Climate Change: Challenges & Adaptive Strategies

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Abstract: *"Climate change is hitting the poor first and hardest": We are so used to hearing these words; so used to the extent that these words have literally lost their implications to our own lives as human beings! However, there is vast empirical evidence and theoretical literature on the adverse effects of climate change around the globe. No part of this world is immune to climate change and variability. Climate change is constantly taking place in the whole world, and this change will result in impacts whose direction, magnitude, timing and trajectory is not fully predictable. This piece of work looks at climate change and variability in general; we are however, biased towards Africa and Zimbabwe, firstly because that is where most agricultural activities are rain-fed, and secondly due to our point of view that Africa is where there are most of the world's poorest people. In this consciousness, the need to address climate change effects is inevitable. The study envisages to stimulate policy discourse in light of climate change. We advise farmers to take into consideration the suggested adaptive strategies, in order to ensure survival in face of climate change.*

Keywords: *Adaptive Strategies, Africa, Climate change, Farmers, Food Security, Zimbabwe*

1. INTRODUCTION:

One of the most widespread anthropogenic challenges affecting agricultural production is climate change and climate variability [1]. The changing climate is exacerbating existing vulnerabilities of the poorest people who depend on semi-subsistance agriculture for their survival [2; 3; 4]. Climate change is a shift of climatic conditions in a directional incremental mode, with values of climatic elements changing significantly [5]. Climate change is a statistically significant variation in either the mean of the climate or in its variability which may be due to natural processes or external forcing or to persistent anthropogenic changes in the composition of the atmosphere or in land use [6]. Climate change refers to any significant change in the measures of climate change lasting for an extended period in time [7]. This is not limited to changes in temperature, wind patterns and precipitation among other factors that occur several decades or longer. [3] defines climate change as the change in the state of climate that can be identified (via statistical tests) and by changes in the mean and or variability of its properties that persists for an extended period typically decade or longer. Climate change, as defined by the [8], is a long term change in the statistical distribution of weather conditions or changes in distribution of weather events with respect to an average either of a specific region or may occur across the whole earth. Normally, it is caused by natural factors, natural processing and human activities.

However, in this study, climate change is defined as the long term changes in statistically measurable weather conditions (eg. rainfall, wind and temperature). Although climate change is difficult to predict, there is a general agreement among economists, climate change activists and policy makers that the whole world is facing a real and serious long term threat from climate change. Considering that the agricultural sector in Zimbabwe, just like in most parts of the world, is a rain fed sector, climate change will continue to have substantial negative impacts on agricultural production.

Declining rainfall and increasing temperature have had a negative impact on agricultural production and food security in developing countries [9]. These climate changes are expected to have adverse socioeconomic impacts mainly specifically on rural farmers because these rural household farmers depend on agriculture as their source of livelihoods thus making them more vulnerable to climate change [10]. In a scenario where majority of the population such as more than 80% is heavily relying on rain fed agriculture, rural livelihoods and security are highly vulnerable to these climatic changes [11].

Approximately 70% of Africans rely on farming for their livelihood with more than 95% of the agriculture being rain fed [12]. Due to changing weather patterns, agricultural yield in most areas is projected to decline by 50% as early as 2020. The agriculture sector is the most climate sensitive sector in any country, in the sense that agricultural production processes heavily rely on the natural heat for energy and water for irrigation, which are both climates related factors. While it is true that there may be gains in some regions of the world where the climate would

change to favourable conditions, it is important to note that the overall effects of climate change on agriculture are projected to be negative, thereby, threatening global food security.

Climate change has greatly affected agriculture in Zimbabwe, whose economy is agro-based. Climate change poses a big threat on food security in Zimbabwe. Climate change effects have been experienced in all the farming regions in Zimbabwe. Major shifts have occurred in the drought prone regions, region 4 and 5, which have become drier than before. This has greatly affected agricultural production output and has apparently resulted in increased unemployment and food insecurity. This has also affected the economic growth of Zimbabwe. Therefore adoption to climate change is critical.

