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# Biophysical Impacts of Climate Change on Crop Productivity of the Rural Small Scale Farming Sector in Swaziland

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**Abstract:** ***The study reviewed the impacts of Biophysical factors which ameliorate the environment for productivity of small scale farmers in the rural farming sector in Swaziland. The study reviewed, with special reference to its impact on Maize and bean production as these are the dominant crops in Swaziland. The major biophysical impacts examined by the study was temperature, precipitation, soil factors including technological factors as they affect yield of maize and beans in all four agro-ecological zones of the Kingdom of Swaziland. The degree of variability in these parameters was evaluated using primary and secondary data on climatic elements and agronomic parameters spanning a period of 30 years. The statistics used a two-way analysis of variance (ANOVA) and co-efficient of variation. There were significant differences in the average maize yield, temperature and rainfall in all four agro-ecological zones. The level of food security in all small holder households declined in the Lowveld increasing food insecurity in the majority of households ($p<0.05$). Less variability was shown by annual temperature and rainfall in the first and third decad. Adoption of Conservation Agriculture (CA), change of cropping pattern for the Middleveld and 3owveld and irrigation for maize production in the Lowveld for production of green mealies is recommended. Maize production is recommended for the Highveld and wet Middleveld. However, Good agricultural practices must be adopted and practiced for increased yield of maize in all agro-ecological zones.***

**Keywords:** Good agriculture practices; Agro-ecological zones. Climate change

## 1. Introduction

In Swaziland just like most southern African Countries, agriculture, both crop and Livestock, plays a very significant role in providing food and income for the majority of small holder farmers. In Swaziland the Agriculture Sector is key to economic development of the country. Especially that the majority about 70% of the population rely on a subsistence based food production system Thompson (2013). The majority of small holder agriculture is rain fed. A small proportion 2% of total grain production is under irrigation FAO (2015) Climate change, or climate variability, and its impacts has emerged as a serious threat to the agriculture sector, not only in Swaziland but the entire southern Africa. The impacts of this phenomenon is considered a threat to Sustainable development, with far reaching impacts on environment, food security, human health, natural resources, economic activities and physical infrastructure (IPCC, 2007).

Drought and extreme dry spells have been common since the Biophysical factors of climate change phenomenon manifested itself. Also, Floods, erratic rain fall, and extreme events have been the visible impacts of climate change on the productivity of small holder farmers in Swaziland. The subsequent emergence of new diseases and pests have also impounded the situation. According to URT (2005) famine resulting from either floods or drought have become increasingly common in the 1990's and is undermining all efforts on food security. Climate change there-fore is indeed a global phenomenon and as stated by Devereux and Edward (2004), countries in east Africa are already among the most food insecure in the world. SARUA, (2014) states that climate change as a risk multiplier introduces new climate risks. Already the observed temperature changes for Southern Africa are higher than the increases reported for other parts of the world (IPPC, 2007), projections indicate an increase of 3.5 degrees C. in annual temperature (up to 3.7 degrees C. in Spring) when comparing the period 1980 to 1999 with the period 2080 to 2099. Mean warming over land surfaces in Southern Africa is likely to exceed the average land global temperature increase in all seasons.

The Swazi VAC report, (2016), in view of the magnitude of the impact of the drought on the population, reported that the Swazi government declared it a national emergency. The Government has made efforts to address the growing humanitarian needs in collaboration with partners, coordinated by the National Disaster Management Agency. A donor conference was held to brief the donor community on the National Drought Emergency Mitigation and Adaptation Plan (NERMAP) 2016-2022 and the current situation of the drought in the country. The NERMAP (2016-2022) had estimated that from March 2016 a minimum of 300,000 people, (about one third of the population), will be in need of food assistance. These are the tangible impacts of the Climate change on Smaller holder productivity. The government has committed substantial resources for the emergency and has requested technical and financial assistance from the international community to support the emergency response plan. This is indeed in line with the assertions by Devereux and Edward (2004) that countries in East Africa are amongst the most food insecure countries in the world. The Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) for Swaziland (SNC, 2012) recognises that the country is highly vulnerable to climate change effects. Over the period covering 1960-2005, most meteorological stations reported significant increases in both mean minimum and mean maximum temperature, with heterogeneous trends in rainfall indices concern (SNC 2012). Other studies conducted in Swaziland by Nkondze., et al (2013) on climate change impacts in Swaziland studying the impact of climate change on livestock found that Livestock has been lost due to, among other factors, excessive heat, shortage of water and feed and unknown diseases. The study, also, found that Livestock production is sensitive to climate change in the study area in the Mpolonjeni ADP, implying that there is an impact of climate change on livestock production.

