Can Sustainable Agriculture Practices Remedy the Negative Effects of Climate Change on Food Security in Zambia?





Jesuit Centre for Theological Reflection (JCTR)

Written by Gregory Chanda Chilufya (Consultant)

& edited by Miniva Chibuye and Sosten Banba, Social Conditions Programme (JCTR)

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List of Abbreviations

ACCE	Africa Carbon Credit Exchange
ACF	Agriculture Consultative Forum
AIDS	Acquired Immune Deficiency Syndrome
BMI	Body Mass Index
CA	Conservation Agriculture
CAP	Conservation Agriculture Programme
CASPP	Conservation Agriculture Scaling Up for increased Productivity and Production
CCFU	Climate Change Facilitation Unit
CF	Conservation Farming
C-FAARM	Consortium for Food Security Agricultural, AIDS Resilience and Marketing
CFU	Conservation Farming Unit
DMMU	Disaster Management and Mitigation Unit
FAO	Food and Agriculture Organisation
FISP	Farmer Input Support Programme
FISRI	Farmer Input Support Response Initiative
FNDP	Fifth National Development Plan
GCM	Global Climate Model
GHG	Green House Gases
HIV	Human Immune Virus
JCTR	Jesuit Centre for Theological Reflection
MACO	Ministry of Agriculture and Cooperatives
MLFD	Ministry of Livestock and Fisheries Development
MTNER	Ministry of Tourism, Environment and Natural Resources
NAP	National Agricultural Policy
NAPA	National Adaptation Programme of Action
NCCRS	National Climate Change Response Strategy
NPE	National Policy on Environment
Pelum	Participatory Ecological Land Use Management
SSFs	Small scale farmers
UNFCC	United Nations Framework Convention on Climate Change
WFP	World Food Programme
ZAWA	Zambia Wildlife Authority
ZDHS	Zambia Demographic and Health Survey
ZMD	Zambia Meteorological Department

1 Introduction

1.1. Background

This report was commissioned by the Jesuit Centre for Theological Reflection (JCTR) to inform advocacy and communication on conditions relating to food security and climate change. The study was undertaken during the period that the National Climate Change Response Strategy and its Communication Strategy were being formulated by the Ministry of Tourism, Environment and Natural Resources. As such, this study will in some way, complement their consultation processes.

1.2. Summary of terms of reference

The scope of the study was detailed in the terms of reference as follows;

1. To document the temperature variability in Zambia over a period of time. How significant has it been?
2. To establish whether the recent floods and drought incidences can be attributed to climate change.
3. To determine how climate change has affected food security in Zambia.
4. To establish whether there are anticipated positive effects on crops as a result of climate change in Zambia. If so which ones?
5. To establish which areas will be most affected by climate change in Zambia
6. To ascertain to what extent sustainable agricultural systems (conservation and organic farming) can be used to curb the effects of climate change on food security.
7. To identify and document other responses to climate change.

1.3. Methodology

The data collection was composed of the following; -

- Collecting data from key Government ministries e.g. the Meteorological Department, Ministry of Tourism, Environment and Natural Resources, Ministry of Agriculture and Cooperatives;

- Conducted key informant interviews at organisations in Lusaka such as Ministry of Agriculture and Cooperatives (MACO), Ministry of Livestock and Fisheries Development (MLFD), World Food Programme (WFP), Disaster Management and Mitigation Unit (DMMU), Agricultural Consultative Forum (ACF), Participatory Ecological Land Use Management (Pelum) and the Zambia Wildlife Authority (ZAWA). The list of the people consulted is in Annex 1;

- Document review as detailed in the references; and

- Conducted field visits to least three areas affected by either frequent floods or droughts. Respondents were interviewed in the following areas during data collection: Shangombo District in agro-ecological Region IIa (Western Province) – Annex 2; Mpika District in agro-ecological Region III (Northern Province) – Annex 3 and Sinazongwe District in agro-ecological Region I (Southern Province) – Annex 4. The agro-ecological regions are described in section 3.1. Data collection was undertaken in Shangombo and Sinazongwe based on advice provided by the DMMU. Northern Province, and Mpika in particular, was included to learn of climate change issues in the high rainfall Region III as many activities on climate change have so far concentrated on Regions I and II. However, it was important to note there are also localized regions that may be affected by climate change in Region III.

2 | Background to the discourse on climate change

The following summary on the global discourse on climate change establishes the meanings of the terms used in this study. This section does not attempt to delve into the scientific debate about the existence and causes of climate change. Rather, it deals with climate change as elaborated and experienced in Zambia.

2.1. Climate change - The change level

The United Nations Framework Convention on Climate Change (UNFCC) adopted the following definition of climate change;

> **"Climate change" means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.**[1]

It further elaborated "adverse effects of climate change" as changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare".

Zambia signed the UNFCC on 11 June 1992, ratified it on 28 May 1993 and it entered into force on 21 March 1994. The Ministry of Tourism, Environment and Natural Resources adopted a definition of climate change similar to the UNFCC in the National Policy on Environment (2007), namely, "Human-induced changes taking place in the world's climate, especially trends towards global warming, which will deeply impact upon most ecosystems"[2]

The above definitions of climate change can be simplified as "significant change in average weather parameters, mainly temperature and rain-fall, over an extended period *that is attributed to human activities*"[3]

Some climate change arises from natural factors such as changes in the sun's intensity, the earth-sun distance and the earth's orbit around the sun. This natural climate change is slow, small and has been always there. This is termed climate variability. However, it is the increased human activities (notably industrial, agricultural and land use) that are changing the composition of the Earth's atmosphere at an unprecedented pace.4 The discussions in this report are limited to the agricultural and land use aspects of climate change.

The State of Environment in Zambia (2000) also alludes to the fact that climate change refers to any change in classical 30-year climatology regardless of its causes. This sets the minimum timeline within which this study addresses climate change and food security in Zambia.

The effective implementation of the National Policy on Environment with respect to atmosphere and climate should produce the following outputs and benefits:

- The release of green-house gases and the phasing out of ozone depleting substances should conform to what is applicable to Zambia under the respective international conventions and their protocols to combat global warming and climate change.
- Crop varieties and forestry rehabilitation activities that can harness effectively atmospheric carbon dioxide should be selected and their use encouraged.

Unlike the National Policy on Environment, the National Agricultural Policy (2004 – 2015) (NAP) does not mention the term climate change per se. However, it makes references to issues relating to climate change. Its vision for the agricultural sector is *"to promote development of an efficient, competitive and sustainable agricultural sector, which assures food security and increased income".*

1 United Nations Framework Convention on Climate Change.
2 Ministry of Tourism, 2007, Environment and Natural Resources, National Policy on Environment.
3 Professor Prem Jain, MTENR Climate Change Facilitation Unit, Focus on Climate Change, MTENR-CCFU website 2010.
4 Professor Prem Jain, MTENR Climate Change Facilitation Unit, Focus on Climate Change, MTENR-CCFU website 2010.

Some of the NAP objectives relevant to climate change include;

- To assure national and household food security; and
- To ensure that the existing agricultural resource base is maintained and improved upon.

To achieve the above objectives, some of the strategies include the following;

- Promotion of sustainable and environmentally sound agricultural practices;
- Promoting conservation of fisheries resources;
- Strengthening emergency preparedness through early warning and timely and efficient crop forecasting;
- Promoting irrigation development; and
- Maintaining agro-biodiversity and promoting conservation of aquatic ecosystem and sustainable utilization of natural resources.

The National Policy on Environment further elaborates the above strategies to include environment education in research, extension and livestock production.

The above objectives and strategies of the NAP highlight the need for practitioners in climate change to be wary of relying on technical terms, only, to communicate their messages. This is because simple or different terms may be used to convey the same messages. This is largely true when dealing with communities who may have their own ways of expressing their perspectives on climate change, not only in English, but also in their local languages.

The Fifth National Development Plan (FNDP), implemented between 2005 and 2010, recognised Zambia's response to climate change through formulation of the National Adaptation Programme of Action (NAPA). Furthermore, it stated that the predicted temperature warming was expected to decrease rainfall in the range of 8 to 30 percent and drought frequencies expected to be more pronounced in agro-ecological zone I[5] which covers the valley areas - (Gwembe, Lunsemfwa and Luangwa and the southern parts of Western and Southern provinces).

In relation to this study, the main determinants of the suitability of climate for agricultural activities are temperature, relative humidity, sunshine, radiation, wind, evaporation and rainfall6.

The above determinants of the suitability of climate for agricultural activities impact on the livelihoods of the people dependent on the weather, especially those practicing rainfed based agriculture. The Living Conditions Monitoring Survey Report 2004 found that there were many people involved in agriculture. It determined that the percentage distribution of employed persons by industrial sector in urban areas among persons aged 12 years and above was 20 percent for both sexes, 16 percent for males and 25 percent for females. The percentage distribution for the rural areas was 92 percent for both sexes, 89 percent for males and 94 percent for females. Given the foregoing, any adverse weather changes can have a significant impact on the livelihoods and food security of the majority of people, especially, those living in the rural areas.

2.2. Food security – The effect level

The World Food Summit of 1996 defined food security as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life". Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences.

Food security is built on three pillars[7]:

- Food availability, i.e., sufficient quantities of food available on a consistent basis;
- Food access, i.e., having sufficient resources to obtain appropriate foods for a nutritious diet; and
- Food use, i.e., appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation.

5 Please see Section 3.1 for the definition of the agro-ecological regions in Zambia. The word zone was used in the NAPA in reference to the 36 zones that exist within the three agro-ecological regions.

6 M.R. Muchinda, 1985, Agrometeorological Report No.9, Agricultural Climate for Zambia, Meteorological Department fo Zambia

7 World Food Summit of 1996, http://www.who.int/trade/glossary/story028/en/

2.3. Livelihoods – The response level

The definition of livelihoods is incorporated here as it has been recognised that human activities, namely different types of livelihoods, contribute to climate change and are in turn affected by climate change. These livelihoods also have to change in relation to their corresponding climate change effects.

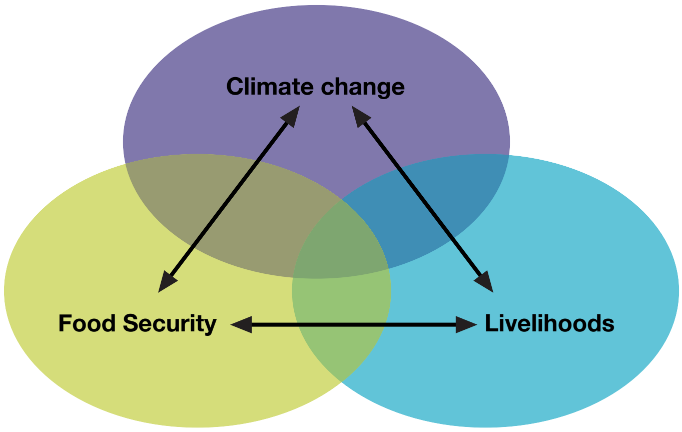
Fewsnet defines livelihoods as *"the means by which households obtain and maintain access to essential resources to ensure their immediate and long-term survival."*

The above definition of livelihoods provides a common thread that links the three factors of food security, i.e. food availability, access and use.

2.4. Inter-relationship between climate change, livelihoods and food security

Figure 1, below, illustrates their complex causal-effect relationship. The causal-effect-response tagging of climate change, food security and livelihoods in Figure 1 may seem presumptuous. However, the seeming presumption also belies the ongoing debate on the existence of climate change, its causes and the required responses. This is because the existence and causes of climate change are still subject to debate amongst informed scientists. This is further complicated by the political and economic orientation of practitioners that debate about climate change and responses to it.

Figure 1: Inter-relationship between climate change, food security and livelihoods.



At livelihoods level, the discussions have involved the contribution of livelihoods to climate change and the possible adaptation and mitigation measures that may be engaged in including sustainable 7agriculture.

3 Evidence of climate change in Zambia

Rainfall and temperature changes are the variables of climate change addressed below.

3.1. Environmental endowments

The discussion of climate change in Zambia requires an understanding of some of its endowments. The NAPA of 2007 (year) documented the following national data about Zambia;

- Area: 752,614 km^2
- Population: 10 million
- 9 provinces, 72 districts
- Literacy: 74%
- HIV prevalence (adult population): 16%
- Climate: tropical
- Rainfall: 1100– 600mm
- Arable land: 42 million hectares (58%)
- Cultivated area: 14%
- Irrigated area / potential: 12%
- Rural Population: 64%
- Woodland: 47%
- Total labour force: 4.39 million
- Female labour force/total: 45%

There are three agro-ecological regions that Zambia has been demarcated into for planning and development processes. The agro-ecological Regions I, II and III are characterised using measurements of rainfall against topography. Zambia is further divided into 36 agro-ecological zones that are characterised using the same rainfall against topography data but also include other factors like vegetation cover and soil. The agro-ecological regions are described below;

1. Region I is low rainfall region (less than 800mm annually) situated at altitudes of 300 – 900 metres above sea level in the valley areas. This region has an agriculture growing season of 80-120 days. The region contains a diversity of soil types ranging from slightly acidic Nitosols to alkaline Luvisols with pockets of Vertisols, Arenosols, Leptosols and Solonetz. The use of these soils is limited by lack of adequate water availability and high soil erosion potential[8].
2. Region II has moderate rainfall (800-1200mm annually) situated at altitudes of 900 – 1300 metres above sea level on the central and eastern plateau. This region has an agricultural growing season of 100 – 140 days. The region is sub-divided based on soil types. In Sub-region IIa, in the centre of the eastern parts of the country, soils are largely classified as Lixisols, Luvisols, Alisols, Acrisols and Leptosols with respective association and Vertisols in the Kafue floodplain. These soils types comprise some of the best agricultural land in Zambia and host much of the country's commercial farming sector. Subregion IIb in the western of the country contains a range of Arenosols, Gleysols, Histosis and Podzols that are limited by soil acidity, poor drainage and water logging conditions[9], and
3. Region III with annual rainfall above 1200 mm covers the northern areas with altitudes of 1100 –1770 metres above sea level. This region has an agricultural growing season of 160 days. Soils in this region are predominantly Acrisols, Alisols, Solonchaks, Leptosols and some Ferallsols developed under conditions of high leaching intensity[10].

8 PaViDia, 2009, Field Manual, Volume 3: Sustainable Agricultural Practices.
9 PaViDia, 2009, Field Manual, Volume 3: Sustainable Agricultural Practices
10 MACO/JICA, PaViDia, 2009, Field Manual, Volume 3: Sustainable Agricultural Practices.

A detailed description of each of the soil types mentioned above is in Annex 5. However, a general description of the soils is in the table below. The description of the soils is accompanied by the limitations each of the soils has to crop production.

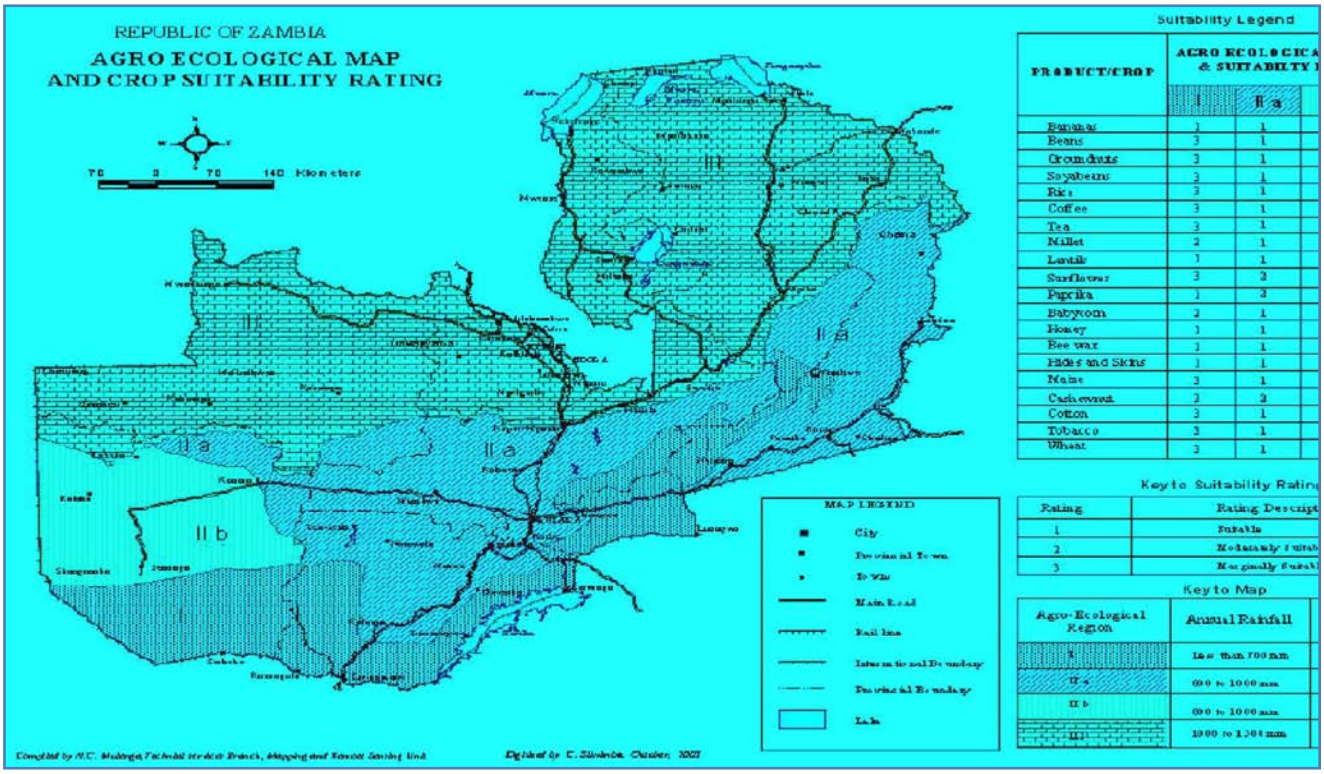
Table 1: Soils in agro-ecological zones and their imitation in crop production

Zone	General description of Soils	Limitations to Crop Production
Zone I	Loamy and clay with course of fine tops Reddish coarse sandy soils Poorly drained sandy soils Shallow and gravel soils in rolling to hilly areas including escarpment zones	Slightly acidic to alkaline. Minor fertility limitations Low pH, available water and nutrient capacity reserve Severe wetness, acidic and low fertility Limited depth and unsuitable for cultivation
Zone II	Moderately leached clayey to loamy soils Slightly leached clayey soils Coarse sandy loams in large valley dambos Sandy soils on Kalahari sand	Low nutrient reserves and water holding capacity Slight to moderate acidity. Difficult to work due to heavy textured soil Imperfect to poorly drained, Limitation due to wetness Medium to strong acidity, course textured top soil, low water holding capacity and nutrient reserves
Zone III	Red to brown clayey loamy soils Shallow and gravel soils in rolling hilly areas Clayey soils, red in colour Poorly to very poorly drained flood plain soils Course sandy soils in pan dambos on Kalahari sand	Very strong acidity and strongly leached Limited depth Moderately to strongly leached. Fewer limitations Variable texture and acidity Very strong acidity

Source: Oliver O. Saasa, et al, 1999, Comparative Economic Advantage of Alternative Agricultural Production Activities in Zambia, Institute of Social and economic Research

The above physical endowments and climatic conditions were illustrated in the agro-ecological and crop suitability rating map included here as Figure 2.

