ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of DEVELOPMENT RESEARCH

International Journal of Development Research
Vol. 4, Issue, 3, pp. 693-699, March, 2014

Full Length Research Article

IMPACT OF CLIMATE VARIABILITY ON SMALLHOLDER HOUSEHOLDS AND INDIGENOUS COPING STRATEGIES IN BONGO DISTRICT

***Philip Aniah, Augustine Yelfaanibe and Abindaw Bernard, A.**

Department of Development Studies, University for Development Studies, WA Upper West Region

ARTICLE INFO

Article History:
Received 22nd December, 2013
Received in revised form
03rd January, 2014
Accepted 13th February, 2014
Published online 25th March, 2014

Key words:
Climate variability,
Livelihood,
Impact,
Coping mechanism,
Smallholder households.

ABSTRACT

Agriculture is one of the sectors most vulnerable to climate variability impact. The impact is very severe in Africa, where agriculture is predominantly for the daily subsistence, and where adaptive capacity is low. This study considers the Upper East Region of Ghana-Bongo district, as a case study and examines the climatic impacts on the livelihood of small holder households in the region. The study also looked at the local/indigenous coping mechanisms that small holder households have been adapting to reduce their vulnerability to climate change. The study uses semi-structured interview to gather primary data from local communities, government officials and experts. Secondary data were gathered from published and unpublished sources. The result indicates that droughts, delays in rainfall, erratic precipitation, and heavy and unseasonal rain are challenges to the livelihood of the whole region. To cope with the impacts, smallholder households use stone/grass/mud bonding, organic manure application as strategies. Even though all households in the region are vulnerable to climatic change, the problem is more acute for the poor, landless, women, large sized families, unaffordability of agricultural inputs, and water shortage. The study suggests further studies should be conducted to identify, scientifically proof and document the available coping mechanisms, indigenous knowledge/ and innovation.

INTRODUCTION

Many are of the opinion that agriculture is the sector most susceptible to climate variability. This is attributed to the fact that the two most important direct agricultural production inputs, precipitation and temperature are greatly affected by climate variability (Deschenes & Greenstone, 2006). Climate variability also indirectly affects agriculture by influencing emergence and distribution of crop pests and livestock diseases, exacerbating the frequency and distribution of adverse weather conditions, reducing water supplies and irrigation; and enhancing the severity of soil erosion (Watson *et al*. 1998; IPCC, 2001). Despite worldwide coverage of climate variability impacts, there are intra- and inter-sectoral variations in vulnerability depending on location, adaptive capacity and other socioeconomic and environmental factors. In Europe, for instance, the agricultural sector is believed to benefit from gradual climate variability due to the carbon effect and the warming climate (Tol *et al*., 2000; McCarthy, 2001). On the other hand, on continents such as Africa, a continent that has contributed almost nothing to anthropogenic climate variability, the impact is believed to be enhanced. This is attributed to the continent's low adaptive capacity, over-dependence on agricultural sector, marginal climate and existence of many other stressors (Collier *et al*. 2008; McCarthy, 2001). The negative consequences of climate change in Africa are already happening as prevalent from frequent floods, droughts and shift in marginal agricultural systems (Collier *et al*. 2008). The climate change impact on agriculture is believed to be stronger in Sub-Saharan Africa (Kurukulasuriya & Mendelsohn, 2007). To identify and quantify the impact of climate variability on socio-economic sectors and ecosystems, many global studies have been carried-out and policy changes for mitigation and adaptation have been proposed. However, though there are sufficient evidences of climate variability and its impacts, the global policy decisions have faced continued political hindrances. Further and more importantly, the traditional top-down approach (global study) has little local and regional specificity and has failed to address the regional and local impacts and the local abilities to adapt to climate change impacts (Yarnal, 1998; Smit & Pilifosova, 2003). This is particularly a challenge in case of subsistent agriculture sector. This is because modeling or predicting climate variability impact on predominantly subsistent farmer households at international