The study explored farmer perceptions on climate change, impacts and vulnerability, with scientific analysis of the prevailing climatic regimes in the four agro-ecological zones of the country. The findings of this study is expected to be used by stakeholders in the agriculture sector including small holder farmers and policy maker to address issues on Climate change. The overall goal being to examine the impacts of climate change on agriculture production systems and what strategies could be employed to improve and or ameliorates the impact of this phenomenon. The Study:-

i) Reviewed factors influencing production in the four agro-ecological zones.
ii) Determined temperature trends and precipitation to assess their impacts on small holder agriculture production,
iii) Established small holder perceptions on climate change and their capacity to adapt.
iv) Examined critical negative factors affecting maize and bean production in the 4 agro-ecological zones.

### 1.1 The Hypothesis to be tested

The study reviewed the impact of certain natural factors (exogenous factors) such as precipitation and temperature and their effect on the productivity of small holder agriculture production, with reference to Maize and beans. *($\mu$=0).* On the other hand to test that these exogenous factors have no influence on the productivity of small holder farmers in Swaziland but the non-application of good agriculture practices (endogenous factors) that are responsible for poor yields among small holder farmers *($\mu$=1)*. In the simpler context small holder farmers do not manage their crops adequately in terms of proper, land preparation, Proper seed selection, weeding, application of inputs; in optimum quantities; managing their soil fertility issues, and control pests and diseases and then blame rainfall and Climate variability on their low levels of production.

### 1.2 Limitation of the Study

The study will not review the market forces to production and level of wealth of these small holder farmers involved in maize production. All small holder farmers, were solicited selected from all four administrative regions of the Country. However, the corresponding agro-ecological Zones formed the subject of the study and the study areas. The study was further limited to Rural Development Areas (RDA), which are centres of excellence for agricultural information dissemination.

## 2. Research Methodology

### 2.1 The Study Area

The study was carried out in Swaziland's four agro-ecological zones, between Latitudes 25° 43' and 27° 19' Longitude 30°47° and 32°08'. The country has a total area of 1,7360 sq km (FAO Aquastat 2014) and is traditionally divided into four agro-ecological zones. However according to Murdoch (1968), based on elevation, landforms, geology, soils and vegetation, the country was further divided into six Agro-ecological Zones or Physiographic regions. However, for the purposes of this study the four Agro-ecological Zones shall be used. Small holder farmers (SHF) from a total of 17 Rural Development Areas (RDA's) were subject of the Study. These areas are located in all the Agro-ecological Zones (AEZ); Highveld (6), Middleveld (6) Lowveld (4) and Lubombo plateaux (1).

Swaziland has a subtropical climate with summer rains. About 75 percent of the precipitation falls from October to March. The climatic conditions range from sub-humid and temperate in the Highveld to semi-arid in the Lowveld. The national long-term average rainfall is 788 mm/year. Table 1 gives the average rainfall for the four traditional Agro-ecological zones.

### 2.2 Climatic Conditions

Swaziland has a unimodal rainfall regime which is concentrated in a period of six months between October to March. The country has an annual rainfall of 450 -1550+ mm per year and the Climate is predominately Subtropical. Table 1. Shows the average rainfall for the six Agro-ecological Zones.

**Table 1:** Rainfall in the Agro-ecological Zones of Swaziland

| Agro-Ecological Zones | Rainfall (mm/Year |
|---|---|
| Highveld | 700 – 1550 |
| Wet Middleveld | 850 - 1000 |
| Lower Middleveld | 700 – 800 |
| Western Lowveld | 450 – 550 |
| Eastern Lowveld | 400 – 450 |
| Lubombo Plateau | 550 – 700 |

Ssource: FAO aqua STAT. 2014: Murdoch, [1968]

*Highveld:* The Highveld is to the extreme West of the country, it is the upper part of the escarpment. It is characterised by steep slopes of valleys and plateau and is mountainous with altitudes above 1,200masl. Rainfall is dependable ranging from 700 to 1,550mm. Temperatures of 16.2 degrees Celsius are common.