Figure 2: Agro-Ecological Map and Crop Suitability Rating for Zambia



Source: MTENR, Zambia, Formulation of the National Adaptation Programme Of Action on Climate Change (Final Report) September 2007

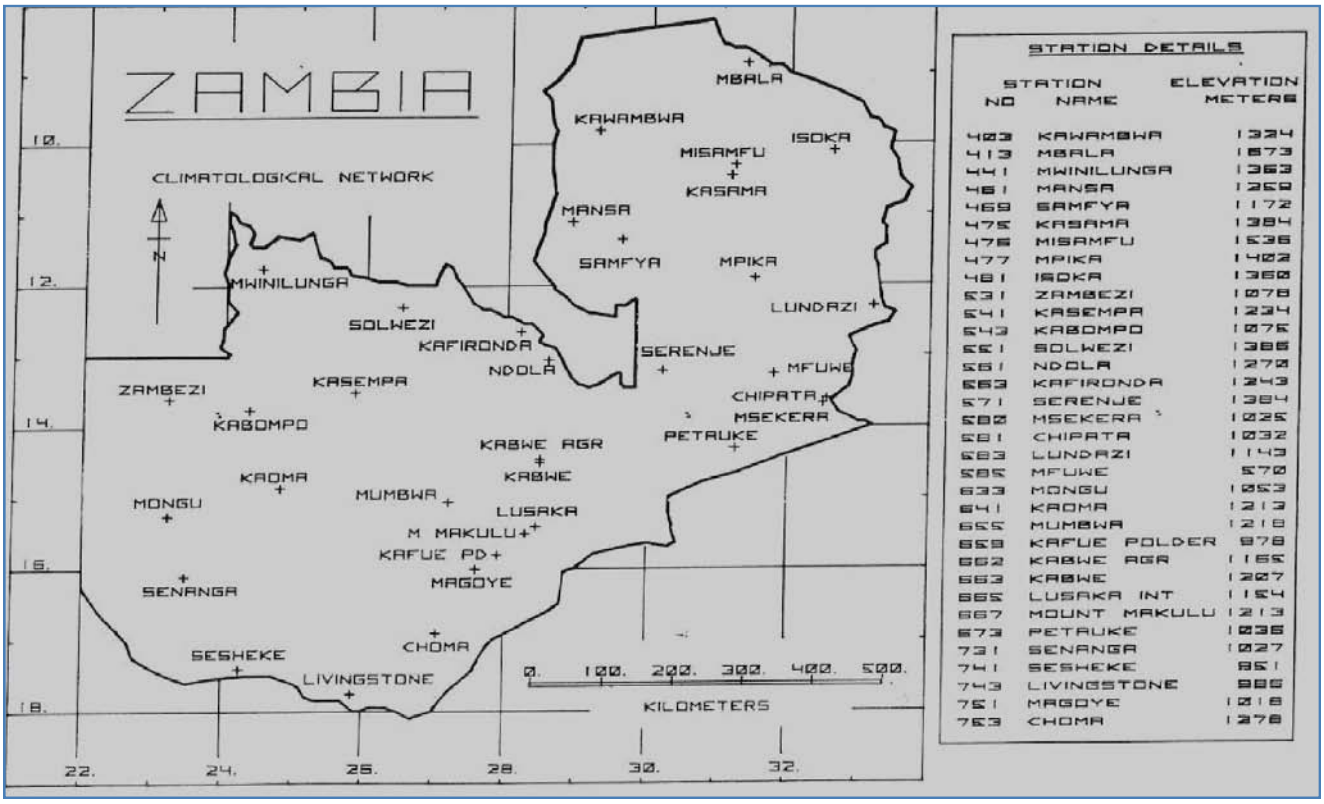
3.2. Weather data collection infrastructure[11]

The Zambia Meteorological Department (ZMD) collects weather data from 38 weather stations. These are comprised of 16 in airstrips, 9 in farmer training institutes or agromet stations and 13 independent. These stations are situated in 30 of the 72 districts. Only 9 of these 38 weather stations are agromets that assist in understanding agricultural related factors. None of these are located in agro-ecological region I. It has been recognized that most agricultural related projects are located in Region II where the weather is more favourable and results are easier to show than in Region 1. The map below illustrates the location of most meteorological stations whilst the legend provides additional data on location. However, the map does not include the Mkushi station. The data from the above ZMD stations is supplemented by data collected by volunteers including the farming community.

The stations listed herein are those managed by ZMD. Other stations managed by ZMD partners including, farmers, have supplied weather data that has been incorporated into its database. The challenge has been assuring continuity, timeliness and validity of the data.

11 Camco, Preliminary Meeting Report on Interviews with Key Stakeholders in Lusaka on National Climate Change Response Strategy (NCCRS) Development Process On 21st to 23rd June 2010 Report Completed on 9TH July 2010

Figure 3: Zambia climatological network



Source: Zambia Meteorological Department Climatological Network Map

Most of the 38 weather stations are situated in Region II and III. This is despite Region I being the most vulnerable to climate change as rainfall in the region is lower and highly influenced by latitude. Rainfall is a much more variable part of the climate than temperature, humidity, wind and pressure[12]. As such, rainfall analysis would be more effective if there was a higher density of observation points and records of observations over longer periods. The current number of ZMD stations provides a distribution of one station per 19,806 km2 against the World Meteorological Organisation standard13 of one station per 1,000 km2.

The above skewed distribution of weather stations causes a gap in data to fully inform debate on climate change. The amount of rainfall per season or day is more variable within the locality of each station than temperature. This creates further need for more stations to better capture rainfall. This requirement for more stations is further compounded by the need for data to be collected every hour of the day and transmitted to ZMD for consolidation and analysis. The challenge then arises wherein the captured data ought to be collected and transmitted in real time to ZMD for it to be processed, disseminated and made useful to end users.

Coupled to the above gap in geographic information, there are certain parameters influencing rainfall and temperature that are not captured including evaporation, radiation, ozone and pollution. This makes current knowledge about climate in Zambia incomplete.

12 SH Walker, 1973, The Climate of Western Province Zambia, Notes and Records, Supplementary Report 1, Foreign and Commonwealth Office Overseas Development Administration.
13 P. Hutchinson, 1973, Meteorological Notes Series A No. 12, The Redesign of the Climatological Network of Zambia.

3.3. *Physical manifestations of climate change*

In layman's terms, incidences relating to climate change have been experienced by people in ways contained in the table below.

Table 2: Chronology of major weather events

Year	Event
1949 *	Country wide drought
1968, June**	Lower screen and ground minimum temperatures of -7.1oC and -10.7oC respectively recorded at Sesheke; rime and hoar frost occurred on branches of trees there for the first time, causing considerable alarm and despondency; citrus fruits adversely affected
1972/1973**	Rainy season for many areas was poorest in 50 years; drought caused substantial drop in crop yields and a reduction in groundwater reserves
1973/1974***	Floods
1978 Feb.**	Floods around Lusaka
1978, Feb.**	Heavy rains caused some damage to agricultural crops in many parts of Zambia
1979, Jan.**	Drought reduced maize production by 25-40%
1980 Feb.**	Three week dry spell from mid-January to mid-February caused considerable losses to the 1980 maize crop in Southern Province
1981/1982**	Below normal rainfall caused reductions in crop and livestock production. Rainfall deficits from 30 to 50 percent in Southern and Western Provinces. Luano Valley experienced famine
1982/1983**	Frequent dry spells in January, February and March led to poor performance of agricultural sector especially in Southern, Central and Western Provinces
1983/1984**	Drought reduced agricultural yields for the third consecutive season; worst affected areas were Southern, Central and Western Provinces
1986/1987**	Frequent dry spells between February and March led to widespread crop failure in Southern, Central and Western provinces
1989 Jan- Feb**	Heavy rains in mid season caused extensive water logging in crop fields; in Chipata district 60% of the total seasonal rainfall was received in January alone. Around Lusaka many people were made homeless as their houses collapsed.
1990 March**	Persistent dry spell caused severe moisture stress in the major maize growing areas of Southern, Central, Lusaka and Eastern Provinces
1991 Jan/Feb**	Southern, Central and Lusaka Provinces experienced dry weather conditions. Marketed maize was only 46% of annual requirement
1991/1992**	Worst drought in recorded history covering 26 districts in the southern half of the country
1994/1995***	Prolonged drought
2000/2007****	Both were drought years
2002/2003****	Floods
2006/2007****	Floods in 41 districts in all nine provinces

Source: * H. Sichingabula, Coping with Drought Through Sustainable Agricultural Development in Zambia, **M.R. Muchinda, 25 Years of Meteorological Service in Zambia (1967-1992), ***IUCN IUCN Summary proceedings of the IUCN Drought Study Follow-up Workshop on the Environmental Impact of the 1991-1992 drought in Zambia and the ****International Emergency Disaster Database.

The intensity and frequency of droughts and floods has been increasing (NAPA). The geographical distribution of these events has also been changing. These climatic variations have caused immense food security problems including destruction to humans, wildlife and economic infrastructure.

The climate change manifestations in Table 2 make it difficult for the respondents in Sinazongwe, Shangombo and Mpika to plan their agricultural practices as the hazards that range from floods, excess heat and drought are not predictable. These happen at seemingly random intervals making it difficult for them to make their annual agricultural plans as they do not know what type of hazard to prepare for. For instance, the 2007 drought was characterised by heavy rains that caused floods early in the season. This was followed by a dry spell that resulted in a hydrological drought that contributed to crop failure and subsequently caused hunger and poverty, especially, in rural areas. At the national scale this resulted in the contribution of agriculture to gross domestic product dropping from 18 percent to 1.9 percent.

3.4. Temperature variability in Zambia over a period of time

The range of temperature that is suitable for plant growth ranges between +15° Celsius and +40° Celsius Dr Javaheri Feriedoon, Dr. Joyce Mulila-Mitti, Mr. Godfrey Mitti and Mrs. Elizabeth Phiri, 1996, Integrated Crop Management; A Guide for Sustainable Smallholder Farming . Plant growth is inhibited at temperature falling outside this range.

The mean annual temperature in Zambia ranges between 18° and 20° Celsius[15]. The highest annual average temperature is 32° degrees Celsius and the lowest temperature averages 4° Celsius.

Since the early 1970's there has been a modest warming in the cool season (June, July and August) mean minimum temperature, whilst considering warming (by about) 1degree centigrade of the mean maximum temperature has been observed in the hot season (September, October and November) especially over the northern half of Zambia[16].

The NAPA estimates the mean temperature scenarios for all the Regions show a similar trend of increasing mean temperatures for the period 2010 to 2070. There is an estimated average increase of about 2ºC (24.5 to 26ºC) for this sixty years period. The years 2013, 2040 and 2062 show the lowest mean temperature in Regions I. Region II has lowest mean temperatures in the years 2013, 2041, and 2061, whilst Region III records a higher number of low temperatures especially after 2050.

> The respondents in Shangombo located on the western part of Zambia, invariably mentioned that they were suffering from excess heat, i.e. temperatures higher than they had become used to over time. They related this heat to the drought that caused stress to their crops and animals. They said livestock suffered as pastures caught fire easily and water was a problem. Excess heat was observed to also occur during the rainy season, in February, which is outside the normal dry hot season. This excess heat was associated to a dry spell that takes place during the end of January and February, at a time the crops are not yet mature contributing to poor yields.
>
> In Mpika the respondents also reported excess heat that led to drying up of streams or reducing water flow in some streams. The excess heat has dried up some of the dambos leading to reduced area cultivated therein. Furthermore, stress has been observed in tree and grass growth. Sometimes the high temperatures that are reached during the day last well after midnight, making it hard for people to rest. To make it worse it got colder the rest of the night than it used to before.
>
> The respondents in Southern Province reported very high heat reaching at least 42O Celsius between October and November. They reported that when they experience a longer hot season the farmers expect good rains. Drought in turn results in very high production of wild fruits that include inji, baobab, busika and ngayi.

3.5. Rainfall variability in Zambia over a period of time

In Zambia, rainfall is by far the most important source of moisture for agricultural production amongst smallholder farmers. As such, rainfall dictates the growing season for the majority of farmers[17]. The figure below shows the trends in annual precipitation in the regions, stated as zones, in the NAPA.

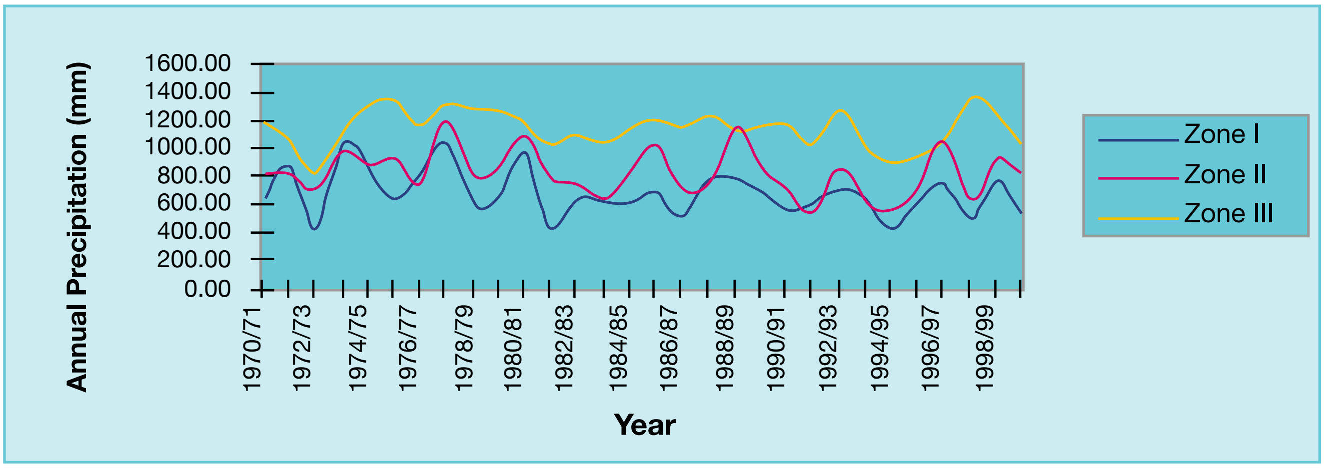
14 Dr Javaheri Feriedoon, Dr. Joyce Mulila-Mitti, Mr. Godfrey Mitti and Mrs. Elizabeth Phiri, 1996, Integrated Crop Management; A Guide for Sustainable Smallholder Farming.

15 Environmental Council of Zambia, State of Environment in Zambia 2000

16 MTENR, 2002, Zambia National Action Programme for Combating Desertification & Mitigating Serious Effects of Drought in the Context of the United Nations Convention to Combat Desertification (quoting Chipeta 2000 and Mumba 1995)

17 Dr Javaheri Feriedoon, Dr. Joyce Mulila-Mitti, Mr. Godfrey Mitti and Mrs. Elizabeth Phiri, 1996, Integrated Crop Management; A Guide for Sustainable Smallholder Farming

Figure 4: Trends in Annual Precipitation in Zones



Source: Zambia NAPA, 2007

The key rainfall features of the above period from each of the three regions as detailed in the NAPA are as follows;

- **Region I:** This region usually has less than 800mm of rain annually. 12 rainy seasons had rainfall above the 30 year average and 17 episodes had rainfall below average. There was a higher degree of annual rainfall variability between 1970 and 1980 as compared to 1981-2000. The overall assessment was that, i*n general, rainfall patterns in Region I revealed a significant tendency of rainfall deficits and dryness.*

- **Region II:** Between 1970/71 and 1980/81 the frequency of above average rainfall was more than that of below average. The period 1981-1991 had fewer observed occurrences of above average rainfall compared to 1970/81. The frequency and degree of dry episodes increased even further after the year 1991/92. The region has the highest rainfall with maximum over the baseline period being 1,372 mm and a minimum of 836 mm. The average rainfall over the baseline period was 1,151 mm.

