter growing seasons, prompting them to find local varieties that are faster maturing. A four-cell analysis of maize, conducted in Chikankata, showed that Bbilimba (Gankata) is cultivated by many households on a large area of land. This is because this variety is preferred for consumption and also has good commercial qualities, such as high yield, and large cobs and grains. Many households grow Kafwamba and Tandanzala on small areas. These varieties are very early maturing and are consumed during the peak hunger period of February/March before the main harvest. Much of these are consumed fresh during this period and therefore there is only enough seed to plant in a small area of land. The grain of Kafwamba is also multicoloured, making it unattractive for commerce. A variety called 'Kenya' is being grown by a few households on a large area because although its taste is preferred and it is relatively high yielding, most households still prefer Bbilimba. So, the few households that cultivate Kenya do so in order to trade locally. Balankana and Hampungani are grown by just a few households on small areas of land. Balankana is mainly cultivated to be consumed as a roasted snack, while Hampungani is cultivated for sentimental reasons, as it produces twin cobs even though yield is low. In fact, farmers indicated that this was once a lost variety because of very limited seed availability.

Chikankata four-cell analysis of maize

Many households, large area -Bbilimba	**Many households, small area** -Kafwamba -Tandanzala
Few households, large area -Kenya	**Few households, small area** -Balankana -Hampungani

In addition, the custodians of these local maize varieties in Chikankata are mainly old men and women; for varieties like Balankana, which are cultivated for roasting, women are the main custodians. These custodians hold a lot of indigenous knowledge for their use, management and conservation.

3.4 Case studies on PGRFA exchanges

3.4.1 The National Plant Genetic Resources Centre

The National Plant Genetic Resources Centre (NPGRC) is responsible for most *ex situ* conservation activities in the country. Currently (2015), the NPGRC has 7,278 accessions belonging to different crop species maintained as seed samples. The *ex situ* collection also includes 100 germplasm materials of cassava maintained as living plants in a field gene bank. Since 2001, the NPGRC has distributed 1,936 samples of these accessions of different crop species to various research and learning institutions, NGOS and farmers. These include maize, cowpea, sorghum, pearl millet, finger millet, beans, sweet potato, cassava, sesame and local leafy vegetables, as shown in Table 5. Germplasm accessions have also been distributed to farmers and individuals on request.

The NPGRC has adopted the Standard Material Transfer Agreement (SMTA) for accessing PGRFA included in Annex 1 of the ITPGRFA, and has also developed a separate material transfer agreement (MTA) for PGRFA that are not on Annex 1, and for Zambian beneficiaries (See Appendix 1).

From 2011 to 2012, ZARI partnered with Enza Zaden, a private vegetable seed company in the Netherlands, in the areas of germplasm collection, accessions regeneration and seed multiplication, with a focus on traditional leafy vegetables. As can be seen in Table 4, this company obtained a number of accessions, but the NPGRC has not yet followed-up to find out the fate of the germplasm provided, not just to this company but generally to all recipients of Zambian germplasm. This is purely an indication of inadequate capacity of the national gene bank to conduct follow-ups on the germplasm that it distributes.

Table 4. Germplasm distributed from the national gene bank, 2001-2015

Crop	Recipients	Accessions
African eggplant	Enza Zaden	1
Amaranthus	Enza Zaden, Swaziland University, Golden Valley Agricultural Research Trust (GART), farmer, ZARI Vegetable Programme	46
Bambara	SCCI, Mulungushi University, Swaziland University	68
Beans	ZARI Bean Programme, University of Zambia (UNZA), SCCI	196
Brassica	Enza Zaden	3
Cassava	Swaziland University	9
Cleome	GART, farmer, Swaziland University	10
Corchorus	GART	1

Cowpea	ZARI Food Legume Programme, GART, IITA, Biodiversity Community Network (BCN)	209
Cucurbita	ZARI Vegetable Programme, Swaziland University, GART, UNZA, Enza Zaden	277
Gourds	Enza Zaden	15
Hibiscus	GART	2
Luffa	Enza Zaden	3
Maize	UNZA, Imperial College, CIMMYT, ZARI Maize Team, Norwegian University, farmer	460
Okra	GART	1
Pearl millet	ZARI Kaoma, SCCI, BCN	124
Rice	SCCI, UNZA	41
Sesame	UNZA	4
Solanum	Enza Zaden	3
Sorghum	ZARI Sorghum Team, Norwegian University, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), BCN	445
Sweet potato	BCN	1
Thorn cucumber	Enza Zaden	2
Watermelon	Enza Zaden, GART	3
Others	Various	12
Total		**1,936**

Source: NPGRC database

3.4.2 Exchange and access of genetic resources through research projects and CGIAR centres

Germplasm introductions from external sources outside the country continue to be a major feature of the crop development and improvement programmes for all crops in the country, with the exception of bambara groundnut, which depends entirely on local germplasm. The major sources of introduced germplasm are CGIAR centres, such as ICRISAT, CIMMYT, the International Center for Tropical Agriculture (CIAT), the International Potato Center (CIP), and the International Rice Research Institute (IRRI). According to data from the ITPGRFA Secretariat, in the past eight years Zambia has received over 11,000 accessions of different crops held by international gene bank collections worldwide (Table 5). Most notably, the greatest number of accessions are of wheat and maize.

Table 5. Materials sent from CGIAR centres to Zambia between 2007-2015 using the SMTA

Crop	Accessions
Cassava	22
Cowpea	15
Faba bean	2
Groundnut	109
In-trust forage collection under the ITPGRFA	7
Maize	3,295
Pigeon pea	95
Rice	468
Wheat	7,330
Total accessions	**11,343**

Source: ITPGRFA Secretariat

The South African Development Community (SADC)/ICRISAT Sorghum and Millet Improvement Program (SMIP) was launched in 1983, in response to a recommendation made by the SADC heads of state. Working with national programmes and the SADC Plant Genetic Resources Centre, SMIP helped conduct germplasm collection missions for sorghum and pearl millet in eight countries, including Zambia. A 'seed bank' was established at Matopos in Zimbabwe, which now contains 13,500 accessions that are indigenous to southern Africa, and another 75,000 lines of genetic stock, breeding lines, and populations developed jointly by National Agricultural Research System (NARS)/ICRISAT teams in the region. These efforts have helped preserve and document indigenous genetic diversity, and create a more diverse gene pool from which national breeding programmes can select and incorporate specific traits. SMIP has distributed over 130,000 sorghum and pearl millet genotypes to SADC national programmes, assisting them in the development of a range of new varieties suitable for their own environments. Over the years, 46 improved varieties (27 sorghum and 19 pearl millet) have been released in Botswana, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia, and Zimbabwe. In comparison, only 24 varieties had been released before SMIP was launched. This led to widespread adoption of new varieties in these countries; in Zambia, for example, NARS/SMIP varieties are grown on 38% of the sorghum area.

In 2012, Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) funded an 'early win' project in Tanzania, Malawi and Zambia, led by ICRISAT, whose aims were to increase production of both basic and certified seed for six target crops (maize, beans, cowpea, soybean, medium-duration pigeon pea and groundnut). The specific objectives were to:

- Accelerate the production of breeder and basic seed of improved varieties released by NARS.
- Build the capacity of NARS and small-scale private seed producers through investment in training in seed production, management and use.
- Foster public-private partnerships to increase the sustainability of seed systems serving smallholders.

ZARI has been successful in releasing a range of hybrids and open-pollinated varieties, and the liberalization of the seed market has further contributed to the diffusion of a wide mix of varieties supplied – and sometimes planted – by numerous seed companies. Zambian smallholders have a long history of growing improved maize varieties, though adoption rates are still rather low. The national maize research programme and seed companies have released a wide array of maize hybrids since the 1970s.

After the Zambian seed sector was liberalized in the 1990s, the number of released maize varieties proliferated, and seed companies have diversified. By the end of 2010, 203 improved maize varieties had been released (Table 6). Of these, the farmers surveyed in a Harvest Plus study conducted in 2011 (De Groote, et al., 2014) grew 106 improved maize varieties, as well as numerous local varieties and recycled hybrids. More than half of the farmers planted more than one variety, but few grew more than two varieties, and the maximum number of varieties grown during that season was five. Not one variety stands out as the most popular; not a single variety covers more than 10% of the area cultivated with maize, and the 20 most popular varieties together covered less than half of the maize area. About 16% of the maize area was taken up by local maize varieties. Agronomic characteristics are the most important criteria that farmers use when selecting a variety. Yield, drought resistance, and field pest resistance are by far the most important attributes farmers consider.

Table 6. Crop varieties released in Zambia

Crop	Varieties released since 2010	Total varieties released
Maize	67	264
Sorghum	8	25
Pearl millet	1	11

Finger millet	0	7
Wheat (irrigated)	8	44
Wheat (rain-fed)	0	5
Triticale	2	3
Rice (paddy)	3	16
Rice (upland)	3	5
Barley	1	3
Bambara nut	0	2
Beans	7	32
Cowpea	1	6
Soybean	8	40
Pigeon pea	1	2
Velvet bean	0	3
Castor	0	1
Groundnut	8	24
Sunflower	3	30
Guar	0	1
Cotton	6	16
Kenaf	0	3
Potato	10	21
Cassava	0	7
Sweet potato	5	13
Pasture grass	3	19
Pasture legumes	0	19
Tobacco	14	52
Vegetables	0	114
Total	159	788

Source: SCCI (2015)

Some of the varieties registered are new national varieties, some are varieties imported from other countries that are adapted for national use, and some are imported varieties, which have been developed by plant breeders in other countries and by the CGIAR centres. However, Zambia produces 80,000 metric tonnes (mt) of seed and is a net exporter of mostly hybrid maize seed. Less than one percent of seed sold in the country is imported and this is mainly vegetable seed (Thapa and Keyser, 2012). The situation is different for legume crops, where there is less demand for certified seed and therefore less production as farmers tend to use their own farm-saved seed for these crops much more than they do for maize.

While the formal seed system concentrates on developing and marketing varieties for large-scale commercial production, there are examples of their contribution to farmer-managed seed systems. For example, maize germplasm from open-pollinated varieties (OPVs), developed by both the public and private sectors, is used in informal seed systems. For most self-pollinated crop species, such as groundnut, developed varieties are usually integrated into the informal system where the seed is recycled over many generations and exchanged locally in the communities. In this system, farmers only differentiate based on seed colour and size, and the maturity period. The varieties shown in Table 7 show a maturity range from 90 to 160 days, thus offering farmers a wide choice in selecting the best variety to suit the rainfall patterns.

