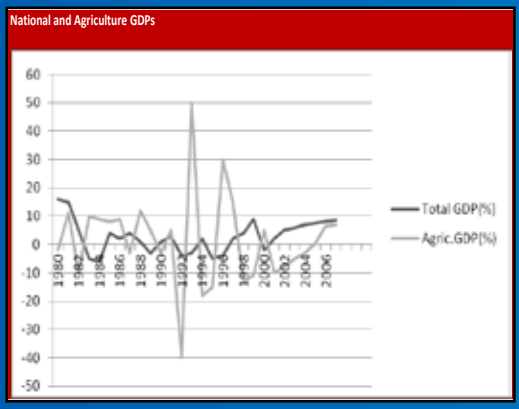
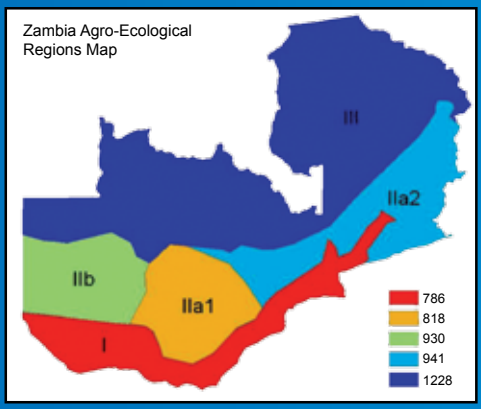
The Zambia Academy of Sciences (ZaAS)

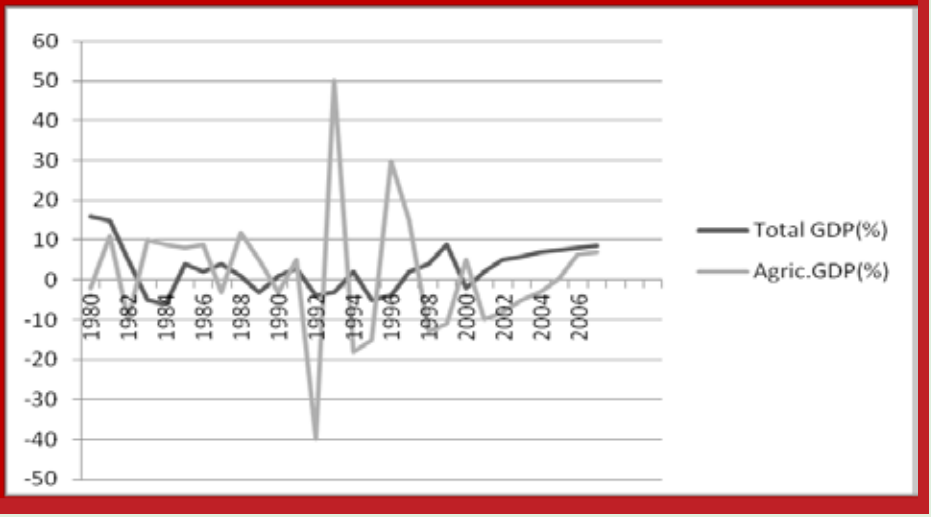




ADAPTATION OF ZAMBIAN AGRICULTURE TO CLIMATE CHANGE

A Review Of The Utilisation Of The Agro-Ecological Regions. A Summary for Policy Makers

National and Agriculture GDPs



Zambia's agriculture sector is highly vulnerable to climate change. The vulnerability will vary in different agro-ecological regions of the country. Climate change is contributing to low growth of the Zambian economy. Agro-Ecological Regions (AERs) has been used in Zambia for policy and adaptive management purposes since its development in the late 1970's and early 1980's and was based on climatological and soil characteristics but without climate change considerations. In the face of climate change scenarios, the assumptions underpinning the AERs may not hold. The purpose of this review was to assess the possible impacts of climate change on the effectiveness of AERs and make necessary recommendations. Average temperatures have increased but precipitation levels have reduced. The pattern of rainfall has changed with a trend of late onset and early cessation of rainy season. These changes have serious implications for natural systems and farming systems and AERs in general. Climate change will worsen the already low maize yields experienced by the country's agriculture which compared to the global productivity is much lower than averages at 1.5Mt/ha compared to global yield of 4.7Mt/ha. In order to reverse the climate change induced country's loss in agriculture GDP and national GDP, Zambia should climate proof policies including the Agriculture Policy and revise the Agro-Ecological Regions Map to reflect current and future scenarios under climate change.