- **Region III:** There were 16 occurrences of rainfall above average and 13 occurrences below 30 year average. *The region was characterized by a less variable annual rainfall compared to Regions I and Region II.*

The NAPA using the HADCM3 Global Climate Model (GCM) projected rainfall and temperatures scenarios for each zone for a sixty year period from 2010 to 2070. It concluded that there will be increased precipitation in all the three regions. However, there are alternative interpretations of data that predict a reduction in precipitation.

3.6. Significance of climate change

One of the major significances of climate change is its effects on food security especially by how it affects food production.

3.6.1. Phenology of crop production

One of the meanings of phenology[18] presented in Mr. Moses Gumbo's paper is the Webster's dictionary (1985) definition of the term as the "study of the relationship between weather (or climate) and periodic biological activities such as the development phases (stages) of plants or migration of birds, i.e., occurrence of biological phenomena is intimately linked to the seasonal climatic variations". Some examples of phonology-weather-interactions presented in the paper are outlined in the table below. Changes in climate in relation to the phenology of the crops may affect their productivity and the productivity of all other inputs used in their production.

The above definition of phenology, and its conceptual framework, may conceptually be transposed to other economic and social activities. For instance, the traditional cultural events that celebrate the first major harvest of each year will have to change to suit the maturing of crops for the first harvest as influenced by the changes in climate.

18 Moses Gumbo, 1992, Phenological Stages of Some Major Crops in Zambia, A Paper Presented at the Training Workshop on the National Early Warning System of Food Security for Crop Husbandry and Farm Management Officers at NRDC in Lusaka

Table 3: Examples of crop phenology-weather-interaction

Crop	Phenology-weather-interaction
Maize	• Weather is the major determinant • Planting early results in higher yields than late planting • Increased mean temperature shortens duration of vegetative phase and tasselling • Temperature and water stress at silking or after silking result in the following; ¸ 25% yield loss prior to silking ¸ 50% yield decrease at silking ¸ 21% decrease after silking
Sorghum	• Temperature and photoperiod (day length) are two major factors dictating rate of development • At emergence soil moisture, temperature, frost free days and planting date influence stand established • At 3rd leaf stage to flowering soil moisture, temperature, day length, affect development of tillers, leaves, grains, panicle and seeds are critical
Millet	• The phenology-weather-interaction mentioned above for sorghum also applies to millet
Soyabeans	• Day length dictates time of planting • Moisture stress at pod development and pod-filling reduce seed size (around March in Zambia)
Groundnuts	• Temperature is the dominant controlling factor of development • Pod yield is influenced by day length • Long days result in increased vegetative growth and reduced reproductive growth • High temperature reduce yields due to pollen death, fewer pegs and pods, and increased vegetative instead of reproductive growth
Beans	• Beans respond well to moderate temperature and warm soils
Cassava	• Reduced temperatures result in reduced development of leaves • Cassava has no critical periods that markedly affect yields forming organs

Source: Moses Gumbo, 1992, Phenological Stages of Some Major Crops in Zambia

The day length requirements of various crops alluded to in the table above differs from plant to plant. **Sorghum,** having originated just north of the equator, requires consistent daylight of up to 12 hours to trigger an internal genetic mechanism that enables them to stop producing leaves and other vegetation and to channel energy into reproduction – first flowers and then seed[19] **Soyabeans** originated in the Far East and is a short-day plant with genotypes varying widely in the day length tolerated without inhibition of flowering[20]. The phenology of **groundnuts** is determined primarily by temperature, with cool temperatures delaying flowering. In controlled environments, photoperiod has been shown to influence the proportion of flowers producing pods and distribution of assimilates between vegetative and reproductive structures (harvest index) in some cultivars. Long photoperiods (greater than 14 hours) generally increase vegetative growth and short photoperiods (less than 10 hours) increase reproductive growth[21].

Even though Table 3 above deals with cultivated crops, the NAPA recognizes that the distribution of vegetation types is related to the amount of rainfall, moisture content and temperature prevailing at a given area. It concludes climatic changes (drought and high temperatures) seem to be jeopardizing regeneration of Miombo forest, which normally regenerates easily and fast.

The NAPA further recognized that for livestock, as temperatures rose, the cattle population reduced, and as they fell, the population increased. This scenario was related to the amount of rainfall; extreme temperatures are associated with droughts (less rainfall) and vice versa. Thus, as the amount of rainfall increased, the number of

19 Jeffrey A. Dahlberg, Resetting Sorghum's Internal Clock; Programme of converting tropical plants is unique among crops, USDA-ARS Tropical Agriculture Research Station.

20 J. Smartt , 1985, Evolution of Grain Legumes. V. The Oilseeds, , (1985), 21: 305-319, Copyright © Cambridge University Press 1985.

21 Protabase Record display, Arachis hypogaea L., www.prota.org.

animals also increased. This situation may be explained in relation to increased plant growth and the subsequent increased availability of pastures leading to good nutrition, enhanced immunity and productive capacity.

In light of Table 2 above, the respondents in all the three Districts visited reported increasingly higher temperatures during the rainy season. This phenomena requires to be linked to the extension messages as to the type and variety of each crop the farmers grow if they are to get good harvests

3.6.2. Changes in start and end date of rainy season

In addition to the amounts and patterns of rains, Figure 3 and Table 2 respectively, the most visual/physical factor that drives the cycle of crop and livestock production is the onset of the rainy season. Figure 5 below shows the mean start and end dates for the rainy season as illustrated by Peter Hutchinson[22]. The figure is premised on Chaplin's (1954) definition of the start of wet season in Zambia wherein he defined it as "the first day of the period of 4 days on at least 3 of which more than 0.25mm was recorded, the total rain for the period being 10.2mm or more. The closing date is similarly described as the last day of a period conforming to these limits. This figure is the reverse of the one presented by S.H. Walker[23] that presented a similar figure showing the mean opening and closing dates of the dry season in Zambia. These dates may be useful as baseline data for determining changes in existing rainfall start and end dates in various agro-ecological zones.

For Zambia's rainfed agriculture, the above is important as it dictates the planting season for most agricultural production amongst smallholder farmers.

The respondents in Western Province, Shangombo, reported that the first rains now typically fall around mid-December instead of sometime in October. They further reported that the rains also have a tendency of ending early in February instead of March. This worsens the negative effects of the excess heat that is experienced end of January and in February on the crops, livestock and humans. The changes in the rains have caused the communities to rely more on the livestock (especially cattle) and natural resources for sustenance. Some community members have also adopted dambo gardening to use the residual moisture after the rains. They also undertake limited irrigation of gardens. The farmers have also adopted crop diversification and conservation agriculture. During more difficult times, some community members ration food to make it last longer. The drought tolerant crops that the community members have gone back to growing include sorghum and millet. Millet has been especially successful. Piecework has also emerged as an important response to changed start and end of the rains.

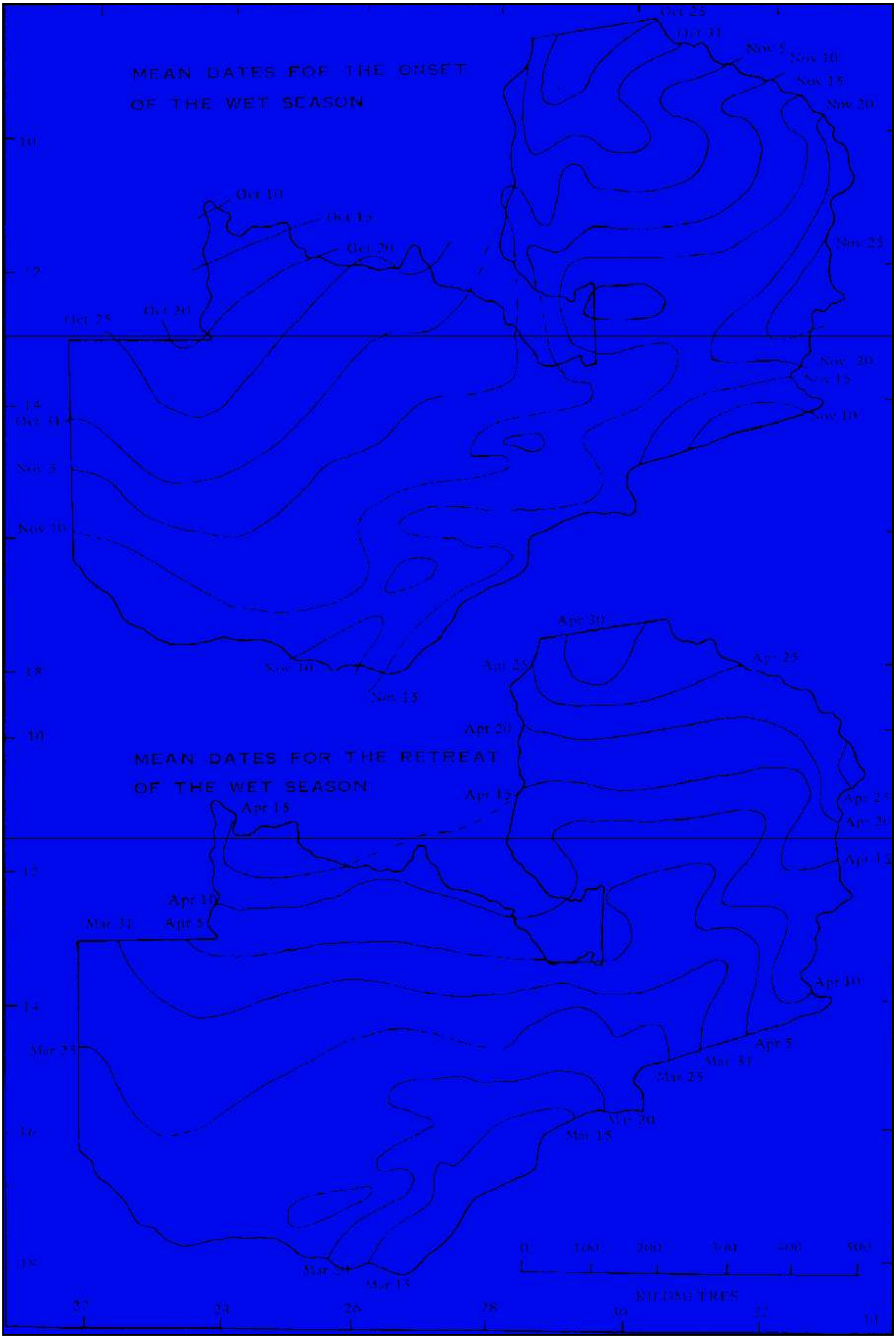
The respondents in Northern Province reported that the rainy season lasted from November to April but it now starts raining between December to early April. Despite this, the rain intensity is high over short periods of time and the respondents suspect that this leads to flush floods, soil erosion and leaching of the soil. The rain cycle has been observed to result in reduced mushroom growth, one of the main sources of food and income in the province. They also observed that some species of mushrooms do not seem to sprout anymore. The drought or dry spells that are experienced led people to start using the dambos much more as they retained water for longer periods. The longer periods of the drought were seen to contribute to the drying up of even large bodies of water like Lake Mweru wa Ntipa, though siltation and blockage of water inlets into the lake may also be considered as contributing factors. The water table has been noticed to drop leading to a need to deepen wells and drill new deeper boreholes. The dry spells have affected the growth of grass as there is now inadequate tender grass for their livestock. They reported that the cutting down of trees in line with chitemene farming practices may have contributed to climate change and the drying up of streams. The chitemene farming practices involve the cutting of branches off trees over a wide area and burning them onto an area less that the area from which the branches have been collected from. The ash is used as fertilizer for the land. The land is used for a limited duration of seasons, up to three-four years and is abandoned to fallow as its productivity declines. The farmer then proceeds to open up another piece of land. The respondents have reacted to the changes in rainfall by growing more cassava (especially Bangweulu specie), millet, sorghum, sweet potatoes (Chingovwa), planting their maize early, using early maturing varieties of maize and finger millet and growing vegetables near stream or rivers. Nerica (upland) rice is just being introduced. However, more capacity strengthening on the proper techniques of utilizing dambos is required as there is a risk of damaging them through improper farming methods. Conservation agricultural techniques, especially potholing, have been introduced.

22 Peter Hutchinson, "The Climate of Zambia" the Geographic Association
23 SH Walker, 1973,The Climate of Western Province, Zambia Notes and Records Supplement to Land Resources Study No. 8, Foreign and Commonwealth Office, Overseas Development Administration

The respondents in Southern Province reported that the farmers in the Sinazongwe had been used to poor rains for a long time. As such, the increase in rainfall in the last ten years caught them by surprise. This heavy rain has contributed to a lot of erosion of the top soil especially since the area has undulating landscape comprised of the plateau and valley areas. The farmers can expect the rains to start as soon as the Musante tree shoots. The farmers also expect good rains when they observe mist in the hills and there is an abundance of bees. The farmers can also predict good rains when the petals of certain trees (Muledolo) fall into the basins they would have made by August. The observation of a ring around the moon was also cited as one indicator of good rains. The camp extension officers access the Meteorological Department weather forecasts and they use this information to advise the farmers on how to plan their agricultural season. The farmers close to Lake Kariba in Southern Province where the soil is fertile plant maize, okra, cowpeas by the banks of the lake. However, this fertile land along the Lake Kariba is not available for gardening during the flood season as the water takes time to recede and any crops planted along the river get washed away. Farmers have also started using more inorganic fertiliser than before. They previously relied on the natural fertility of the soil or used animal manure. The farmers have also been taught by the Government extension staff to use medium maturing varieties when long rains are predicted and drought tolerant crops when short rains are expected. The crops advised in response to short rainy season include sorghum, bullrush millet and cowpeas. The farmers resilience to the changes in weather patterns is affected by their widespread livestock ownership comprised of goats and cattle. The cattle are mainly sold and the income is used for paying secondary school fees whilst the goats are mainly used for primary school fees. Cattle and goats are rarely killed for consumption. MACO, through programmes like the Farmer Input Support Response Initiative and the Conservation Agriculture Support Programme, is introducing conservation agriculture (minimum/zero tillage, ripping, basins, liming and manure) to assist offset the negative impact of changed rainfall starting and ending dates. The changes in rain season duration and intensity are discussed in greater detail below in section 3.6.3. Similar programmes have also been introduced by The Catholic Relief Service as the lead agency for the Consortium for Food Security Agricultural, AIDS Resilience and Marketing (C-FAARM) in Zambia in collaboration with CARE, World Vision and Land O' Lakes. . The respondents reported that the effects of conservation agriculture are more apparent during the seasons when droughts are experienced season than during normal rains. However, this is an observation of yields only and does not take into account the input requirements and current yield of conventional agriculture. In a season where there is plenty of rain the basins have a tendency to collect too much water causing the maize to turn yellow.

However, the adoption of drought tolerant sorghum and bullrush millet is not without challenges. In Sinazongwe they were found to yield poor harvests and demand more labour as they require scaring of birds that feed on them. Maize performed better as it is supported by improved seed and inorganic fertilisers. From a consumption point of view, in Sinazongwe and Mpika, sorghum and millet were said to be better as the nshima they produced gave one a feeling of satisfaction for a longer time.

Figure 5: Mean dates for the onset and retreat of the wet season.



Source: Peter Hutchinson, “The Climate of Zambia” the Geographic Association

3.6.3 Changes in the pattern of rainfall

Table 2, already alluded to above, shows that the pattern of rainfall, especially the agricultural drought in January and February, causes stress in crops at critical stages of their growth. This can reduce their productivity leading to reduced own food production for home consumption, reduced sales for income generation and contribution to the national food supplies. It also has the potential to contribute to increased food prices. Furthermore, changes in rainfall patterns affect the growth of plants that domesticated animals rely on for food, especially, those owned by small-scale farmers.

As already mentioned above, the respondents in Northern, Southern and Western Provinces have already felt the impacts of the above changes in rainfall pattern. Their responses have included taking up conservation agriculture where the knowledge is extended to them, use of dambos, shorter maturing varieties and drought tolerant varieties. One other change is that of environmental refugees who move from the flooded areas to drier land during the rainy season as experienced in Shangombo and Mpika. Human relocation in Sinazongwe also included people starting cultivating land on the uphill from their present fields. This was in areas where erosion had washed away most of the top soil.

The change in the pattern of rainfall, i.e. heavier rainfall in short durations of time, has been associated with damage to infrastructure. Respondents reported that schools and health centres were submerged in Shangombo in 2009. Roads and bridges were washed away in Shangombo during the 2009 floods. In Sinazongwe, evidence of heavier rains was quoted by respondents as the 2009 washing away of a bridge that was built in the 1970's. This damage to infrastructure causes challenges in movements of inputs to farmers and farm produce to the market. For instance, the top dressing fertilizer arrived in Sinazongwe during the last week of January 2011 because of the bad road and the low carrying capacity of the temporal bridge across one of the rivers. This fertilizer would not be delivered to the south west part of the district as it cannot be reached. The farmers that received the fertilizer would not use it as their maize had already tasseled and would thus keep it for the following year. The damaged infrastructure also threatened the safety of already stored produce. The Sinazeze storage collapsed in 2010 and the previous year's maize was stored outside. It could not be moved to the available shed in Maamba as the trucks cannot cross some bridges.