Table 7. Groundnut varieties released in Zambia, 1950-2015

Variety name	Botanical group	Seed colour	Days to mature	Year of release	Yield (tonnes/hectare)
Chalimbana	Virginia	Tan	140-160	1964	0.8-1.5
Makulu Red	Virginia	Red	130-145	1963	2.0-2.5
Natal Common	Spanish	Tan	90-100	1954	0.5-1.5
MGS 2	Virginia	Tan	140-150	1988	1.5-2.5
MGV 4	Virginia	Red	120-140	1991	1.5-2.5
Chipego	Spanish	Tan	110-120	1995	1.0-1.5
Champion	Virginia	Pink	150-160	1998	2.5-3.0
Comet	Spanish	Tan	90-100	1984	1.0-2.0
Luena	Spanish	Tan	90-100	1998	1.0-2.0
Chishango	Virginia	Tan	120-130	2003	2.0-2.5
Katete	Spanish	Tan	90-100	2005	1.0-1.5
MGV 5	Virginia	Tan	120-130	2008	2.5-3.0

Source: Makweti, Charlie and Kanenga (2015)

Sorghum and millet are important traditional cereal crops for food security in many parts of the country, and are largely grown by smallholder farmers. However, these crops face stiff competition from maize in the production system, mainly because of the massive support that maize production receives in the form of inputs and grain marketing. Maize is also the preferred cereal in urban areas, giving it a superior market advantage.

Consequently, the adoption rate for sorghum and millet varieties by smallholder farmers is far less compared to that of maize. The changing climate in some of the areas where these crops have been displaced by maize will inadvertently cause a reversal of crop choices as sorghum and millets become much more suited to the new climate. This is especially true for the southern part of the country, particularly the valley areas that are getting hotter and drier. The response has been the increased number of sorghum varieties released in 2015, as shown in Table 8.

Table 8. Sorghum varieties released in Zambia

Variety	Year of release	Title holder/agent
Red Swazi (R/OP)	1960/70s	Various
ZSV 1 (OP)	1982	Zambia Seed Company Ltd
Framida (R/OP)	1960s	Zambia Seed Company Ltd
WSH 287	1987	Zambia Seed Company Ltd
Sima (OP)	1989	Zambia Seed Company Ltd
Kuyuma (OP)	1989	Zambia Seed Company Ltd
MMSH 413 (R)	1992	Zambia Seed Company Ltd
MMSH 375 (R)	1992	Zambia Seed Company Ltd
ZSV 12 (OP)	1995	Zambia Seed Company Ltd
ZSV 15 (OP)	1998	Zambia Seed Company Ltd
MMSH 1257	1998	Zambia Seed Company Ltd
MMSH 1324	1998	Zambia Seed Company Ltd
WP 13	2005	ZARI
MMSH 1365	2005	ZARI
MMSH 625	2005	ZARI
SC Shaku	2007	SeedCo International (Z) Ltd
ZSV 36R	2013	ZARI

Mr Buster	2015	Advanta
ZSV 16	2015	Zamseed
ZSV 17	2015	Zamseed
Rakodzi	2015	Klein Karoo Seeds
Shirikure	2015	Klein Karoo Seeds
Vumba	2015	Klein Karoo Seeds

Source: SCCI (2015)

For pearl millet and finger millet, there have not been many new releases in the last ten years, as can be seen in Table 9. These two crops, together with cassava and sorghum, will be expected to increase in production as communities respond to climate change. The use of traditional varieties is predominant in these crops.

Table 9. Millet varieties released in Zambia

Variety	Year of release	Title holder/agent
Pearl millet		
L 197	1970s	Zambia Seed Company Ltd
ZPMV 871	1987	Zambia Seed Company Ltd
Kaufela	1989	Zambia Seed Company Ltd
Lubasi	1993	Zambia Seed Company Ltd
SaWAepo	1997	Zambia Seed Company Ltd
Tuso	1998	Zambia Seed Company Ltd
Kuomboka	1999	Zambia Seed Company Ltd
Mulatiwa	2005	ZARI
Liseli	2005	ZARI
Dola	2007	ZARI
Finger millet		
Steadfast	-	Zambia Seed Company Ltd
Lima	1989	Zambia Seed Company Ltd

Nyika	1996	Zambia Seed Company Ltd
Senga	1996	Zambia Seed Company Ltd
Chibuli	2001	Soil and Crops Research Branch (SCRB) – Ministry of Agriculture, Food and Fisheries (MAFF)
Sumina	2009	ZARI
Chipa	2009	ZARI

Source: SCCI (2015)

The development and use of climate-resilient seed will largely depend on the ease of access to genetic resources, governed by nationally and internationally agreed procedures for exchanging genetic resources and information. Approximately 6,391 accessions of various crops collected from Zambia are currently conserved in international collections hosted by various CGIAR centres that have signed Article 15 agreements with the Governing Body of the ITPGRFA. Those materials are made available under the SMTA. Information about those collections – and other collections, including those held by the United States Department of Agriculture (USDA) and European national gene banks – is available from the Genesys database. Samples of 4,814 of these accessions have also been duplicated for safety in the Svalbard Global Seed Vault.

The Seed Control and Certification Institute (SCCI) regulates seed production through the Plant Variety and Seeds Act, and provides for the protection of plant breeders' rights and the registration of plant varieties, through the Plant Breeders' Rights Act. Table 10 summarizes some examples of recent genetic resources exchanges between various stakeholders in the seed sector.

Table 10. Exchanges of genetic resources and information

Organization/programme	Data/information *Genetic resources and information exchanged between different kinds of stakeholders.* *Details about crops involved, quantity exchanged and purpose; and type of agreements, conditions and benefits*	Sources
SCCI and Feed the Future programme, funded by the United States Agency for International Development (USAID) in eastern Zambia	4 drought-tolerant maize varieties released by SCCI in September 2014; 5 varieties of groundnut released in late 2015; 2 soybean varieties released in 2015.	Feed the Future projects: Production, Finance and Improved Technology Plus (PROFIT+);

to improve resilience of households		Commercial Agribusines for Sustainable Horticulture (CASH); Zambia Economic Resilience Program for Improved Food Security (MAWA); Food Security Research Project III (FSRP); Better Life Alliance (BLA).
Harvest Plus and ZARI	Maize varieties, enriched with vitamin A, developed; 3 vitamin A-rich maize varieties released in 2012.	Harvest Plus
CYMMIT Drought-Tolerant Maize for Africa (DTMA)	22 drought-tolerant maize varieties developed between 2007 and 2014 by DTMA, through ZARI and five seed companies (ZamSeed, Capstone, Kamano, Progene and SeedCo.	DTMA
SNV	The Strengthening Agriculture Value Chains through Adoption of Climate-Smart Agriculture (SAVCA-CSA) project promoted climate-smart crop production, strengthened supply chain linkages that enhance food security, income and employment, and strived to build resilience among 13,000 smallholder farmers growing rice and soybean in the northern and western part of the country (2014-2015).	SNV Zambia project briefs
Sorghum and Millet Improvement Programme (SMIP), managed by ICRISAT	A total of 5,330 improved sorghum genetic materials supplied to Zambia from ICRISAT over a period of 15 years from 1983, including 6 varieties released in the country from ICRISAT germplasm.	ICRISAT/SMIP

Catholic Relief Services (CRS)	CRS-Zambia has been implementing the Diversity and Nutrition for Enhanced Resilience (DiNERs) programme on variety deployment since 2002. In the first year, the programme used the formal and informal seed systems, concentrating on seed fairs to build links between communities and seed producers (certified and QDS seed of improved varieties). Demand for seed has risen (50% for maize and 33% for beans). Emphasis was on communication; it will further develop direct links with seed producers in the second year. This will be supported by SMS services and the distribution of small packets of seed. The aim of DiNERs is to provide access to information on available varieties for farmers, and also to varieties that are available as QDS seed. Like traditional seed fairs, DiNERs supports private sector linkages between rural communities and commercial seed suppliers. DiNERs will also ensure that rural communities can access diverse types of seed and other planting materials essential for improving household nutrition and increasing resilience in the face of climatic shocks. DiNERs has included seedlings of fruit tree species, indigenous legumes and vegetables and cereal crops. Access to varieties (released and local) of priority crops is made possible through small samples and vouchers at seed fairs. Small vouchers equivalent to between US$0.50 and US$5 are used to buy seed in small quantities of up to a total of $20 (Rwomushana and Heemskerk, 2015).	CRS
Community seed producers	Seed produced by community producers in 2008/2009 includes various varieties of OPV maize, groundnut, cowpea, sugar beans and bambara nut.	Self Help Africa (SHA)

National Plant Genetic Resources Centre (NPGRC) provides applicants with samples based on the SMTA	782 accessions were distributed to various organizations and individuals, including farmers, between 1997 and 2008.	National gene bank database
CIAT with support from FAO/United Nations Development Programme (UNDP)	10 beans varieties were released between 1982 and 2013.	ZARI and CIAT
Programme for Luapula Agricultural and Rural Development (PLARD)', working with ZARI and farmers' associations	In order to increase the availability of good quality seed, a seed multiplication initiative for beans and groundnut was started in the 2008/2009 farming season, using the community seed bank model. In this type of programme, farmers are given seed to plant, and are required to pay back a portion of their harvest in seed.	PLARD

The main objective of community seed production is to increase availability of reasonably priced, quality seed of popular crops. The major crops produced by the community seed enterprises are OPV maize, groundnut, cowpea, sugar beans and bambara nut. The key challenge faced is access to foundation seed, especially groundnut and bambara nut, and access to markets. The ability to source foundation seed in a timely manner is crucial for the success of community seed schemes. Contract production for seed houses is also practiced; for example, Stewards Globe Ltd contracted farmers to multiply a maize OPV that had been developed from farmers' varieties, and which is relatively drought-tolerant (Mulvany and Mpande, 2013).

3.5 Access, exchange and benefit sharing of PGRFA and information: successes and challenges

Functional linkages between the formal and informal seed sectors are needed to support the evolution of the seed sector in general. The informal seed sector maintains numerous local varieties of many crops and is the primary source of germplasm for new crop varieties developed by the formal sector, which produces commercial varieties using modern breeding techniques.

A seed system security assessment conducted in eastern Zambia, led by CIAT, found that a very small cluster of crops dominates food production. On a basis of seed quantity, maize, groundnut and cotton accounted for 95% of seed planted (USAID, 2013). The assessment also found that there are challenges in accessing groundnut seed due to the limited production of basic seed of released varieties. Access to new varieties by farmers was limited to only maize and groundnut, with no farmer accessing new varieties of beans, cowpea or pigeon pea, all of which are popular crops whose diversification is essential for adaptation to climate change.

Crop improvement for food crops has been taking place within the public domain of ZARI programmes supported by CGIAR centres. However, access to varieties in the public domain by smallholder farmers is problematic. The funding for public breeding programmes generally originates from the government and is inadequate. According to the 'Yellow Book' of 2015 (MoFNP, 2015), which lists agricultural budget allocations planned by the government, only a paltry US$200,000 was earmarked for breeding, to cover all crops across the whole country, from an agricultural budget of about US$300 million. This level of resources is inadequate for increasing foundation seed to obtain a large enough number of varieties for the purposes of developing climate-resilient varieties for small-scale farmers.

Other causes for the limited availability of these varieties for smallholder farmers are the lengthy and complex release procedures, quantity and quality problems related to breeder and foundation seed, lack of incentives for breeders to distribute varieties to the private and community-based seed systems, capacity issues within the national agricultural research system, and also the capacity gap in relation to access to variety release and deployment (Rwomushana and Heemskerk, 2015).

Another related problem is the unsuitability of certain varieties that are developed without the involvement or participation of farmers, in defining the breeding objectives and determining priority traits. This ultimately leads to disinterest in the variety and/or low adoption rates.