Purpose of the Study

Climate change has negative consequences noted by frequency in floods, droughts and shift in marginal agriculture systems [13]. Agriculture production in Zimbabwe has continued to decline due to climatic changes. This is harmful to the economy of Zimbabwe which is agro-based, and has negatively affected the livelihood for most rural households who primarily depend on agriculture. Therefore, this study seeks to systematically review climate change dynamics and propose possible adaptive strategies for farmers in Zimbabwe, Africa and other parts of the world at large.

2. CLIMATE & CLIMATE CHANGE:

The dynamic interaction between the atmosphere, oceans, cryosphere and the terrestrial and marine biospheres determines the global climate at the Earth's surface [14; 15]. The increasing accumulation of greenhouse gases (GHGs) in the global atmosphere and increasing regional concentrations of aerosol particulates are now understood to have detectable effects on the global climate system [16]. Scientists believe that changes in the atmospheric composition due to increasing concentrations of greenhouse gases (mainly carbon dioxide, methane and nitrous oxide), changes in land cover and agricultural activities are responsible for warming the earth surface, causing global increases in temperature [3; 13; 17; 18].

Although there are still debates among scholars with regard to whether climate change is induced by anthropogenic activities or is as a result of natural climate variability, the balance of scientific opinion is that changes in the composition of the atmosphere are attributed to human activities that lead to global warming [3; 6; 19]. According to [19], the total anthropogenic GHG emissions have continued to increase from 1970 to 2010, with the highest amount noted between 2000 and 2010. The release of carbon dioxide into the atmosphere from the burning of fossil fuels and industrial activities contributed about 78% of the total GHG emissions from 1970 to 2010, with a similar increase from the period 2000 to 2010 [3; 7]. The rising temperatures heat the land mass and the surrounding oceans, causing increases in surface temperatures and changes in precipitation, which are important drivers of global climate change [13; 20].

Whilst the trends and patterns of climate change projections are generally consistent, they are subject to varying degrees of uncertainty due to limitations in measurements and knowledge of the interactivity between earth systems [20; 21]. Global temperatures near the earth surface increased by 0.74°C from 1906 to 2005 and are estimated to increase by about 6.4°C on average during the 21st century [3]. Recent evidence and predictions from computer models indicate that climate changes are accelerating and will lead to wide-ranging shifts in climate variables [3; 22]. Apparently, global climatic models (GCMs) indicate a possibility of an increase in the global mean temperature of between 1.5 and 5.8°C by the end of 2100, which is ostensibly attributed to population growth, energy use and land-cover changes. [19] however, argues that the previous three decades, from 1983 to 2012, are most likely to be the warmest periods of the last 1 400 years in the Northern Hemisphere, whereas the globally average surface temperature data for the land and sea combined show a warming of 0.85 [0.65 to 1.6]°C over the period from 1880 to 2012. The projected increase in temperature, as noted by [19 & 22], will affect ecosystems and biological behaviour. Some of the effects that have widely been discussed include snow melting and glacier retreat, drought and desertification, floods, frequent fire, sea level rise, species shifts and heightened diseases increase [3; 6; 19].

Specifically, researchers suggest that, with the warming conditions, precipitation patterns are likely to change, with increases up to 20% projected in some parts of the world, although drought conditions will also be exacerbated, particularly in Africa [13; 23; 24]. In European countries climate change has led to temperature rises, shift in rainfall patterns, a rise in sea level, hazardous events such as floods and droughts [25]. Changes in temperature and precipitation also are projected to influence extreme weather events (floods, drought and storms); affect food production (availability) and prices; water availability and access; nutrition and health status [3; 18; 26].

Therefore, the socioeconomic impacts are likely to be significant and will impact humans through a variety of direct and indirect ways [3; 27]. Generally, the impacts of climate change and climate variability are projected to have enormous and devastating global consequences on the global scale, but the most adverse impacts are predicted to occur in developing countries due to their fewer resources to cope with, and adapt to, the changing conditions, which is due to their geographic location (within vulnerable and fragile environments) and their over-reliance on agriculture, which is a climate-sensitive sector [3; 18; 28]. The vulnerability to climate change, in turn, will pose multiple threats to economic growth and poverty reduction in Africa [3; 29].