****Corresponding author: Philip Aniah***
Department of Development Studies, University for Development Studies, WA Upper West Region

level is a very difficult task due to its lack of standard definitions, absence or difficulty to get benchmark data, its location-specificity, the households' ability to integrate on-farm and off-farm activities, and finally the farmer's vulnerability to a range of stressors (Morton, 2007). Owing to the above mentioned facts, it is thus, imperative to understand the actual dynamics of climate variability impacts at the lowest levels of the society, such as households, communities and districts (Deressa *et al*., 2008), and in that way enhance the relevancy of the top-down policy approaches (Ford & Smit, 2004). This study aims to answer two questions that are what are the impacts of climate variability on indigenous coping strategies of smallholder households and how are smallholder households coping with the impacts of climate variability. The empirical results of this study is based on current climate impact data and interviews with local stakeholders from the Gowrie, Kunkua, Dua, Beo communities of the Upper East Region of Ghana. The study also examined directional change in the current climate impacts and responses, and predicting future adaptive capacity and constraints of the communities. The study seeks to remediate both knowledge about climate variability and socio-economic conditions in the Gowrie, Kunkua, Dua, and Beo communities. Although the study focuses on the Bongo District of the Upper East Region of Ghana, it is held that the result generated from this study is relevant to many areas of the county as well as other countries with a similar climate and socio-economic structures.

MATERIALS AND METHODS

A participatory research approach was adopted. This approach provided greater insight and enabled local communities themselves to identify the impacts of climate variability and solutions to their own problems. The approach involved a triangulation of appropriate participatory tools of enquiry. Apart from secondary data, much of the primary data was qualitative. This study is based on both primary and secondary data sources and information. Published materials such as books, journals and different organization reports are the main sources of secondary information. Records from the offices of the Environmental Protection Agency (EPA) and Ghana Metrological Agency (GMA) as well as Ministry of Food and Agriculture (MOFA) in the area were analyzed to determine the impacts, coping strategies and other relevant parameters of focus. Face to face interview was done to collect the required information and data. Moreover, questionnaire and structured interview were used to collect field level data and information. The collected data were analyzed by using the statistical software-Excel, and SPSS. Random sampling was considered in selecting the study units'. Since the study area consists of four communities (Gowrie, Kunkua, Dua and Beo), Data was collected from all of these communities. Twenty four (24) households were randomly picked from each community. Hence, a total of 96 households were randomly chosen from the whole study area. The study followed both the qualitative and quantitative approaches. The quantitative aspect focused on the empirical data which were numerical in nature such as yield/output levels. It involved trend analysis using the Statistical Package for Social Scientist (SPSS). The qualitative analysis involved descriptions, content analysis, interpretations and implications of the results.

Some Theoretical Reflections

Causes of Climate Change: Climate change occurs as a result of both internal variability within the climate system and external factors. The external causes may be natural or induced by human activity. The primary cause of climate change is increase in the concentration of carbon dioxide and other greenhouse gases in the atmosphere because of human activities mainly fossil fuel burning and removal of forests (Lovejoy and Hannah,2005). At global scale, the main cause of Greenhouse Gas (GHG) emissions is from carbon dioxide (70%), primarily from burning of fossil fuel (petroleum) imported from industrialized countries, while the other sources for GHG are methane(CH4) and nitrous oxide(N2O) caused by deforestation and agricultural activities, particularly the use of pesticides (Yohannes Gebre Michael and Mebratu Kifle, 2009). Rising fossil fuel burning and land use changes have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the Earth's atmosphere (UNFCCC, 2007). Greenhouse gases and aerosols affect climate by altering incoming solar radiation and out-going infrared (thermal) radiation that are part of Earth's energy balance. Changing the atmospheric abundance or properties of these gases and particles can lead to a warming or cooling of the climate system. Since the start of the industrial era (about 1750), the overall effect of human activities on climate has been a warming influence. The human impact on climate during this era greatly exceeds that due to known changes in natural processes, such as solar changes and volcanic eruptions (IPCC, 2007).

