International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Impacts of Climate Variability and Change and Farmers' Responsiveness in the Agricultural Sector in Zimbabwe

W. Muzari[1], S. Muvhunzi[1], G. Soropa[2], O. L. Kupika[3]

[1]Department of Agricultural Engineering, Chinhoyi University of Technology, P. Bag 7724, Chinhoyi, Zimbabwe
[2]Department of Crop Science and Post Harvest Technology, Chinhoyi University of Technology
[3]Department of Wildlife, Ecology and Conservation, Chinhoyi University of Technology

Abstract: ***Agriculture makes a substantial contribution to Zimbabwe's economy in terms of employment creation, household incomes, food security and economic growth. In recent decades, the performance of the agricultural sector has been hampered by frequent droughts. The paper uses research results from published and unpublished works to determine the impacts of climate variability and change on crop production, agricultural land use, crop marketing, livestock production, and rural poverty. It also looks at the positive impacts of climate change and farmers' perspectives on climate change and variability. The adverse impacts of climate change are thought to dominate in the drier semi-arid smallholder communal farming regions. A small temperature rise has been estimated to substantially reduce farm incomes and increase the expanse of drier zones. Meat, milk and draft power productivity will decrease owing to droughts that affect vegetation and water resources in the rangelands. Rural poverty will be exacerbated by climate change. Finally, extended periods of wet weather due to excessive rains will adversely affect crop marketing through crop quality deterioration and destruction of physical marketing infrastructure. However, droughts, floods and excessive rains can also have positive impacts in the form of increased remittances from migrants who migrated in search of alternative sources of livelihood. Moreover, in the aftermath of droughts and excessive rains, livestock have access to abundant water and good quality vegetation to feed on. Furthermore, enough water is available for domestic purposes and watering gardens. Wild fruits and late-planted crops also flourish to the benefit of rural households. Farmers in Zimbabwe perceive that rainfall has become more unpredictable and that the prevalence of mid-season drought spells has increased. In addition, years of below-normal rainfall are becoming more frequent, semi-arid areas are getting drier, temperatures have increased, and droughts and floods are often occurring back-to-back in the same season.***

Keywords: impacts, climate variability, climate change, farmer, agricultural sector

1. Introduction

Agriculture is the mainstay of Zimbabwe's economy. It makes substantial impact in terms of employment creation, contribution to household income, food security and economic growth (Mutekwa, 2009). The bulk of raw materials for agro-based industries comes from the domestic agricultural sector. (Chipindu, 2011). In recent decades, the country has been prone to droughts which have decimated livestock numbers and crop production levels. The Land Redistribution and Resettlement Programme, which reached its peak in the post-2000 period, has resulted in major changes in land tenure, landholding sizes and utilization patterns in the agricultural sector (Chipindu, 2011). In addition to the large-scale commercial, small-scale commercial and communal farming sub-sectors, the land reform programme has given rise to three new sub-sectors, namely the old resettlement, the A1 (village-type), and A2 (larger sub-divisions of former large scale farms). There are differences in the capacity of farmers to adapt to the impacts of climate variability and change among these agricultural sub-sectors (Parry et al., 1999; Rosenzweig & Hillel, 1995).

2. Climate Change and Variability Impacts on Crop Production

A study done to see how agricultural production would respond to climate change in Zimbabwe indicates that a 2.5 ^{o}C increase in temperature would decrease net farm revenues by USD 0.4 billion (Mubaya, 2010). A 5 ^{o}C rise in temperature would decrease net farm revenues across all farms, dryland farms and farms with irrigation by USD 0.4 billion, USD 0.5 billion and USD 0.003 billion respectively (Mano & Nhemachena, 2006). Moreover, a 7% decrease in precipitation would result in a decrease in net farm revenue by USD 0.3 billion for all farms (Mubaya, 2010).

The major climate change variable that affects maize yields under rain-fed conditions is temperature rise, which shortens the crop growth period, particularly the grain-filling period (Mwamuka et al., 1995). These changes are more pronounced in Natural Region IV of Zimbabwe, where the bulk of the smallholder farmers are concentrated. Although irrigation will boost maize production in all areas, the yields are lower under climate change conditions than under normal climate.

3. Climate Change Impacts on Agricultural Land Use

Downing (1992) used a simple index of the atmospheric water balance to assess how agricultural land use may be affected due to changes in climate. The following were some of his findings.