*Middleveld*: This is in the east of the Highveld. has an average elevation of 700masl with rainfall ranging between 550mm and 550 mm. In the Wet Middleveld up to 1,114 mm. The Average Temperatures of 19 degrees across.

*Lowveld:* has an average elevation of 200masl and contains the hottest and driest parts of the country with average of 21.2 degrees, but can rise to 34.0 degrees. Rainfed agriculture is risky because of the frequency of droughts.

**The distribution of the respondents in the study areas (RDAs)**

The country's population was about 1,087,200 Million (July 2018 est), of which 76.2 percent are rural. This population is reliant of Agriculture for their livelihood. The population density is 62 inhabitants/km2. About 52 percent of the population is female, while 48 percent are males. The study Agro-ecological zones, as reviewed through the RDA's, cover a significant area of the country. The Highveld, Middleveld and Lowveld occupy about one-third of the country each, with the Lubombo plateaux occupying less than one tenth of the country. Table 2 shows the distribution of respondents

The terrain and conditions under which small holder farmers practice their Agriculture offers a great challenge. The pose a challenge to mechanization as they are steep, with high percentage slopes (Sikhondze, 2013 UNP). The soils may be rocky and not suitable for tractor implements. About 30% of the ploughs bought under the Food security Project were stretched during ploughing in some soils in the Highveld. (MoA report, 2015).

**Table 2:** Number of Respondents Aggregated by Gender

| Agro-Ecological Zones | No. of Respondents | |
|---|---|---|
| | Male | Female |
| Highveld | 17 | 43 |
| Middleveld | 26 | 32 |
| Lowerveld | 23 | 17 |
| Lubombo Plateaux | 6 | 4 |
| | 72 | 98 |

## 3. Data Collection and processing

A total of 17 Rural Development Areas (RDAs) in the four agro-ecological zone were used for the study. A list of respondents were selected by the local agriculture Extension officer. The selected farmers were drawn from a comprehensive data source of all maize farmers in the RDA. About Ten (10) farmers were given a questionnaire to answer, while five (5) formed the Focus Group for Discussion. Qualitative data was collected using the structured questionnaire from the ten farmers per RDA. A total of 170 respondents were interviewed. Quantitative data was obtained through the questionnaire, data was analysed using the SPSS version 16 program. Rainfall and temperature trend analysis was done from series data obtained from the Meteorological Division. Descriptive statistics were run to give frequencies and percentages.
And cross tabulations were used for comparison of selected parameters within and without an agro-ecological Zone.

The production function was used to determine yield ***Ÿ*** (output per ha) given variable external inputs used to produce the crop. ***Š*** *(soil fertility,)* and exogenous factors to a farmer that are subject to natural endowments ***N*** (climate), rainfall and temperature. External Inputs ***Ê*** ***(***Fertilizer**,** used to produce the crops.

**(1) Ÿ=*f* (Ê, Š, N)**

These production factors are non- linear and imply that the derivative of output with respect to any of the selected inputs ***Ê,*** will likely depend on the exogenous variables, ***Š*** *and* ***N.***The production Function is crop specific so that a different function must be estimated for each crop. The functional form vary although it is generally recognized that variable inputs have positive but declining marginal value and that some factors such as temperature have a concave nonlinear shape. Concavity of the production function guarantees the rule that must hold for all production functions. This law is that of diminishing marginal returns to ensure existence of an economic optimum. This law states that adding more of one input while holding others constant eventually results in smaller increments in the level of output.

Generally, production function tends to be multiplicative (not additive) which is represented by the following constant elasticity function

**(2)** $\ddot{Y}=f\,(\hat{E}^{\alpha}\,\check{S}^{\beta}\,N^{\sigma})$

Where $\alpha$, $\beta$, $\sigma$ are estimated coefficients, such a function is usually estimated using Logs.