Vulnerability of Bongo District Agriculture to Climate Change

Most agricultural activities are inherently sensitive to weather variability and this may result in the agricultural industry being extremely vulnerable to climate change. Adaptation to climate change is not only essential to maintain agricultural production and for agricultural economies and communities to remain in existence; but also to reduce vulnerability for future generations (Pearce, 2009). According to IPCC (2001) Vulnerability is defined as ''the degree to which a system is susceptible to, and unable to cope with adverse effects of climate change, including climate variability and extremes''. Ghana is one of the most vulnerable countries to harsh climatic conditions. Ghana suffers from extreme climates, mostly manifested in the form of frequent droughts. The vulnerability of the Agriculture to climate change and weather variability is greatly influenced by its adaptive capacity which influenced by factors such as economic Wealth infrastructure and technology, Institutions and Services, Information, knowledge and skills, equity and social capital. Developing countries are particularly vulnerable to climate change because of the sensitivity of their fragile environments; small changes in climate can cause large environmental changes through, for example, rapid desertification. Accordingly, Ghana agriculture is very vulnerable to climate change due to factors compounding the impact of climate change such as rapid population growth, land degradation, widespread poverty, dependency on rain fed agriculture, lack of awareness by policy and decision-makers about climate change and lack of appropriate policies and legislation (Wondwossen Sintayehu, 2008; Daniel Kassahun, 2008).

Impacts of Climate Variability on Food Security

Climate change will act as a multiplier of existing threats to food security: It will make natural disasters more frequent and

intense, land and water more scarce and difficult to access, and increases in productivity even harder to achieve. The implications for people who are poor and already food insecure and malnourished are immense (UNFCCC, 2009). Particularly in the least developed countries, it is the livelihoods and lives of the poorest and most vulnerable, including women, children and marginal communities, which are also at greatest risk to suffer from to the potential impacts of climate change. This is due to their high exposure to natural hazards, their direct dependence on climate sensitive resources such as plants, trees, animals, water and land, and their limited capacity to adapt to and cope with climate change impacts. Climate change may affect agriculture through: changes in temperature and precipitation, Changes in soil moisture and soil fertility, changes in the length of growing season and increased probability of extreme climatic conditions (McGuigan *et al*., 2002). According to Pearce (2009), major climate change impacts on crop production includes crop damage/loss, lower yields, reduced seeding area, income loss, harvest difficulties, increased pest activity, and delayed seeding. However the degree of these impacts varies based on agro- ecosystem.

Coping Strategies to Adverse Climatic Impacts

Societies are dynamic and they use all possible strategies to reduce the vulnerability to climatic impacts. There are two kinds of responses to crisis that overlaps across the temporal scale, coping mechanisms and adaptive capacity. Coping mechanisms are the actual responses to crisis on livelihood systems in the face of unwelcome situations, and are considered as short-term responses (Berkes & Jolly 2001). Adaptive strategies are the strategies in which a region or a sector responds to changes in their livelihood through either autonomous or planned adaptation (ibid; Campbell 2008). Coping mechanisms may develop into adaptive strategies through times (Berkes & Jolly 2001). However, it is difficult to make a clear distinction between coping mechanisms and adaptations; this study considers both schemes as coping strategies (ibid.). The resilience or the robustness of coping mechanisms differ depending on the availability and access to resources and technology (Adger *et al*. 2003). In this study, local/indigenous coping strategies are assessed from the collected information.

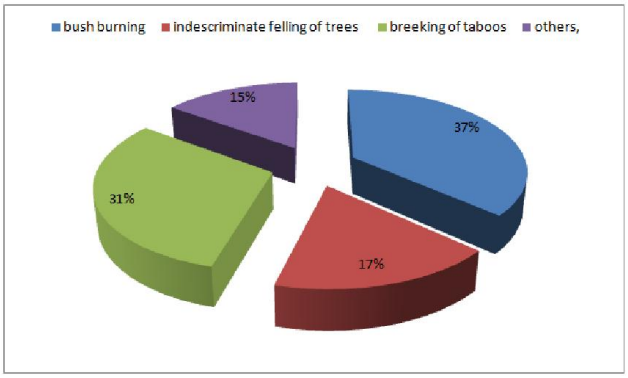
RESULTS

Perceived Causes of Climate Variability

The respondents attributed several reasons to the seasonal variations of the rainfall amounts in the area. The respondents (37%) indicated that climate variability is caused by bush burning About 31% of the respondents in this study also said that climate variability occurred when taboos were broken in the community and 17.3% indicated that climate variability was caused by indiscriminate felling of trees. Furthermore, 15% of the sampled population believed that climate variability is caused by inappropriate farming practices, over grazing which has led to depletion of forest reserves.