Foreword

The Zambia Academy of Sciences (ZaAS), a not-for profit, and non-political organisation, was established for a purpose of "Promoting Excellence in Scientific and Technical Endeavours" in Zambia. I am glad to see that as a young academy, we are on the right path towards fulfilling our objectives and especially our role of advancing the cause of science and technology. I would like to reiterate that ZaAS is ready and willing to contribute, as scientists in the sustainable development of our country as we strongly believe that Zambia can truly develop only through advancement in science and technology.

This first Policy Brief by ZaAS is in line with the aspirations of the Constitution of the Academy and specifically Articles 4 and 5 that empowers the Academy to initiate studies or can be requested by stakeholders including Government or persons to undertake such research for purposes of scientific advice, guidance or for purposes of advancing science and technology in Zambia.

This document addresses the impact of climate change on agriculture and the different agro-ecological regions of Zambia. Climate change is a challenge universally considered the single most threatening situation facing mankind today since time immemorial. Zambia's Agro Ecological Regions (AERs) Zoning as a planning and adaptive management tool, was developed in late 1970's and early 1980's to guide agricultural production, scientific research and investment. The reliability of this tool and the entire agriculture sector is threatened by climate change. The decision to undertake a comprehensive review of the impact of climate change on Agro Ecological Regions could not have come at a better time than now when the country has just experienced one of worst attacks of army worms invasion ever recorded in the history of our country. The army worm attack follows a year when some parts of Zambia received late rains or received too much rain in a short space of time. The combined effects of army worms attack and rainfall pattern has dealt a serious blow to the country's food security goals as well as pushing back gains made towards the attainment of MDGs especially MDG 1 on food security and reducing poverty. These challenges, the nation has faced, just confirm to the need for strengthening scientific research.

This report is a brief summary of the main report that will also be presented to the Government of the Republic of Zambia as well as to other relevant stakeholders.

This work was undertaken with the support of our partners; the Network of African Science Academies (NASAC), Inter-Academy Panel (IAP) and the Germany Academy of Sciences the Leopoldina to whom we are greatly indebted.

Mwananyanda Mbikusita Lewanika, PhD
President,
Zambia Academy of Sciences,
Lusaka, Zambia.
13th April 2013

1.0 Introduction

Zambia's agriculture sector like that of many developing countries is highly vulnerable to climate change. The severity of impacts will vary in different agro-ecological regions of the world. Based on historical climatological data, models show that climate change is contributing to low growth of the Zambian economy. Among the agriculture adaptation strategies that have been used in Zambia, is the Agro-Ecological Regions (AERs), a policy and an Adaptive Management Tool that was developed in the late 1970's and early 1980's based on rainfall, temperatures and soil characteristics but without climate change considerations. Therefore, in the face of climate change scenarios, the assumptions underpinning the AERs may not hold and its effectiveness as an adaptation tool in agriculture is being questioned.

2.0 Purpose

The purpose of this review was to assess the possible impacts of climate change on the effectiveness of AERs and make necessary recommendations based on the findings of this review. In this review, the period of observation for Zambia spans six decades, 1950-2010.

3.0 Evidence of Climate Change

Climate change may be caused by natural internal processes or external forcings, or to persistent anthropogenic changes such as continued increased emissions and concentration into the atmosphere of green houses (GHGs) and causing global warming and climate change. The IPCC concluded that; The balance of evidence suggests a discernible human influence on global climate. Unless, GHGs levels are stabilized to agreed thresholds levels, global warming will continue with temperatures rising to dangerously high levels that will threaten the very survival of the earth.

3.1 Global Level

As a result of current GHG emissions, global average temperatures are expected to continue rising and ranging between 2.4 to 6.4 degrees Celsius by the year 2100. Rainfall patterns on the other hand are expected to significantly vary across continents and even within countries. The North is generally expected to receive more rainfall compared to the South. These changes in precipitation, temperatures and GHGs, will have a profound effect on natural systems and economic sectors including agriculture and health. In some areas agricultural yields will improve while in others, productivity and yields will reduce.

3.2 Regional Level

Countries of the Southern African region including Zambia have experienced negative impacts associated with climate change especially in the recent past decades where the frequency and severity of extreme events such as droughts and floods has increased. Average temperatures have increased but precipitation levels

have reduced. The pattern of rainfall has changed with a trend of late onset and early cessation of rainy season. These changes have serious implications for natural systems and farming systems as well as crop or plant growing season.

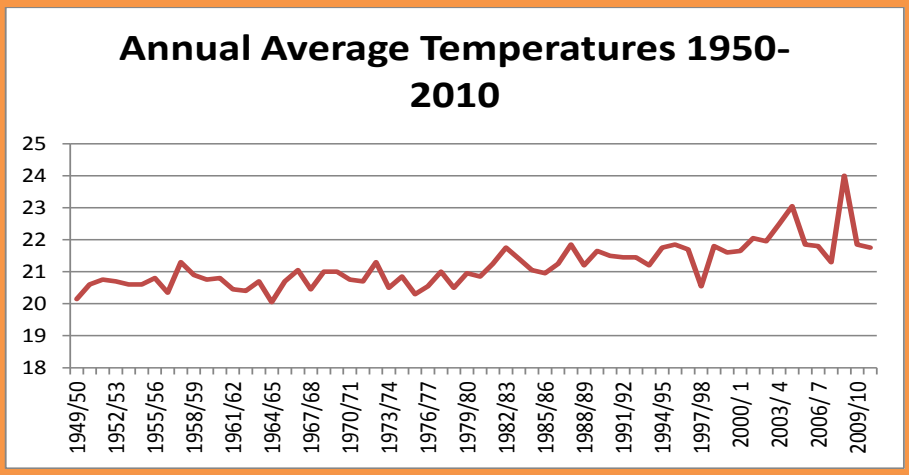
3.3 National Level

The global and regional picture on climate change is also evident at the country level. There is gradual increase in average temperatures averaging 0.3^{0}C per decade. A sharp rise is observed starting in the early 1980s. A declining trend in amounts of rainfall is also observed in the same period. An increasing temperature and reducing precipitation along other environmental factors negatively affects growing season and contributes to increased evapotranspiration.

3.3.1 Historical Temperature Trends 1950-2010

According to the latest meteorological data (Figure 1) provided by the Zambia Meteorology Department (ZMD, 2013), the temperature rise averages 0.3^{0}C per decade in the first three decades (1950-1980) but from 1950-2010, the increase is approximately 0.6^{0}C per decade for the six decades under review. These changes are similar to global reported trends.

Gradual Rising Annual Temperatures



[1]Source ZMD 2013

Studies undertaken at three different sites in three different AERs, observed increase in temperature at the rate of 0.34^{0}C, 0.26^{0}C, and 0.48^{0}C per decade for Kapiri Mposhi (AER II), Mwansabombwe (AER III) and Sesheke (AER I) respectively. This shows that the country is becoming warmer with time.

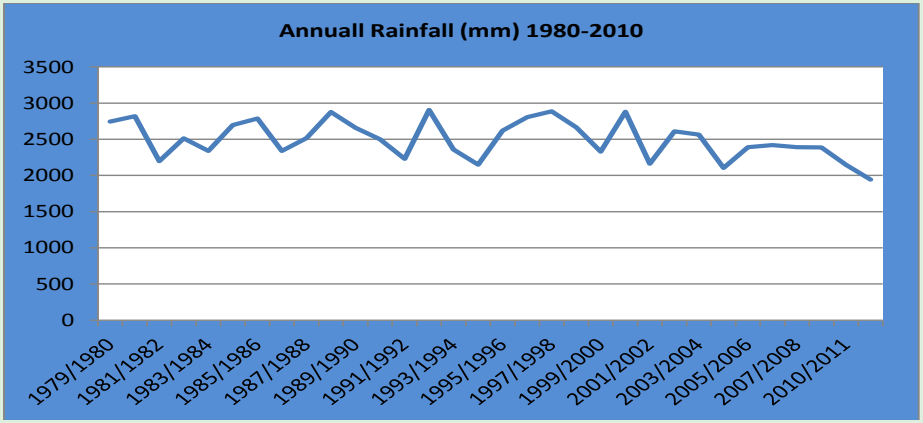
1 Data provided by ZMD 2013

3.3.2 Rainfall Trends between 1950 and 2010

There is an observed declining rainfall pattern across Zambia with the Southwest Region (largely AER I) receiving less rain compared to other AERs of the country.

Figure 2 Declining Annual Rainfall Trend 1980-2010

Declining Annual Rainfall Trend over time



[2]Source: ZMD 2013

This rainfall trend has shown a sharp decline especially starting in the 1980s and shows that the country is getting drier but more pronounced in the Southwestern regions of the country which also experience higher frequency of climate extreme events (droughts and flash floods).

3.4 Major Observation(s)

Due to changes to climatologic parameters, Zambia's agro-ecological systems are likely to have changed or shifted but a more detailed study should be undertaken to confirm the changes and thereby revise the AERs map of Zambia.