**(3)** $Ln(\ddot{Y})=\alpha Ln(E)+\beta Ln(\check{S})+\sigma Ln(N)$

The log linear production function implies that inputs in a proportional manner , such as a 10% increase in fertilizer will increase output by an X% rather than a specific amount such as Kg/ha. This means that inputs will be more effective on land with advantageous natural endowments, ***N*** (rainfall and good temperature, and with a better ***Š*** (good soils) and supplied external inputs such as fertilizer, with considerations for top dress and lime application in the Highveld and moist Middleveld. So farmers will utilize their production function to maximise on their yield.

Any increase in *Š* and *N* that increases the productivity will increase input intensity. This means that the application of ***E***(optimal levels fertilizer, good primary and secondary land preparation, and accessing mechanization early in the season or when the Soils are at very good moisture Content) will contribute significantly to ***Ÿ (***output increase/Yield). Similarly, an improvement in ***N***(climate precipitation and Temperature) may also contribute meaningfully to an increase in Yield. Using these first order conditions one can deduce that an input demand function given the exogenous variables ***(E)*** which are the responsibility of a farmer, solving for ***Ÿ*** Yield an input demand function can be represented as follows:

**(4)** $\ddot{Y}_n=f(\Delta E, \Delta S, \Delta N$

The production function and the input demand function can be used to test the relative importance of Climate Change natural conditions and technology variables. Of the two factors of production function is the elasticity of inputs is **α,** the elasticity of Soil factors ***β*** and the elasticity of climate change factors ***σ***. If an input is more it is highly significant. The other measure is the proportion of the variance across the four ecological zones. How much of the observed variance of yields across the four ecological zones can be explained by each independent variables (the ecological zones). The advantage of the production function theorem is that it is clear that all relevant factors impacting on productivity are significant util proven otherwise.



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**Analysis**

This study aims to determine the production function for maize in the four agro-ecological zones. In conducting this study, A cross sectional regression was used to estimate the loglinear production function of (3). The justification for the use of this analysis is that they capture the adjustments that farmers are likely to make in different conditions.

It also captures the cost of inputs fertilizer, to help explain why there is variation in the range of inputs used across the ecological zones. By reviewing the yield variations across ecological zones, the production function helped to explain the yield variation across the four ecological zones.

The variance in yields by all the three factors is *var*Ÿ = [Ÿ(Ï, Š,N)-Ÿ (Ï, S,N]$^2$ the share of this variance explained Ÿ versus , Ï S, and N is share (Ï) = *var*Ÿ (Ï)/ *var* (Ÿ) (Ï, S,N)

## 4. Results and Discussion

This study, of the impact of Climate change on the productivity of small holder farmers in the four agro-ecological zones of Swaziland did indeed determine that small holder farmers have perceived that factors such as Rainfall, temperature, soil conditions have impacted on the productivity of Maize and Beans at various levels depending on the agro-ecological zones. The following table shows farmers perception on climate change factors as a phenomenon impacting agriculture production on Small holders farmers fields.

**Small Holder Perception on Climate Change Factors**

**Table 3:** Shows the perceptions of Small holder farmers views, on Climate Change Factors across the agro-ecological Zones in Swaziland

| | Precipitation | | Heat | | Drought | | |
|---|---|---|---|---|---|---|---|
| Agro-ecological Zones | Decrease in Rainfall % | Increase in Rainfall % | Increase in Temperature % | Decrease in temp % | Drought % | Don't know % | No change % |
| Highveld | 43 | 57 | 59 | 41 | 51 | 0 | 49 |
| Middleveld | 61 | 39 | 68 | 32 | 62 | 33 | 5.0 |
| Lowveld | 53 | 47 | 43 | 46 | 54 | 25 | 10 |
| Lubombo Plateaux | 69 | 31 | 46 | 54 | 28 | 9 | 63 |

**Table 4:** Prioritized negative factors affecting Maize and Bean Yields across Agro-ecological Zones

| Critical Negative factors affecting Maize and Bean production | Highveld | Middleveld | Lowveld | Lubombo |
|---|---|---|---|---|
| | (N=40) | (N=40) | (N=50) | (N=40) |

**Rank**

| Agro-ecological Zone | No.1 | No,2 | No.3 | No.4 |
|---|---|---|---|---|
| Highveld | Poor Agriculture Practices | Increased Pests and Diseases | Inadequate Rainfall | Inadequate Rainfall |
| Middleveld | Low Soil Fertility | Drought High Temperature | Late Ploughing | Increased Pests and disease |
| Lowveld | Increased Pests and diseases | Inadequate Rainfall | Lack of Extension Advice | Late Ploughing |
| Lubombo Plateaux | Inadequate Rainfall | Late Ploughing | Labour Shortage | Drought (high Temperature) |

**Source: Survey, 2016**

In the Highveld, the majority of farmers rated poor Agriculture practices, Increased pests and diseases and Inadequate rainfall as the critical negative factors affecting the production of maize and beans in the Middleveld, Lowveld and Lubombo respectively. According to IPNI (2013) in their leaflet on Maize production, sites Primary Tillage as the foundation of every crop production system and the critical Agriculture Practice. It states it is the main cost factor in Maize Production The principal aim is to improve soil structure, because water availability during the growing season is the single most important factor in crop production. It must optimize infiltration and minimize evaporation. IPNI (2013) further lists the following as good agricultural practices for better maize; Land preparation and seed selection, fertilizer application, planting and management. If these are poorly done, production and productivity will be negatively affected. Across the minority with an average of 4.2 % of respondents across all agro-ecological zone, I identified poor agriculture practice as critical negative factors affecting maize and bean production in Swaziland. From the study it can be deduced that, even the contribution of poor access to farm inputs, late ploughing and planting and high costs of ploughing were not Identified by a very minority of farmers as negatively affecting maize and bean production. This study concurs with the IPNIs identification of the application of good agriculture practices as critical factors for Improved Maize and bean Production among small holder farmers.

It evident from the prioritized factors that indeed farmers across the agro-ecological zones acknowledged the changes in climate over the years, judging from the responses on the level of rainfall and Temperature. Of the factors advanced as negatively impacting their production, All agro-ecological zones (100%) identified inadequate rainfall, and Increased pests and diseases as the critical factors affecting maize and Bean production. This was followed by drought (High Temperature) and late ploughing, 75% of the zones, as the next critical factors negatively affecting their crop productivity about 50% of the AEZ identified extension Advice as lacking and impacting negatively their agriculture production enterprises, other factors, identified by 25% of the AEZ were shortage of labour and Low Soil fertility. It is not surprising that the Highveld, identified low soil fertility (FAO,2005) also identified this factor as the, factor, Limiting yields in this region. The Lowveld identified shortage of labour as one of the factors to be considered, is not out of the ordinary since the Lowveld is predominantly a

Cotton growing region and cotton production is labour intensive. In responding to the question, it can not be ruled out that farmers had cotton in their mind.

**Inadequate Rainfall**
The results show that (43%) of the respondents in the Highveld and 61% in the Middleveld agreed that there was indeed a decrease in rainfall in the past 20 years, while (53%) respondents from the Lowveld and 69% from Lubombo agreed that there was a marked level of decrease in rain fall. With respect an increase in rainfall, less respondents, than those that saw a decrease saw an increase responded to the affirmative. The respondents stated that during the critical months of August, September and half of October, which were traditional rainfall months do not receive rainfall enough to allow for ploughing and planting, especially the maize crop. From the results above the majority of small holder farmers, across the agro-ecological zones, perceived that climate change is indeed a present phenomenon.

Inadequate rainfall is a factor universally identified as critical for Maize production.Indeed,food production is intimately related to on water availability (Strong.; (1989). The optimum moisture for maize and bean germination is 60% of soil capacity (Duplessis,(2013). It is not surprising that in the study the general perception among the respondents across the regions was that rainfall amounts and patterns have decreased over the last decade. For small holder farmers growing Maize under rain fed conditions they have experienced decreased maize yields. The number of dry spells and onset of rains have delayed planting. The majority about (89.4 %) across the regions cited inadequate rainfall as the critical factor impacting negatively on maize production, with Shiselweni and Lubombo with 100% respondents. The respondents also indicated that, other than inadequate rainfall, the distribution and onset of rains were delayed. This factor was indeed very important in influencing the Yields obtained by small holder farmers in the different agro-ecological zones. As stated by Plavsic et al (2014) there is a close relationship between the crop yield and water supply to the crop. In this study, the findings concur with Most studies on Climate change that the impact of reduced rainfall has negative impact on maize productivity.

**High Temperature and Drought**
The advent of Agricultural drought, in most countries is a constant reminder of the immediate and large scale impacts on food production. The changes in weather patterns are ultimately responsible for reduction in rainfall. Maize is a warm weather crop and is not grown in area where the mean daily temperature is less than 19 degrees or when the mean of the summer months is less than 23 degrees although the minimum temperature for germination is 16 to 18 degrees. At 20 degrees, maize should germinate within six to nine days. The critical temperature detrimentally affecting yield is 32 degrees (Duplessis (2013). Respondents in this study did identify drought and high temperature as a critical factor negatively affecting maize and bean production. Although the average annual temperature for the four Agricultural Zones differ, the respondents were however unanimous in their observation that drought, heat spells and high temperatures have a negative impact on maize production yields.

**Pests and Diseases**
The results above show that the majority, about an average of about 80% across all districts an agro ecological zones agree that increased pests and diseases do affect negatively the production of maize and beans. Farmers stated that climate change has brought about increased pests and diseases, in the mind farmers associated the Fall Army Worm (FAW) to climate change. Empirical studies on climate change had shown that indeed one of the impacts is new disease and pests. Increased diseases and pests may be also rise from changes in production systems, enhanced resistance of pests to pesticides. Similarly increased rainfall brings along humid conditions due to temperature and moisture leading to the spread of leaf disease. Crop responses to warming climates, suggests that yields will decrease as growing seasons temperature increase, Deurtch et al show that this effect may be exacerbated by insect pests. Insects already consume 5 to 20 % of major grain crops. The authors model for the three most important grain crops wheat rice and maize. Yield lost to insects will increase by 10 to 25% per degree Celsius of warming hitting hardest the temperate zone.

**Lack of Extension advice**
The results show that small holder farmers regard extension services as moderately visible (53.8%), as extension officers are known, their intervention is visible in the communities. However, some older respondents reported that extension services were highly visible during the 90's as compared to now. Regarding source of knowledge, small holder farmers cited the presence of the extension officers (public, Private and NGO extension), other farmers and experience accumulated over their years of involvement in agriculture as other significant information drivers, critical for improving their agriculture knowledge on climate change.

**Table 5:** Source of Knowledge on Climate Change for farmers

| Crops | Source of Knowledge | Frequency | Percentage % |
|---|---|---|---|
| Maize and Beans | Extension Officer (Public and NGO) | 60 | 35.3 |
| | Lead farmers (Farmer to Farmer) | 40 | 23.5 |
| | Experience over years | 19 | 30 |
| | Seed Officers from Seed Companies | 19 | 11.2 |
| | | 170 | 100 |

**Field survey 2016**

From the results of the study, the majority about 40% of the respondents indicated having gained knowledge from the advice from public extension officers as well as from officers from Non-Governmental Organizations (NGO). About 28% indicated having got advice from lead farmers (farmer to farmer), while 32% said their involvement in agriculture over the years has given them experience to tackle agriculture challenges. When further probed, this group did indicate that currently they did not have an extension officer in their areas. It can be concluded that the contribution of extension to farmers knowledge of Climate change is significant considering that even the lead farmers are products of the extension service. Aymone, (2009) states that better access to extension services seems to have a strong positive influence on the probability of choosing an adaptation measures. He argues that farmers who have access to extension are more likely to be aware of changing climatic conditions and to have knowledge on the various management practices that they can use to adapt to changing climatic conditions.