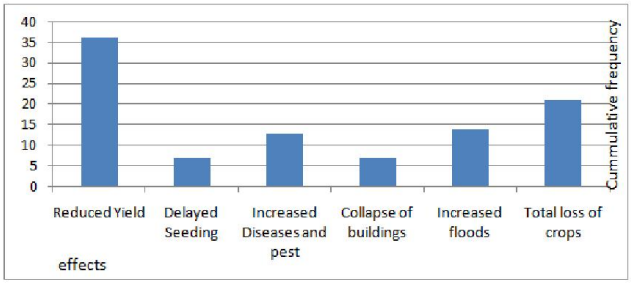
The Impacts of Climate Variability

The occurrences of weather events seriously affected crop production activities. As rain fed crop production is dependent on the onset of the rainy season. Late onsets of the rain hinder agricultural operations such as land preparation and sowing time. The onset of rain for the main growing season is in March/April but sometimes delays in the onset might go till May and mid June in extreme cases. The early offset of the rain when most of the crops are at flowering stage also directly affected fruit setting of the crops. The effects of the events found to be variable from place to place are based on the type of event, adaptive capacity and resource endowment of the area. Occurrences of floods have also become more frequent in the study communities. In general, the effects of weather events vary from reduced seeding, increase of diseases and pests, depletion of water bodies and forest reserves, soil fertility decline, collapse of buildings and the total loss of crops. However, lack of organized data on crop production at the study communities hinders to present the effect in terms of the actual yield.



Source: Field Survey, June 2013

Figure 1. Causes of seasonal variations in rainfall.



Source: Field Survey, June 2013.

Figure 2. Frequency of Significant Weather Effects

Source: Field Survey, June 2013.

Figure 3. Trend of agriculture production in the Bongo District

As observed from figure 3, the fluctuations (the production decline in 2001, 2002 and 2008) of yield at the study communities was mainly attributed to weather events such as drought, late onset of rains, erratic rain and early off set of the rains. The total production data for major rain fed crops (cereals) for the whole community obtained from Sustainable Family Agriculture and Educational Support Project (SUFAEP) and the Ministry of food and Agriculture (MOFA) also showed declining trends. Accordingly, the total seasonal rainfall (Bongo District) also showed declining trends after the year 1995.

Indigenous Coping Strategies of Smallholder Households

The adaptation strategies most commonly used included tree planting, soil conservation, late planting and irrigation among others. In terms of proportions about 21% adopted planting trees. Another 15% planted different crop varieties as a coping strategy against climate variability and about13% relied on early planting. The proportions of people who relied on irrigation and late planting also constituted 4% and 5% respectively. Soil conservation schemes used included, stone/grass bunding, composting/organic manure application (30.4%) is the strategy most commonly adapted. The use of different varieties of crops (11.1%) is another strategy adopted by farmers. Early planting and water harvesting are other adaptation strategies each accounting 4.1% of strategies used by farmers. Other strategies used by farmers constituted about 8.3%. As the variability of weather conditions increase from time to time, the smallholder households have been adjusting their farm operations so that they can reduce the harm and exploit beneficial opportunities. The coping mechanisms depend on the perception of the farmers about climate variability, income levels and availability of resources. The study revealed that, 42% of farmers do not undertake any action to cope up with weather related hazards. This can be attributed to lack of awareness and resources. In terms of awareness, 58 % of the farmers know or discuss about climate variability and the resulting weather variability's, but most of the farmers who have not yet developed planned adaptation actions constituted 42 % of the sampled population.

Some Indigenous Coping Strategies of Smallholder Households of the Bongo District

Source: Field Survey, August, 2013.

Plates 1 and 2. Stone bunding along Gullies to control gully and sheet erosion

Source: Field Survey, August, 2013.

Plates 3 and 4. Stone bunding with Grass reenforcement, On farm erosion control

Source: Field Survey, April, 2013.