With temperature increase of 2 ^{o}C the wet zones in Zimbabwe (with a water surplus) decrease by a third from

9 percent to about 2.5 percent. In addition, the drier zones will double in area. A further increase in temperature of +4 ^{o}C reduces the summer water-surplus zones to less than 2 percent of Zimbabwe, approximately corresponding to the 1991-92 drought. Furthermore, crop yields in marginal zones would become more variable.

Simulations done by Muchena (1991) indicated that with +2 ^{o}C of warming, yields currently expected 70 percent of the time would be exceeded only in 40 percent of the years. Such studies indicate that smallholder farmers in the marginal semi-arid regions of Zimbabwe are the most vulnerable to climate change.

4. Climate Change and Variability Impacts on Crop Marketing

Climate variability and change in Zimbabwe has often resulted in extended periods of wet weather. Prolonged damp conditions cause crops to rot, thus reducing their quality. Poor quality crops fetch low prices on the market, and this is detrimental to the farming objective of maximizing profit from farming operations. Flooding conditions also destroy roads and bridges, and this discourages transporters of crop and livestock produce as well as agricultural inputs and equipment from operating in agricultural producing areas (Muteka, 2009). Farmers, particularly smallholders, will remain stuck with their produce, or will be unable to obtain inputs for the next agricultural season, until the rural road infrastructure has been repaired. Due to shortages of public funds however, rural roads, especially in the smallholder communal farming areas, can go unrepaired for years, and this jeopardizes agricultural marketing activities.

5. Impacts on Livestock Production

Climate change reduces precipitation and consequently vegetative vigour and water resources in the grazing lands. Livestock that feed on the vegetation and water will have lower body weight, leading to reduced meat, milk and draft power productivity (Muteka, 2009; Mubaya, 2010; Meadows & Hoffman, 2003; Puigdefabregas, 1998; Vetter, 2009). Livestock productivity is clearly dependent on the associated productivity of vegetation in the rangelands (Meadows, 2005).

In addition, alternate wet, dry and hot conditions have led to the prevalence of livestock diseases such as foot and mouth, anthrax, black leg and lumpy skin in the Zimbabwean livestock sub-sector (Parker et al., 2002; Hall, 1988).

6. Climate Change Impacts On Rural Poverty

In Zimbabwe, agriculture provides employment, income, food security and nutrition for the majority of the rural population. Poor performance of the agricultural sector in terms of productivity and income will therefore jeopardize rural livelihoods and increase the incidence of rural poverty (Mubaya, 2010; Kurukusirya & Rosenthal, 2003).

Climate variability and change in Zimbabwe has resulted in sale of assets, indebtedness, out-migration, low incomes, hunger, malnutrition, poverty, and dependence on food relief among smallholders (Muteka, 2009; Mubaya, 2010). The ultimate results are perennial shortages of school fees, high school drop-out rates among pupils, and escalating crime rates among the youths. (Mubaya, 2010).

7. Positive Impacts of Climate Change

During drought periods in Zimbabwe, the most vibrant section of the rural population, namely able-bodied youths, have migrated to the towns, cities and neighbouring countries in search of salaried employment. The migrants have frequently benefited by obtaining a higher and more stable source of income than agriculture. In addition, the population that remained in the rural areas have also benefited from the remittances in cash and kind sent back home from the distant work places. Previous research in Zimbabwe has indeed confirmed that remittances and livelihood diversification are important sources of livelihood (Drimie & Gandure 2005; Scoones, 1996).

Floods and excessive rains also have made some positive contributions to on farmers' livelihoods. In the aftermath of floods, livestock have access to good quality vegetation to feed on (Mubaya, 2010). During this time, pastures and vegetation tend to be lavish green and of good quality, and there is adequate water for livestock, which is essential for good animal health (Turpie et al., 2002). Enough water is also available for use in the home (washing, bathing and cooking) and for watering the vegetable gardens.

Excessive rains also result in good fruiting of trees and households benefit from the consumption of wild fruits (Mubaya, 2010). In Zimbabwe, late but abundant rains cause late-planted crops to yield heavier than usual.

8. Farmers' Perspectives on Climate Change and Variability

A better understanding of farmer perceptions regarding climate change and variability, current adaptation measures and their determinants is an essential pre-requisite for a well-informed climate change adaptation policy (Nhemachena & Hassan, 2007; Legesse, 2006; Eyob, 1999). Smallholders' perceptions of risk responses will determine the type and effectiveness of intervention measures in the country.

Smallholders in Zimbabwe have observed the following changes in climate in recent decades. First, rainfall patterns have become highly unpredictable. Secondly, the prevalence of mid-season dry spells has increased (Muteka, 2009). Thirdly, years of below-normal rainfall are becoming more frequent, worsening the food insecurity situation among smallholders. Fourth, it is not uncommon to experience droughts and floods back-to-back during the same season. (Mubaya, 2010). Fifth, semi-arid areas are getting drier (Muteka, 2009), and rainy seasons have become shorter. Sixth, temperatures have increased (Mubaya, 2009), and farmers have started experiencing warmer winters than before.

The greater proportion of smallholder farmers in Zimbabwe perceives climate change as a purely natural phenomenon, without any human intervention being responsible for climate change. There is also an indication that farmers seriously disregard the role played by anthropogenic activities in the increase in climate variability and change. Rather, they attribute the changes to supernatural causes. For example, farmers in Lower Gweru in Zimbabwe "assert that causes of climate change have also been due factors such as the wrath of cultural spirits and God who have meted out punishment to Zimbabwe. The punishment has been for the failure of people to continue to appease their spirits and conduct traditional rites such as the rainmaking ceremony (*mukwerera*) for asking for rain from God and for showing gratitude for the rains in the previous season" (Mubaya, 2010). Farmers in the semi-arid regions of Zimbabwe such as Lower Gweru and Zvishavane closely associate changes in weather conditions with crop productivity (Mubaya, 2010; Muteka, 2009).

9. Farmers' Responses to Climate Variability and Change

Recurrent droughts in Zimbabwe and Southern Africa have alerted the farmers to the need to re-examine land use and management practices and farm infrastructure. Feasible responses to climate change and adaptation include diversification of crop and livestock varieties (Benioff et al. , 1996; Downing et al., 1997; Baker & Viglizzo, 1998); switching to drought-tolerant small grains and maize varieties (Mubaya, 2010); appropriate management practices (Matarira et al., 1995; Mubaya, 2010); and making full use of weather information (Matarira et al., 1995).

In the semi-arid communal areas of Zimbabwe, most farmers adapt by planting short season varieties, crop diversification, and varying planting dates (Muteka, 2009). The main thrust of these strategies is increased crop diversification and escaping sensitive growth stages through crop management practices that ensure that critical crop growth stages do not coincide with harsh climatic conditions in the season, such as mid-season droughts (Nhemachena & Hassan, 2007). Crop diversification improves household food security since different crops are affected differently by the same climatic conditions. Also, given the high frequency of mid-season droughts, smallholder farmers grow short season and drought-resistant crop varieties, such as sorghum, rapoko (finger millet), and mhunga (pearl millet) (Muteka, 2009). For a staple crop, such as maize, instead of planting local varieties, farmers have opted for hybrid maize that takes a shorter period to mature and yields more than the traditional varieties in good years. However, indigenous varieties that are more adapted to local conditions are being lost as farmers prefer high yielding hybrid maize varieties.

As stated above, farmers may also switch to different crop types or change to more drought- and disease-tolerant crops. Farmers may introduce irrigation systems in areas where high temperatures and rates of evapotranspiration lead to reduced levels of available moisture (Matarira et al., 1995). Switching from monocultures to more diversified agricultural systems will help farmers to cope with changing climatic conditions. Monocultures are more vulnerable to climate change, pests and diseases. The use of livestock breeds adaptable to drought and the use of supplementary feeds (including crop fodder) will give farmers greater flexibility in adapting to climate change.

Changes in management practices can offset many of the potentially negative impacts of climate change (Smith & Mueller-Vollmer, 1993). The timing of various farming operations (e.g. planting dates, application of fertilizers, pesticides and herbicides) will become more critical if farmers are to reduce their vulnerabilities to the impacts of climate change. Adjusting the cropping sequence, including changing the timing of sowing, planting, spraying, and harvesting, to take advantage of the changing duration of growing seasons and associated heat and moisture levels is another option (Kurukulasurya & Rosenthal, 2003). Altering the time at which fields are sowed or planted can also help farmers regulate the length of the growing season to better suit the changed environment. Farmer adaptation can also involve changing the timing of irrigation (de Loe et al., 1999) or use of other inputs such as fertilizers (Chiotti & Johnston, 1995. Besides the timing of the various operations, planting densities and application rates of agro-chemicals and fertilizers will also be of major importance. Brlacich et al. (2000) suggest that altering the intensity of fertilizer and pesticide application as well as capital and labour inputs can help reduce risks from climate change in farm production. The use of conservation tillage, inter-cropping and crop rotation practices will enhance the long-term sustainability of soils and improve the resilience of crops to changes due to climate change (EPA, 1992). Other adaptation strategies in semi-arid areas of the country include growing legumes (such as beans) towards the end of the rainy season when cereals fail, mainly due to excessive rainfall, and application of more fertilizers when nutrients are heavily leached from the soils. Legumes mature fast and provide nutritious relish. They also fetch good prices on the market. However, application of chemical fertilizers as an adaptation strategy has its own challenges; chemical fertilizers are scarce and exorbitantly priced in Zimbabwe and most smallholder farmers cannot afford them.

Changes in land use practices such as the location of crop and livestock production, rotating or shifting production between crops and livestock, and shifting production away from marginal areas can help reduce soil erosion and improve moisture and nutrient retention. The latter includes not only changes in land allocation for different uses, but also the abandonment of land altogether and the cultivation of new land (Kaiser et al., 1993; Lewandrowski & Brazee, 1993; Reilly, 1995; El-Shaer et al., 1996; Erda, 1996; Easterling, 1996; Iglesias et al., 1996; Mizina et al., 1999; Parry, 2000). For areas where cropping becomes non-viable, livestock and dairy production can take over as the major agricultural activity (Matarira et al., 1995).

In addition, Baker et al. (1998) highlight several adaptation measures for livestock and rangeland management that have emerged to offset climate impacts. Possibilities include shifts in biological diversity, species composition and/ or distribution. The options also include change in grazing management (timing, duration, and location) or in mix of grazers or browsers; varying supplementary feeding; changing the location of watering points; altering the breeding management programme; changes in rangeland management practices; modifying operation production strategies as well as changing market strategies. Other recommendations based on recommendations in IPCC (1996) include adjusting livestock stocking rates; implementing feed conservation techniques and fodder banks to moderate the consequences for animal production during periods of poor crops; changing the mix of grazing or browsing animals; altering animal distribution by the use of mineral blocks, watering points, and fences; implementing weed management programmes; restoring degraded areas; and increasing native rangeland vegetation or plant-adapted species.

A range of management practices have also emerged that can assist farmers adapt to loss of soil moisture and organic carbon contents and increased soil erosion as a result of changing climatic conditions. These include improved nutrient management techniques to maintain soil fertility and prevent erosion (Erda, 1996; Parry et al., 2000). The introduction of management techniques that conserve soil moisture, such as reduced or no tillage, in order to maintain soil organic carbon contents can result in improved soil structure and fertility. Furthermore, changing land topography through land contouring and terracing and construction of diversions and reservoirs and water storage and recharge areas can help reduce vulnerability by reducing runoff and erosion and promoting nutrient restocking in soils (Smit, 1993; Easterling, 1996; Loe et al., 1999).

In light of the increased frequency of droughts, farmers can further adapt by changing the selection of crops. Inevitably, this will lead to shifts in the distribution of agricultural land use, which in itself will have impacts on soils (Kurukulasuriya & Rosental, 2003). Soil and water conservation strategies, such as water harvesting activities, which are currently being practiced by a considerable proportion of smallholder farmers in Zimbabwe, are being intensified by NGOs and Agricultural Extension Officers (Muteka, 2009).

Alternative farm strategies include increasing production per unit of evapotranspiration with the use of new and improved varieties, reducing water use in land preparation as well as loss (through seepage and percolation) during the crop growth period, and adopting efficient water use methods. The diffusion of appropriate technology to enhance greater water use efficiency (e.g. through drip irrigation) is therefore imperative.

It is important to note that the success of these options also requires that others first be in place. For example, Kurukulasuriya and Rosenthal (2003) suggest that investment in institutional support to promote the dissemination of knowledge through extension is crucial. They further add that this should be supported by appropriate land reforms that establish property rights as well as measures that enhance farmers' financial ability to undertake the necessary adaptation (e.g., by improving access to credit and banking facilities in rural areas).

Seasonal effects and climatic uncertainty that characterize the agricultural sector effectively mean that diversification of income and employment opportunities is an important adaptation strategy for households in the sector. In dryland areas, traditional practices to help cope with drought include the accrual of a surplus in a superior year, in the form of cash or assets (e.g. cattle) for use in poorer years (Burton, 2001). While measures such as crop storage, sales, and household savings can and do offer relief from temporary or seasonality effects, risk and market imperfections that abound in rural settings render diversification into off-farm opportunities necessary to reduce income instability (Alderman & Paxson, 1992).