Some of the main observations made on this topic by ISSD Africa (Rwomushana and Heemskerk, 2015) are that:

- Africa has a heterogeneous population with diverse cultural values leading to many different demands and required traits of varieties. There is also wide variation in food habits. This makes the still-prominent form of breeding, which focuses solely on yield and market demands, unsuitable. The variety portfolio requires diversification in adaptation to needs and agro-ecologies, which is why the reintroduction of well-adapted local varieties from gene banks or other sources is important.
- Farmer preferences are so diverse that they cannot all be dealt with by breeders without the involvement of the farmers themselves, hence the need for participatory plant breeding. Farmer tests and trials on plant varietal selection are needed, involving male and female farmers, to identify suitable traits such as cooking quality, fodder quality, marketability, etc.

Access to information on the characteristics and availability of varieties is one of the main constraints in accessing varieties that are available in the public system. Information on newly released varieties for farmers, as well as farmers' feedback on these varieties, is one of the traditional functions of public agricultural extension, but these systems are not sufficiently effective. Usually, limited information is available to both farmers and local seed producers, about which varieties are available and how they can be accessed.

While plant breeders' rights are in place, farmers' rights and community rights are not formally recognized. Limited and inconsistent funding to ZARI and other public institutions responsible for the development of improved varieties and their promotion, result in the limited availability of new improved varieties of important food crops suitable for the small-scale farmer.

The supply of breeder seed and foundation seed of local crops and subsistence crops, to seed companies and other organizations engaged in the seed sector (e.g. NGOs, associations, etc.), is inadequate. The low rate of release of varieties for crops with less commercial value acts as a further disincentive. In addition, ZARI is still biased towards conducting crop improvement activities in which the private sector is involved in the breeding of crops such as hybrid maize, wheat and soybean. This restricted investment in crop improvement, and the inadequate access to materials developed by public research results in the limited use of quality seed of improved varieties of self-pollinated crops among the small-scale farmers.

3.6 The need for policy initiatives to address challenges in PGRFA exchange

3.6.1 National seed laws and regional initiatives for the harmonization of international laws

Until 1998, Zambia had no seed policy, and the Plant Varieties and Seed Act guided the operations of the seed industry. A national seed policy was developed in 1999 and embedded in the National Agricultural Policy: 2004-2015, which has since been revised. The seed policy and act provide a basis to regulate the seed sector through seed testing, seed crop inspection, variety registration, variety protection and the enforcement of seed quality standards to facilitate seed trade, quarantine, multiplication, and the protection of plant breeders' rights.

The overall objective of the national seed policy is to ensure that quality seed of various crops is made available to farmers in an efficient and convenient manner to ensure increased agricultural production. The policy has identified the following measures and strategies to achieve this objective:

- Regulate the seed sector through seed testing, seed crop inspection, variety registration, variety protection and the enforcement of seed quality standards to facilitate seed trade, quarantine and other seed related issues.
- Promote the development of the informal seed sector by providing accessibility to breeder/basic seed from research, and coordinate the sector in creating a sustainable cottage (rural) seed industry.
- Regulate multiplication, trading and adoption of seed of genetically modified crops.
- Ensure the protection of plant breeders', farmers' and community rights.

As can be seen, the policy takes an inclusive approach in addressing formal and informal seed systems. It is at the implementation level that all efforts, including legislation, have tended to be lopsided towards the formal system.

It is a requirement under current regulations that all varieties are subjected to up to three years testing before being released for sale. This includes varieties developed elsewhere and imported into the country for release. There is an ongoing debate on the value of this regulation, which is intended to protect the farmer but which the suppliers argue increases release costs as the source of the material is deemed to have similar climatic conditions as Zambia. This is one of the underlying reasons behind harmonizing seed trade for the Common Market for Eastern and Southern Africa (COMESA), where testing will only be carried out in two countries and thereafter varieties will become eligible for release in all member countries.

The whole process of variety registration is also questionable, and the argument is the same, that this is intended to safeguard the farmer against inappropriate varieties. However, this also inadvertently blocks the inclusion of traditional varieties, regardless of how good and popular they may be, because there is no mechanism for including them since the criteria used to qualify a variety, such as uniformity, works against most of these varieties. If there is political will to include certain traditional varieties based on farmers' experiences and popularity, this would encourage other seed requirements, such as viability and seed purity, when this seed is being traded or exchanged.

Currently, the seed laws specifically state that only registered varieties may be bought or sold in Zambia. In other words, only 788 varieties of various crops are allowed to be traded. This is in stark contrast to the rights that are conferred by the ITPGRFA on farmers to exchange and sell the seed of their varieties. Therefore, while farmers frequently exchange their seed, the scope to which this can be done is restricted by the inhibitory seed laws.

3.6.2 Genetic resources policy, and access and benefit sharing

Zambia participated in the Genetic Resources Policy Initiative (GRPI), coordinated and implemented by Bioversity International, which aimed to strengthen the capacity of developing countries to design comprehensive policy frameworks for genetic resources. A number of policy-related problems affecting the conservation, management and use of genetic resources were identified. These included inadequate appreciation of the value of genetic resources; limited knowledge on what genetic resources are available, their conservation and use; and low level of awareness on issues related to ownership rights, access to genetic resources and benefit sharing at all levels. In order to address these problems, three main activity areas touching on policy research and advocacy were implemented during Phase 2 of GRPI in Zambia from 2005 to 2007; these areas were:

- Creating awareness on the value of genetic resources and related knowledge, conducted through a range of activities focused on increasing understanding and awareness regarding the role of genetic resources in Zambia.
- Assessing conditions of ownership and access to local genetic resources, conducted through a range of activities aimed at the domestication of the ITPGRFA and associated policy development.
- Promoting the incorporation of traditional crop varieties in local seed systems, conducted through a range of activities aimed at promoting the role and value of traditional varieties at local and national levels.

In 2008, ZARI informed the Secretariat of the ITPGRFA that it had placed a total number of 4,340 accessions in the Multilateral System of Access and Benefit Sharing of the ITPGRFA (MLS). The National Plant Genetic Resources Centre (NPGRC) has used agronomic and morphological characterization techniques to add value to some of the main collections, and has characterized 1,886 accessions of sorghum, cowpea, finger millet, maize, beans and pearl millet in order to facilitate utilization of these genetic resources by the international community. These actions promote transparency and help other contracting parties to the ITPGRFA to understand the status and the importance of the collections within the MLS.

While the country has made significant progress in relation to the ITPGRFA, it still lags far behind in relation to developing structures for implementing access and benefit sharing mechanisms, as agreed in the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity (Nagoya Protocol/CBD), which the country is yet to even ratify.

The rationale behind harmonizing seed trade regulations in COMESA is to expedite regional trade and farmers' access to improved seed; overcome lengthy variety testing and release procedures before seed can be marketed; and obviate the need to comply with different national certification standards, and quality control and phytosanitary measures. One of the objectives is to increase drought- and heat-tolerant varieties to deal with climate change. Seed harmonization basically concerns centralized seed registration, streamlined and uniform seed certification, and a phytosanitary system designed to expedite release of registered seed in the region, availability of certified seed, and seamless regional cross-border trade.

However, the harmonized laws impede trade of locally adapted varieties between farmers across the borders, giving rise to broader policy issues regarding facilitating and supporting a regional market for good quality and disease-free farmers' varieties, and special standards for the certification of farmers' varieties. The laws create an exclusive seed market for certified improved, commercial varieties of seed and excludes farmers' varieties from this marketing system.

Small-scale farmers seeking to develop or maintain varieties, create local seed enterprises, or cultivate locally adapted varieties, are excluded from the system. There is a need to protect the trade in local landraces, and to overcome barriers to legal cross-border trade between farmers of local varieties (Keyser, 2013).

Diversification is a measure to adapt to climate change, but it also helps to smooth out production and marketing risks as well as impacts of economic shocks. It is possible to cope with longer or shorter rainy seasons through variety diversification, which can also raise and spread income, increase soil fertility and enrich the nutritional status of households.

One of the strategies outlined in the national climate change policy is to enhance farming systems that encourage crop diversification, including the cultivation and consumption of indigenous and more drought-tolerant food crops like cassava, millet, sorghum and sweet potato.

ISSD Africa initiated a programme to contribute to increased access to public varieties for the private sector, and to coordinate donor activities in the development and deployment of public varieties. The objectives are to make more public varieties available to seed producers and farmers, develop licensing agreements and allocation mechanisms, and improve information and communication systems for variety catalogues. ISSD is also striving to increase the participation of the private sector (both formal and informal) in producing improved public varieties and making them available to farmers. The inclusion of PGRFA perspectives in national climate change adaptation planning is inconsistent, even though policies aimed at enhancing the availability of materials are crucial for climate change adaptation.

3.6.3 Recent policy developments in ABS and exchange of PGRFA and information

Farmers have a long tradition of producing, saving and exchanging seed. The local varieties used are generally derived from mass selection, which consists of choosing those plants that seem to be the most interesting in a population, and using their seeds to plant the following season. The operation is repeated generation after generation, which makes it possible to improve crop performance progressively. The plants obtained are neither identical to the previous generation nor identical to each other. The seed obtained via mass selection contain heterogeneous individuals, which gives it abilities of adaptation and resistance. Yet these are considered inferior and don't qualify in the formal seed certification system, which only accepts homogeneity and uniformity. Farmers generally practice mass selection, even on commercial open-pollinated varieties. The government has to make a policy shift that recognizes and even rewards this form of varietal improvement as part of the whole system of crop improvement.

3.6.4 International legal agreements on ABS ratified in Zambia

Zambia is a member of the following international organizations or legal instruments:

- FAO's Commission on Genetic Resources for Food and Agriculture (CGRFA), which governs all agricultural biodiversity.
- The ITPGRFA, a legally binding treaty that has a multilateral system for access and benefit sharing and articles on conservation, sustainable use and farmers' rights.
- The International Plant Protection Convention, which aims to protect cultivated and wild plants by preventing the introduction and spread of pests and diseases.
- The Convention on Biological Diversity (CBD), which sets the governance of biodiversity at genetic, species and ecosystem levels, within national jurisdictions.
- The Cartagena Protocol on Biosafety (CPB), which regulates the transboundary movement of living modified organisms such as genetically modified seed.
- The World Trade Organization (WTO) with its Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), whose clause 27.3.b requires all members to have systems for plant variety protection.
- The World Intellectual Property Organization (WIPO), which governs the 'ownership' of traditional knowledge among other issues, and houses the International Union for the Protection of New Varieties of Plants (UPOV), of which the country has been striving unsuccessfully to become a member. Zambia has its own Plant Breeders' Rights Act, 2007[3], which protects breeders' rights and provides some exemption to small-scale farmers to allow them to continue with their time-

[3] Available at http://www.aatf-africa.org/userfiles/Zambia%20PVP.pdf, accessed 10 March 2017.

tested seed access and management traditions. To qualify to join UPOV, the country is expected to revise its law by restricting these farmer exemptions.

Zambia has not yet ratified the Nagoya Protocol but has developed an MTA for the exchange of crop materials that are not included in Annex 1 of the ITPGRFA (Appendix 1).