Plates 5 and 6. Irrigation: De silted ponds with harvested water from rainfall

Source: Field Survey, April, 2013

Plates 7. Harvested tomatoes

Source: Field Survey, June, 2013.

Plates 8. Composting/Organic Manure Application and crop residue Management

DISCUSSION

The study established that, the respondents in the study area perceived/held that "climate variability is caused by "breaking of taboos". However, they admitted that there are other human causes such as bush burning and deforestation. An official of the Ghana Meteorological Agency said "climate variability is caused by human activities, cutting down trees indiscriminately for fuel wood, charcoal, farming, and housing expansion thus making the land bear" he added. "This has caused the change in rainfall patterns". In another interview, an official of the Forestry Commission attributed the causes of climate variability to tree felling which has led to the loss of vegetation. Other factors included inappropriate farming practices thus bush burning, over grazing which has led to the depletion of forest reserves and the drying up of water bodies. To Lovejoy and Hannah, (2005), the primary cause of climate change is increase in the concentration of carbon dioxide and other greenhouse gases in the atmosphere mainly because of human activities such as fossil fuel burning and removal of forests. According to Yohannes and Kifle, (2009), the main cause of greenhouse gas (GHG) emissions is from carbon dioxide (70%), primarily from burning of fossil fuel (petroleum) imported from industrialized countries, while the other sources of GHG are methane (CH4) and nitrous oxide (N2O) caused by deforestation and agricultural activities, particularly the use of pesticides which confirms the study.

This goes to reiterate the point made by the Canada's Action on Climate Change, "Climate change can be caused by human activities, such as the burning of fossil fuels and the conversion of land for forestry and agriculture". The prolonged and increasing temperature, combined with declining rain fall and the frequency of drought, as well as marked degradation of soils, have resulted in a succession of bad crop years. Deressa *et al*. (2008) indicated that crop yields declined by 32.8% as a result of shocks such as drought, hailstorm, and flood among others. Farmers therefore try to develop their own strategies to mitigate climate impacts. In the Bongo District, prolonged drought occurred in the year 2001/2002 resulting in significant loss of production. According to a model farmer, "about 2.5 acres of land was cultivated and about 6 bags of millet was obtained during the main growing season when there was adequate rainfall" The

loss in 2001/2002 was estimated at about 4 bags of millet) compared to the previous year. Moreover, the onset of the rain for the main growing season started late in mid May and resulted in heavy rain fall which seriously affected the output of households. This research is also consistent with the research conducted by Pearce (2009), which indicates that major climate change impacts on crop production includes crop damage/loss, lower yields, reduced seeding area, income loss, harvest difficulties and increased pest activity. The research is further confirmed by FAO (2008) which indicates that climate change impacts could be divided into two; physiological effects on crops, pasture, forest and livestock (quality and quantity): change in land soil and water resources (quantity and quality): increased weed and pest challenges as well as socio-economic impacts: decline in yields and production; reduced marginal GDP from agriculture, increases in the number of people at risk of hunger and food insecurity; migration and civil unrest. The findings is in tandem with Steffen *et al* (2004) and Christensen *et al*. (2007), comments that "climate change increases the vulnerability of the poor in the areas of water supply, exposure to disease, increasing sensitivity of livelihood activities and undermining of growth opportunities". The prolonged and increasing temperature, combined with declining rain fall and the frequency of drought, as well as the marked degradation of soils, have resulted in a succession of bad crop years.

Deressa *et al*. (2008) indicated that crop yield declined by 32.8% as a result of shocks such as drought, hailstorm, and flood. Farmers therefore try to develop their own strategies to mitigate climate impacts and Yaro, (2004), the effects of climate variability in Ghana will vary geographically, The North, Transitional and Coastal zones are projected to be the most affected through drought, shortened farming seasons, and sea erosion. The adaptation methods most commonly cited in the literature include the use of new crop varieties and livestock species that are more suited to drier conditions, irrigation, crop diversification, mixed crop livestock farming systems, changes of planting dates, diversification from farm to nonfarm activities, increased use of water and soil conservation techniques, and trees planted for shade and shelter (Nhemachena and Hassen, 2007). It can be observed in the study area that people are changing the composition of livelihood portfolios by relying more on non-agricultural sources of income, by adding more market-oriented agricultural activities such as cotton, onions, tomatoes and by changing their food production strategies to more drought-adapted varieties on the one hand and to less water-stressed fields on the other hand (where they produce vegetables and rice). Animal husbandry is changing as well, with relatively more emphasis on goats, pigs and fowls.