Climate change is likely to result in high frequency of drought and floods that is likely to challenge farmers eroding their assets leaving them more vulnerable [30]. Climate change is likely to cause hotter days and more frequent and larger heat waves, it might result in extreme events such as decrease in availability of fresh water and food, interact with health care services and also an enhancement of disease spreads as a result of increased rainfall and temperatures [31].

3. CLIMATE CHANGE IN AFRICA:

Africa is the largest tropical landmass, split almost equally by the equator into both hemispheres [16]. Due to its extensive landmass, stretching from about 35°N to 35°S, climate regimes vary from humid equatorial regimes, arid and semi-arid regimes to sub-tropical Mediterranean-type climates with different degrees of temporal variability in rainfall and temperature [13; 24; 32]. Climate change is expected to make some regions wetter (such as the eastern parts of Africa), while other regions like the southern and northern parts of Africa will get drier and more adversely affected by the changes [13; 24].

The climate of Africa is influenced and modified by four major global drivers, which are the Inter- Tropical Convergence Zone (ITCZ), the El Niño-Southern Oscillation (ENSO), circulation patterns in the Indian Ocean, and the West African Monsoon, all of which determine the annual seasonality and variability of rainfall and temperature across the African continent [13; 23; 32; 33]. In addition, the climate of Africa is further significantly modified by the presence of large contrasts in topography and the existence of water bodies such as lakes and rivers across the continent [34 in 16].

Increases in temperature will affect the natural interactions of these diverse drivers, causing droughts, floods, heat waves, wind storms and other extreme weather events within the climates of Africa [13; 35]. For instance, increased fluctuations and variability in rainfall in many parts of Africa, including the Sahel region, eastern and southern parts of Africa, have been associated with the changing temperature conditions in ENSO [16; 32; 36], and the occurrence of the recent drought conditions in equatorial and sub-tropical Eastern Africa from the 1980s to the 2000s is attributed to the increased sea surface temperatures in the southwest part of the Indian Ocean [37]. The overall temperature throughout the African continent has increased by approximately 0.7°C during the 20th century, and some general circulation models project an increase in warming across the continent, ranging from 0.2°C per decade (low scenario) to more than 0.5°C per decade (high scenario) [3; 16; 24]. The warming rate in the 20th century was at the rate of 0.05°C per decade [3].

While future changes in mean seasonal rainfall in Africa are less well-defined [16] researchers such as [24 & 38], suggest that warming conditions will result in rainfall increases around the equatorial region of East Africa. Due to climate change, rainfall in the wet season is likely to increase by 5 - 20%, although drought conditions may also be increased by 5 - 10% in the dry seasons. Too much rain at once can cause disastrous floods, while too little can make an area unproductive or even uninhabitable [38].

While warming patterns on the African continent seem to be synonymous, climate change on a large continent like Africa will not always be uniform. In fact, different areas will likely experience different climate change impacts over time and space. For example, some areas will get wetter and others will become drier, hence varied responses to the impacts between individuals, households, classes, businesses, states, and ecosystems in different places on the continent [3; 17; 23; 39].

However, there is general agreement on the proposition that most African countries are vulnerable to the effect of climate change and climate variability due to their dependence on rain-fed agriculture and natural resources, which constitute a large part of local livelihoods [3; 6]. Agriculture contributes about 70% of the GDP of some African economies [3]. Unfortunately, climate change and climate variability are projected to reduce yield from rain-fed agriculture by up to 50% by 2020 for some of the countries in Africa.

More agricultural losses are expected to occur in areas such as the Sahel, East Africa and Southern Africa (where Zimbabwe belongs), coupled with changes in the length of growing period, flooding and drought. Also, projections suggest that between 75 and 250 million people in Africa will experience increased water problems by 2020 as a result of climate change, which will lead to increased water demand and the exacerbation of water-related problems [3]. Additionally, limited resources increase the vulnerability of the less-developed countries to the impacts of climate change and variability. Poverty, which is linked to a higher dependence on natural resources, also constrains most of the community's adaptive options in less-developed countries (like Zimbabwe) [18].

Developing countries, especially in Africa, possess many coping and adaptation strategies in order to manage a range of issues including climate extremes (e.g., drought and floods). However, under possible increases of such stresses, most of these strategies are likely to be insufficient to adapt to climate variability and change, given the problems of endemic poverty, poor institutional arrangement, poor access to information and growing health burdens [3].

4. IMPACTS OF CLIMATE CHANGE ON AGRICULTURE IN AFRICA:

Climate change impacts are the effects of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts (all impacts that may occur given a

projected change in climate, without considering adaptation) and residual impacts (the impacts of climate change that would occur after adaptation) [3].

The expected changes in climatic conditions will adversely affect farming activities and hence result in reduced agricultural production, particularly food production, hence food insecurity, increased incidence of both flooding and drought, the spread of diseases and increased risk of conflicts over scarce resources such as land and water [19; 40].

However, while developed regions of the world are concerned more about abatement strategies (mitigation), Africa is concentrating more on developing coping and adaptation techniques geared towards the likely future climatic conditions, and on mitigating the sources of emission [41]. This is the case because many of the developed regions of the world expect the consequences of climate change to occur far into the future, while Africa is already experiencing the adverse consequences of climate change in the present [13].

The wet and dry conditions will have negative impacts on the availability of water resources, food and agriculture security, human health and biodiversity due to the fact that Africa is ill-equipped with resources that could be used in managing increased precipitation during the wet season, as well as increased drought conditions during the already dry seasons [3; 19]. Climate change is likely to cause greater environmental and social stress in many parts of Africa already having difficulties in coping with environmental stress [16].

Overall the continent is reported to have experienced decreased rainfall over the last 60 years, and models suggest that changes in the frequency and intensity of extreme events such as floods may occur when there is only a small change in climate [16]. However, [3], predicts a decline in precipitation in most of the subtropical regions – some by as much as about 20%, with varied increases in the number of extreme precipitation events.

Changes caused by increased frequencies of drought will pose a great risk to agriculture, because many crops will fail to cope with the increasing temperatures and changes in precipitation, posing greater risk to agriculture in Africa, where rain patterns are more variable [38] and climatic conditions are at a marginally productive stage [16].

Although records indicate that there has been an increase in rainfall, particularly in East Africa, over the last century [3; 13; 24; 33; 42], not all places have necessarily experienced similar conditions as predicted by the models. For example, although simulation models suggest that countries in the Sahel and the Horn of Africa may receive more rainfall during the wet seasons and increased dry conditions during the already dry seasons, the Sahel has experienced many multidecadal periods of drought with increases in temperature of up to 1.5°C since the last glaciation [13; 23; 32], causing widespread famine requiring humanitarian food aid [32]. [24] show that the warming conditions are also expected to cause an increase in the mean sea level along the coastline of Africa, where a rise in sea level of about 25 cm is projected, which will affect the coastal resources and the livelihoods of the dependent populations.

Agriculture in most parts of the world depends directly on climate [21], and especially so in Zimbabwe and Africa at large. Climate change and variability are threatening agricultural systems, and hence livelihoods, as well as the food security of people in Africa whose lives depend on agriculture [43]. Agriculture constitutes a large share of the African economies through a mixture of subsistence and commercial production [16].

However, farmers all over the world, and not just in Africa, are facing challenges in meeting food demands from the growing population under the current climatic conditions, while at the same time promoting sustainable development [44]. Climate extremes and variability, evident through increases in the frequency and intensity of droughts, flooding, heat waves and storm damage, will have severe impacts on agriculture and therefore food production, because most food crops are sensitive to the direct effects of higher temperature, decreased precipitation and flooding, as well as being indirectly affected through soil functions, nutrient dynamics and pest attack [23].

However, [19] strongly argues that there now is a global temperature increase of 4°C, above the late 20th- century level. Coupled with exacerbating food demand, this will result in more food insecurity globally. Wheat, rice and maize production in the tropical and temperate regions is expected to be negatively affected by local temperature increases of 2°C or more above late 20th- century levels. According to [45], the number of African food crises per year has tripled from the 1980s to the 2000s.