4.0 Impacts of Climate Change on Agriculture and Health In Zambia

Climate change will have different effects in different regions of the world. Some regions are predicted to have their agriculture productivity increased and recording high yields where as in some areas, agriculture is projected to suffer negative impacts such that yields will significantly drop. This scenario is equally applicable to Zambia where different agro-ecological regions will experience variable impacts.

4.1 Agriculture Productivity

Climate change will worsen the already low yields experienced by the country's agriculture which compared to the global productivity is much lower than averages. For

2 Data provided by ZMD 2013

the years 2001 to 2010, Zambia's average maize yield is 1.5Mt/ha compared to global yield of 4.7Mt/ha. Whereas much of AER II will continue to be highly productive and producing relatively high maize yields, the once acclaimed maize belt in the South of the country (AER I), will be experiencing low maize yields. The continued low maize yields and increasing livestock diseases will contribute to food insecurity and trigger a climate-environmental migration from the drier South to the wetter North with potential for conflict and national insecurity over land.

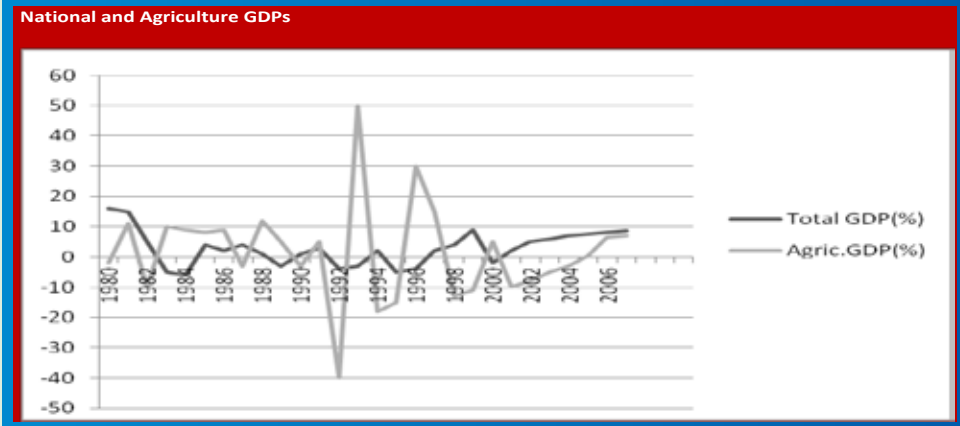
4.2 Agriculture Policy Implications

The national Agriculture Policy was developed on the premise that it is the main engine of Zambia's economic growth. It highlights Government's strategies for increasing the productivity of the sector in order to realize national food security, incomes and reducing poverty. As a way of climate proofing the Policy, it is recommended that climate change adaptation strategies should be incorporated into the existing strategies in the current Policy rather than developing a separate climate change policy for the sector.

4.3 Socio-Economic Impacts of Climate Change and National GDP

Agriculture contributes 20% of GDP and accounts for more than 60% of labour force. In the rural areas, agriculture is the main employer responsible for almost 87-90% of employment. The majority of farmers almost 98% can be classified as small scale farmers whose agricultural activities are almost 100% dependent on rain. There is evidence that the rainfall pattern has direct correlation to Zambia's agriculture productivity and its contribution to the GDP (Figure 3).

Figure 3. Agriculture and National GDP Relationship, 1980-2007



[3] Slightly adopted from World Bank (2008)

Following the 1992 drought that hit much of Southern Africa, it was estimated that Zambia lost US$1.7 billion (equivalent of a 39% drop in agricultural output) and a

3 Slightly adopted from World Bank (2008)

2.8 percentage decline in the country's GDP. The 1992 drought resulted in less severe impact on South Africa's GDP compared to Zambia's GDP that has a weaker capacity for adaptation.

4.3.1 Food security

Climate change will negatively affect national food security situations due to altered agronomic conditions and lower yields. These effects will negatively affect Zambia and may contribute to threatening national food security with the poor rural to be most affected. Therefore, climate change adaptation strategies that focus on increasing yields or grazing efficiency per given land space should be encouraged and promoted.

4.3.2 Reduced cultivatable and range land

It is expected that the combined synergic effects of continued; rising temperatures (Figure 1), declining rainfall pattern (Figure 2)and increasing evapotranspiration, will lead to increased areas becoming more arid and further reducing traditional conventional agro-farming systems resulting in reduced crop yields and livestock populations. These effects will also lead to more intensified land pressures with high potential for conflict and national security.

4.3.3 Livestock losses

Reduced precipitation will not only impact crop production, but will also lead poor range lands for livestock grazing. Rural pastoral farmers will be forced to migrate into areas that have water and pasture. The interface will lead to epizootic diseases that will be too costly especially to poor resourced small scale farmers.

4.3.4 Poverty

With over 65% of Zambia's population being rural based, agriculture is still the only sustainable vehicle for poverty reduction and food security. Zambia's rural poverty levels for the decade 1990 to 2010, remained very high averaging 83% compared to that of urban areas at 44%. These statistics make the attainment of MDG1 by 2015 a near impossibility. Poverty and food insecurity will be magnified under climate change scenario. To realize the full potential of agriculture, government policies including the agriculture policy and the current AER should be climate proofed.

4.4 Health

Although the AERs are not being used in the health sector, it should be acknowledged that human and animal health forms part of the farming systems which are also an important factor in classification of agro-regions. Since climate change will bring about extreme weather events such as droughts, floods and high temperatures, human health will inevitably be affected in different proportions, directly and indirectly and will also depend on the vulnerability of the particular population. The poor will disproportionately be much more negatively affected.

4.4.1 Rainfall Distribution, AERs Positions and Malaria Prevalence maps

Climate Change will affect distribution of vector-borne diseases such as malaria through altered; vector ecology, physiology, behaviour and distribution and through prolonged or shortened effective transmission periods. Although malaria prevalence map shows a national distribution, there is variation in number of cases and shows that the cases are

more prevalent in the Northern and Eastern regions of the country in Agro-Eco logical Regions III and II respectively where the rainfall above 1,000mm with an exception of Livingstone in the Southwestern region of the country with rainfall below 800mm in AER I.

4.4.2 Malnutrition and stunted growth rates

Zambia, with a very high rural population also has a high percentage of children that are suffering from malnutrition estimated at 45% during the period 2003-2005. The percentage of stunted children is 45-50% while 16% of children between age 3-59 months from very poor households are underweight. With low agriculture productivity as a result of climate change, the number of malnourished children will increase and so will the number of stunted children. Climate change will exacerbate malnutrition in all age groups but with much more devastating effects on children.

4.4.3 Other Human Diseases

Other diseases including water borne and zoonotic diseases are also influenced by climatic factors including rainfall. Diarrhoeal diseases such as cholera are closely related to both environmental and climatic conditions. In the mid 1990s and early 2000, there were some reported cases of outbreaks of bubonic plague in different parts of Zambia and the trigger factor in almost all the cases was too much rainfall that forced natural host rodents to seek drier grounds in human dwellings to set up a perfect zoonotic situation that caused humans to be infected by bubonic plague bacteria.

4.5 Attainment of Millennium Development Goals (MDGs)

Climate change is likely to set back development gains by affecting key economic and social sectors such as agriculture, water resources, infrastructures and health. The negative impacts of climate change on agriculture coupled with a declining environmental integrity will lead to food insecurity thereby exacerbating rural poverty and making the realization of most MDGs almost impossible.

4.6 Major Observations

Unless the AERs are revised in line with the observed (present) and projected climate change scenario, Zambia's agriculture is likely to suffer losses and this will in turn affect the country's GDP leading to a slowing and in worst case scenario a stagnant economic growth as currently agriculture contributes 20% of national GDP.

The use of the AERs in health sector is not very clear and requires more specific and detailed studies to establish any link.

5.0 Agro-Ecological Regions

Agro-Ecological Regions (AERs) refer to land areas that are characterized by similarities in terms of climatic conditions, environmental (geophysical, soils), agro-farming systems which includes cropping and livestock or animal production systems and services. The classification is therefore based on multiple but almost homogenous factors that are in most cases inter-related and impact on each other. Zambia's AERs were developed in the 1970's and early 1980's and did not incorporate climate change.

5.1 Agro-Ecological Regions of Zambia

Zambia has three major Agro-Ecological Regions (AERs); Regions I, II and III. These regions are distinguished and classified largely based on climatic, geo-physical, soil types, land use, some farming systems and socio-economic parameters. Each AER has distinct fea-

tures such as temperature range, thermal regimes, rainfall amounts and patterns, growing seasons, cropping systems, soil types and farming system including crops and livestock or farm animals and biodiversity.