The responses by smallholder households in the different communities vary from no action to changing crop diversity and farming practices. These major responses include composting/organic manure application, early planting, crop residue management, stone/grass bunding and irrigation. Rainfall patterns increase the probability of adoption of yield-related adaptation strategies. And this adoption, in turn, reduces the vulnerability of society to change in climate (Smith *et al*. 1996). Irrigation had low response as it is based on the resource endowment of the area (availability of surface water, Land) and capital requirement of constructing river diversion structure, this lack of input for irrigable agriculture is also a challenge for the farmers to grow crops during the dry period. According to an official of SUFAEP, "the use of Stone/grass bunding has also become a common practice in the Bongo district in the last 5 years. Primarily, Stone/grass bunding is practiced among the small holder farmers due to soil infertility caused by erosion". He added that, "about 72% of the farmers in these communities have erosion problem on their farm; however only 31.2% of the farmers undertake soil conservation activities such as terracing, and stone bunds". He further added that, "the grasses used for the grass bunding (vertivirer nagretania, vertivire zezaniod) controls erosion both on farm and along gullies. These grasses are also used for weaving baskets, local hats and as broom for sweeping compounds and as far as tree planting is concerned 41% of the respondent's plant trees on their farms while the rest do not plant trees due to land scarcity, lack of seedlings and intensive care required". From field observation and respondents' response, majority of the farmers opt to plant Eucalyptus than planting economic trees such as dawadawa and shea trees. There is long record of adapting to impacts of weather and climate through changes in behaviour, choices of technology and infrastructure, use of market instruments and public policies. Crop diversification, weather and seasonal climate forecasting, drought early warning systems, flood protection, weather derivatives, and establishment of coastal-setbacks are only a few examples of proactive adaptation measures. Adaptation can be reactive such as emergency response, disaster recovery, and even migration (Kurukulasuriya and Rosenthal, 2003).

Conclusions

This study revealed that the increasing trend of climate variability and its effects on livelihood of smallholder households in the Upper East Region is exacerbating the vulnerability at the macro and micro level of different socio-economic activities of the society. The frequent rain delay, erratic precipitation, drought, and heavy rainfall and unseasonal rainfall are great concerns for all communities in the region. The current local coping mechanisms are the use of Stone/grass bunding, composting/ organic manure application, crop residue management, early planting of crops and irrigation. The overarching stressors that are enhancing societal vulnerability to crisis are land scarcity and unemployment, unaffordability and unavailability of agricultural input and water shortage. Though, all households are vulnerable to climate variability, vulnerability is heightened on the poor, landless, children, women and large family sizes. As the climatic and non-climatic stressors continued to increase the degradation of natural resource base and is more likely to exacerbate the society's vulnerability.

Recommendations

Promotion of development programs and addressing vulnerable groups through the development of better proxy indicators of societal vulnerability and addressing them from short and long term perspectives, e.g., institutional policy intervention in market during the impacts, post-impact recovery strategies, discouraging land use change. Further study should be conducted to identify, scientifically proof and document the available coping mechanisms and indigenous knowledge/innovation.

REFERENCES

Adger, W.N. *et al*., 2003. Adaptation to climate change in the developing world. Progress in Development Studies, 3(3), 179.

Averyt KB, Tignor M, Miller HL (eds) Climate change 2007, the physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, pp 847–940

Berkes, F. and Jolly, D. 2001. Adapting to climate change: Social-Ecological resilience in Canadian Western Arctic community. Conservation Ecology 5(2):18

Campbell, A., 2008. Managing Australian Landscapes in a Changing Climate a Climate Change Primer for Regional Natural Resource Management Bodies. Department of Climate Change.

Collier, P., Conway, G. & Venables, T., 2008. Climate change and Africa. Oxford Review of Economic Policy, 24(2), 337.