Most livelihoods in Africa depend on agriculture as the major source of food, income, authority, stability and resilience [20]. However, most of the agricultural activities are practised in small-scale subsistence farms and entirely depend on natural conditions, most notably rainfall and temperature [9; 21; 26]. The farming environment is characterised by low production rates as a result of harsh weather conditions, such as high average temperatures and low, variable rainfall, which have always kept African crop yields low; this exacerbates food insecurity [46].

The projected anthropogenic climatic changes will further pose additional threats to agricultural production and food insecurity, particularly to the resource-poor African households whose current food requirement options are limited [26; 39; 47; 48]. A small shift in local temperature (currently projected to increase by 1 to 2°C by 2030) will affect the traditional equilibrium, such as that between food crops vs. energy crops and cultivated lands vs. rangelands. This will likely result in conflicts between sectors, as well as increasing vulnerability for agriculture-dependent subsistence farmers [3; 26; 49].Thus, mitigation and adaptation measures in the agricultural sector are essential to lessen the impacts of climate change and to meet the demand for food, whilst still protecting the livelihoods of subsistence farmers [44].

However, [19] argues that the projected increase in temperature that causes changes in climate systems will require the development of new mitigation and adaptation strategies beyond the existing ones. Projected changes in climatic conditions will mean that current adaptation and mitigation measures are not sufficient to manage the projected changes in climatic system, thus efforts are required to develop new strategies beyond the existing ones.

Mitigation and adaptation are the two main strategies for addressing, managing and tackling the impacts caused by climate change [50]. Mitigation refers actions aimed at reducing GHG emissions or vulnerability to the effects of such emission [51]. Mitigation, as described by [52] are strategies aimed at minimising future climate change through reducing current emissions which is attained by weakening the link between economic growth and greenhouse gas emissions. Mitigation actions include energy efficiency measures, use of cleaner fuels, promoting car-pooling and use of public transport, fitting catalytic converters to car exhausts and scrubbers to power station chimneys, use of natural ventilation to reduce the need for air conditioners and planting trees [51].

Adaptation, on the other hand, refers to actions targeting changes to lifestyles, livelihoods and lived environments in order to be better able to cope with environmental changes [51]. Adaptation focuses on the implementation of policies and changes in management activities, institutional settings and infrastructure that enable effective responses to climate change [9; 52]. [3], defines adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Both adaptation and mitigation can reduce the impacts of climate change on agriculture and hence contribute significantly to reducing farmers' vulnerability to climate change and increasing the food security of households [46].

Adaptation can take different forms depending on "who or what adapts and adaptation to what?" [53]. [53] argue that, in unmanaged natural systems, adaptations are autonomous and reactive, while in public agencies adaptations are usually planned and may be anticipatory. Hence adaptation can be classified into different types, such as being based on purposefulness. A common division of adaptation is made between autonomous and planned adaptation. Autonomous adaptation, also known as spontaneous adaptation, "does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems" [54], whilst planned adaptation is "the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state" [54].

Based on timing, adaptation can be categorised into anticipatory (also known as proactive) and responsive responses (also known as reactive) [42; 53]. Anticipatory adaptation takes place before the impacts of climate change are observed, while reactive adaptation takes place after the impacts of climate change are observed [54]. The ability of a country to respond to the impacts of climate change using a variety of strategies that require financial, social, economic and institutional capacity is known as the adaptation capacity [3].

Adaptation capacity is the ability of a system to adjust to climate change, including climate variability, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences [3]. It requires the entire capabilities, resources and institutions of a country or region to implement effective adaptation measures. Africa and other low-income countries have limited resources to cope with and adapt to the impacts of climate change [3; 26]. Based on this assertion, a small change in climate will result in severe impacts on the livelihoods and ecosystems of low income countries like Zimbabwe.

However, despite limited adaptation capacity, many of the agriculture-dependent household societies have long been developing adaptation strategies that have helped them to cope and survive the impacts posed by changing weather conditions [26]. On the basis of three adaptation categories, [42] describe response management options taken by household farmers in making adjustments in their technology, production and consumption decisions. They suggest that, during anticipatory responses, management options (such as choice of risk-tolerant varieties, investment in water management and diversification of both farming and other associated livelihood enterprises) are taken prior to the onset of the season. With in-season responses, management options include the adjustment of crop and resource management in response to specific climate shocks, and reactive responses that minimise the livelihood impacts of adverse climatic shocks (e.g. distress sale of assets, borrowing, and cutting expenditure on nonessential items).