5.1.1 Agro-Ecological Region I

The region's average annual rainfall range is 400-750mm and average temperatures of 30-36^{0}C. The region has diverse and slightly acidic and eroded soil types that are frequently exposed to climatic events such as droughts and flash floods. Due to precipitation or moisture stress and short plant growing season of 60-90 days, the region is characterized by drought tolerant and early maturing subsistence mixed cropping systems. This is the driest of the three AERs.

5.1.2 Agro-ecological Region II

The Region's average annual rainfall range is 750-1000mm and average temperatures of 30-32^{0}C. Recent rainfall maps (Figure 6), show that some parts of the Eastern Province appear to be receiving higher than the current designated average rainfall almost in the ranges of Region III. The Region has the most fertile soils except the Western regions that have water logged sandy soils. It has good plant growing season range of 90-150 days capable of supporting growth of almost all crops grown in Zambia. Much of the country's agriculture is in this region and comprises both mixed cropping subsistence to commercial farming.

5.1.3 Agro-ecological Region III

This is the largest AER covering 50% of Zambia's land area and average annual rainfall of 1,200-1,500mm and average temperatures of 30-33^{0}C with extreme northern parts receiving annual average rainfall above this range. The effects of heavy rainfall are evident in the soil type which is highly leached. The Region has the longest plant growing season of 140-200 days. The farming systems are predominantly mixed crop subsistence but there is an observed migration from the drier AERs to this wetter region and commercial agriculture is being promoted. Moisture in this area is generally not a limiting factor to agriculture.

5.2 The use of Agro-Ecological Regions as a Climate Change Adaptation Strategy

Since the late 1970's, the AERs have strategically been used to guide government policy on how to support agriculture in different geographical and climatic regions of the country. However, the AERs were developed without incorporating climate change science and it is proposed that climate change has changed many parameters that were used and therefore rendered the AERs less effective but also possible that the geophysical boundaries could have changed as has been documented shown in Zimbabwe. AERs classification has been used as a key policy as well as an adaptive management tool in Zambia's agriculture sector.

5.3 Effectiveness of the Current AERs

As a result of some observed shifts in rainfall amounts and patterns, the increasing temperatures and increased frequencies of extreme climate events, the current AERs geographical boundaries and climatological characteristics could have changed or shifted.

Rainfall has generally decreased and shows a decline across the country. It can be said with a degree of confidence that conditions in some AERs have changed since the 1970s baselines.

5.4 Major Observations

The current AERs landscape zoning is still useful. However, as a result of climate change, some parameters that were used in zoning three decades ago, have changed and these include; declining rainfall gradient across the country, increased average temperatures and increased evapotranspiration (where it is getting higher in the Southwest regions of the country). Therefore, the AER as a tool may not be as effective for supporting policy and adaptation in agriculture. It is therefore recommended that the AERs be revised to reflect current and future scenarios under climate change.

6.0 Recommendations

Zambian agriculture is highly vulnerable to climate change and yields will continue to be low unless policy measures are climate proofed. As a result of climate change, the country's loss in agriculture GDP is approximately US$430 million per year. Zambia should climate proof policies including the Agro-Ecological Regions Map. Therefore, it is recommended that;

i. In order to reverse the country's loss in agriculture GDP and national GDP, as a result of climate change, Zambia should climate proof policies including the Agriculture Policy and the Agro-Ecological Regions Map,

ii. In view of the fact that parameters that were used to develop AERs have changed over the past three decades, it is recommended that Zambia reviews the current AERs to respond to the present and future projected conditions imposed by climate change. As part of the review, it is advisable that crop suitability maps should be revised and research into development of suitable cultivars be strengthened,

iii. Zambia should identify and prioritize adaptation and vulnerability reduction measures and promote agro-production systems that offer resilience to climate change, increase crop yields per hectare and where possible add mitigation benefits,

iv. As a long term measure, the Government should support and or develop programmes and measures that sustain improved socio-economic status of those AERs (especially regions I and II that are becoming less productive) in order to stem "drier-wetter" environmental migration that could become future source of serious internal conflict and security risk,

v. The country should strengthen and or build capacity for scientific research institutions involved in agriculture with allocation of reasonable resources including human, technology and financial, and;

vi. Climate change induced collapse of agriculture has direct and indirect impacts on health. It is recommended that a study be done to assess the impact of climate change, agriculture and health in a high rural, high poverty but highly productive agricultural province such as the Eastern Province.

The Zambia Academy of Sciences (ZaAS)
Zambia Academy of Sciences,
C/O National Institute for Industrial and Scientific Research,
P O Box 310158
LUSAKA 15302, Zambia