Christensen JH, Hewitson B, Busuioc A, Chen A, Gao X, Held I, Jones R, Koli RK, Kwon W T, Laprise R, Rueda VM, Mearns L, Menendez CG, Raisanen J, Rinke A, Sarr A, Wheton P 2007, Regional climate projections. In: Solomon S, Qin D, Manning M, Chen Z, Marquis M,

Daniel Kassahun 2008. Impacts of climate change on Ethiopia: a review of the literature. In: Green Forum (ed.), Climate change – a burning issue for Ethiopia: proceedings of the 2ndGreen Forum Conference held in Addis Ababa, 31 October- November 2007 (Addis Ababa: Green Forum), pp9–35.

Deschenes, O. & Greenstone, M., 2006. The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather. American Economic Review, 97(1), 354-385.

Deressa, T., Hassan, R.M. & Ringler, C., 2008. Measuring Ethiopian Farmers' Vulnerability to

Climate Change Across Regional States. International Food Policy Institute.

FAO 2008. Climate change and food security: a framework document, Food and Agriculture organization of the United Nations, Rome.

Ford, J.D. & Smit, B., 2004. A Framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. Arctic, 57(4), 389-400.

Inter-Governmental Panel on Climate Change, 2001. Climate Change 2001: Impacts, Adaptation, and Vulnerability: Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

IPCC 2001. Climate change 2001: The Third Assessment Report of Intergovernmental Panel on Climate Change. Cambridge University Press, UK.

IPPC 2007. Climate change Synthesis report, an assessment of IPCC.

Kurukulasuriya, P. & Mendelsohn, R., 2007. A Ricardian analysis of the impact of Climate change on African cropland, The World Bank. Available at: http://ssrn.com/abstract=1005544.

Kurukulasuriya, P. and Rosenthal, S. 2003. Climate change and agriculture: A review of impacts and adaptations. Paper No. 91 in Climate Change Series, Agriculture and

Rural Development Department and Environment Department, World Bank, Washington, DC. Long, J., Cromwell, E. and Gold, K. 2000. On-farm management

Lovejoy, E. T. and Hannah, L. 2005. Climate change and Biodiversity. Yale university press new heaven and London, Sheridan books, Ann Arbor, Michigan.

McCarthy, J.J., 2001. Climate Change 2001: Impacts, Adaptation, and vulnerability: Contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

McGuigan C., Reynolds R. and Daniel W. M. 2002. Poverty and climate change: assessing impacts in developing countries and the initiatives of the international community. London School of Economics Consultancy, Project for the Overseas Development Institute.

Morton, J.F., 2007. The Impact of Climate Change on Smallholder and Subsistence Agriculture. Proceedings of the National Academy of Sciences, 104(50).

Nhemachena C, Hassan R 2007, Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion Paper No. 00714.

Pearce, W. T. 2009. Living with Climate Change: How Prairie Farmers Deal with increasing Weather Variability. Natural Resource Institute: university of Manitoba, 70 Dysart Road Winnipeg Manitoba, Canada, R3T 2N2.

Smit, B. & Pilifosova, O., 2003. From Adaptation to Adaptive Capacity and Vulnerability Reduction. In London: Imperial College Press, p. 9.

Tol, R. S. J., S. Fankhauser, R. G. Richels and J. B. Smith 2000, 'How Much Damage Will Climate Change Do? Recent Estimates', World Economics 1(4), 179–206.

UNFCCC 2009. Climate Change: Impacts, Vulnerabilities and adaptation in developing countries.

Watson, R.T., Zinyoera, M.C., and Moss, R.H. 1998. The Regional Impacts of Climate Change: An Assessment of Vulnerability. A Special Report of IPCC Working Group II. Cambridge: Cambridge University Press.

Wondwossen Sintayehu, 2008. Climate change: global and national response. In: Green Forum (ed.), Climate change – a burning issue for Ethiopia: proceedings of the 2nd Green Forum Conference held in Addis Ababa, 31 October–2 November 2007 (Addis Ababa: Green Forum), pp37–69.

Yarnal, B., 1998. Integrated Regional Assessment and Climate Change Impacts in river Basins. