DETERMINANTS OF CHOICE OF CROP VARIETY AS CLIMATE CHANGE
ADAPTATION OPTION IN ARID REGIONS OF ZIMBABWE

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ABSTRACT
Impacts of climate change in developing countries remain poorly understood because few studies have successfully analyses the overall impact of climate on developing country economies. Agricultural growth is widely viewed as an effective and most important way to reduce poverty in developing countries which are hardly hit by the adverse effects of climate change (Datt and Ravallion, 1996). Despite this knowledge the main challenge is how to increase agricultural productivity to improve household welfare and increase food security in these changing and challenging climatic conditions. This study used the multinomial logit model to analyse the determinants of farmers’ choice of crop variety in the face of climate change. The estimation of the multinomial logit was done by using the sorghum variety options as dependent variable and where farmers grow other crop different from sorghum as the reference state. Results show that the key determinants of choosing crop variety are; the price of existing crop variety, level of education of farmers, the size of the farms, government policies and incentives and credit availability.

KEY WORDS
Climate change; Arid regions; Biotic; Drought resistant crops; Multinomial logit.

Climate change is change in the numerical distribution of weather around an average over periods of time that range from decades to millions of years (Wigley, 1999; McCarthy, et al., 2001; IPCC, 2007a). Climate change may be limited to a specific region or may occur across policy, climate change usually refers to changes in modern climate which is sometimes qualified as anthropogenic or human induced climate change or "Global Warming" (Wigley, 1999; USAID, 2007; Biermann, 2007).

Empirical evidence (IPCC, 2007b; Assan and Kumar, 2009) shows that climate change and environmental variability is emerging as one of the most important challenges of the 21st century. World bank (2003) also notes that frequency of heavy precipitation events has increased over most land areas and widespread changes in extreme temperatures has been recorded over the last 50 years. These recent trends, according to World Bank (2003), show a tendency towards greater extremes where arid or semi-arid areas especially in northern, western, eastern and parts of southern Africa will become steadily drier, with increased magnitude and variability of precipitations and storms. Climate science contends that even if all anthropogenic greenhouse gas emissions ceased immediately, the world would still experience substantial climate change (IPCC, 2007a; JNCC, 2008).

Climate change affects agriculture and food production in complex ways (IPCC, 2007b; Hassan and Nhemachena, 2008; Dinar et al, 2008). It affects food production directly through changes in agro-ecological conditions and indirectly by influencing growth and distribution of incomes, and thus demand for agricultural products. Since the agriculture sector is the backbone of many developing country economies, decreased output in the sector will have negative impact on the overall economic performance.

Numerous partial equilibrium studies have assessed the micro impacts of climate change on agriculture in developing countries (Deressa 2007, Deressa and Hassan 2009, Hassan and Nhemachena 2008). Though extensive research and empirical work exists on the impact of climate change on agriculture, there is limited focus on the literature review of
impact of climate change on the overall economy. There is need for a detailed review of
literature and the methods of measuring the impact of climate change on the economy.

Many arid regions of Africa are already experiencing unpredictable weather, with more
frequent droughts, floods, and strong winds being experienced. Africa in particular, is
susceptible to climate change and the main reasons include: over reliance on rain-fed
agriculture and other activities that are highly weather-sensitive; inadequate water supply,
and degradation of many of its natural resources. Rapid population growth, inadequate basic
infrastructure, and weakening social institutions and safety nets only increase its
susceptibility to variations and changes in climate, threatening to undo decades of poverty
reduction and development achievements. Given that about 80% of the African countries
regions are classified as Arid and Semi-Arid, climate change poses new other threats to
water availability, agriculture and food security, human and animal health, biodiversity,
transport and tourism among others.

While on one hand, climate has always dictated the kind of crops that people grow or
livestock that people rear, activities of human-kind, on the other hand have over the last two
centuries become a key determinant of climate on a global scale (IPCC, 2007b). The climatic
parameters that influence the socioeconomic prospects and problems are the annual rainfall
(its spatial and temporal distribution) and temperature fluctuations. Some of the
socioeconomic problems emanating from climate related factors have manifested
themselves in sectors such as arable agriculture (both rain-fed and irrigated); livestock
production, energy sector, wildlife sector and health sector among others. This may led to the
problems of desertification, food insecurity, low hydroelectric power production during
drought season; and decimation of livestock through recurrent droughts.