The changes in the pattern of rainfall and the droughts associated to it were observed to also have gender impacts. In Sinazongwe, it was reported that men have a tendency of siting their villages/homes on hills for security purposes. However, it is the women who have to go down the hill to the streams or wells to draw water and bring it up the hill on their heads. In the event of droughts, the women have to walk longer distances to the running streams and wells that have water.

3.6.4 Summary of climate change effects on crops, livestock and fisheries

Table 3, below, summarises the varied effects of climate change as quoted from the NAPA. The table illustrates that climate change causes stress on human beings at the production and distribution level thereby affecting sustainable access to adequate and nutritious food and service delivery.

Table 4: Effects of climate change on crops, livestock and fisheries

Drought	Floods	Extreme Heat	Shorter rainy Season
• **Crop damage/loss leading to food scarcity and hunger** • **Water shortages** • **Reduced fish stocks** • **Income loss** • **Increase in diseases (affecting humans and animals)** • **Decreased water quality** • **Increased soil erosion** • **Decreased soil fertility** • **Increased honey production (if drought is not too severe)**	• Crop damage/ loss, leading to food scarcity and hunger • Loss of crop land and grazing ground • Decline in fish catches • Increase in diseases (malaria, dysentery, cholera, etc.) • Destruction of infrastructure (houses, roads) • Life loss (humans and livestock) Interference with energy production due to change in water flows.	• Loss of life, Increase in diseases affecting animals, crops and humans (especially malaria) • Decreased human capacity to do work • Loss of life (animals and humans) • Crop damage/loss • Reduced fish stocks • Decreased livestock feed • Reduced water quality	• Increase in risk of crop failure • Crop damage/loss • Decreased income from crop selling for those with reduced production • Crop seeds do not reach maturity (which negatively affects the next crop generation) • Reduced forest regeneration

Source: MTENR, Zambia, Formulation of the National Adaptation Programme of Action on Climate Change (Final Report) September 2007

All the effects of climate change mentioned in the above table have been experienced in Shangombo, Sinazongwe and Mpika. Droughts have caused stress on the livestock as the pastures dry out quickly and the bushfires burn the pastures more intensely. The reduced pastures in Shangombo were observed to contribute to increased disease transfer as the cattle from different households were crowded onto limited pastures. Floods and wet conditions were also cited to cause damage to the cattle's hooves in Shangombo. This has been made worse by human, domesticated livestock and wild animal conflicts as the feeding range is made smaller by the drought or floods in Shangombo. Elephants were noted to have invaded sorghum fields.

Amongst the people the spread of water borne diseases (e.g., diarrhoea) were reported during droughts when there were limited water sources and during floods (malaria) when water based disease vectors were able to breed in stagnant waters in Shangombo and Sinazongwe.

It was observed during the technical committee meeting at JCTR that the decline in fish catches attributed to floods in the Table 3 above, though temporal, may have caused negative socio-economic impacts. The floods may also have had the potential of increasing fish multiplication as the fish was spread over a wider range. Consequently, the fish feeding area was also bigger. These factors had the potential for increasing future catches.

4 Areas that will be most affected by climate change in Zambia

4.1. Geographical areas susceptible to climate change

Table 4, below, shows some of the districts that have had repeated instances of both floods and droughts. The status of these districts was documented by the Disaster Management and Mitigation Unit (DMMU) through the 2010 Comprehensive Vulnerability Assessment and Analysis. District based vulnerability profiles and maps of hazards and risks are being developed. Based on historic precedence, it is most likely that these same districts are likely to be affected most by climate change.

Table 5: Areas most likely to be affected by climate change

Province	Districts
Central	Mkushi and Serenje
Eastern	Chama, Mambwe, Nyimba and Petauke
Lusaka	Chongwe, Kafue and Luangwa
North-western	Chavuma, Mwinilunga and Zambezi
Southern	Gwembe, Itezhi-tezhi, Namwala, Siavonga, Sinazongwe and Kazungula
Western	Kalabo, Lukulu, Mongu, Senanga, Sesheke and Shangombo

Source: DMMU

For 2011 it had been predicted that the following districts would suffer above normal rains potentially causing floods, i.e. Chadiza, Chibombo, Chipata, Choma, Chongwe, Gwembe, Itezhi-Tezhi, Kabompo, Kafue, Kalabo, Kaoma, Kasempa, Katete, Kazungula, Livingstone, Luangwa, Lukulu, Lusaka, Mazabuka, Mongu, Mufumbwe, Mumbwa, Namwala, Nyimba, Petauke, Senanga, Sesheke, Shangombo, Siavonga, Sinazongwe and Zambezi. This meant that 34 out of 73 districts would be affected. Based on buffer and spatial analysis the DMMU anticipated that about 113,745 households would be affected with a total population of 682,871 people.

The NAPA singled out Region I as one region that is consistently experiencing climatic hazards in terms of droughts and water scarcity. Although the rainfall trends may not be that vivid, there is a general tendency of rainfall declining and shifting towards dryness[24]. This is supported by the chronology of major weather events in Zambia depicted in Table 1.

The State of Environment in Zambia 2000[25] further observes that, in terms of environmental degradation, Region II is the most vulnerable from;

- Use of heavy machinery which tends to cause soil compaction; and
- Application of relatively heavy amounts of fertilisers degrades productive land and reduces it PH levels.

The above environmental degradation calls for utilization of sustainable agricultural practices that not only provide improved productivity but maintain the nutrient and structural integrity of the soil or assists to rebuild the soil nutrient levels and structure. The biased emphasis of the Farmer Input Support Programme (FISP), and its predecessors, e.g. the Fertiliser Support Programme, on inorganic fertilizer utilization may need review. This may be especially so in relation to the recommended fertiliser application regime in relation to all the other agricultural practices including land preparation, weeding and time of planting.

There has also been a trend arising from unplanned settlement patterns that have resulted in floods in Lusaka and other urban areas. This is due to limited capacity of the councils to enforce existing council regulations and

24 MTENR, NAPA
25 Environmental Council of Zambia, State of Environment in Zambia 2000

a historical legacy from past failure to regulate settlements. The regulations have to do with the planning and location of urban settlement patterns in relation to the environmental and geography of suitability of each area.

The climatic conditions are also such that areas that suffer floods are not always necessarily the same areas that receive the most rain. Areas like Luangwa District in the valley regularly suffer from rain deficits but are prone to flooding as they lie further downstream of big rivers and receive the water from heavy rains experienced upstream.

4.2. Attribution of the recent floods and drought incidences to climate change

The NAPA acknowledges that the recent floods and droughts are effects of climate change. The ZMD also recognises that climate change is real in Zambia. This is reflected in the increased frequency and intensity of floods and droughts.

The Zambia DMMU recognises that climate related disasters and recurring problems exist in Zambia. The 2005 drought, the mix of floods and dry spells in some parts of Zambia in subsequent years were also attributed to climate change.

The National Stakeholders Consultative Meeting for the Development of a comprehensive National Climate Change Response Strategy (NCCRS) recognised that it is very difficult to quantify the contribution of climate change to current impacts. It therefore recommended that the focus should be on trends, not precise percentages or quantitative data, and on mainstreaming climate change within strategic documents26.

26 CAMCO, Report on the National Stakeholders Consultative Meeting for the Development of a comprehensive National Climate Change Response Strategy (NCCRS) National Workshop, Held at the Mulungushi International Conference Centre, Lusaka on 15th June 2010.

5 | Effects of climate change on food security in Zambia

The effects of climate change on food security are in addition to the other factors that interact to cause changes in food security. As such, the effects of climate change on food security in Zambia are contextualised within the broader framework of the many factors affecting food security in Zambia.

5.1. Patterns of livelihoods

The LCMS 2004 found that 69 percent of the employed people, i.e. 3,954,612, reported that they were engaged in agriculture, forest and fisheries activities. The other 30 percent was engaged in mining and quarrying (2%), manufacturing (0%), electricity, gas and water, construction (0%), trade, wholesale and retail distribution (10%), hotels and restaurants (1%), transport and communication, finance, insurance, and real estate (1%) and community, social and personal services (9%). The high proportion of people relying on agriculture, forest and fisheries highlights how relevant the dialogue and the responses to climate change are for Zambia.

The high proportion of people engaged in agriculture highlights the importance of agriculture as a livelihood strategy for most people. The importance of this livelihood strategy is further emphasised by the amount of funds that are used to subsidise maize production. This subsidy is often seen as not correlated to the productivity of the farmers. For instance, the average maize productivity for 2009/2010 that recorded a bumper harvest was 2.25 metric tonnes per hectare in contrast to the 1988 maize yield per hectare of 2.69 metric tonnes per hectare[27]. This seems to connote that farming has not been made an economic business wherein available technology is mobilized and used to produce to its highest potential. In this instance, many existing maize growing technologies can actually produce 6-8 metric tonnes per hectare for early maturing varieties up to 8-12 metric tonnes per hectare[28] Given this, caution will have to be paid to defining who a farmer is in relation to their potential to utilise the available technology and also in relation to farming as a default livelihood or social safety net.

The way farmers use their inputs affects their productivity regardless of the type of technology they use. Farmers have been taught over the years to start the season with a clean field. They have done this by burning the crop residue resulting in reduction in available organic matter to improve soil structure. This contributes to hidden hunger as the soils nutrients are degraded contributing to poor yields. The use of inorganic fertilisers does not easily compensate for these deficiencies whereas rock phosphate and animal manure may perform better. Furthermore, the response of the soil to inorganic fertilisers is reduced when the soil's biomass is low. Rock phosphate and animal manure are not yet widely used. Given the foregoing the Farmer Input Support Programme may need evaluation to take these issues that affect the productivity of farmers.

5.2. Patterns of crop production

The table below shows a high concentration on growing of maize followed by cassava as staples.

Table 6: Proportion of agricultural households engaged in growing various types of crops by residence.

Residence	No. of Agric. H/holds	Percent growing									
		Maize	Cassava	Mill-et	Sorghum	Rice	Mixed beans	Soya-beans	Sweet potato	Irish potato	G/ nuts
Total Zambia	1,372,760	86	34	9	4	2	13	3	17	1	30
Rural	1,158,741	85	37	10	2	2	14	3	18	2	31
Urban	214,019	93	14	1	2	2	8	1	11	-	24

Source: CSO Living Conditions Monitoring Survey 2004[29]

27 Central Statistical Office, Database.
28 Zamseed, 2009, in GART 2009 Yearbook.
29 Note that this is the latest official document on living conditions. At the time this report was being written, the 2006 report was still in draft form, hence not yet official

Maize is grown extensively in all provinces. There is a higher proportion of people growing cassava in Luapula (90%), Northern (70%), Northwestern (48%) and Western (40%). This drought tolerant and year round productive crop is ideal for the Region I and II that were recognized as susceptible to climate change and environmental degradation. However, traditional eating habits that have developed over a long time sometimes hinder the adoption of cassava, even as contribution to coping strategies.

The use of sorghum and millet as climate change adaptation measures has faced mixed responses as already stated above, mainly because they do not get the same subsidies applied to maize and the labour required in chasing away birds from their fields. Millet was reported to perform better than sorghum in Shangombo. Millet and sorghum were still not yielding well in Sinazongwe.

5.3. Patterns of livestock ownership

The highest livestock ownership proportions were recorded in Southern Province (49%), Eastern Province (43%), Lusaka Province (38%), Central Province (31%) and Western Province (30%). These provinces fall within the climate change vulnerable Regions I and II.

Chicken ownership is highest for all livestock as depicted in the table below. The husbandry of cattle and goats are the second highest. These livestock are usually raised free range and affect the environment by the amount of foliage they consume and consumption of crop residue.

Table 7: Percent of agricultural households owning various livestock.

Residence	No. of Agric Households	Households owning livestock	Percent growing						
			Cattle	Goats beans	Pigs beans	Sheep beans	Chicken beans	Ducks/ Geese	Guinea fowl
Total Zambia	1,372,760	434,345	52	53	28	4	97	97	97
Rural	1,158,741	406,722	52	53	28	4	98	98	98
Urban	214,019	27,623	54	42	24	5	89	89	89

Source: CSO Living Conditions Monitoring Survey 2004

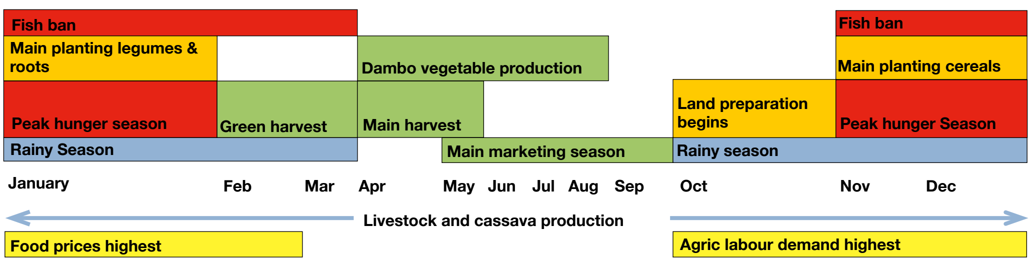
5.4. Evidence of food security issues

The Priority Surveys (1991-1993) and the Living conditions Monitoring Surveys (1996-2006- draft report) reveal that the national incidence of poverty has ranged between a high of 74 percent to 64 percent in 2006. Generally, the incidence of poverty reduced between 1991 and 2006 in almost all the provinces except in Central, North-Western and Western. Western province consistently emerged as the poorest province in all the six surveys. The incidence of poverty in Western Province remained the same (84 percent) in 1991 and 2006. The three provinces listed above have the following contrasting features when looked at in terms of agro-ecological and crop suitability rating that is contained in Figure 2;

- Central Province lies in Region IIa in which 100 percent of the products are suitable to moderately suitable for production;
- Northwestern Province lies in Region III in which 100 percent of the products are suitable to moderately suitable for production; and
- Western Province that lies in both Region I and IIb. In the area covered by Region 1, 40 percent of the products are suitable to moderately suitable for production. In the area covered by Region IIb 5 percent of the products are suitable to moderately suitable for production.

The meaning of the Priority and Living Conditions Monitoring Surveys can easily be interpreted into the generic food availability calendar for the smallholder farmers in Zambia illustrated as an example below.

Figure 6: Generic food availability calendar



The above generic food availability calendar mainly applies to the agricultural practice adopted through extension messages and agricultural subsidy programmes undertaken over the last thirty to forty years. Some of the sustainable agricultural practices being implemented now have shown that the intensity of labour utilisation can be spread out, land preparation started earlier, planting done more timely, weeding improved and food availability increased through improved productivity per unit of input used.

5.5. Factors affecting food security

The NAPA, recognises that the key vulnerabilities of agriculture and food security to the major climatic threats as;

1. Excessive precipitation leading to water logging, erosion and hindrance to field operation; and
2. Increased frequency of droughts in terms of shortening of the growing season and flash floods.

Table 1, above, further provides notes of the sequence and effects of the above events in Zambia and their negative impacts on food security, livelihoods and adaptive capacity of the vulnerable communities.

The Minister of Finance's 2009 budget speech attributed some of the poor performance in the agricultural sector to the following;

(a) high cost of inputs;
(b) limited access to credit, inputs and extension services;
(c) inadequate infrastructure;
(d) poor livestock management;
(e) weaknesses in the Fertiliser Support Programme; and
(f) failure to attract adequate private investment in the sector.

It is worth noting that some of the above factors were highlighted in the Third National Development Plan 1979-1983[30].

One additional constraint not mentioned in the Minister's speech but included in the Third National Development Plan is poor crop, livestock and fisheries management that poses a threat to both productivity (yields per unit area of land) and total production levels.

Besides the above official reasons explaining why the sector has under-performed and not reached its full potential, the following have also been identified as contributing factors[31]:

1. Uncertainties due to transition to a liberalised agric sector that led to demise of key rural institutions.
2. Low crop prices in remote areas due to high transaction costs.
3. Climatic variability and the lack of adaptation of current farming practices by small farmers.
4. Decline in soil fertility in areas which have been historically the most productive.
5. Labour constraints at peak times of the season.
6. Low education and poor health status.
7. Gender discrimination.
8. Decline in the number of households with access to modern farm inputs.
9. Inadequate investments for farm improvements due to unsupportive land tenure system.

Besides the above reasons for the poor performance of agriculture, the generic food calendar in Figure 6 above is also explained by some of the following issues that were reported in all the districts; Human relocation from flooded areas reduces their social capital and productive capacity as they have to start afresh after relocation; fish stocks depletion in natural bodies reduces their access to this protein, insect and pest diseases outbreaks on crops and livestock and depletion of soil productivity due to erosion. Human animal conflicts were reported in Shangombo.

All the above affected the communities' ability to build up resilience to climate change, become more productive and reduce the hunger period illustrated in Figure 6. The Shangombo and Sinazongwe communities that had

30 Government of the Republic of Zambia, 1979, Third National Development Plan

31 Dennis K. Chiwele, RuralNet Associates Limited, Agriculture Development and Food Security in Sub-Saharan Africa: Building a Case for More Support A Case Study of Zambia widespread livestock ownership seemed to fare better. Sale and consumption of Sinazongwe's abundant wild fruit, which grow in abundance during drought years, also filled in as a coping strategy.