Livelihood diversification has increasingly become an important adaptation strategy, particularly in the semi-arid areas of Zimbabwe. Temporary migration among agricultural households is another form of climate variability and climate change adaptation measure among smallholder farmers. Temporary (or "circular") migration in agriculture includes seasonal migration where workers undertake off-farm or non-farm activities for part of the year, and return during harvest time or to plant a new crop. Other activities, such as gold panning, fruit gathering and selling, are on the increase (Mubaya, 2010). However, activities such as gold panning are illegal and environmentally degrading. The movement of labour from one agricultural area to another area, or across sectors, as well as migration between and within urban and rural areas due to environmental, economic, or demographic reasons, is central to a household's ability to ensure security in livelihood (De Haan, 1999). It has the potential to enhance social resilience of households through temporary diversification of sources of livelihood.

That households engaged in agriculture inherently need insurance mechanisms to cope with income risks has long been recognized. There are four types of risks faced by the agricultural sector, and these are production risks; ecological risks; market risks; and regulatory or institutional risks (Moreddu, 2000). Farm households need insurance to hedge themselves against each of these types of risk. Production risks are a result of weather variation, crop disease and various causalities. Market risks depend on input and price variability. Regulatory or institutional risks are due to state intervention in agriculture. Finally, ecological risks are risks due to pollution, natural resource management, and climate change. Insurance programs, formal and informal, as well as private and public, have been discussed as effective measures to help reduce income losses as a result of climate-related impacts (IPCC, 2001). Insurance is an important adaptation measure for improving the welfare of households. There is likely to be a need for both public and private insurance schemes. In the case of climate variability impacts, with relatively lower probability of occurrence and limited risks, private schemes should be sufficient. However, the increased incidence of climate-related economic losses is likely to reduce the profitability of insurance companies, translating to increases in insurance premiums and consumer prices, withdrawal of insurance coverage, and increase in publicly funded compensation and relief programs.

The timely dissemination of climate forecasting information and early warning to farmers (including information on risks) can strengthen the ability of farmers to cope and optimize the management of hydrological variability and change. Monitoring data and indicators of change are also necessary across all sectors in society, not just for policy makers. A key role for state, society, and media is envisioned through both horizontal and vertical exchanges of information through regular meetings with key stakeholders (Kurukulasuriya & Rosenthal, 2003). All countries in the SADC region, including Zimbabwe, offer seasonal climate forecast data after the SACOF meeting (Muteka, 2009). The forecast in Zimbabwe is issued through various media channels, such as radio, newspapers and television. However, smallholder farmers in recent surveys have professed ignorance of the seasonal climate forecast information and they do not use this information to make efficient use of their limited resources through informed on-farm practices and investment decisions to mitigate against low and variable rainfall, particularly in semi-arid areas (Muteka, 2009).

Farmers' adaptive capacity to climate change is undermined by several factors that range from limited understanding of the nature and consequence of climate change, farm members' health status (particularly in relation to HIV/AIDS), unemployment that is supposed to both complement and supplement agricultural incomes, and poor infrastructure (Muteka, 2009). Other major constraints of farm level adaptations are the high costs involved; and embedded traditional practices (old habits die hard). (Skees et al., 1999).

Agriculture in Zimbabwe is affected in many ways by a wide range of government policies that influence input costs, product pricing and marketing arrangements. Parry and Duinker (1990) have noted that relatively minor alterations can have a marked and quite rapid effect on agriculture. Thus, changes in government policy as a result of climate change or anticipated change would have a very significant influence on how agriculture ultimately responds.

The Government of Zimbabwe is currently constructing a number of medium- to large-sized dams (Matarira et al., 1995). Even though this may be a reaction to recent droughts, this can still be considered to be anticipatory. With the construction of these dams, irrigation schemes can also be established. Some irrigation schemes are already operational in some areas. There is growing evidence of high rates of return to investments in smallholder irrigation systems, and large areas of shallow ground water could be put to intensive cultivation with the backing of appropriate research and development (Rukuni, 1994).

10. Conclusions

There is a need for government to undertake a major review of land-use planning with due consideration given to an integrated resources management approach (Matarira et al., 1995). Thus, any exercise to assess the land tenure systems suitable for Zimbabwe should seriously consider the conferring of ownership to land owners together with formal obligations to the landowner to use the land in a sustainable and productive way. Furthermore, policy reform on water rights in Zimbabwe should reflect the need to conserve and utilize water resources more efficiently. Finally, there is a need for the government of Zimbabwe to establish and strengthen existing institutions that are geared toward extending credit to small-scale and subsistence farmers, and facilitate cost-effective marketing of their produce.