Increased temperatures are likely to exacerbate the drought conditions already
experienced and may in future have significant effect on water and food availability. More
unpredictability in seasonal rainfall has caused an increase in short heavy rainfall periods
leading to flooding, landslides and water pollution which may be worse during coming years.
Increased incidences of drought and persistent susceptibility of the rural poor to the
variations and change in climate has posed serious threat not only on the capacity of
poverty-reduction initiatives but also on agricultural production activities and food security,
especially in the arid and semi-arid regions.

Agricultural growth is widely viewed as an effective and most important way to reduce
poverty in developing countries which are hardly hit by the adverse effects of climate change
(Datt and Ravallion, 1996). Despite this knowledge the main challenge is how to increase
agricultural productivity to improve household welfare and increase food security in these
changing and challenging climatic conditions. Area expansion and irrigation have become a
minimal source of output growth, thus growth will depend more on adoption of yield
increasing varieties and crop/variety diversification (Hossain, 1989). Agriculture productivity
can only come from growth in yields from adoption of new improved crop varieties from
agricultural technology. Agricultural technology can be an important factor for improving
household welfare in rural areas in the face of frequent droughts due to climate change and,
the adoption of the new crop varieties can leads to increased agricultural productivity.
Increased productivity can help reduce poverty by increasing farmers’ income, reducing food
prices and therefore enhancing increments in consumption (Diagne et al., 2009). To increase
agricultural productivity rural household must adopt the new improved crop varieties which
mature early and are drought tolerant. The benefits of these crop improvement technologies
depend on household adoption patterns which are influenced by different socio-economic
and farm type factors. Thus, the impact of new crop varieties will be affected by both local
conditions and household characteristics.

Though the new crop variety can improve productivity, food and crop resilience cannot
be guaranteed because these varieties are susceptible to pests and disease compared to the
traditional varieties. Climate change affects both the biotic and abiotic factors of crop
systems that threaten crop sustainability and production conditions (Matson et al., 1997). To
buffer crop production from the effects of greater climate variability and extreme events,
variety diversification is the most rational and cost effective method. Many agricultural based
economies have few other livelihoods strategies (Tilman et al., 2002), thus the development of resilience agricultural systems through varieties diversification is essential since many communities depends on agriculture for livelihoods (Altieri, 1999). In Africa many small farms have little capital to invest in expensive adaptation strategies and pests and disease control mechanisms, hence they are more vulnerable to food insecurity. Farmers can promote natural barriers to diseases and pests and increase production stability through crop varieties diversification.

Food insecurity and poverty is widespread in rural Africa because of persistent crop failure due to increased frequency of drought. The proportion of people suffering from food insecurity is high in arid and semi-arid region because they lack the capacity to adapt to climate change. In this regard, various adaptations have been undertaken in these areas to improve crop productivity. However most of these strategies that have targeted water and soil management have failed to ascertain food security for rural households. In drought stricken areas the Zimbabwe government started promoting the development and adoption of crop varieties of small grain crops to increase household food supply. The aim was to improve the productivity of sorghum and millet in drier regions of the country. With the help of donors and research institutions, several improved crop varieties of different crops have been developed and disseminated to the farmers. In spite of these efforts, empirical studies proved that adoption of these crop varieties by rural farmers is still limited leading to reduced yield in drought prone areas. According to Sech (2008), the unavailability of new variety seeds is the major constraint to successful adoption in many rural areas. Thus in order to ascertain agriculture productivity and food security, access to seeds must increase to lead to higher yield (Dontsop-Nguezet et al., 2011). These new varieties are prone to diseases and pests thus to improve food and crop resilience there is need for diversification with the traditional crop varieties.

Though several research have attempted to analyse the impact of climate and factors affecting the choice of adaptation methods in crop, livestock and mixed crop livestock production systems in Africa (Maddison, 2006; Kurukulasuriya and Mendelsohn, 2008; Seo and Mendelsohn, 2008; Hassan and Nhemachena, 2008), the determinants of farmers’ choice of crop varieties have not been investigated in detail in Zimbabwe. The primary goal of this paper is to investigate the determinants of farmers’ choice of crop variety in Chivi district. This district in Masvingo province is chosen because it represents an ideal arid region (region 5) in Zimbabwe.