5.6. Population affected by food insecurity

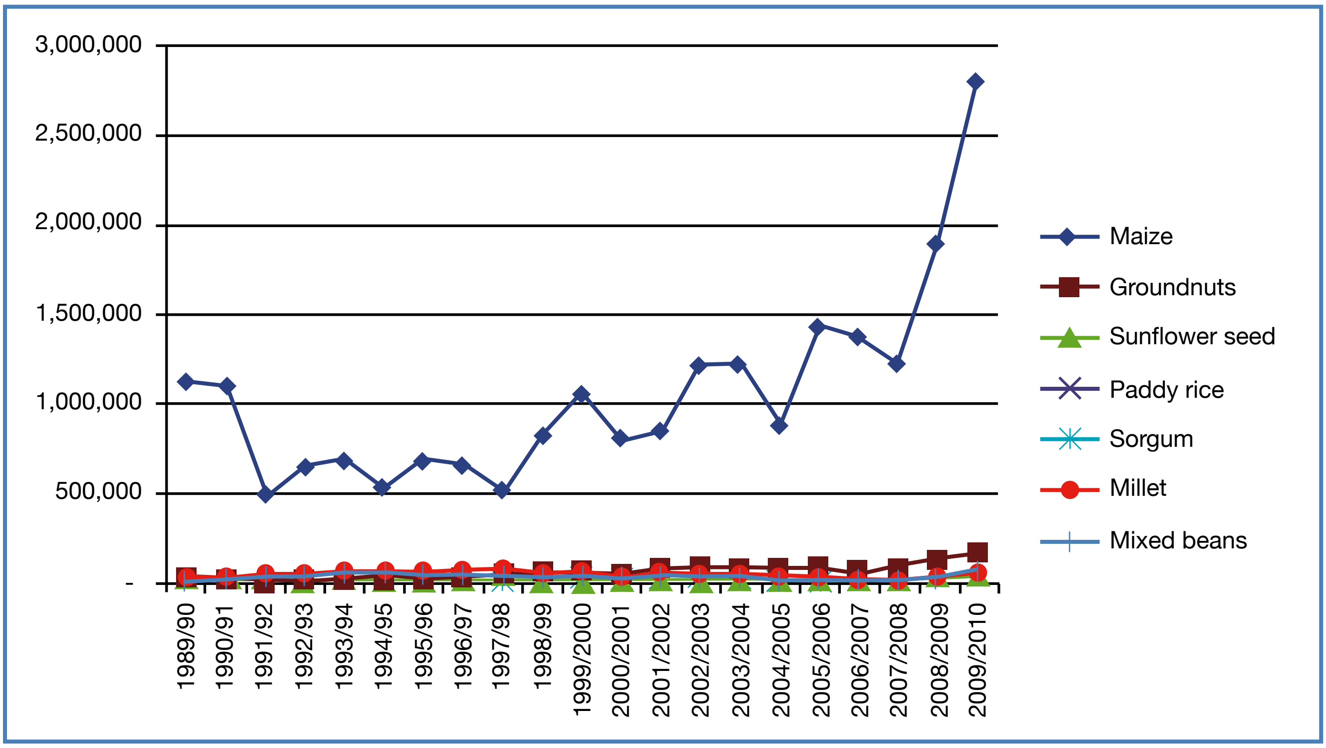
The population that has been recognised as being most vulnerable to food insecurity includes the following[32];

- Livestock farmers in Southern and Western Provinces. These farmers suffer the worst from both the drought and floods that destroy their crops and negatively affect the growth and availability of pasture. These provinces are within agro-ecological regions I and IIb. These districts also have a disproportionately larger number of their districts identified as some of the areas most likely to be affected by climate change by DMMU in Table 4 above;
- Child headed households throughout the country;
- The aged in rural parts of the country looking after orphans;
- Unemployed in urban areas; and
- Population in drought and flood prone areas, mostly southern and western parts.

5.7. Food availability: sufficient quantities of food available on a consistent basis

The figure below shows the lack of consistency in production levels of the rainfed food crops. The yields of the crops also follow a similar fluctuation. The increases and decreases in production can be matched to flood and drought cycles contained in Table 1 above. Both droughts and floods are associated with reduced agricultural yields[33]. Times of increased food production lead to increased food security for staple foods. However, they are also associated with problems in marketing of the excess crop for income generation to pay for other needs. The omission of other crops that people rely on for sustenance like sweet potatoes, cassava, Irish potatoes, and cowpeas is due to the fact that their production data was not consistently collected. This belies of the often mentioned issue that more attention has been paid to maize at the expense of other crops.

Figure 7: Production in tonnes of selected food crops 1989/90 - 2007/2008.



Source: Derived from CSO crop forecasting (2005 – 2010) and post harvest (1989 – 2005) data

32 Fewsnet
33 CAMCO, Report on the National Stakeholders Consultative Meeting for the Development of a comprehensive National Climate Change Response Strategy (NCCRS) National Workshop, Held at the Mulungushi International Conference Centre, Lusaka on 15th June 2010

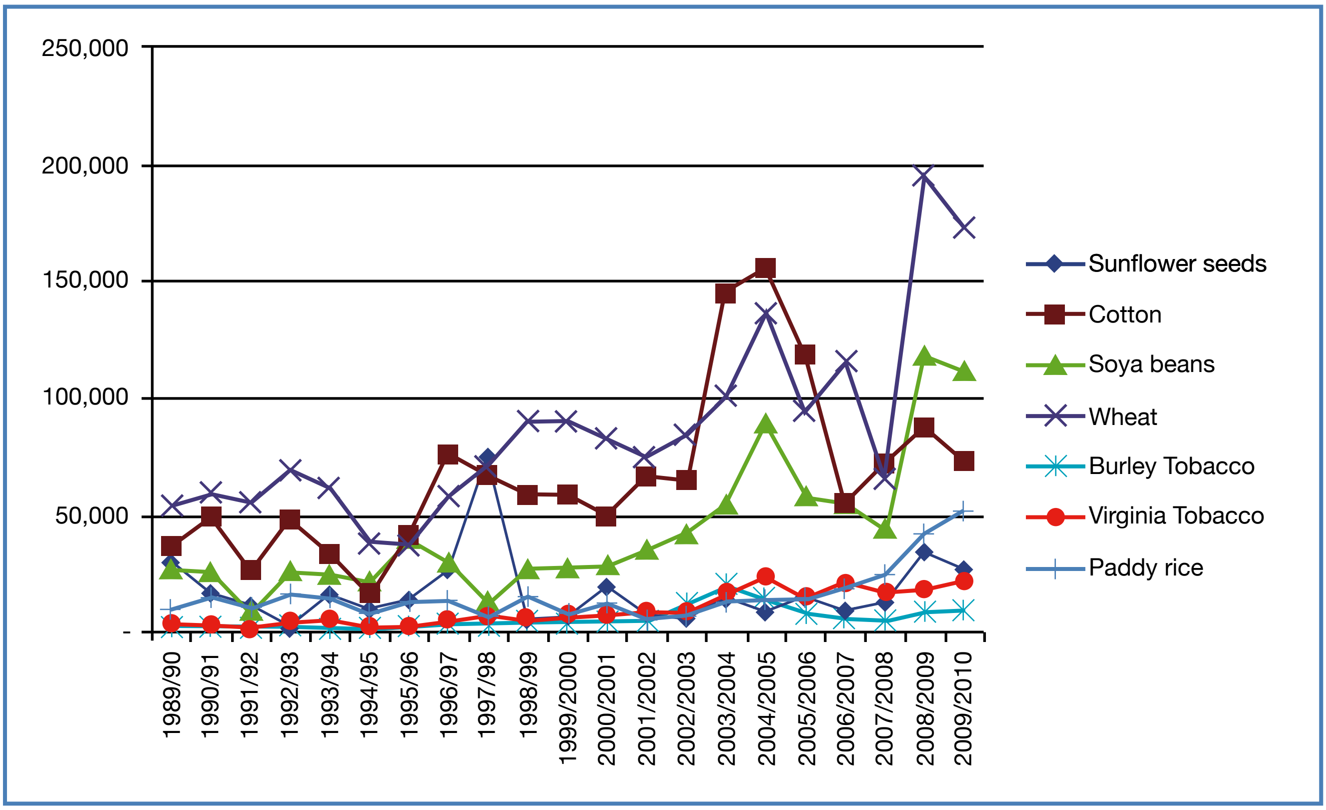
The 1982, 1983 and 1984 drought was documented to have resulted in drops in production of maize (52%, 40% and 29%), sunflower (57%, 37% and 40%) and groundnuts (50%, 29% and 26%) respectively in Chisekese, Mazabuka District[34].

5.8. Food access: having sufficient resources to obtain appropriate foods for a nutritious diet

The production of cash crops as illustrated in Figure 8 also shows similar trends to that of the food crops above. The decrease in production levels, coupled to uncertain market availability and prices, leads to reduced income for use in accessing goods and other services. The respondents in Shangombo, Sinazongwe and Mpika testified to this also citing the damage to road and bridge infrastructure by floods as causing challenges in accessing markets and inputs. In Shangombo the state of the roads are very bad that water transport is sometimes the preferred means of transport despite it being more costly than road transportation. This discourages private buyers and the ones that turn up offer low prices.

The above has mainly concentrated on the effects of climate change on the farming population. However, reduced agricultural production usually also leads to increased food prices for both the urban and rural populations. In fact, using the Jesuit Centre for Theological Reflection data, it was found that availability of food in rural areas has a direct impact on affordability of food in urban areas[35].

Figure 8: Production in tonnes of selected cash crops 1989/90 - 2007/2008.



Source: Derived from CSO crop forecasting (2005 – 2010) and post harvest (1989 – 2005) data

5.9. Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation.

The use of available food is addressed here in the light of how it translates into childhood and adult nutrition status.

34 FK Michelo, 1985, Impact of Drought on Agricultural Production in Chisekesi Area Mazabuka District Unpublished Undergraduate Dissertation in Henry Sichingabula.

35 Miniva Chibuye, Understanding Seasonality on the Quality of Life Through the Innovative JCTR Rural Basket. http://event.future-agricultures.org/index.php?option=com_docman&task=doc_details&gid=89&Itemid=44.

5.9.1 Food eating habits

Examples of some of the documented eating habits in Zambia were captured in The Common Zambian Foodstuffs Ethnicity, Preparation and Nutrient Composition of Selected Foods Report[36]. These examples illustrate how available food is utilised by people of various ethnicities.

Generally, the same range of staples (maize, sorghum, millet and cassava), with some variations in terms of preference and alternatives among ethnic groups, are processed into flour for the making of nshima (a thick porridge eaten with relish). Nshima is the main energy supplier in the Zambian diet. Most ethnic groups consume their nshima mainly with cultivated food legumes and vegetables and wild vegetables.

The levels of protein of animal origin are generally low in the diet of most Zambian people. With the exception of the cattle rearing communities of Western, Southern and Central Provinces where cattle are a symbol of wealth, and where milk is a part of the diet; and the fishing communities along major rivers such as the Zambezi, the Kafue and on lake shores such as Lake Kariba, Mweru and Tanganyika shores.

Wild vegetables and fruits are normally collected by children, where they are available but because of economic gain near urban areas, many women spend long hours gathering mushrooms for market. In farming communities, mushroom gathering tends to compete with weeding.

The number of meals consumed in a day and foods eaten varies from one ethnic group to another. The Lozi, Mbunda, Kaonde and Lunda ethnic groups consume three meals a day, i.e. breakfast, lunch and supper. The Bemba speaking people usually only have breakfast in the morning and a late afternoon main meal ''because the women are too busy during the day to prepare meals". For the Bemba there is no difference between foods eaten at different times of the day. Any type of food can be eaten at any time, if available. The Tonga and Goba speaking people of Siavonga may have breakfast, but usually have one main meal in the late afternoon or early evening. Snacks and beverages if available, are consumed at unspecified times during the day or where distinct breakfast and lunch are not taken.

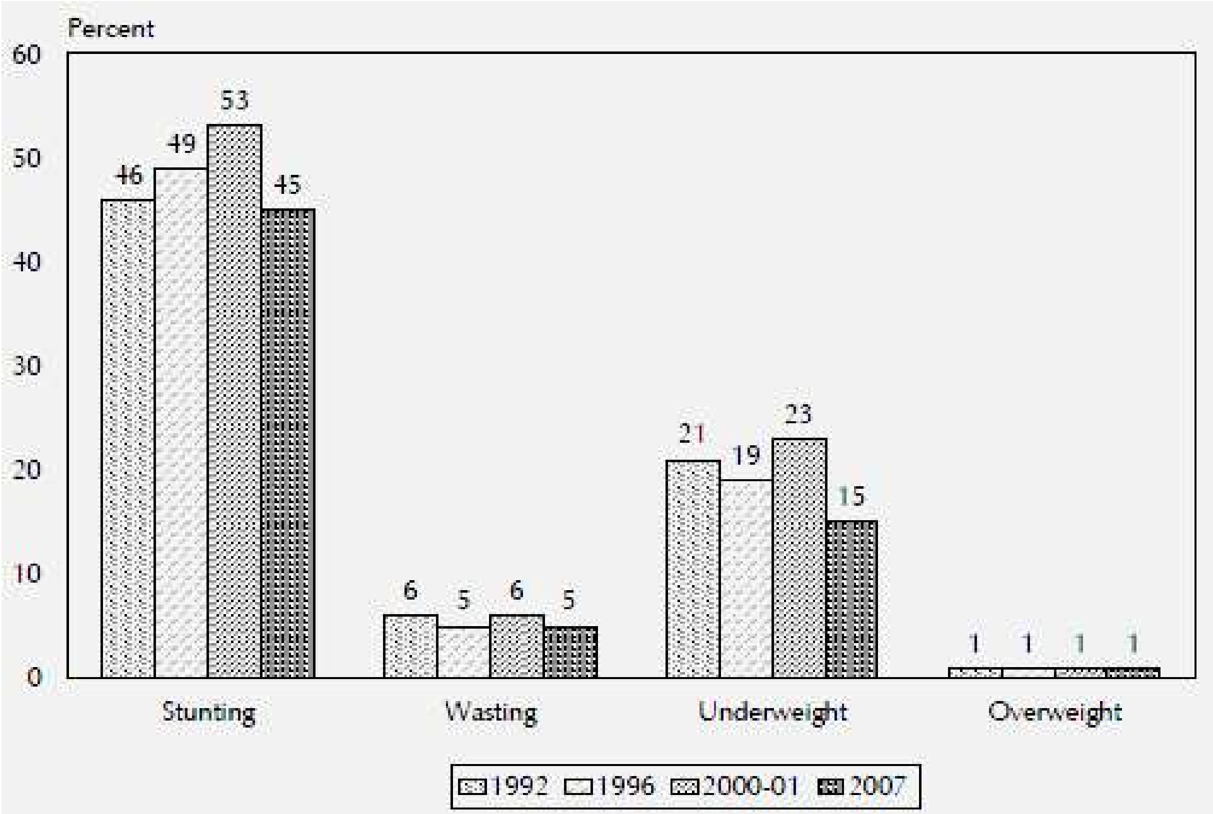
5.9.2 Child nutrition status

The figure below shows the rates of stunting, wasting, underweight and overweight for the periods 1992, 1996, 2000/2001 and 2007. The levels of stunting (measure of h*eight-for-age)* shown in the figure are very high. In 2007, more rural children were stunted (48 percent) than urban children (39 percent). Provincial variations in nutritional status of children was substantial, with stunting being highest in Luapula Province (56 percent) and lowest in Western and Southern provinces (36 percent each). This was an interesting finding considering that these latter two provinces lie within the climate sensitive Regions I and IIa. However, the food eating habits illustrated in 5.9.1, i.e. more protein in the diet of cattle rearing populations in Southern and Western Provinces may contribute to the lower stunting therein.

The Zambia Demographic and Health Survey (ZDHS) 2007 indicated that the introduction of weaning foods to children aged 9-11 months may increase exposure to infections. This increased exposure to infections, coupled to inappropriate and/or inadequate feeding practices, may contribute to faltering nutritional status among children in this age group. This was observed to contribute to the doubling of the children underweight from 7 percent among children under age 6 months to 15 percent among children age 9-11 months.

36 Drinah Banda Nyirenda, Ph.D., Martha Musukwa, MSc. Raider Habulembe Mugode, BSc., 2007, The Common Zambian Foodstuffs Ethnicity, Preparation and Nutrient Composition of Selected Food Report.

Figure 9: Trends in Nutritional Status of children under Five Years



Source: Zambia Demographic and Health Survey 2007

5.9.3. Adult nutrition status

The adult nutrition status is addressed here from the female perspective as presented in the ZDHS. The ZDHS 2007 found that more than seven in ten women (71 percent) have a normal Body Mass Index (BMI), one in ten women are undernourished or thin, and about one in five (19 percent) are overweight or obese. The BMI, or the Quetelet index, is used to measure thinness and obesity. BMI is defined as weight in kilograms divided by height in metres squared (kg/m2). A cut-off point of 18.5 is used to define thinness or acute undernutrition and a BMI of 25.0 or above usually indicates overweight or obesity. The height of a woman is associated with past socio-economic status and nutrition during childhood and adolescence.