References

[1] ActionAid International (2006). Climate Change and Smallholder Farmers in Malawi: Understanding Poor People's Experiences in Climate Change Adaptation.
[2] Alderman, H. and C.H. Paxson (1992). Do the Poor Insure? A Synthesis of the Literature on Risk and Consumption in Developing Countries. World Bank Policy Research Working Paper 1008. Washington, D.C.
[3] Burton, I. (2001). Vulnerability and Adaptation to Climate Change in the Drylands. The Global Drylands Partnership, Washington, D.C.
[4] Chipindu, B. (2011). Review of Current Status of the Agricultural Sector in Zimbabwe. Presentation at the Inter-Agency Consultation Meeting on User Interface Platform (UIP), Agriculture, Food Security and Water Sectors of the Global Framework for Climate Services, FAO, Rome, Italy, 26-28 September 2011.
[5] Downing, T.E. (1992). Climate Change and Vulnerable Places: Global Food Security and Country Studies in Zimbabwe, Kenya, Senegal and Chile. Research Report No. 1, Environmental Change Unit, University of Oxford, Oxford.
[6] Ellis, F. (1998). Household Strategies and Rural Livelihoods Diversification. The Journal of Development Studies 35 (1): 1-38.
[7] Environmental Protection Agency (EPA) (1992). Agriculture. Climate Change Discussion Series. United States Environmental Protection Agency. Office of Policy, Planning and Evaluation.
[8] IPCC (2001). Climate Change 2001: Impacts, Adaptation and Vulnerability.
[9] Kinuthia, J.H. (1997). Global Warming and Climate Impacts in Southern Africa: How Might Things Change? Kenya Meteorological Department, Nairobi, Kenya.
[10] Kurukulasururiya, P. and S. Rosenthal (2003). Climate Change and Agriculture: A Review of Impacts and Adaptations. Climate Change Series Paper No. 91. The World Bank Environment

Department. Published jointly with the Agriculture and Rural Development Department Department.
[11] Matarira, C.H., J.M. Makadho and F.C. Mwamuka (1995). Zimbabwe: Climate Change Impacts on Maize Production and Adaptive Measures for the Agricultural Sector. CSP Interim Reports-Zimbabwe.
[12] Matarira, C.H., W. Kamukondiwa, F.C. Mwamuka, J.M. Makadho, and L.S. Unganai (1996). Vulnerability and Adaptation Assessment for Zimbabwe. U.S. Country Studies Program, Washington, D.C.
[13] Mubaya, C.P. (2010). Farmer Strategies Towards Climate Variability and Change in Zimbabwe and Zambia. Submitted in accordance with the requirements for the degree Philosophae Doctor, Faculty of Economic and Management Sciences, Centre for Development Support, University of the Free State, Bloemfontein.
[14] Muchena, P. (1991). Implications of Climate Change for Maize Yields in Zimbabwe. Plant Protection Research Institute. Department of Research and Specialist Services, Harare, Zimbabwe.
[15] Muchena, P. (1994). Implications of Climate Change for Maize Yields in Zimbabwe. In C. Rosenzweig and A. Iglesias (eds.)
[16] Mutekwa, V.T. (2009). Climate Change Impacts and Adaptation in the Agricultural Sector: The Case of Smallholder Farmers in Zimbabwe. Journal of Sustainable Development in Africa (Volume 11, No.2): 237-256
[17] Nhemachena, C. and R. Hassan (20070. Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa. IFPRI Discussion Paer 00714 August. International Food Policy Research Institute, Washington, D.C.
[18] Rosenzweig, C. and D. Hillel (1995). Climate Change and the Global Harvest: Potential Impacts of the Greenhouse Effect on Agriculture. Oxford University Press, New York, N.Y.
[19] Rukuni, M. (1994). Getting Agriculture Moving in East and Southern Africa and Framework for Action. Discussion Paper for East and Southern Africa Conference of Agricultural Ministers held in Harare, Zimbabwe, 12-15 April 1994. Commissioned by The World Bank for Global Coalition for Africa.
[20] Smith, J.B. and J. Mueller-Vollmer (1993). Setting Priorities for Adapting to Climate Change. RCG/ Haigler Bailly Inc