**ANALYTICAL AND EMPIRICAL FRAMEWORK**

Smallholder farmer in arid regions may decide to grow a particular crop variety or practice a certain cropping pattern if the perceived utility is greater than from other choices available. Let $U_j$ and $U_k$ represent utility from two cropping choices, then random utility models are given by:

$$U_j = \beta_j X_i + \epsilon_j$$ and $$U_k = \beta_k X_i + \epsilon_k,$$

where $X_i$ is a vector of explanatory variables; $\beta_j, \beta_k$ - represent estimation parameters and, $\epsilon_j, \epsilon_k$ -represents error terms. Thus the farmer will decide to grow crop $j$ if perceived utility ($U_j$) is greater than from other cropping options ($U_k$). The probability that a household will grow crop variety j is given by:

$$p(\beta_j X_i - \beta_k X_k + \epsilon_j - \epsilon_k > 0 / X)$$

The study used the multinomial logit model to analyse the determinants of farmers’ choice of crop variety in the face of climate change. The multinomial logit model is used
because it allows the analysis of decisions across more than two categories and computationally simple (Tse, 1987). Let \( y \) denote the choice of crop variety taking value (1,2,\ldots,j) and \( x \) represents a set of conditional variables. The multinomial model response probabilities are given:

\[
P(y = j / x) = \frac{\exp(x\beta_j)}{1 + \sum_{i=1}^{j} \exp(x\beta_i)}
\]

To calculate the expected change in probability of a particular crop variety, we calculate the marginal effects as follows:

\[
\frac{\partial p_j}{\partial x_k} = P_j(\beta_{jk} - \sum_{j=1}^{j-1} P_j\beta_{jk})
\]

For this study, there are four main cropping patterns that are being practised in Chivi district: 1. No sorghum production; 2. Growing of traditional varieties; 3. Growing of new crop varieties; 4. Growing mixed varieties.

**DATA AND VARIABLES**

Data for this study was collected from both primary and secondary sources. While primary data was obtained from survey and interviewing households in Chivi District, secondary data was obtained from documentary reviews among institutional libraries.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Expected sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agehh</td>
<td>Age of household head at the time of adoption</td>
<td>+ or -</td>
</tr>
<tr>
<td>Educa</td>
<td>Years of formal education of household head</td>
<td>+</td>
</tr>
<tr>
<td>Farmize</td>
<td>Farm size in acres at the time of adoption</td>
<td>+</td>
</tr>
<tr>
<td>Credit</td>
<td>Access to credit facility</td>
<td>+</td>
</tr>
<tr>
<td>Input price</td>
<td>price of sorghum seeds variety at adoption year($/10kg bag)</td>
<td>-</td>
</tr>
<tr>
<td>distance</td>
<td>Distance from input market(km)</td>
<td>-</td>
</tr>
<tr>
<td>Extension</td>
<td>Farmer received information on new sorghum variety at the first adoption</td>
<td>+</td>
</tr>
</tbody>
</table>

A structured questionnaire was used to gather both qualitative and quantitative information covering aspects about climate change adaptation and sorghum varieties grown by farming households in Chivi District.

**RESULTS AND DISCUSSIONS**

The estimation of the multinomial logit was done by using the sorghum variety options as dependent variable and where farmers grow other crop different from sorghum as the reference state. The main problem of the multinomial logit results is that they only give the direction of the independent variables on the dependent variable and no actual magnitude of the probability. This study presented the marginal effects which measures the expected change in the probability of a particular choice. The chi2 statistics was highly significant (\( P < 0.0000 \)) denoting a strong explanatory power of the model.

Education of household tend to decrease the probability of growing the traditional sorghum varieties and increase the probability of farmers to grow new sorghum varieties which are better adapted to drier conditions. A unit increase in years of schooling will result in
about 52 percent decrease in traditional sorghum varieties production and a 5 percent change of growing new early maturing varieties.

Age of household head which represent farming experience influence the choice of sorghum varieties by farming household in Chivi district. Age of household head tend to decrease the probability of growing traditional sorghum varieties but increases the probability of growing new sorghum varieties. For instance, a unit increase in age result in 64 percent decrease in the probability of growing traditional varieties and a 5 percent increase in the probability of growing new sorghum varieties.

Table 2. Descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agehh</td>
<td>41.94</td>
<td>12.15</td>
<td>1,00</td>
</tr>
<tr>
<td>education</td>
<td>1.35</td>
<td>1.23</td>
<td>1,00</td>
</tr>
<tr>
<td>Distance</td>
<td>5.74</td>
<td>1.48</td>
<td>1,00</td>
</tr>
<tr>
<td>Credit</td>
<td>-</td>
<td>-</td>
<td>1,00</td>
</tr>
<tr>
<td>Input price</td>
<td>10.62</td>
<td>8.03</td>
<td>92.34</td>
</tr>
<tr>
<td>extension</td>
<td>-</td>
<td>-</td>
<td>14.05</td>
</tr>
<tr>
<td>Farm size</td>
<td>8.19</td>
<td>12.02</td>
<td>1,00</td>
</tr>
</tbody>
</table>