Women in rural areas (11 percent) are more likely to be underweight than those in urban areas (8 percent), while women in the North-Western and in Western Provinces are more likely to be underweight than those in other provinces (14 percent each), and women in Copperbelt and Eastern provinces are least likely to be underweight (7 percent each). Women with no education are more likely to be undernourished (12 percent) than those with more than secondary education (6 percent).

5.9.4. Adequate water

The definition of food security in section 2.2 included food use and particularly adequate water .The ZDHS 2007 concludes that the source of drinking water is an indicator of whether it is suitable for drinking. Only 41 percent of the households have access to improved sources of water. Households in urban areas are more likely to have access to improved sources of water than those in rural areas (83 percent compared with 19 percent). More than half of the households (56 percent) draw their water from an unimproved source. Almost half of the households in urban areas (49 percent) have water on their premises, while about one in every ten households (8 percent) in rural areas has water on their premises. Overall, 23 percent of the households take 30 or more minutes to obtain water; 8 percent in urban areas compared with 30 percent in the rural areas.

Table 8: Percentage distribution of households and de jure population by characteristics of source of drinking water and percentage using appropriate method to treat drinking water, according to residence, Zambia 2007

Characteristic	Households			Population		
	Urban	Rural	Total	Urban	Rural	Total
Source of drinking water						
Improved source	82.2	19.2	41.0	82.0	19.6	41.8
Piped water into dwelling/ yard/plot	39.7	1.4	14.7	42.5	1.3	16.0
Public tap/standpipe	36.9	1.9	14.0	33.8	1.8	13.2
Protected dug well	5.6	15.9	12.3	5.7	16.4	12.6
Non-improved source	13.7	78.0	55.8	14.0	77.7	55.0
Unprotected dug well	12.6	46.8	35.0	13.1	46.9	34.9
Tanker truck/cart with small tank	0.00	0.00	0.00	0.00	0.00	0.00
Surface water	1.1	31.1	20.7	1.0	30.7	20.1
Bottled water, improved source for cooking/washing	0.3	0.0	0.1	0.2	0.0	0.1
Other	3.8	2.8	3.2	3.8	2.8	3.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: ZDHS 2007

The source of adequate, clean and safe water is affected by climate change related drought or floods. This affects the welfare of the people, especially the women, who have multiple roles that include water gathering, food production and preparation of the meals. Women have to walk further when water sources dry out during the drought seasons. They also have the burden of caring for people who fall sick from water borne diseases. All the above negatively affect the women's burden in ensuring that adequate food is placed on the table and that the food nutrition is not negated by sickness. Poor nutrition further affects the outputs of labour for food production and income generation.

5.9.5. Adequate sanitation

As mentioned above, the definition of food use in section 2.2 includes adequate sanitation. Almost four in ten households in Zambia (39 percent) use pit latrines that are open or have no slab: 27 percent in urban areas and 45 percent in rural areas. Flush toilets are mainly found in urban areas and are used by 26 percent of households, compared with 1 percent in rural areas. Overall, 25 percent of households in Zambia have no toilet facilities. This problem is more common in rural areas (37 percent) than in urban areas (2 percent).

The quality of sanitation affects people when climate related floods occur. In areas that have pit latrines the flood waters flush out the waste from the latrines and contaminates drinking, cooking and washing/bathing water sources. This contributes to the incidence of water borne diseases that limits people's uptake of nutrition from the food they consume. Poor nutrition in turn affects the labour availability for on farm and off farm work, negatively affecting farm food production. This does not bode well for household food security.

6 | Sustainable agricultural systems (conservation and organic farming), a remedy for negative effects of climate change on food security?

6.1. This section will try to ascertain to what extent sustainable agricultural systems can be used to curb the effects of climate change on food security in Zambia.

6.2. Definition of Sustainable agricultural systems

The Swedish Cooperative Centre[37] defines sustainable agriculture as "a way of farming that is environmentally friendly, economically viable and socially just".

1. Environmentally friendly is defined to mean that the quality of natural resources is maintained;
2. Economically viable is defined to mean that the farmers can produce enough for self-sufficiency; and
3. Socially just is defined to mean that it is an equitable system for all people including those yet to be born.

It has been recommended that the definition of 'economically viable' should include adequate income generation not just self-sufficiency as people engaged in agriculture have needs other than foods. These needs have to be paid or bartered for if they are to be fulfilled.

The above definition of sustainable agriculture is similar to the Food and Agriculture Organisation definition of conservation agriculture as "a way of farming that conserves, improves and makes more efficient use of natural resources through integrated management of the available resources combined with external inputs"[38].

6.3. Principles of conservation agriculture

The following are the major principles of conservation agriculture;

1. Minimum soil disturbance;
2. Maintaining soil cover by mulching, cover crops, intercropping and minimal burning of crop residues; and
3. Mixing and rotating crops, especially with legumes.

The adoption of the above principles is best implemented by changed agricultural farm management practices that include the following;

1. Timely implementation;
2. Precise operations; and
3. Efficient use of inputs.

6.4. Significance of each conservation agriculture principle

6.4.1. Minimum soil disturbance

Sustainable and organic agricultural systems can help reduce agricultural green house gases (GHG) emissions through energy conservation, lower levels of carbon-based inputs, lower use of synthetic fertilizer and other features that minimize GHG emissions and sequester carbon in the soil[39].

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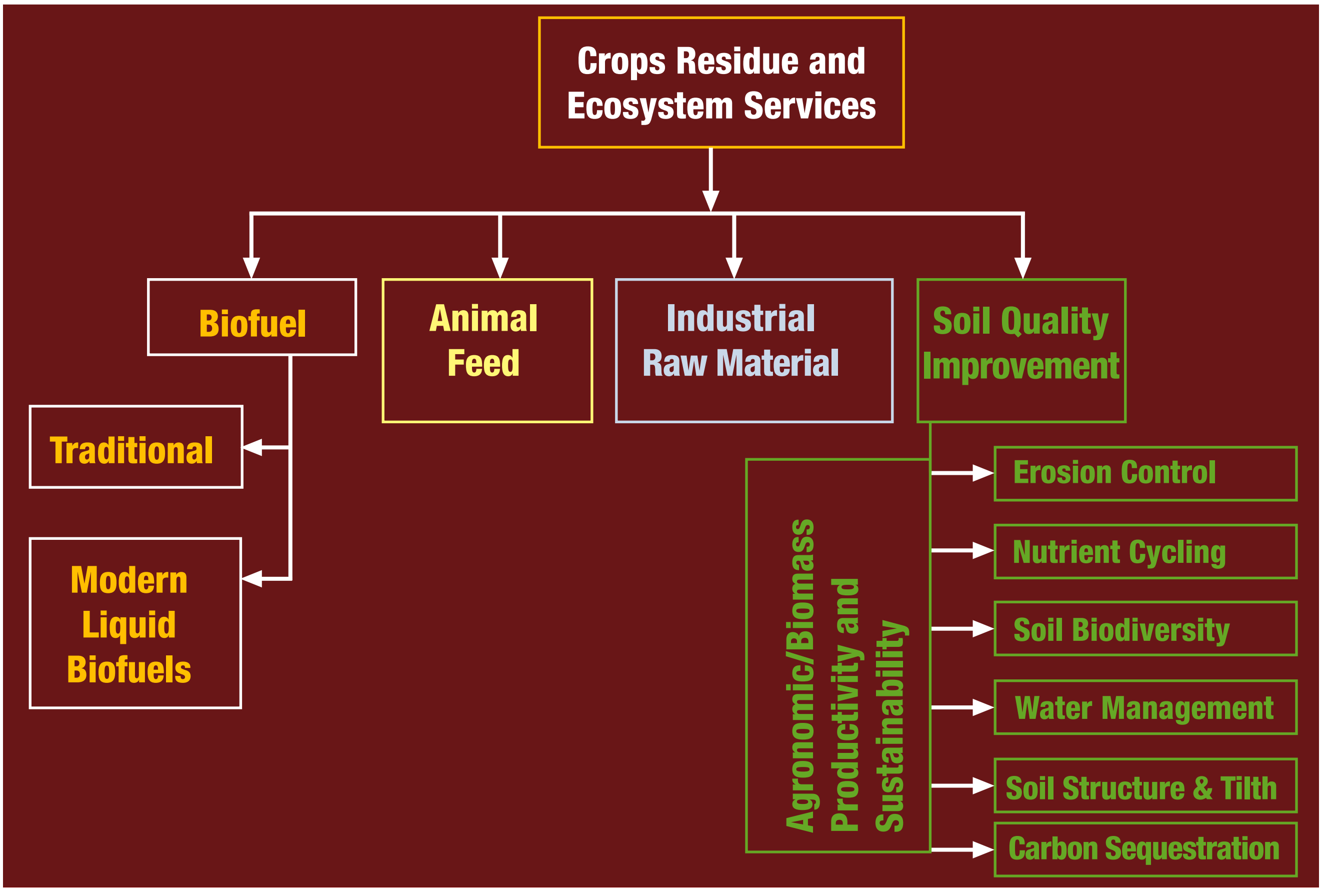
37 Swedish Cooperative Centre, Sustainable Agriculture Study Circle Material, Second Edition, 2007
38 Golden Valley Agricultural Research Trust, 2009 Year Book.
39 National Sustainable Agriculture Coalition, 2009, Agriculture and Climate Change: Impact and Opportunities ant the farm level, A Policy Position Paper.

The use of potholing and basins in conservation agriculture also helps to harvest rain water especially in times when the rains are below normal levels. Caution was raised by farmers that these may be actually retaining too much water during seasons when the rains are adequate or above normal. The minimum soil disturbance also ensures a more productive utilisation of labour where it is used to turn over only the soil where seeds shall be sown.

6.4.2. Mulching and minimal burning of crop residues

The amount of organic matter, mostly carbon, in soil is a key driver of soil quality, including higher fertility, better ability to hold water and more resistance to wind erosion. By increasing the organic carbon content of soils through organic and sustainable practices, farmers can make their operations more resilient in the face of climate change and in many cropping systems will also have a net reduction in GHG emissions40. The keeping of mulch and crop residues is also a good way of recycling some of the nutrients that plants take out of the soil back into it. Figure 10 below shows the competing uses that crop residues can be put to.

Figure 10: Crop residues have competing uses.



Source: Rattan Lal, Crop Residues and Soil Carbon, Carbon Management and Sequestration Center the Ohio State University, Columbus

For farmers in all the districts, further education on soil quality improvement is still relevant even though some of them have already been sensitized on conservation farming. The use of stover, i.e. crop residues, as supplementary livestock feed is ever more relevant for the Shangombo and Sinazongwe District farmers that have a lot of cattle and suffer droughts that reduce available pasture.

6.4.3. Mixing and rotating crops, especially with legumes.

The mixing and rotating of crops especially with legumes is significant for communities with low income generation. They can thus produce some of their own balanced diet and take advantage of the varying seasonal changes in rainfall. Failure of one crop may be compensated by success of another crop. The rotation will thus not only improve available food nutrition but enhance soil quality. The responses in Shangombo and Sinazongwe Districts

40 National Sustainable Agriculture Coalition, 2009, Agriculture and Climate Change: Impact and Opportunities ant the farm level, A Policy Position Paper.

that besides sorghum and millet, cowpeas are included in the conservation agricultural practices show a practical recognition of the need for including legumes in the cropping cycle.

6.5. Resources available at the Districts for sustainable agricultural practice

Some of the common resources the communities that were visited had are in the table below. These resources are assets that can be tapped into to introduce or deepen the practice of sustainable farming.

Table 9: Available community level assets

Asset	Contribution
Labour	The labour that is currently underutilised in the cool and dry seasons (June through September) can be used for land preparation in digging potholes, basins and ridging
Livestock (Cattle and goats)	Manure, alternative income sources, draft power
Good soils in the Zambezi basin and Lake Kariba shores	Reduced external input requirements, pasture and water
Drought resistant crops	Sorghum, millet and cowpeas have been introduced and their adaptation potential tried by some of the farmers. This provides some examples of farm level experiences.
Water	Garden irrigation using shallow wells, furrows and boreholes
Plentiful fish	Alternative livelihoods and income for agricultural inputs purchase
Education in conservation agriculture	This is a base upon which to deepen the dialogue and demonstrations with farmers on the value of conservation agriculture.
Forests	Catch fires easily during droughts and flood during excess rains reducing their utilisation
Ploughs, hoes and axes	The experience in utilising these tools makes transition to ridges and chaka hoes easier.

However, in many cases the floods have damaged the road infrastructure making it difficult to move inputs to farmers and their produce out to markets.

6.6. Agroforestry component of conservation agriculture

In addition to the principles of conservation agriculture mentioned above, agriculture of the future must meet the triple challenge of: raising food production per unit area; reducing the vulnerability of agricultural systems to climate change; and reducing greenhouse gas emissions from agriculture. Agriculture with trees is ideally placed to tackle all three challenges[41]. This brings the additional mechanism of utilising trees in contributing to improved agricultural production and mitigating the impacts of climate change. Trees can assist in the following three ways;

i. Trees on farms sequester carbon and contribute to mitigating climate change
ii. Trees on farms enhance resilience to climate variability and
iii. Tree-based agricultural systems improve food security and livelihoods[42].

The World Agroforestry Centre uses Faidherbia Albida as an example of a tree that can be incorporated into the agricultural practises. This tree is special because of its 'reversed leaf phenology' meaning it is dormant and sheds its leaves during the early rainy season and its leaves only grow when the dry season begins. This feature makes it compatible with food crops because it does not compete with them for light, nutrients and water.

The Conservation Farming Unit (CFU) reports that 60 years of research shows on each hectare, mature trees supply the equivalent of 300kg of complete fertiliser and 250kg of lime[42]. The nutritive leaves can be used as fodder or as mulch.

41 World Agroforestry Centre, 2009, Policy Brief, Trees on farms: Tackling the triple challenge of mitigation, adaptation and food security.
42 Ibid
43 CFU Zambia Conservation Agriculture Programme (CAP) –a brief update

The value of the incorporation of agroforestry into agricultural practice was recognised as a greenhouse mitigation strategy under the Kyoto Protocol that is a strategy for biological carbon sequestration[44]. The forest based systems can have the largest known potential to mitigate climate change through conservation of existing carbon systems, expansion of carbon sinks.

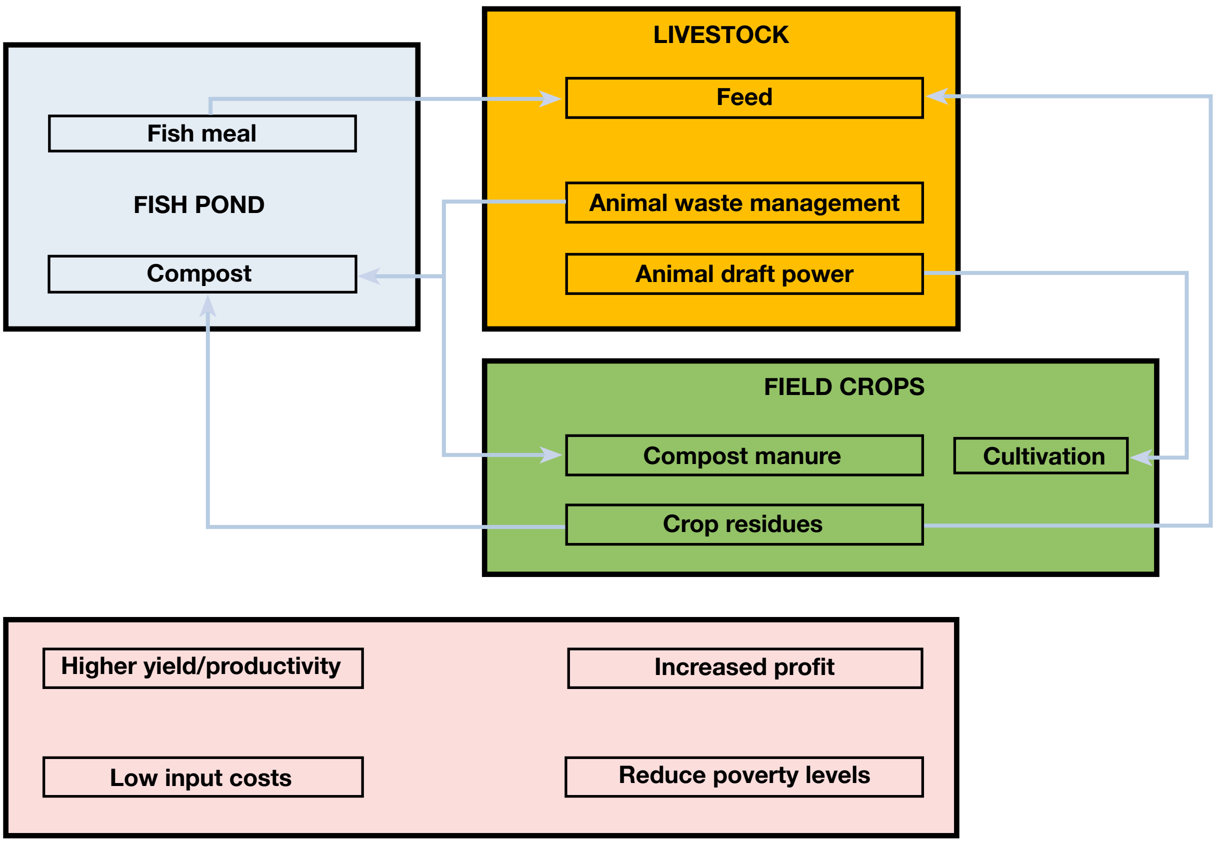
In Zambia, the value of agroforestry can be contrasted to existing slash and burn agricultural practices that consume the forest for agricultural use rather than expand the forest. These systems are not sustainable as the soils lose their fertility quickly and new fields have to be opened up every few years. Introducing agroforestry, as has already been done, can mitigate carbon dioxide release through using tree foliage and increase the size of the carbon sink that can be traded on. Agroforestry further offers a mechanism for measuring the new carbon sinks that are created at farm level.