Adaptation can also be classified as private and public. Private adaptation is a response by an individual household or a firm to an environmental change for one's own benefit [55]. As argued by [54] private adaptation is initiated and implemented by individuals, households or private companies, while public adaptation is initiated and implemented by governments at all levels.

Most rural farmers develop short-term coping strategies that enable them to manage short-term climate change impacts, as opposed to long-term strategies in terms of which they can make use of the benefits associated with the changing conditions [52]. Hence, this makes it necessary to differentiate between the two strategies for managing the impacts of climate change – short-term coping strategies and longer term adaptation strategies. Coping strategies refer to "the strategies that have evolved over time through peoples' long experience in dealing with the known and understood natural variation that they expect in seasons combined with their specific responses to the season as it unfolds", whilst adaptation strategies refer to long-term (beyond a single season) strategies that are needed for people

to respond to a new set of evolving conditions (biophysical, social and economic) that they have not previously experienced.

The extent to which communities are able to successfully respond to a new set of circumstances that they have not experienced before will depend upon their adaptive capacity [52]. As argued by [56], indigenous farmers in dry-lands have always been adjusting their livelihood strategies to large variations in climate, both short and long term. Some innovative households in the communities have improved on traditional practices and developed various coping strategies that enable them to survive under extreme climatic events.

5. CLIMATE CHANGE, AGRICULTURE & THE ECONOMY OF ZIMBABWE:

Agriculture is a very important sector in the economy of Zimbabwe, whose contribution to GDP is quite significant. The agriculture sector in Zimbabwe remains the primary source of livelihoods for most rural communities. Nowadays, especially due to the current economic hardships, the agriculture sector has turned out to be the major source of livelihood for every Zimbabwean, whether in rural or urban areas. The contribution of the agricultural sector in the economy of Zimbabwe is evidenced by its impact on overall economic growth, households' income generation, and food security. Unfortunately climate change is now short-changing farmers of their harvests. Rainfall in Zimbabwe is no longer reliable. It can be late and heavy or early and erratic. In the winter season, sometimes it is not really cold but rather warm. Climate changes and variability experienced in Zimbabwe have to be internalized if farmers deserve bumper harvests.

The agriculture sector in Zimbabwe is basically divided into two categories, namely large and small scale sectors. The large scale sector, as already noted by [57], used to be well resourced and predominantly located in high agricultural and economic potential areas of the country. Today things have changed. Most large scale farmers no longer have resources. The resources are either not working at all or were sold for some reasons better known to the farmers themselves.

On the other hand, the smallholder farmers (small scale sector) are generally characterised by both marginality and remoteness in the sense that most of them are located in areas that normally experience low and highly unreliable and variable rainfall, high temperatures, poor soils and far away from markets (urban centers and growth points). Small scale farmers in Zimbabwe are poorly resourced. They rarely use technology in their production activities. They also don't have access to credit. Now, these small scale farmers are more vulnerable to climate change and variability as compared to large scale farmers. This is attributed to the fact that smallholder farmers have little or no adaptive capacity primarily due to poverty. In Zimbabwe, rainfall is now erratic and unreliable. Many farmers in recent years have suffered continued bad harvests, particularly due to either late or erratic rainfall.