**Poor Access to farm inputs:** Agriculture is intimately linked to other aspects pf development. This is true of its relationship to urban growth and growth of urban incomes. It is paradoxical that those who suffer famine were the smallholder farmers in rural areas. Maurice F. Strong (1989). With regards to poor access to inputs, empirical evidence has shown that small holder farmers do respond positively to incentives to farmers as much as commercial farmers. In this study a bout 3.4% of the respondents did indicate the impact of access to farm inputs as another hindrance to negatively influencing production of Maize and beans. This perception was more prevalent for farmers in the dry areas of the Middleveld and Lowveld. In this study However, Small holder farmers across all Agroecological Zones did not consider access to Inputs as a critical negative factor to Maize and Bean Production. This finding is true, because due to the Inputs support program which started in 2013/14 Season farmers have had access to inputs and these were no longer limiting

**Low Soil fertility**

Soil fertility depletion in small holder farms is currently recognized as the fundamental biophysical course of declining per capita food production in Africa (Sanchez et al 1997.,I Haque., N.Z. Lupwayi, 2003). Therefore, soil Improvement in the different agro-ecological zones are critical for improved soil fertility. Even though respondents from the various Agro-ecological zones differed in their perception and soil improvement practices, they were unanimous in that soil fertility is another constraint to crop production in Swaziland. Soils are low in fertility and they are being depleted by constant cultivation (Anon, 2010). Even though, during the Winter Months in the Highveld farmers distribute kraal manure to improve soil fertility in the fields earmarked for planting, this is not in the right quantity and quality.

**Coping strategy**

Gbetibouo (2009) observed that despite the fact that most farmers perceived climate to have changed, very few have actually taken measures to adapt. This is disputed by this study as from the Study, it is observed that the majority of farmers adopted climate mitigation measures such as changing the planting dates (76%) as one coping strategy. This was followed by diversification (56%) to other drought tolerant crops and use of different varieties (49% ) than maize and diversification to Sweet-potato. Conservation agriculture was recommended by farmers not as a coping strategy but an alternative technology for Environmental management. Alemayehu; et al (2017) found out that changing crop planting dates was the most preferred coping strategy for famers in the Central Highlands of Ethiopia. IPCC, 2007, states that adaptation to climatic change is an essential strategy for reducing the severity and cost of climate change impacts. Adaptation measures help farmers guard against losses due to increasing temperature and increasing precipitation.

## 5. Conclusion

The study, concluded that Small holder farmers in all agro-ecological zones agreed that Climate Variability has resulted in increased temperature and variations in rainfall, and its distribution and pattern. These findings and the data obtained from the meteorological unit concur in that, during the period from 1985 to 2015, the rainfall figures showed variations in the Seasonal amounts.

The perception of small holder farmers on the seasonal shift expressed that the season now starts around October to December when meaning full rainfall starts falling. To cope with this climate change phenomenon, farmers have opted to use different varieties of maize, change planting dates, adopt soil conservation technologies, and diversify to root crops such as Sweet-potato. As coping strategies against the impact of Climate change. It is now imperative that Small holder farmers have to adapt to the dictates of climate change if small holder agriculture has to thrive in the country.

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## Biographical Note

Son to a small holder farmer in Swaziland, Wilson developed a liking for agriculture from a young age. From the age of 10 years he would join his father in the ploughing activities. This childhood experience helped him choose his career. After high School he joined the University of Botswana and Swaziland to pursues a Diploma in Agriculture. Then his Batchelors degree at Mississippi State University in the USA, with a major in Seed Science. He obtained a Masters Degree in Agriculture extension after which he enrolled at the University of South Africa (UNISA) for his PhD in Environmental Management.

He was one of the only two Seed Technologist in the country, moving on to become the National Seed Scientist. He joined the Food and Agriculture Organization (FAO) of the United Nations as National Project Director. He was then Deputy Director for Agriculture Extension. He is a member of various Boards, including being in the board of Directors for the national Agriculture Marketing Board (NAMBOARD). Also being a Board of Director at the Lutheran Development Service (LDS).

Published in the GERMAN ADULT EDUCATION JOURNAL and in New Zealand where he studied Seed Technology at Massey University. Currently, he is managing a 37.8 Million USD project in Swaziland funded by the Indian Exim Bank of India. Part time Lecturer at the University of Swaziland.

Wilson is a rounded agriculture and environmentalist who is very much concerned about the Biophysical factors of Climate change and their impacts on Small holder farmers productivity and food security. This is borne from his humble beginning as a son of a small holder farmer in Swaziland.