Table 3. Results of multinomial logit model (marginal effects)

<table>
<thead>
<tr>
<th>variable</th>
<th>Traditional varieties</th>
<th>New varieties</th>
<th>Mixed varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agehh</td>
<td>-0.6475** (-2.54)</td>
<td>0.0531* (1.10)</td>
<td>0.0303</td>
</tr>
<tr>
<td>education</td>
<td>-0.5266*** (-2.04)</td>
<td>0.053* (1.71)</td>
<td>0.0179</td>
</tr>
<tr>
<td>distance</td>
<td>-0.0556 (-0.39)</td>
<td>0.242 (1.07)</td>
<td>0.582*</td>
</tr>
<tr>
<td>Credit</td>
<td>0.203*** (3.54)</td>
<td>0.1024* (1.88)</td>
<td>0.018**</td>
</tr>
<tr>
<td>Input price</td>
<td>0.205*** (3.94)</td>
<td>-0.155*** (2.75)</td>
<td>0.120**</td>
</tr>
<tr>
<td>extension</td>
<td>0.080 (0.55)</td>
<td>-0.3260 (-1.43)</td>
<td>-3.318</td>
</tr>
<tr>
<td>Farm size</td>
<td>0.490*** (5.23)</td>
<td>0.147* (1.98)</td>
<td>0.065*</td>
</tr>
</tbody>
</table>

Note: *** denotes significance at 1%, ** denotes significance at 5%, * denotes significance at 10%. Log likelihood = -137.10; Prob(chi2)=0.0000; LR chi2(32)=127.58; T-statistics in parenthesis.

Price of sorghum seeds significantly influences the probability of farmers to grow different sorghum varieties. Input price tends to increase the probability of growing traditional sorghum varieties which are ready available to farmers but tends to decrease the probability of growing new and mixed varieties. A unit increase in the price of sorghum seeds result in 21 percent increase in growing of traditional varieties and 15 percent decrease in probability of growing the new sorghum varieties. Since most of these rural farmers have limited income sources, increase in the price of sorghum render it unaffordable to most farmers thus the start to growing the traditional seeds from previous year’s harvest.

The size of the farm owned by each household tends to influence the growing of both traditional and new sorghum varieties. A unit increase in farm size result in 49 percent increase in probability of growing traditional sorghum varieties, 15 and 6 percent increase in probability of growing new and mixed sorghum varieties respectively. This may be because when the farmers has large pieces of land they can afford to apportion the land and grow different varieties on these land apartament, thereby increasing the success rate of crops.

Availability of credit to farmers increases the probability of growing different sorghum varieties by farming households. Credit increases the probability of growing both the traditional and new sorghum varieties or even mixing the sorghum varieties. A unit increase prin credit facility to farmers lead to 20 percent increase in the probability of growing traditional sorghum varieties and 10 percent increase in the probability of growing new
sorghum varieties. The credit facility to farmers will enable farmers to afford certified seeds of both traditional and new varieties which are highly productive. Thus when farmers have access to credit they can grow the traditional varieties or new varieties and be able to have increase yields.

CONCLUSION AND RECOMMENDATIONS

From the results of the study presented above, it is recommended that authorities in developing countries such as Zimbabwe should put in place policies design to increase educational standards of households. Educated and literate farmers are less resistant to change. The price of small grain such as sorghum inputs plays a significant role in encouraging the introduction of new crop varieties. This implies that the price elasticity of demand for sorghum seed is elastic. A marginal increase of the price of traditional brand will result in a huge decrease in the quantity demanded for that seed brand. The savings can be used to purchase other varieties of sorghum seed. Alternatively authorities could subsidize the price of preferred sorghum seeds or any drought resistant seed. The government can also introduce policies and incentives to farmers who grow new small drought resistant crops in semi-arid and arid regions. Such incentives could be in form of tax rebates or shows where winners would walk away with prizes. The government through financial institutions such the land bank or commercial banks can provide credit facilities to farmers. With the Zimbabwean’s ongoing land reform, the government should consider allocating optimal farms to new farmers who are in semi-arid and arid areas of Zimbabwe. With more land a farmer will have space to grow both existing and new varieties small grain crops. In conclusion this study established that in the face of changing climate, introducing new crop varieties in semi-arid and arid regions could result in more food security and increase in farmers’ welfare. However, it is of great importance to identity key determinants of choosing crop variety.

REFERENCES