3.6.5 Status of implementation of ratified international policy instruments

The country has struggled to fully implement all these international agreements, and in many cases fulfilled only partially some of the aspects, mostly due to limited capacity and resources. However, failure to implement some of the agreements has been mostly due to lack of political will, as has been the case with aspects of the ITPGRFA, where farmers' rights have been completely overshadowed by plant breeders' rights. During the initial process of formulating the draft for plant breeders' rights, drafts on farmers' rights were also being developed. It was, however, decided to separate the two at the point of enactment and no progress has been made on the latter draft since then.

The ITPGRFA underscores the importance of plant genetic resources for food security. Through its MLS, it facilitates access to 35 major food crops and 29 forage crops. At the same time, it provides for fair and equitable benefit sharing arising from the utilization of these resources if the resulting products are not freely available for further improvement and research.

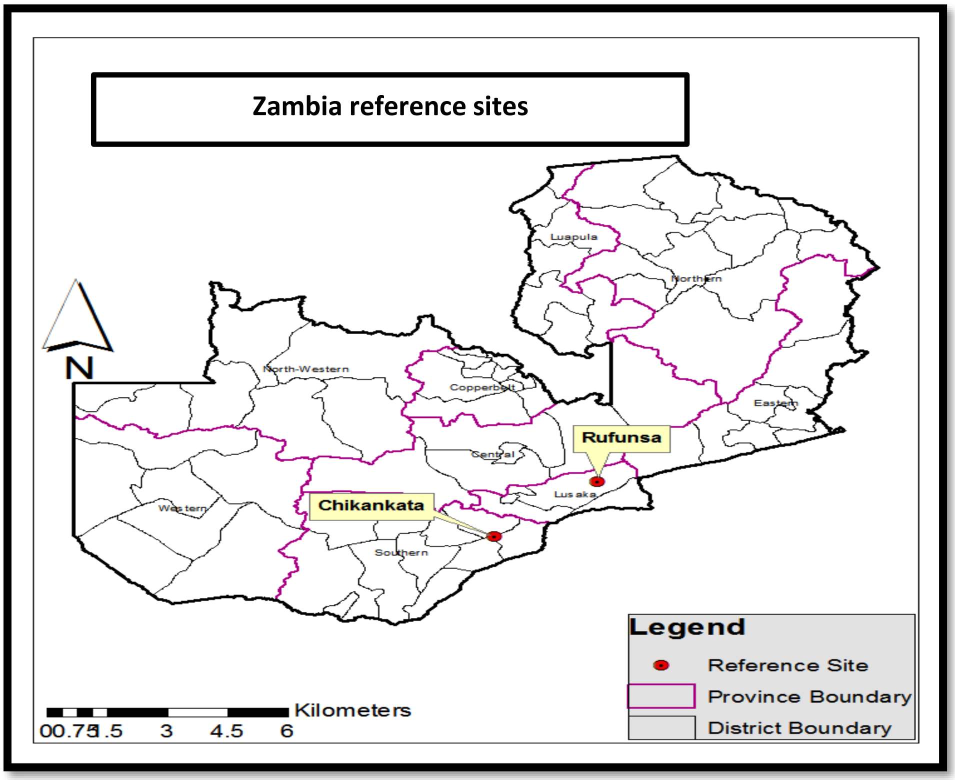
The ITPGRFA reiterates the principle of national sovereignty over plant genetic resources for food and agriculture. The Nagoya Protocol recognizes the ITPGRFA as a special international ABS agreement. Thus, parties to the ITPGRFA are free to apply the Nagoya Protocol to plant genetic resources for food and agriculture that are not covered by the MLS. Zambia is not a member of the Nagoya Protocol, but even if it were, the Nagoya Protocol would not change the way Zambia would operate under the ITPGRFA.

A holistic implementation of all appropriate international agreements would lay the ground for enhancing the conservation and utilization of plant genetic resources in the country, and especially for strengthening the link between conservation, variety development and adoption. By using these resources over the millennia, coupled with targeted selection and adaptation to existing conditions, farmers worldwide have developed a great deal of diversity within crop species. This is of crucial importance for the ability to adapt to future environmental conditions, continued development of varieties, and breeding to resist against disease and pests. Modern plant breeding depends on that gene pool that has been created over the years by small-scale farmers. However, the plant variety protection laws that accompany modern breeding can lead to a decrease in this multitude of agricultural varieties, if plant variety protection is enacted.

3.7 Crop-climate modelling to identify potentially adaptable materials for present and future climate-related challenges in selected communities in Zambia

Crop-climate modelling for maize in Chikankata and sorghum in Rufunsa (Figure 1) was carried out to identify suitable germplasm from within the country and internationally, for introduction to these areas. Modelling was conducted to identify materials that can be grown today and in 2050, when the climate is expected to change significantly.

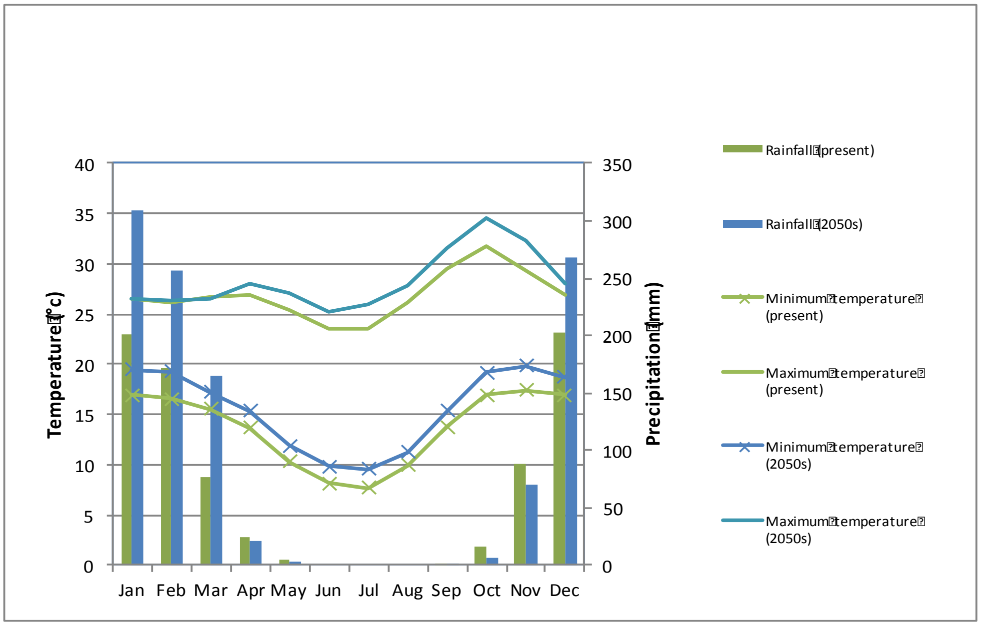
Figure 1. Chikankata and Rufunsa reference sites



3.7.1 Present and predicted future climate for Chikankata and Rufunsa

Appendices 2 and 3 show maps with rainfall and temperature respectively, comparing present and future (2050s) values for Zambia. Comparative climatic data for Chikankata (Figure 2) show that both annual minimum and maximum temperatures will increase by almost 2 °C by 2050. Rainfall is also projected to increase significantly, from 786 to 1,100 millimetres (mm). The temperature and rainfall pattern in 2050 may still be suitable for maize production, but varieties adapted to higher minimum temperature during the growing period may need to be introduced (Figure 3).

Figure 2. Comparative analysis of temperature and precipitation at present and in the 2050s in Chikankata



Source: WorldClim

Figure 3. Bioclimatic variables for the present and 2050's climate in Chikankata

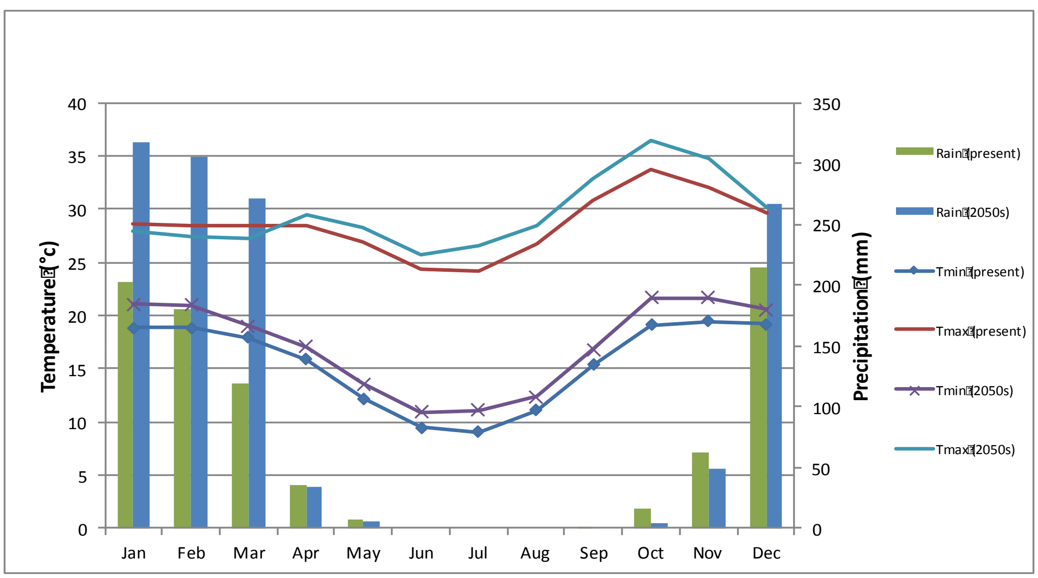
Present		**2050s**	
Bioclimatic variable	**Value**	**Bioclimatic variable**	**Value**
Annual mean temperature [1]	21.7	Annual mean temperature [1]	23.0
Mean monthly temperature range [2]	12.6	Mean monthly temperature range [2]	12.6
Isothermality (2/7) (* 100) [3]	51.1	Isothermality (2/7) (* 100) [3]	50.6
Temperature seasonality (std * 100) [4]	295.0	Temperature seasonality (std * 100) [4]	292.2
Max temperature of warmest month [5]	34.4	Max temperature of warmest month [5]	35.9
Min temperature of coldest month [6]	9.7	Min temperature of coldest month [6]	10.9
Temperature annual range (5-6) [7]	24.7	Temperature annual range (5-6) [7]	25.0
Mean temperature of wettest quarter [8]	22.8	Mean temperature of wettest quarter [8]	23.9
Mean temperature of driest quarter [9]	18.1	Mean temperature of driest quarter [9]	19.5

Mean temperature of warmest quarter [10]	25.3	Mean temperature of warmest quarter [10]	26.6
Mean temperature of coldest quarter [11]	18.1	Mean temperature of coldest quarter [11]	19.4
Annual precipitation [12]	1,108	Annual precipitation [12]	1,062
Precipitation of wettest month [13]	309	Precipitation of wettest month [13]	299
Precipitation of driest month [14]	0	Precipitation of driest month [14]	0
Precipitation seasonality (cv) [15]	133.1	Precipitation seasonality (cv) [15]	133.7
Precipitation of wettest quarter [16]	836	Precipitation of wettest quarter [16]	801
Precipitation of driest quarter [17]	0	Precipitation of driest quarter [17]	0
Precipitation of warmest quarter [18]	78	Precipitation of warmest quarter [18]	70
Precipitation of coldest quarter [19]	3	Precipitation of coldest quarter [19]	3

Source: WorldClim

The annual minimum temperature is expected to increase by 1 °C by 2050 in Rufunsa, while the maximum temperature will remain the same; rainfall is expected to increase significantly from 839 mm to 1,262 mm (Figure 4). The minimum temperature during the growing season will increase by almost 2 °C, while the maximum temperature will reduce slightly (Figure 5). These conditions will suit both sorghum and maize but adapted varieties may need to be introduced.

Figure 4. Comparative analysis of temperature and precipitation at present and in the 2050s in Rufunsa



Source: WorldClim

Figure 5. Bioclimatic variables for the present and 2050's climate in Rufunsa

Present		2050s	
Bioclimatic variable	**Value**	**Bioclimatic variable**	**Value**
Annual mean temperature [1]	22.4	Annual mean temperature [1]	23.4
Mean monthly temperature range [2]	13.1	Mean monthly temperature range [2]	12.4
Isothermality (2/7) (* 100) [3]	53.1	Isothermality (2/7) (* 100) [3]	48.3
Temperature seasonality (STD * 100) [4]	329.3	Temperature seasonality (STD * 100) [4]	337.5
Max temperature of warmest month [5]	34.0	Max temperature of warmest month [5]	36.5
Min temperature of coldest month [6]	9.3	Min temperature of coldest month [6]	10.9
Temperature annual range (5-6) [7]	24.7	Temperature annual range (5-6) [7]	25.6
Mean temperature of wettest quarter [8]	24.3	Mean temperature of wettest quarter [8]	23.9
Mean temperature of driest quarter [9]	17.8	Mean temperature of driest quarter [9]	19.2
Mean temperature of warmest quarter [10]	25.8	Mean temperature of warmest quarter [10]	27.6
Mean temperature of coldest quarter [11]	17.8	Mean temperature of coldest quarter [11]	19.2
Annual precipitation [12]	827	Annual precipitation [12]	1254
Precipitation of wettest month [13]	214	Precipitation of wettest month [13]	318
Precipitation of driest month [14]	0	Precipitation of driest month [14]	0
Precipitation seasonality (CV) [15]	122.0	Precipitation seasonality (CV) [15]	132.7
Precipitation of wettest quarter [16]	588	Precipitation of wettest quarter [16]	894
Precipitation of driest quarter [17]	0	Precipitation of driest quarter [17]	0
Precipitation of warmest quarter [18]	290	Precipitation of warmest quarter [18]	320
Precipitation of coldest quarter [19]	0	Precipitation of coldest quarter [19]	0

Source: WorldClim

3.7.2 Selected accessions of maize for present and future climate-related challenges in Chikankata

Using climate and crop suitability data, and passport information concerning the 300 accessions of maize conserved in the national gene bank (Figure 6), 48 accessions were identified as potentially suitable for present climate conditions (Figure 7), and only eleven were deemed suitable for future climate conditions predicted for 2050 (Figure 8). This demonstrated that as the climate is changing, a decreasing proportion of the national maize collection will be suitably adapted for future climatic conditions. This underscores the importance of the country having access to international collections for sources of genetic traits that are adapted to future climatic conditions. This further justifies the country's participation in the international system of plant genetic resources conservation and governance.

Figure 6. National gene bank collections of maize in Zambia[4]

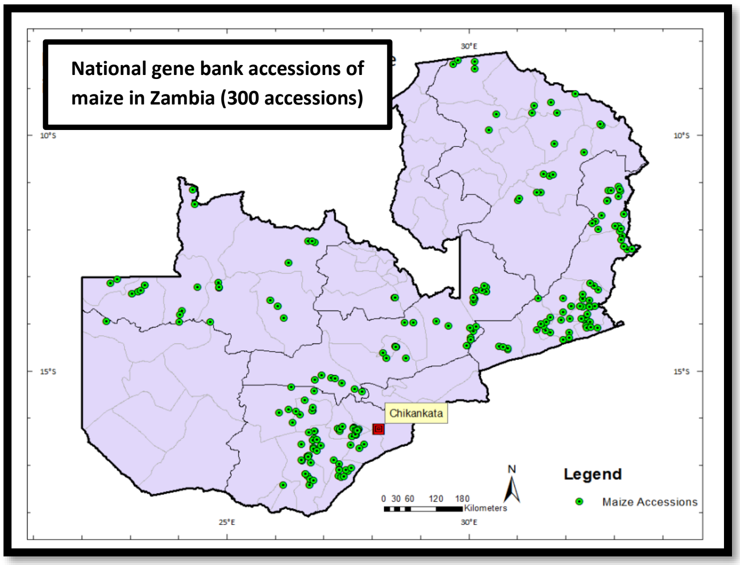
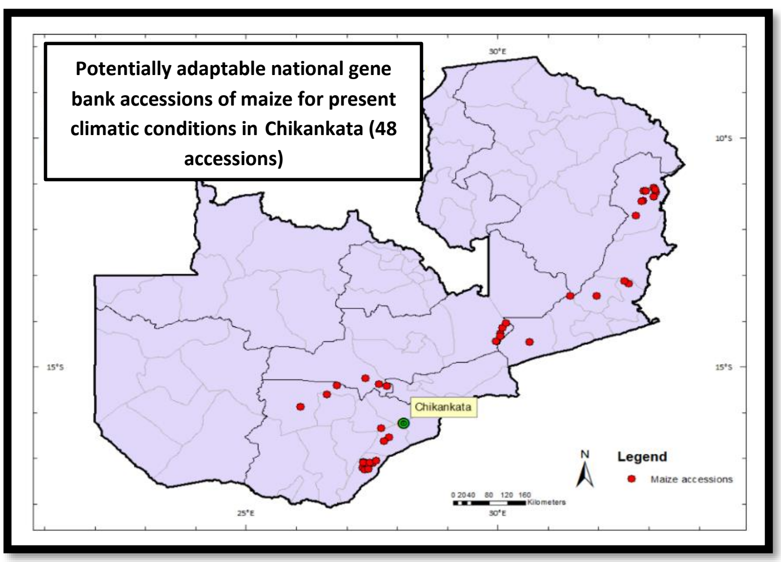
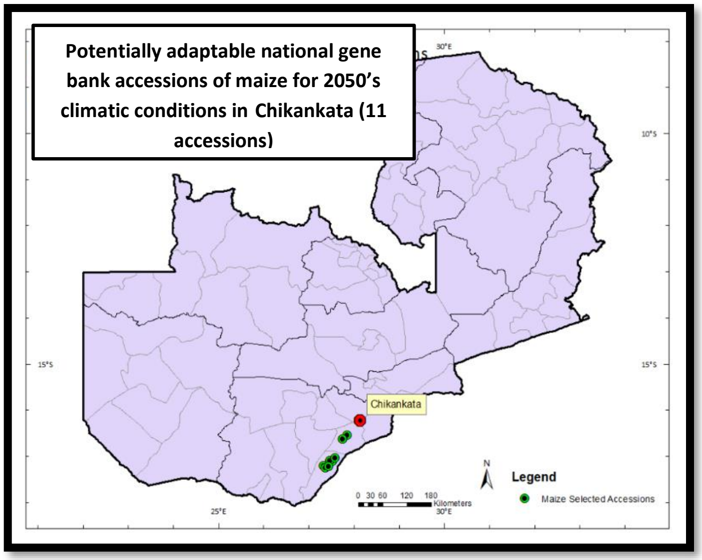


Figure 7. National gene bank accessions of maize potentially adaptable to present climatic conditions in Chikankata



[4] Figures 6 – 17 were developed by the authors using data from Genesys and national gene banks.

Figure 8. National gene bank accessions of maize potentially adaptable to 2050's climatic conditions in Chikankata



Looking at international gene bank collections (Figure 9) and using the same method, accessions of maize were selected based on their adaptability to present and future temperatures and precipitation for Chikankata. According to the maps, the accessions that are most adaptable to present climatic conditions are from South and Central America (Figure 10). However, for future climatic conditions, some of the accessions that were originally collected in Africa are potentially adaptable (Figure 11). Therefore, Zambia will need to look to its neighbours for germplasm. The number of accessions suitable for the future climate were lower than those for the present climate.

Figure 9. Geographic origins of maize collections around the world

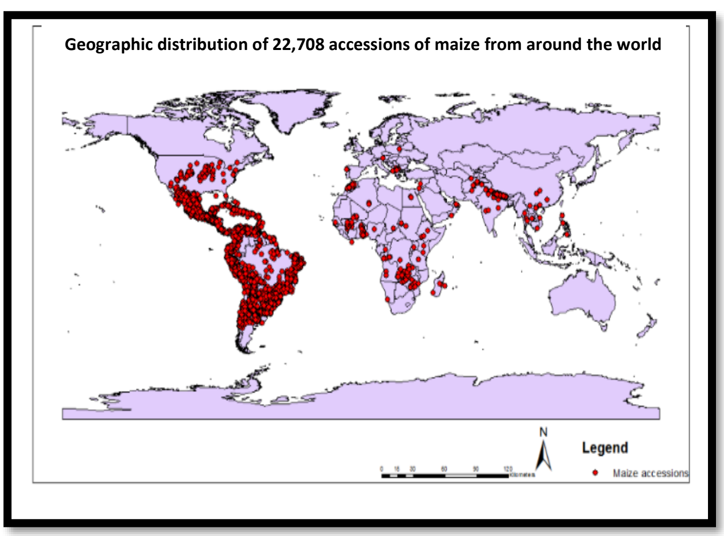


Figure 10. Maize accessions potentially adaptable to present climatic conditions in Chikankata

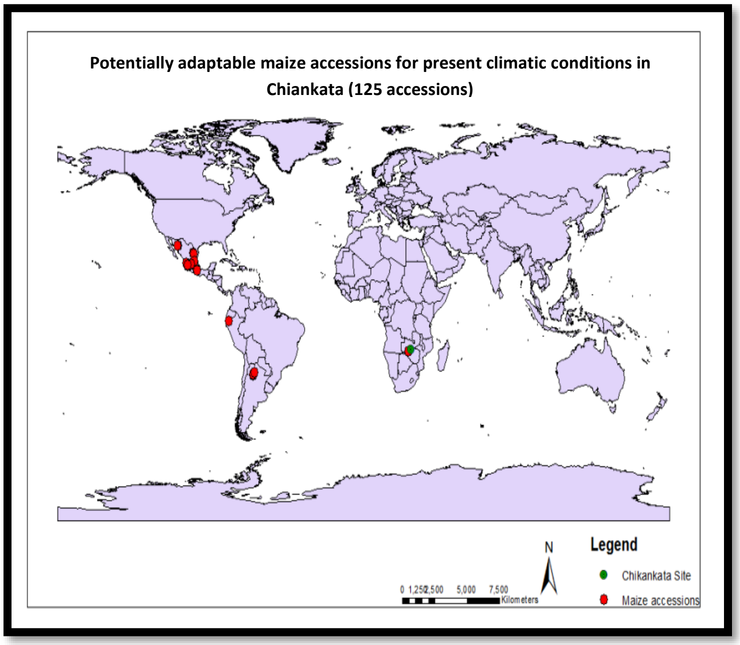
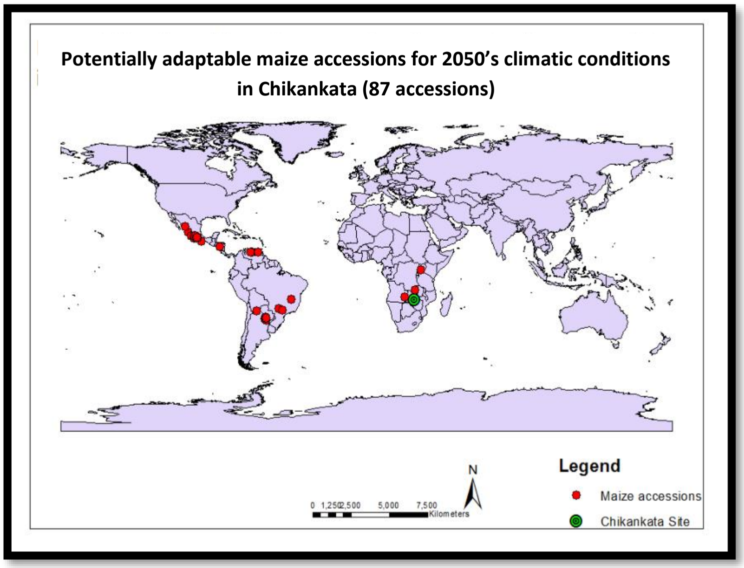


Figure 11. Maize accessions potentially adaptable to 2050's climatic conditions in Chikankata



3.7.3 Selected accessions of sorghum for present and future climatic conditions in Rufunsa

Based on average temperatures and precipitation for present and 2050's climatic conditions in Rufunsa, accessions of sorghum were selected from a list of 176 national gene bank accessions (Figure 12), and from international collections, comprising 23,931 accessions of sorghum held by CGIAR centres and other gene banks, whose information is accessible from the Genesys database (Figure 13). According to the maps, the most adaptable germplasm from national gene bank collections is from the south-eastern part of the country (Figure 14). It is also evident that in the 2050s, as the climate continues to change and temperatures increase, the adaptable accessions in the national gene bank collections would reduce (Figure 15), requiring the necessity to look further afield.

Figure 12. National gene bank collections of sorghum in Zambia

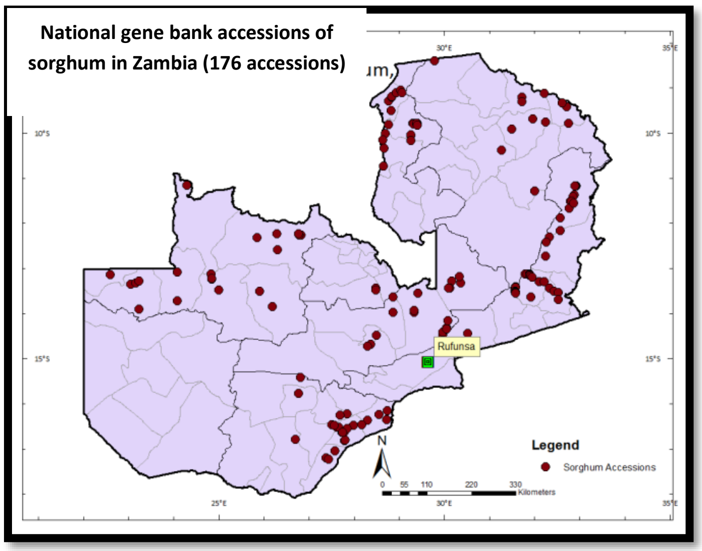


Figure 13. Geographic distribution of 23,931 sorghum accessions worldwide

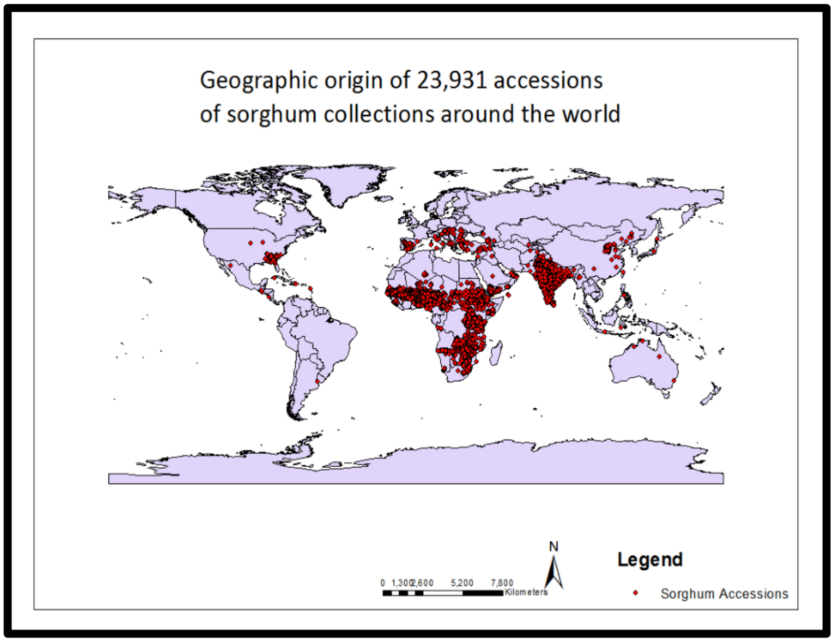


Figure 14. National gene bank accessions of sorghum potentially adaptable to present climatic conditions in Rufunsa

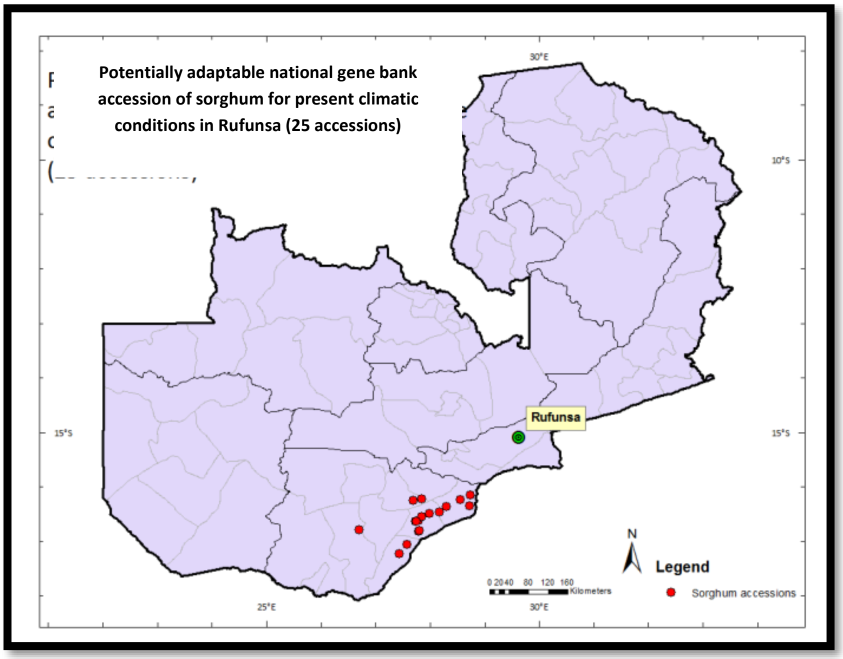
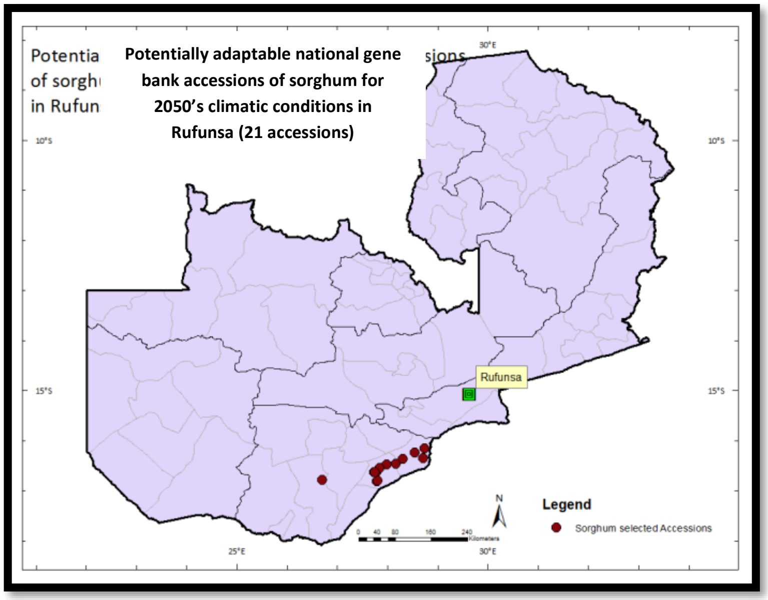


Figure 15. National gene bank accessions of sorghum potentially adaptable to 2050's climatic conditions in Rufunsa



Maps of international gene bank collections (Figures 16 and 17) show that most collections of sorghum potentially adaptable to present climatic conditions are in eastern and southern Africa, while collections of sorghum potentially adaptable to future climatic conditions are in the Sahel in Africa and in Asia, mainly India.

Figure 16. International gene bank accessions of sorghum potentially adaptable to present climatic conditions in Rufunsa

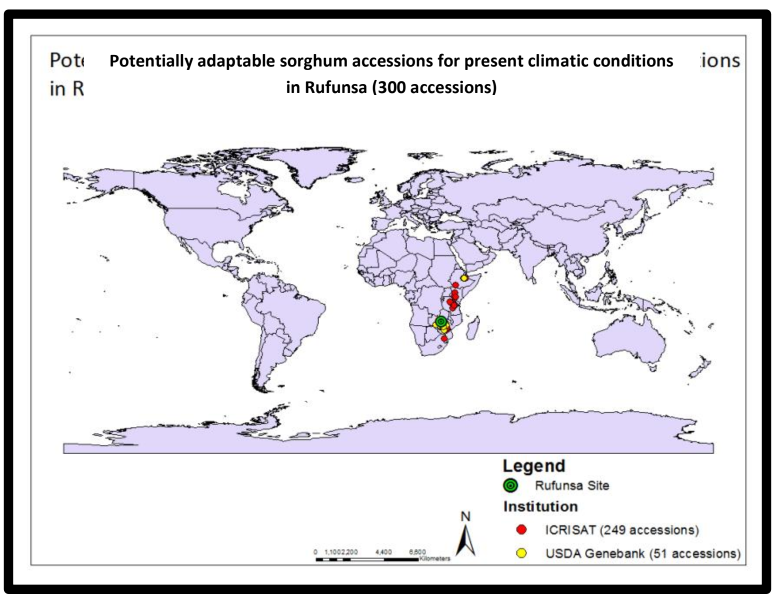
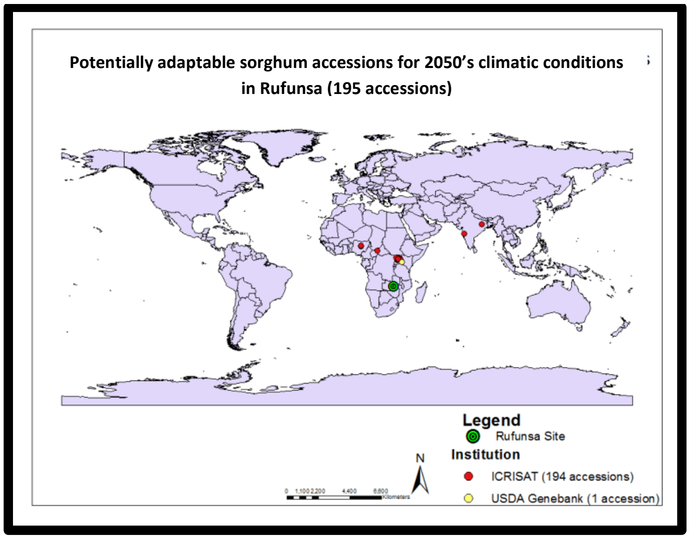


Figure 17. International gene bank accessions of sorghum potentially adaptable to 2050's climatic conditions in Rufunsa



The crop-climate modelling exercise highlights the interdependence of countries on genetic resources with desired traits such as climate resilience. Table 11 below gives a summary of germplasm requirements, based on present and future climatic challenges. The table shows that as climate changes national collections from the gene bank will not be sufficient to meet climate-related challenges, but international gene bank collections will present an opportunity for the country's resilience; in the future, Zambia will need to access maize accessions from at least nine countries, and sorghum from four countries.

Table 11. Numbers of accessions held in national and international collections that are potentially adaptable to current and 2050's climatic conditions

Reference site	Crop	Total accessions of crop in national gene bank	Accessions from national gene bank potentially adaptable to present climatic conditions	Accessions from national gene bank potentially adaptable to 2050's conditions	Number of accessions of crop in foreign gene banks (included in Genesys)	Foreign gene bank accessions potentially adaptable to present climatic conditions	Number of countries from which the materials adaptable to present conditions were collected (or were improved)	Number of accessions in foreign gene banks (in Genesys) potentially adaptable to 2050's conditions	Number of local varieties identified by farmers
Chikankata	Maize	300	48	11	22,800	125	9	87	5
Rufunsa	Sorghum	176	25	21	23,941	300	4	195	7

The modelling exercise also reiterates the importance of being a member of the ITPGRFA, which provides for access to germplasm held in gene banks all over the world. This, together with the Nagoya Protocol on access and benefit sharing, makes the country less vulnerable to climate change by having a wide gene pool of germplasm available for plant breeding.

4. SUMMARY ANALYSIS, CONCLUSIONS AND RECOMMENDATIONS ON ADAPTING PGRFA TO COUNTRY-SPECIFIC CLIMATE CHANGES

4.1 Past, present and future patterns of genetic resources exchanges

Most plant breeding in the country is currently focused on maize, with both public and private sector participation. There are also some plant breeding programmes for sorghum and millets, groundnut, beans and cowpea.

An important missing link for all crops, other than those addressed by private companies, is the access to basic seed of improved varieties. The community-based efforts of NGOs that are currently emerging may fill the gap left between the larger seed companies that focus on maize and the farmer-managed seed systems, thereby improving the availability of quality seed both for local and improved varieties for all crops important to food security in the country (Nakaponda, 2012).

The government's FISP, and marketing support for maize, often distorts the decision-making process for farmers in relation to choice of crops and varieties. A case in point is the study conducted in Shibuyunji by Microthink Institute (Mubanga et al., 2015). Results showed that despite being confronted by late onset of rains, and post-germination crop attacks by army worms that made maize production extremely precarious, 61.5% of the affected smallholder farmers still replanted their cultivated land with maize. The farmers had a choice of whether to replant maize that had a ready market from the Food Reserve Agency, or to plant a drought-tolerant crop, such as sorghum or millet, which would have guaranteed them with household food security from their own production. They mainly chose the former option. They increased production of other crops such as soybean, sunflower and cotton when contract farming with private business entities became available. Markets determined smallholder farmers' crop production choices, more than household food security from their own production or the availability of climate information forecasting poor rainfall distribution. The study concluded that (i) prior knowledge of climate information does not necessarily result in a change of smallholder farmers' crop production choices in response to a predicted climate anomaly; and (ii) markets are a major determinant of crops cultivated by smallholder farmers, and hence adaptation measures involving crop diversification should be designed with market availability in mind.

4.2 ABS experiences

Access and benefit sharing of PGRFA, particularly for climate change adaptation, is a major precursor to achieving a climate-resilient seed system in Zambia. The movement of PGRFA in and out of the country has ensured that this resilience is not just being achieved in Zambia but in many parts of the world because of the platform made possible by the ITPGRFA and the Nagoya Protocol. Information about flows of PGRFA into and out of the country and within the country, from the Genesys database and the ITPGRFA Secretariat, shows the interdependence of countries and also the interdependence of research institutions and breeders from both public and private sectors.

A suitable access and benefit-sharing mechanism is lacking, particularly in the context of PGR exchanges in local rural communities, which needs to be addressed. A process aimed at developing a national access and benefit-sharing mechanism has been initiated through a working group coordinated by the Ministry of Lands, Natural Resources and Environmental Protection. In order to formulate and effectively implement national access and benefit-sharing legislation, Zambia requires capacities drawn from a wide range of disciplines.

Farmers' rights are considered critical to ensuring the conservation and sustainable use PGRFA. According to Article 9 of the ITPGRFA, the implementation and realization of farmers' rights rests with the national governments. Measures suggested under this article include the protection of traditional knowledge, equitable benefit sharing, participation in decision-making, and the right to save, use, exchange and sell farm-saved seed and propagating material. Not much has been done in Zambia to implement farmers' rights.

4.3 Options for policy and institutional changes to improve ABS

Gaps in the policy and regulatory frameworks for ABS in Zambia have to be understood in relation to the facilitation of access and exchange of genetic resources for the benefit of breeders and farmers. The national policy and institutional framework must take advantage of the fact that millions of seed samples representing different genetic resources have been secured globally and are available for use through the MLS of the ITPGRFA and the Nagoya Protocol on ABS. Access and use of these materials by local plant breeding institutions will be enhanced by establishing functional institutional structures at national level. This is especially important because germplasm introductions from external sources outside the country continue to be a major feature of the crop development and improvement programmes for key crops in the country.

There is a need for the national gene bank, which is the focal point for the ITPGRFA and the Nagoya Protocol, to liaise much more, under a structure that promotes information exchange and joint programming. The country now needs to ratify the Nagoya Protocol and to develop the necessary legislation, regulations and structures for its implementation. This will broaden access and benefit sharing to cover crops that are not currently included in the MLS under the ITPGRFA. Consequently, germplasm for all crops of interest to breeders will be available for exchange and use. But to achieve this, the Ministry of Lands, Natural Resources and Environmental Protection, which is responsible for the Nagoya Protocol, must work together with SCCI and the NPGRC, to develop guidelines for the implementation of the Nagoya Protocol.

Legal frameworks on seed should also include acts or legally binding clauses to defend seed security, farmers' rights and diverse farmers' varieties and populations that contribute significantly to food security.

5. REFERENCES

Christensen, J. H., Krishna Kumar, K., Aldrian, E., An, S.-I.; Cavalcanti, I. F. A. de Castro, M., Dong, W. Goswami, P., Hall, A., Kanyanga, J.K., Kitoh, A., Kossin, J., Lau, N.-C., Renwick, J., Stephenson, D. B., Xie, S.-P.and Zhou, T. (2013) 'Climate phenomena and their relevance for future regional climate change', in Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. (eds.) *Climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom and New York, NY, USA, pp. 1217-1308.

CIMMYT (2015) *DT Maize,* 4(2), June. Drought Tolerant Maize for Africa. Nairobi: CIMMYT. Available at http://dtma.cimmyt.org/index.php/press-room/bulletins/doc_download/197-dt-maize-vol-4-no-2-june-2015, accessed 10 January 2017.

Climate and Development Knowledge Network (CDKN) (2014) *The IPCC's fifth assessment report: what's in it for Africa?* Available at http://cdkn.org/wp-content/uploads/2014/04/AR5_IPCC_Whats_in_it_for_Africa.pdf, accessed 16 December 2016.

De Groote, H., Gitonga, Z., Smale, M., Asare-Marfo, D., Kasuta, E., Birol, E. and Sonder, K. (2014) 'Smallholder farming and crop variety choice: maize variety choice in Zambia', *HarvestPlus Research for Action 3*. Washington, D.C.: International Food Policy Research Institute (IFPRI). Available at http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/128254/filename/128465.pdf, accessed 16 December 2016.

FAO (2015) *Lessons learned about ways and means to conserve and use genetic diversity to build resilience to climate change in food and agriculture systems. Survey report*. CGRFA-15/15/Inf.16. Fifteenth regular session of the Commission on Genetic Resources for Food and Agriculture (CGRFA), 19-23 January 2015, Rome. Available at http://www.fao.org/3/a-mm501e.pdf, accessed 16 December 2016.

Gannon, C., Kandy, D., Turner, J., Kumar, I., Pilli-Sihvola, K. and Chanda, F.S. (2014) *Near-term climate change in Zambia*. The Hague: Red Cross/Red Crescent Climate Centre.

Hulme, M., Doherty, R., Ngara, T., New, M. and Lister, D. (2001) 'African climate change 1900-2100', *Climate Research*, 17, pp. 145-168.

Jain, S. (2007) 'An empirical economic assessment of impacts of climate change on agriculture in Zambia', *Policy Research Working Paper,* vol. 4291. Washington, D.C.: The World Bank Development Research Group. Available at http://documents.worldbank.org/curated/en/768021468336547326/pdf/wps4291.pdf, accessed 16 December 2016.

Kaczan, D., Arslan, A. and Lipper, L. (2013) 'Climate-smart agriculture? A review of current practice of agroforestry and conservation agriculture in Malawi and Zambia', *ESA working paper* no. 13-07. Rome, Italy: Agricultural Development Economics Division, FAO. Available at http://www.fao.org/3/a-ar715e.pdf, accessed 16 December 2016.

Keyser, J.C. (2013) 'Opening up the markets for seed trade in Africa', *Africa Trade Practice Working Paper,* 2. Available at http://documents.worldbank.org/curated/en/916001468008985797/pdf/818340REVISED00o020379857B00PUBLIC0.pdf, accessed 23 January 2017.

Kirtman, B., Power, S. B., Adedoyin, J. A., Boer, G. J., Bojariu, R., Camilloni, I., Doblas-Reyes, F. J., Fiore, A. M., Kimoto, M., Meehl, G. A., Prather, M., Sarr, A., Schar, C., Sutton, R., van Oldenborgh, G. J., Vecchi, G. and Wang H. J. *Near-term climate change: projections and predictability,* in Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. (eds.) *Climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom and New York, NY, USA.

Lobell, D., Burke, M., Tebaldi, C., Mastrandrea, M., Falcon, W. and Naylor, R. (2008) 'Prioritizing climate change adaptation needs for food security in 2030', *Science*, 319, pp. 607–10. Available at https://web.stanford.edu/~mburke/papers/Lobell_et_al_Science_2008.pdf, accessed 16 December 2016.

Makweti, L., Charlie, H. and Kanenga, K. (2015) *Overview of groundnut research in Zambia* American Peanut Research and Education Society Annual Meeting, Charleston, SC.

McSweeney, C., New, M. and Lizcano, G. (2010) *UNDP climate change country profiles: Zambia*.

Ministry of Finance and National Planning (MoFNP) (2015) *Government of the Republic of Zambia's Yellow Book*. Lusaka: GRZ Ministry of Finance and National Planning.

Ministry of Tourism, Environment and Natural Resources (MTENR) (2007) *Formulation of the national adaptation programme of action on climate change: final report*. Lusaka, Zambia: Government of Zambia, Ministry of Tourism, Environment and Natural Resources. Available at http://unfccc.int/resource/docs/napa/zmb01.pdf, accessed 16 December 2016.

Mubanga, K. H., Umar, B. B., Muchabi, J. and Mubanga, C. (2015) 'What drives smallholder farmers' crop production choices in Central Zambia? Lessons from the 2012/2013 agricultural season', *Journal of Agricultural Studies*, 3(2). Available at www.macrothink.org/journal/index.php/jas/article/download/7125/6062, accessed 16 December 2016.

Mulvany, P. and Mpande, R. (2013*) Final report of the SADC seed security network 2 (SSSN2): end of phase review*. SSSN2 regional programme. Swiss Cooperation Office in South Africa; Swiss Agency for Development and Cooperation.

Mwila, G.P., Ng'uni, D. and Phiri, A. (2008) *Zambia: second report on the state of plant genetic resources for food and agriculture.* Available at ftp://ftp.fao.org/ag/agp/countryreports/ZambiaFinalReport.pdf, accessed 16 December 2016.

Nakaponda, B. (2012*) ISSD briefing note, September 2012: Zambia seed sector assessment*. Wageningen, the Netherlands: Centre for Development Innovation, Wageningen University and Research. Available at www.wageningenur.nl/web/file?uuid=2366c652-55b8-4, accessed 16 December 2016.

Nakaponda, B. (2010*) Final report on community seed banks in SHADF areas of Kaoma, Mpika and Chipata.* Self Help Africa and the Development Fund, Norway (SHADF).

Neubert, S., Kömm, M., Krumsiek, A., Schulte, A. and Tatge, N. (2011) *Agricultural development in a changing climate in Zambia: increasing resilience to climate change and economic shocks in crop production*. Bonn: German Development Institute.

Rwomushana, I. and Heemskerk, W. (2015) ISSD *Thematic scoping paper - access to varieties in the public domain*. Thematic working group 2, June 2015. Wageningen, the Netherlands: Centre for Development Innovation, Wageningen University and Research. Available at http://www.issdseed.org/sites/default/files/resource/issd_africa_scoping_paper_twg_2_-_access_to_varieties.pdf, accessed 16 December 2016.

SCCI (2015) *Official variety register*, Variety Release Committee Secretariat, Seed Control and Certification Institute, 25 September.

Schlenker, W. and Lobell, D. (2010) 'Robust negative impacts of climate change on African agriculture', Environmental Research Letters, 5, pp. 8. Available at http://www.climatechange-foodsecurity.org/uploads/AfricaClAgro2010.pdf, accessed 16 December 2016.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B, Tignor, M. and Miller, H.L. (eds.) (2007) *Climate change 2007: the physical science basis.* Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change, pp. 996. Cambridge, United Kingdom and New York, USA: Cambridge University Press.

Tadross, M., Suarez, P., Lotsch, A., Hachigonta, S., Mdoka, M., Unganai, L., Lucio, F., Kamdonyo, D. and Muchinda, M. (2009) 'Growing-season rainfall and scenarios of future change in southeast Africa: implications for cultivating maize', in *Climate Research*, 40, pp. 147-161. Available at http://www.int-res.com/articles/cr_oa/c040p147.pdf, accessed 16 December 2016.

Thapa, S. and Keyser, J. (2012). *Agribusiness indicators: Zambia*. Agriculture and environmental services. Washington D.C.: World Bank. Available at http://documents.worldbank.org/curated/en/481731468166490328/Agribusiness-indicators-Zambia, accessed 16 December 2016.

Tyson, P. D. (1991) ‘Climatic change in southern Africa: past and present conditions and possible future scenarios’, *Climatic Change*, 18(2), pp. 241-258.

USAID (2013) *Seed system security assessment: eastern Zambia*. Available at pdf.usaid.gov/pdf_docs/pbaaa617.pdf, accessed 16 December 2016.

6. APPENDICES

Appendix 1. MTA for crops not included in Annex 1 of the ITPGRFA

The Zambia National Plant Genetic Resources Centre (NPGRC) maintains a collection of plant genetic resources accessions collected from within Zambia. The NPGRC seeks to conserve the genetic resources that it maintains and to promote the sustainable utilisation and the fair and equitable sharing of the benefits arising out of the utilisation of these genetic resources. The agreement aims to contribute to these objectives.

In the interest of encouraging research and utilisation of and yet not hamper further access to and use of the accessions held in its collection, the NPGRC is mandated to hold the germplasm accessions for the country.

The recipient hereby agrees:

- To solely access the transferred accessions for the purpose of utilisation and conservation for research, breeding and training for food and agriculture;
- Not to claim any intellectual property or other rights that limit the facilitated access to the genetic resources for food and agriculture, or their genetic parts or components, in the form received over the transferred accession (s);
- To ensure that any subsequent person or institution to whom he/she may make available samples of the transferred accession or material that was essentially derived from the accession received is bound by the same provisions of the agreement and undertakes to pass on the same obligations to future recipients;
- In case he/she commercializes a product that is plant genetic resource for food and agriculture and that incorporates germplasm under this Material Transfer Agreement, he/she shall pay to the mechanism referred to in Article 19.3f of the International Treaty on Plant Genetic Resources for Food and Agriculture an equitable share of the benefits arising from the commercialization of that product, except whenever such a product is available without restrictions to others for further research and breeding, in which case the recipient who commercializes is encouraged to make such payment;
- To indemnify the NPGRC against any claims arising out of the use of the transferred accession;
- To furnish the NPGRC with relevant performance data produced by the recipient arising from the characterisation and evaluation of the accession, or its parts and components;
- If publication results from use of the transferred accession or its parts and components, to acknowledge the NPGRC as the supplier of the accession(s) and send copies of such publications to the NPGRC;
- To assume full responsibility for complying with the recipient nation's quarantine and biosafety regulations and rules governing the import or release of genetic material;

The NPGRC makes no warranties as to the safety or title of the accession, nor as to the accuracy or correctness of any passport or other data provided with the accessions. Neither does it make any warranties as to the quality, availability or purity (genetic or mechanical) of the transferred accession.

Samples of the following accession(s) are supplied expressly conditional on acceptance of the above terms of this agreement. The recipient's acceptance of the accession(s) constitutes such agreement to the conditions above.

The NPGRC requests the applicant to complete this agreement before authorisation of access to requested accessions as in the attached list.

Crop species: ____

Number of Accession: ____

Purpose: ____

Name of recipient: ____

Institution: ____

Full address: ____

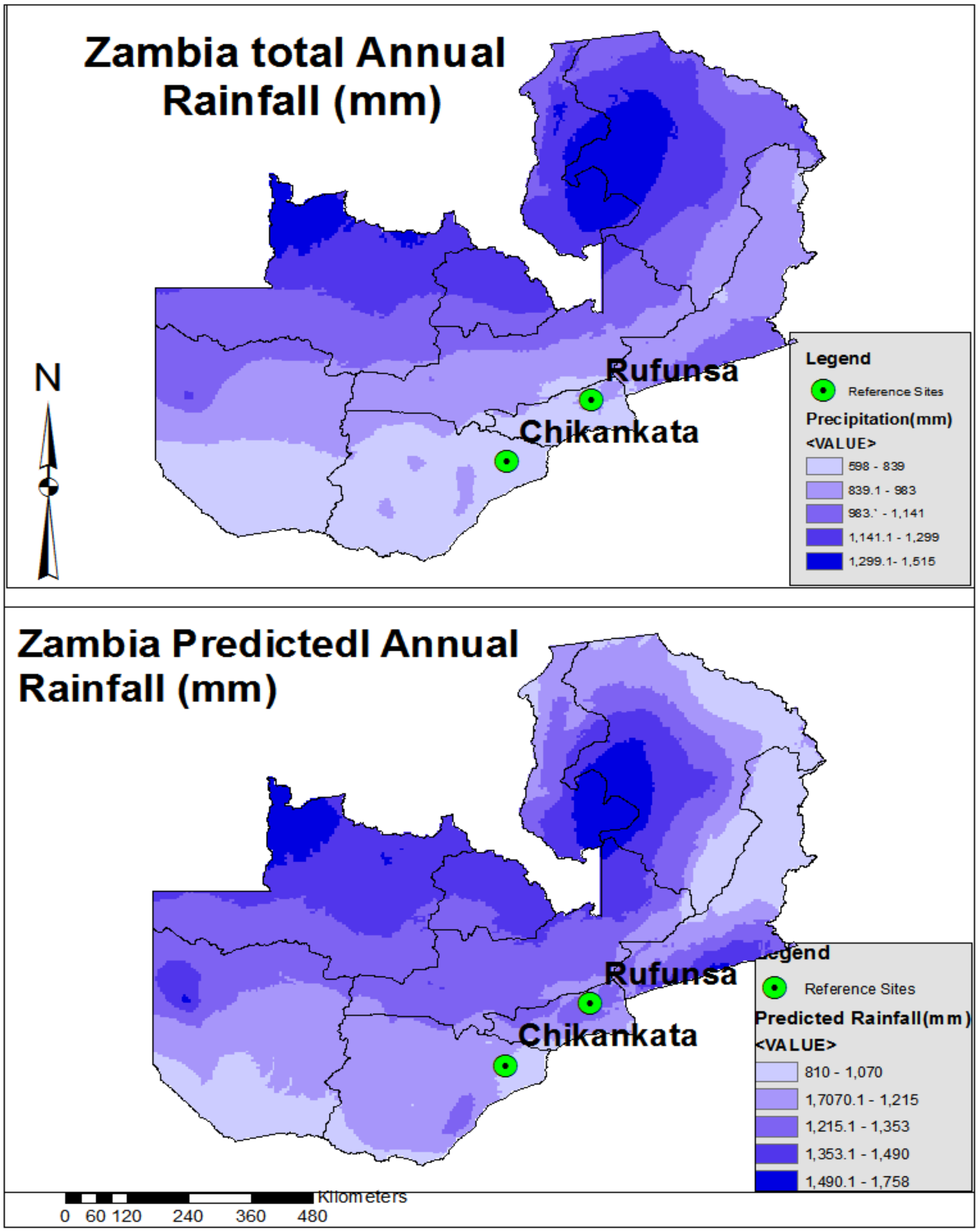
Signature of recipient: _____________________________Date:______________________

Name of Authorizing Officer: ____

Position/Title____

Signature: ____ Date: ____________________

Appendix 2. Changes in precipitation in Zambia: present and projected future (2050s)



Appendix 3. Changes in mean annual temperatures