6.7. Livestock integration to conservation agriculture

In support of sustainable agriculture the Participatory Village Development in Isolated Areas (PaViDia) advocates for integrated farming approach that helps to reduce cash demand for external input utilisation and recycle some of the outputs of each agricultural enterprise into that of another within the same farm enterprise. This concept is illustrated in the figure below. This uses the principle of zero entropy wherein waste is reduced at all levels of the agricultural production.

The integration of livestock into the farm enterprise assists in adapting to climate change as the household has more control on the livestock enterprise. Livestock can be moved to areas that are relatively less affected by climate change or their husbandry micro-environment can be managed, e.g. shelters can be built, water and feed made available. The abundance of small and large livestock ownership in Shangombo can be taken advantage of. The introduction of fish farming in Mpika District may benefit from the integrated fish farming approach.

Figure 11: A form of integrated farming approach



Source: MACO/JICA, PaViDia Field Manual Vol. 3: Sustainable Agriculture Practices

44 Stephen Syampungani et al, 2010, The Potential of Using Agroforestry as a Win-Win Solution to Climate Change. Mitigation, Adaptation and Meeting Food Security Challenges in Southern Africa

6.8. *Expected effects of conservation agriculture*

The fundamental outcome of conservation agriculture is improved yields. Haggblade and Tembo 2003[45] observed that though gains vary across locations and over time, evidence from central Zambia suggests that about 25% of observed gains under conservation farming (CF) stem from higher input use, another 25% from early planting, and about 50% of the yield difference stems from CF cultural practices themselves – the retention of crop residue, the build-up of soil organic material and concentration of nutrients in the basins, and the water harvesting effects of the basins during the sporadic rainfall common in the semi-arid zones of Africa. Early planting also benefits the crop's productivity as it can benefit from the nitrogen flush that occurs with the first rains.

The table below shows some of the expected results of conservation agriculture and their significance. Some of the conservation agriculture practices contribute to redistributing the utilization of labour and reducing the duration of the peak hunger period depicted in Figure 6 above.

Table 10: Expected results and significance of adopting sustainable farming practices

Result[46]	Significance
Protect the soil from the damaging effects of rain splash through maintenance of crop residue or crop cover over the soil	This ought to keep soil erosion in check
Reduce run off and keep more of the rain on the fields, i.e. rain harvesting	This will improve water utilization especially at the critical time of the January-February agricultural drought period This should also reduce siltation of water bodies reducing damage to fisheries
Make the best use of costly fertiliser and seeds	This will optimize returns to agricultural technological packages
Allow farmers to finish land preparation well before the onset of rains so they are ready in good time	The teaching of farmers of good agricultural practices and their adoption should improve yields. This can be used as a bridge for teaching broader farm and off-farm activity management
Increase yields	This will improve food security, increase surplus for income generation and improve returns to inputs
Reduce costs of inputs	This will release some of the funds currently spent on inputs for other use including increased input purchase or switch to other inputs
Smooth out labour demand and utilisation over a wider period	This will ensure that adequate time is set aside for each productive activity.
Better soil structure and nutrient levels	This should keep the field productive over longer period of time and contribute to reducing amount of purchased input required

For the 2009/2010 agriculture season, the Food Security Research Project found that conservation farming can be highly effective with a yield response to fertilizer which is two times greater using planting basins[47]. Despite this, it concluded that there is currently not enough adoption to affect national production as Crop Forecasting Survey data was not designed to sufficiently analyze the contribution of conservation farming on maize production growth at national level. Initial estimates indicate minimal contribution of Conservation Farming to the growth in national production.

45 From Steven Haggblade and Christina Plerhoples, 2010, Productivity Impact Of Conservation Farming On Smallholder Cotton Farmers In Zambia, *Working Paper No. 47, Food Security Research Project*

46 CFU Conservation Farming and Conservation Agriculture Handbook for HOE Farmers in Agro-Ecological Regions 1&IIa – Flat Culture 2009 Edition

47 FSRP/ACF and MACO/Policy and Planning Department, Analysis of the 2009/10 Maize Production Estimate from the Crop Forecast Survey, Presentation at Mulungushi, House, Lusaka28 June 2010.

6.9. Illustration of the advantages of sustainable agriculture

The illustration below of the advantages of sustainable farming augment those already mentioned in section 6.5 above. The contribution of sustainable farming practices to the results in Table 10 above may be illustrated in yields using Dr. Haggblade's identification of the sources of higher yields when comparing conventional plowing to conservation farming basins. The illustration below shows that farming applying sustainable farming principles and practices can contribute to increased yield, as demonstrated for cotton and maize. The information data in Table 11, below, addresses labour based conservation based practices.

Table 11: Sources of higher yields conventional plowing versus conservation faming

	Yield (kg/ha)	
	Cotton	**Maize**
Conventional plowing	820	1,320
Conservation farming basins	1,280	3,000
Sources of difference		
higher input use	90	500
early planting	40	400
water harvesting in basins	330	750
total difference	460	1,650

Source: Stephen Haggblade, 2009, Lessons learned from Zambian Experience with Conservation Farming

The use of mechanized implements like ox drawn rippers not only allows farmers increased yields when they apply conservation farming, as explained above, but also broadens their income generation options. Table 12, below, explains the incremental benefits of farmers graduating from using ploughs to rippers. Given that more commercialized farmers are usually more food secure, it would be a policy imperative to facilitate the graduation of hand hoe based farmers to more mechanized equipment. For communities with a long cattle rearing tradition as in Western and Southern Provinces, the introduction of conservation mechanized tillage equipment would leverage the outputs of the subsidized inputs under the Farmer Input Support Programme (FISP) that are provided to many farmers every year.

Table 12: Ripping versus ploughing – Summary of benefits

Ripping	
Time taken to rip 1 hectare	4.5 hours
Hire ripping window	May to November – 7 months
Hire charge per hectare	K100,000
Hire charge per hour	K22,200
Potential customers per season	40 or more hectares
Potential income for season	K4,000,000 or more
Ploughing	
Time taken to plough 1 hectare	14 hours
Hire plough window	Dec 1st to Dec 20 – 3 weeks
Hire charge per hectare	K 275,000
Hire charge per hour	K19,640
Potential customers per season	4 or more hectares
Potential income for season	K1,100,000

Source: CFU, 2005, Why small-scale Maize and Cotton yields in Zambia are so low

7 | Identification of any anticipated positive effects on food security as a result of climate change in Zambia.

7.1. Reinforcing importance of promoting livelihoods suitable to agro-ecological zones

The table below was generated using the NAPA agro-ecological region and suitability map (appearing as Figure 2 in this document). This table highlights that agro-ecological Region IIa and III are best suited for the production of the twenty products contained in the figure. As such, there is need to enhance their production in these areas and also to identify and support those activities that are best suited to the other regions. Each region's comparative advantage can be tapped into for the benefit of the smallholder farmers and the nation. This process had been pushed intensely through regional based Adaptive Research Planning Teams in MACO and can be revisited over a wider economic spectrum.

Table 13: Percentage of crops rated as suitable for production in each agro-ecological zone

Suitability	Region I	Region II a	Region II b	Region III
1 – Suitable	30	85	5	70
2 - Moderately suitable	10	15	0	30
3 - Marginally suitable	60	0	95	0

Source: Adapted from the NAPA Fig. 1.1 Agro-Ecological Map and Crop Suitability Rating for Zambia

7.2. Livelihood diversification

Climate change effects further reinforce the need to support the review of the classification of the agro-ecological regions in Zambia and their associated crop production suitability. This should inform the re-alignment of the research, extension and input supply services to crops according to the current environmental conditions.

7.3. Farming as a business

Climate change is challenging the farming community to rethink its approach to how it manages its crop and livestock decisions for improved productivity and profit. It has also led to economic decision making by some farmers to migrate from their traditional homes to set-up homes where the climate is conducive for farming. Some Tonga farmers whose farming communities in Southern Province have been heavily affected by changes in rainfall patterns have moved north to areas with better rainfall.

7.4. Crop diversification

The changes in climate highlight the need for the farming community to include other crops that respond better to the new environmental conditions. This also includes the adoption of crops that broaden the nutritional value the diets.

7.5. Increasing returns to agricultural inputs

Coupled to the need to link production to agro-ecological regions, a greater emphasis has been realised to increase the returns of all inputs used in agricultural production. This basically requires an increase in yields achieved by most of the smallholder farmers. The table below provides a basis for comparing the highest yields obtained for specified crops in the last twenty years and the potential yield that can be achieved when the crops are produced under the better management regimes within good climatic conditions. This highlights the losses in agricultural produce that current agricultural practice results in. The highest recorded yields reflected in the table are for conventional agriculture.

Table 14: Yield potential for selected crops

Crop/Yields	Highest recorded National Average Yield last 20 years Tonnes per Ha*.	Potential Yield Tonnes per Ha.
Maize	2.25	3 – 10
Groundnuts	0.8	0.8 – 3.0
Sunflower seeds	4.7	1-2
Cotton	1.6	
Soya beans	2.4	
Wheat	7.4	
Burley Tobacco	3.2	
Virginia Tobacco	2.9	
Paddy rice	1.9	
Sorghum	2.81	4.5 – 8
Millet	0.85	1.9 - 3.3
Mixed beans	0.77	
Sweet potatoes	3.57	18
Cassava		22-31
Irish potatoes	16.10	
Bambarra nuts	1.1	
Cow peas	0.42	0.2 - 0.6
Paprika	2.3	3.5 – 4.0
Castor beans	1.0	
Pineapple	-	
Velvet Beans	0.3	
Cashew nuts	0.1	

Source:* Derived from CSO crop forecasting (2005 – 2010) and post harvest (1989 – 2005) data

Applying the above requirement for increasing the efficiency of inputs utilisation in agriculture, the following scenario can be envisioned; the "bumper harvest" of maize for 2009/2010 was 2,795,483 metric tonnes when national yields were estimated at 2.25 tonnes per hectare. However, if the yield were raised to a minimum of at least 5.13 tonnes per hectare, as obtained by commercial farmers in 2010, for each of the Farmer Input Support Programme recipients using existing technology and even less inputs, production would have easily been 5,402,792 metric tonnes. Within this scenario the farmers are basically harnessing only 52 percent of the maize technology's potential.

Given the above, farmers need to learn to relate different crop yields to different levels of management allowing themselves to move from one level of farming to another[48].

The discussion on increased returns to agricultural inputs can be informed by the following information captured in one of Mr. Gear M. Kajoba's papers[49]. The information was on the dispute in the colonial Department of Agriculture between those who wanted to promote agricultural development in the country by building on indigenous agricultural methods and their features and to select from numerous varieties of sorghum, millet and roots in use and a Mr. Geofrey Clay (Colonial Office Agricultural Advisor) to Northern Rhodesia in 1945 who promoted peasant authorization of hybrid maize along the line of rail to feed the growing urban population. This concentration on maize has continued ever since.

48 Ibid, Dr. Fereidoon et al.
49 Gear M. Kajoba, Coping with Drought Through Sustainable Agricultural Development in Zambia, Annex D7 IUCN Summary proceedings of the IUCN Drought Study Follow-up Workshop on the Environmental Impact of the 1991-1992 drought in Zambia.

The above concentration on maize has seemingly led to less priority being paid to other crops in terms of research, support for their production and marketing and study of their contribution to people's nutrition. The table below showing the potential and actual yields achieved by farmers seems to confirm this assertion.

7.6. Use of conservation farming techniques to the extent possible

This is addressed in greater detail in the following chapter.

7.7. Improved environment for aquaculture

The projected climate change will generally be positive for aquaculture, which is often cited by cold weather[50]. Since many of the changes will entail warmer nights and winters, there should be longer periods of growth and growth should be enhanced. The cost of making structures ice-resistant and of heating water to optimum temperatures should also be lowered. By developing appropriate technologies, farmers can use flooded and saline areas no longer suitable for crops to cultivate fish. Farmers can also recycle water used for fish culture to moderate swings between drought and flood.

7.8. Rethinking of dates and duration of traditional ceremonies

Most traditional ceremonies are built around the celebration of the first harvest. Due to the changes in climate, e.g., the changes in the length of the growing season can affect the date of the main harvest. The climate risks that affect the communities may force them into different crop production cycles that incorporate crops that have not been widely grown for some time. This change in crops and cropping cycles may require changes in people's eating habits. The traditional ceremonies should, therefore, be used to inform people about climate change, how it affects their food security and the hosting of these ceremonies. The learning during these ceremonies can include climate change adaptation and mitigation.

50 IFAD, Tools for project design, Livestock and climate change, Livestock Thematic Papers

8 | Identification and documentation of other responses to climate change

There are a number of climate change responses being implemented in Zambia. Some of these responses address sustainable agriculture whilst others address different issues. Some of the responses may not have been adopted as climate change responses but their application is found to address climate change.

8.1. Sustainable farming oriented responses to climate change

8.1.1. Government's adoption of conservation agriculture

In 1999 the Government endorsed conservation farming as part of the national extension system. Government is planning that at least 600,000 farmers should be practicing conservation agriculture by 2015. MACO is the focal point for the National CA taskforce and it was officially launched in May 2008.

8.1.2. Conservation Agriculture Programme

The Conservation Farming Unit (CFU) was established in 1995 to develop and promote conservation farming and conservation agriculture practices by Zambia smallscale agricultural farmers. The CFU was established in response to the realization that, even in years of reasonable rainfall, the majority of smallscale farmers are unable to produce adequate food to feed themselves and their families until the next harvest.

With support from NORAD, the Zambia National Farmers Union through the CFU is implementing the Conservation Agriculture Programme (CAP). Its goal is the adoption of CA by 350,000 small and medium-scale farmers by 2015. CFU implements the CAP through its own extension system, separate from the Government one. CAP had reached atleast 164,000 beneficiaries by February 2011[51].

8.1.3. Farmer Input Support Response Initiative (FISRI)

The EU Food Facility supported project: Farmer Input Support Response Initiative (FISRI) to Rising Prices of Agricultural Commodities in Zambia (GCP/ ZAM/066/EC) has the overall objective to increase food production through improved access to agricultural inputs and promotion of conservation agriculture (CA) principles among small scale farmers (SSFs) in selected districts of the Central, Lusaka, Western, Southern and Eastern Provinces, in order to mitigate the effects of soaring food prices. The FISRI project, which has a budget of USD 10,364,151 million is being implemented during the period May 2009 till June 2011.

The project targeted 3,920 small-scale farmers to be trained as lead farmers and 400 camp extension workers. Each of the 3,920 lead farmers was supposed to train 15 other participating farmers, bringing the total number of beneficiary farmers to 58,800.

In the first year, the project was initially implemented in the following districts: Chipata, Katete and Petauke in Eastern Province; Kapiri-Mposhi and Mumbwa in Central Province; Mazabuka, Monze, Choma and Kalomo in Southern Province; Kaoma in Western province and Chongwe in Lusaka Province. Following a request from the Government, the project was revised to include: Mansa, Mwense, Kawambwa, Chiengi and Samfya in Luapula Province; Mpongwe in the Copperbelt Province and Sesheke in Western Province; Lundazi, Nyimba and Chadiza in Eastern Province; Isoka in Northern Province; and Kazungula and Sinazongwe in the Southern Province.

8.1.4. Conservation Agriculture Scaling Up for increased Productivity and Production (CASPP)

The outcome of Conservation Agriculture Scaling Up for increased Productivity and Production (CASPP) is to increase the capacity of MACO and Own Farmer Facilitators to provide future extension support to CA beneficiaries in the country. Tentatively the programme will focus on the following district; Chipata, Katete, Petauke, Chongwe, Chibombo, Kapiri, Mumbwa, Mazabuka, Monze, Choma and Kalomo. The programme is implemented in MACO camps not covered by the CFU CAP programme, but in the same districts (to be decided through a joint selection process).

51 Collins Nkatiko, 2011, Conservation Agriculture Training: Experiences from the CFU in Zambia, A Paper presented at the Regional Conservation Agriculture Symposium, Held At The Emperors Hotel, Johannesburg, South Africa 8th- 10th February, 2011.

The input supplied throughout the programme will as far possible be based on local purchase through agro-dealers based on competitive pricing. This will ensure availability of inputs after the programme period through local agro-dealers and community agro-agents.

8.1.5. Adaptation to the effects of drought and climate change in agro-ecological regions I and II

This programme is being implemented during the period 2010 – 2013 by MACO with support from UNDP. The programme has a budget of US$2,786,900. The project aims at reducing the vulnerability of communities to climate change impacts in agro-ecological regions I and II. Its approach is to mainstream adaptation into agricultural planning at national, district and community levels to make the case for investment in agricultural sector. Capacities and systems to anticipate, assess and prepare for climate change risks will be developed at national and sub-national levels down to the communities. Adaptation learning generated from the projects will be used to guide the mainstreaming of adaptation in national fiscal, regulatory and development policy to support adaptive practices on a wider scale.

8.2. Other responses to climate change

8.2.1. The carbon and climate change funds and facilities

Mitigation and adaptation finance facilities were documented in the World Bank/Government of the Republic of Zambia document on climate Change Finance, the Case of Zambia. These funds cover the various resources available for adaptation and mitigation activities.

8.2.2. Carbon credits

Financing for both adaptation and mitigation (the latter through the carbon market) is now being made available by industrialised countries to support climate change efforts in developing countries[52]. The Africa Carbon Credit Exchange (ACCE), based in Lusaka, is a leading African owned and managed marketplace uniquely designed to enable Africa's participation in the global carbon markets. It provides innovative services and solutions to unravel the complexities of carbon markets and addressing the prevailing barriers to their success in Africa[53]. ACCE is unlocking low-carbon Africa by creating a reliable, structured and transparent trading platform for buying and selling compliance and voluntary carbon credits created in Africa – and in doing so, driving environmentally sustainable economic growth on the continent. ACCE provides a one-stop shop for African offset projects to access the linkages, knowledge and technical expertise to bring clarity to the complex carbon markets and facilitate the project financing necessary to make low-carbon Africa a reality.

The location of the ACCE in Zambia, provides the country space to fully engage in the carbon market that may arise out of the carbon sequestration created through sustainable agricultural practices and agro-forestry related issues.

8.2.3. Carbon Tax

The carbon tax is charged on all motor vehicles in line with the capacity of their engines.

8.2.4. The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries

Zambia has accessed the UN REDD funds to a total of US$4.5 million for the country's national REDD+ strategy[54] The miombo eco-region may present opportunities for carbon sequestriation and facilitate the carbon trading. The standing trees that have been protected by communities over time should be given value. Agro-forestry in conservation agriculture can create easily recognizable stands of tress whose carbon sequestration value can be traded.

8.2.5. Revisiting the thinking on floods and droughts

Due to relatively high temperatures, the average annual potential evapo-transpiration in Zambia ranges from 1,394mm to 1,892mm while the country average is 1,574mm[55]. Potential evapo-transpiration is larger than precipitation in Zambia. This means that Zambia is in a hydrological condition of precipitation deficit that amounts from 100 mm to 1100mm per year. This situation has implications on water availability and management in Zambia, particularly in agro-ecological Regions I and II.

52 CAMCO, Report on the National Stakeholders Consultative Meeting for the Development of a comprehensive National Climate Change Response Strategy (NCCRS) National Workshop, Held at the Mulungushi International Conference Centre, Lusaka on 15th June 2010.
53 http://www.africacce.com/.
54 Samuli Leminen, UNDP Programme Officer, July 2010, Making REDD+ Work for Zambia, UN REDD Programme Newsletter.
55 NAPA

Given the above, there should be increased debate on the value of water and how it can be harnessed for agricultural and other uses. The regular thinking of floods always as problems should be refocused to see how the deluge of water they provide can be harnessed for various uses, especially in the dry season.

8.2.6. Improving efficient use of wood based energy efficiency

There has been intensification in the support to programmes that enhance the efficiency of wood fuel and charcoal. A number of companies have set up operations dealing in the manufacture and sale of wood efficient stoves. These reduce the amount of fuel used for cooking of meals, reducing fuel expenses and the labour demand for fire wood collection and charcoal making.

8.2.7. Changing from fossil fuels to cleaner fuels

Support to less polluting energy forms that support the Clean Development Mechanism like solar and small hydro power station to tap into Zambia's vast water resources.

8.2.8. Increasing the use of irrigation

The use of irrigation is being promoted for the whole country. Lower cost irrigation may be possible in Region III given the large amounts of available surface water. Regions I and II may require higher cost options where wells and boreholes have to be dug. Contradictions exist wherein regions I and II that have higher cost irrigation potential also have large markets closer to them. Region III has traditionally suffered from being far way from large markets.

8.2.9. Climate Change Facilitation Unit

One of the Government responses to the recognition of climate change was the establishment of the Climate Change Facilitation Unit (CCFU) in April 2009 by the Ministry of Tourism, Environment and Natural Resources, with support from the United Nations Development Programme (UNDP) and the Norwegian Government56. It is an extended arm of Government mandated to spearhead on-going activities on climate change in the country. Specifically, the CCFU is expected to facilitate the formulation of a National Climate Change Response Strategy. Other specific areas of work for the CCFU include awareness and advocacy, facilitating analytical works as well as strengthening Zambia's participation in international Conferences among others.

56 CCFU website.

9 Policy implications and conclusions

Climate change has been acknowledged as real in Zambia by both practitioners and the farming communities. The farming communities and rest of the population have experienced the full brunt of floods and droughts. The Government and its partners are now pro-actively undertaking measures to respond to climate change.

It is useful to note that Government has not only taken a policy decision to have conservation agriculture as part of its extension methodology but has embarked on programmes that support its adoption as mentioned in section 8.1. One window of opportunity for policy implementation would be to link this policy intent to the Farmer Input Support Programme wherein the beneficiaries should be required as a matter of participation to use conservation agriculture in using the inputs. In adopting this requirement, Government would as a necessity have to retool the entire extension service with the skills and competencies to teach farmers about conservation agriculture.

This report argues that sustainable agriculture can have positive influence on both people's adaptation to climate change and its mitigation. Furthermore, sustainable agriculture can also place people on better food security status if applied properly and consistently. In case of areas where there is resistance to adoption of sustainable agriculture, one strategy would be to introduce its farming practices mentioned in section 6.2, into their conventional agricultural practices. This strategy may be useful, especially, if applied to the beneficiaries of the Farmer Input Support Programme.

The use of sustainable agriculture as a strategy for climate change adaptation in areas like Shangombo, Sinazongwe and Mpika should recognize that even if the principles and practices are uniform, their application must be location specific. In areas of floods, the community has to find alternative land where they can practice any type of cropping be it conventional, organic farming or conservation agriculture. The discussion on sustainable agriculture should not take the tunnel vision of looking only at crops but also at other farm enterprises including livestock, fish farming and farm level value addition. Farm level value addition is not only mechanical processing but could be use of crop outputs as feed for livestock and fish. The CFU's Conservation Farming and Conservation Agriculture Handbooks already provide a wealth of information on how conservation agriculture can be applied in all the three agro-ecological regions of Zambia. Publications from other institutions, including the MACO/JICA PaViDia programme may also come in handy. What is evident from these documents, and others, is the consistent definition and application of concepts.

The availability of champions for sustainable agriculture including the Golden Valley Agricultural Research Trust (GART) and the Kasisi Agricultural Training Centre (KATC) should be leveraged. These champions not only advocate for sustainable agriculture but also provide training services. It would also be useful for the public and private colleges of agriculture, livestock and fisheries to also strengthen sustainable agriculture, climate change, adaptation and mitigation in their curricula.

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Zambia Meteorological Department Climatological Network Map

Annex 1: List of people met in Lusaka

Name	Position	Institution	Contact
Mr. Victor Chiiba	Senior Extension Officer	FEP Unit, MTENR	0977499149 vchiiba@mtenr.gov.zm vickman80@yahoo.com
Mr. Emmanuel Mutamba	Board Chairperson	Pellum Association Zambia	295376/295392 greenlivingmovement@yahoo.com & emutamba@yahoo.com
Mrs. Faustina Mwenda Chipalo	Vice Board Chairperson	Pellum Association Zambia	Mwenda.faustina@gmail.com
Dr. Hyde Haantuba	Coordinator	Agriculture Consultative Forum	acf@zamnet.zm
Mr. Mwangase	Deputy Director	Zambia Meteorological Department	mmilk3@yahoo.co.uk
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Stephen Muliokela (Dr)	Director	Golden Valley Agricultural Research Trust	gart@zamnet.zm

Annex 2: List of respondents Shangombo

Name	Position	Institution	Contact
Mubiana Likando	District Agricultural Coordinator	MACO Shangombo	0977 669871/0965 669871 likanda.mubiana@yahoo.com
Sitali George		MACO Shangombo	0979/0967/570609
Nasilele Njekwa	Agricultural Assistant	MACO Mutomena, Shangombo	0979 2044003
Robert Kanyika	Farm Manager	MACO, Shangombo	0977 350589
Abraham Muluku	District Fisheries Officer	MLFD Shangombo	0967 130766/0978 189993 amuluku@gmail.com
Henry M. Mulemwa	Agricultrual Supervisor	MACO Shangombo	0979 903179
Imasiku Lubinda	Block Extension Officer	MACO, Sioma Shangombo	0978 172827
Mubita Kweleka	Park Ranger	ZAWA, Sioma Shangombo	0977/0967 144616
Society Mayalo	Village Headman	Kabula 2 Village Shangombo	
Francis Katangula	Community member	Nakatapa Village Shangombo	0979 173799
Inutu Siyemiso	Community Member	Kabula 1 Village Shangombo	
Mundi Matomela (M)	Community Member	Kandiyana Village Shangombo	
Daniel Musapela (M)	Community Member	Kandiyana Village Shangombo	
Likando Kutungula (M)	Community Member	Kandiyana Village Shangombo	
Mubita Sipalo (M)	Community Member	Kandiyana Village Shangombo	
Malamo Liseho (M)	Community Member	Kandiyana Village Shangombo	
January Kabanda (M)	Community Member	Kandiyana Village Shangombo	
Damain Kabanda (M)	Community Member	Kandiyana Village Shangombo	
Rapheal Limata (M)	Community Member	Kandiyana Village Shangombo	
Godfrey Muyanwa (M)	Community Member	Kandiyana Village Shangombo	
Ross Masiye (M)	Community Member	Kandiyana Village Shangombo	
Abel Kabaulila (M)	Community Member	Kandiyana Village Shangombo	
George Kabaulila (M)	Community Member	Kandiyana Village Shangombo	
Manyando Muwana (M)	Community Member	Kandiyana Village Shangombo	
Albert Ikaya (M)	Community Member	Kandiyana Village Shangombo	
Mulima Christopher (M)	Community Member	Kandiyana Village Shangombo	
Anna Masiye (F)	Community Member	Kandiyana Village Shangombo	
Scola Chibinda (F)	Community Member	Kandiyana Village Shangombo	
Agness Mwiya (F)	Community Member	Kandiyana Village Shangombo	
Agness Sitali (F)	Community Member	Kandiyana Village Shangombo	
Josephine Lyatamanyi (F)	Community Member	Kandiyana Village Shangombo	
Odima Liyeneno (F)	Community Member	Lihonge Village Shangombo	0974 461217
Nyambe Songiso (F)	Community Member	Sipulamua Village Shangombo	
Manyando Lubinda (F)	Community Member	Silukoma Village Shangombo	
Florence Zulu (F)	Community Member	Natukoma Village Shangombo	
Moola Aongola (M)	Community Member	Nakato Village	
Sililo Mwakamui	Community Member	Nasimbandu Village, Silowana Plains Shangombo	

Annex 3: List of respondents Northern Province

Name	Position	Institution	Contact
Michael Chishimba	Senior Crops Officer	MACO, Kasama	0977 939940
Mutende Musonda	Agricultural Specialist, Irrigation Specialist	MACO, Mpika District	0974 154533
Martin Mukuka Mukolwe	Camp Officer	MACO, Chikakala Camp, Mpika	0979 345361
Joseph Mumbi	Village Headman	Kamana Mwelwa Village	
Mary Mwansa (F)	Community Member	Chikakala Agricultural Camp - Masongo Village	
Agatha Chanda (F) Mwamba Munda(F)	Community Member Community Member	Chikakala Agricultural Camp - Katema Mikuba Chikakala Agricultural Camp - Chisengo Village	
Alice Mwanza (F) Maggie Bwalya (F)	Community Member Community Member	Chikakala Agricultural Camp - Chisengo Village Chikakala Agricultural Camp - Masongo Village	
Annet Chanda (F) Maureen Mulenga (F)	Community Member Community Member	Chikakala Agricultural Camp - Chisengo Village Chikakala Agricultural Camp -Kabulamwiko Village	
Joseph Salimu (M)	Community Member	Chikakala Agricultural Camp – Salimu Village	
Bwalya Chilehse (M)	Community Member	Chikakala Agricultural Camp – Masongo Village	
Musenga Nsofwa (M)	Community Member	Chikakala Agricultural Camp - Masongo Village	
Amon Chimfwembe (M)	Community Member	Chikakala Agricultural Camp - Masongo Village	
Charles Muma (M)	Community Member	Chikakala Agricultural Camp - Masongo Village	
Patrick Chikunkuluka (M)	Community Member	Chikakala Agricultural Camp – Chisengo Village	
Newton Hanamwanza (M)	Community Member	Chikakala Agricultural Camp – Mpepo Village	

Annex 4: List of respondents Southern Province

Name	Position	Institution	Contact
Mr. Richard Mamba Condole	Land Use Planer and Climate Change Focal Point	MACO, Choma	
Mr. Nkhoma	Provincial District Market Development Officer	MACO, Choma	
Mrs. Hamusiya	Camp Extension Officer, Nkandabwe	MACO, Sinazongwe	0977(66) 882608
Mr. Smart Siamomba	Farmer	Sinazongwe	
Mr. Mackson Mwinde	Farmer	Sinazongwe	
Mr. Kelly Mandala	Block Extension Officer	MACO, Maamba	0977 533306 0977 270299
Mrs. Chipepo	Farmer	Maamba	

Annex 5: Definition of soil types

Soil definitions from, WRB Map of World Soil Resources

Lixisols are soils with subsurface accumulation of low activity clays and high base saturation[57].[1] They develop under intensive tropical weathering conditions[58].[2]

Soil definitions from Why Is a Soil Profile So Important? | eHow.com http://www.ehow.com/info_7943227_soil-profile-important.html#ixzz1PLerS3E1e-how

Luvisols

Luvisols are common in forested regions. Hard rock exists at the bottom of the profile, farthest from the surface, but immediately above the rocks are stable layers of sand and, perhaps most importantly, a layer of organic matter at the top with a sealed surface. This layer of organic matter on top of stable layers of sand makes luvisols very well suited to agricultural use.

Gleysols

Gleysols are similar to luvisols in that they have a top layer of organic matter. However, this organic matter is under an open surface, and the layer immediately beneath it is clay, which has low permeability. Because water cannot percolate through this soil the way it does in luvisols, gleysols lack the natural agricultural benefits of luvisols. However, with irrigation, drainage and water control, gleysols have modest agricultural use.

Vertisols

Vertisols are dark, craggy clays that are very difficult to use for agriculture. However, careful long-term management and hard work can bring Vertisols to a point where they can sustain a moderate crop.

Ferrasols

Ferrasols are heavily acidic soils common in tropical areas. They consist of a layer of stable minerals beneath two layers of organic matter. If they are well managed, they excel at appropriate crops, though they are not as well-rounded as luvisols.

Arenosol, one of the 30 soil groups in the classification system of the **Food and Agriculture Organization (FAO)**. Arenosols are sandy-textured soils that lack any significant **soil profile** development. They exhibit only a partially formed surface **horizon** (uppermost layer) that is low in **humus**, and they are bereft of subsurface clay accumulation. Given their excessive permeability and low nutrient content, agricultural use of these soils requires careful management.

The reference soil group of the Leptosols accommodates very shallow soils over hard rock or highly calcareous material, but also deeper soils that are extremely gravelly or stony.

The reference soil group of the Vertisols are churning heavy clay soils with a high proportion of swelling clays. These soils form deep wide cracks from the surface downward when they dry out which happens in most years.

The reference soils group solanchaks includes soils that have high concentration of “soluble salts” at some time in the year. They are largely confined to the arid and semi-arid climatic zones and coastal region in all climates

The reference soil group of the the gleysoils holds wetland soils that, unless drained, are saturated with groundwater for long enough periods to develop a characteristic “gleyic colour pattern”. This pattern is essentially made up of reddish brownish or yellowish colurs at ped surfaces and/or in the upper soil layers, in combination with greyish bluish colour inside the peds and/or deeper in the soil.

Podzols are soils with an ash-gray subsurface horizon, bleached by organic acids, on top of a dark accumulation horizon with brown of black illuviated humus and or reddish iron compounds. Podzols occur in humid areas in the Boreal and temperate zones and locally also in the tropics.

57
58 Zonale Böden der Tropen und Subtropen. Skript Institut für Meteorologie und Klimaforschung Universität Karlsruhe

The reference soil group of the solonetz are mostly very hard in the dry season and sticky in the wet season. Clayey solonetz are nearly always slowly permeable to water. Typical solonetz feature a thin loose litter layer resting on black humified material abour 2-3 cm thick. The surface horizon is brown, granular and shallowbut can also be more than 3 cm thick, it is easily eroded away.

The reference soil group of the alisols comprises strongly acidic soils that have accumulation of high activity clays on the sub-soil. They occur in humid (sub) tropical and warm temperate regions nonparent materials that contain a substantial amount of unstable Al-bearing minerals.

The reference soil group of the acrisols hold soils that are characterised by accumulation of low activity clays in the agric sub surface horizon and by a low base saturation level.

The reference soil group of the nitisols accommodates deep, well drained, red tropical soils with diffuse horizon boundaries and a sub-surface horizon with moe tha 30 percent clay and moderate to stroing angular bloky structure elements that easily fall apart into characteristic shiny polyehydric ("nutty") elements. They strongly are weathered soils but far more productive than most red tropical soils.

2011-06

Can Sustainable Agriculture Practices Remedy the Negative Effects of Climate Change on Food Security in Zambia?

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