Adaptive Strategies to Climate Change

In the face of climate change and variability, in this study, we propose the following adaptive strategies to help farmers in Zimbabwe and other affected countries:

- Use of organic matter
- Changing planting dates
- Changing fertilizers
- Soil conservation
- Use of drought, pest and disease resistant crops
- Mulching
- Planting of trees or agro-forestry practices
- Increased use of fertilizer
- Mixed cropping practices and or crop diversification
- Farm diversification
- Farmers ought to have other income generating projects
- Cover cropping
- Use of early maturity varieties
- Use of minimum tillage systems
- Irrigation practices
- Fallowing

6. LIMITATTIONS TO ADAPTING TO CLIMATE CHANGE:

There is no doubt that Africa has a low and limited capacity to adapt to climate variability and change due to a lack of capital, skills and appropriate adaptation technology [6]. Adapting to climate change requires changes in farming systems and infrastructures, switching crop types to more drought- and heat-tolerant crops, and those areas expected to experience increases in precipitation and temperature will require a shift to higher thermal-requirement

crops so as to make fuller use of the extended and more intense growing season, and control of increased populations of pests, insects, weed and pathogens, most of which require extensive research that most African countries lack [58].
In the process of adaptation, farmers normally face problems in competing with imported food (cheap food, e.g. rice) to cater for the food shortages in the country. Imported food, as is the case in Zimbabwe, is sold at a cheaper price than locally produced food, limiting the ability of those farmers who are already trying to cope and adapt to climate change and climate variability to maintain their livelihoods.

However, since livelihoods at household level are affected by declining income and food security from farming, many will opt for a diversification out of agriculture [59; 60]. As argued by [61], farmers who diversify their means of survival by moving completely or partially out of agriculture are more capable of moving out of poverty. It is evident that most households will adapt to climate change by further seeking to diversify into non-farm livelihood activities *in situ*, or by moving or sending more family members to urban centers and depending on urban-rural remittances, with agriculture remaining as a semi-subsistence activity while cash is generated elsewhere [20; 62]. The same was observed by [49] in South Africa, where Basotho males who worked in the mines supported a large majority of the population with their pay from mining works.

Adaptation to climate change and variability may require the growing of less-favored crops by the farmers, as changing conditions may not favor the growing of crops that are necessarily preferred by farmers. In reality, the adaptation process does not seek complacency with what is suitable to the farmers, but what is favored by the conditions. This may lead to significant disruptions of the rural livelihoods, because the adaptation process is never perfect [58; 64]. For example, the growing of more drought- and famine-tolerant crops would not be preferred by most rural farmers, owing to the fact that it does not ensure equal levels of either food production or nutritional quality, nor does it guarantee equal profits for farmers.

Apparently, literature suggests that adaptation to climate change does not happen automatically, but requires investment in agricultural research and infrastructure [64], in identifying possible current adaptation options that can be taken by farmers in coping with changes, their current and expected future hazards as well as types of crops and their best farming practices under climate change conditions. This is very expensive, and most African countries cannot afford this due to limited resources, such as institution infrastructure, access to capital, information and technology, and increased vulnerability to climate change by the agricultural sector, which is dependent on climate [6; 53].
However, the only available options for most African farmers in coping with and adapting to the impacts of climate change are through their traditional agricultural farming techniques, although timely response actions may be limited due to their infrastructure and economic means [6; 53].

Constraints to Adoption

The following points generally summarize the limitations or constraints to adoption faced by farmers in Zimbabwe and other similar developing countries:

- Limited farm size
- Unpredictable weather
- Inadequate farm labour
- High cost of farm inputs
- Lack of access to adequate water
- Lack of access to timely weather information
- Poor soil fertility
- Lack of access to credit facilities
- Limited access to agricultural extension officers
- Lack of access to agricultural subsidies

7. CONCLUSION & RECOMMEDATIONS:

Many scientists have confirmed that climate change is occurring and it is believed that the impact of climate change will be larger on developing countries, compared to developed countries [3; 65]. This is mainly attributed to the indisputable fact that developing countries such as Zimbabwe usually have agro-based economies, which are known to be heavily dependent on weather conditions and other natural resources. Therefore, as already noted by [66; 67], farmers behavioral change towards adaption and willingness to take action are as important as are policy decisions. It is envisaged that farmers in developing countries such as Zimbabwe will consider the proposed adaptation methods in responding to climate change. Farmers, particularly in Zimbabwe, are encouraged to form associations and or unions which will function as resource centres that help farmers with reliable information (via newspaper articles, (*simplified*) farmers' handbooks, newsletters, work-shops, seminars etc) on climate change and variability, crop variety selection, disease control as well as market research and information.

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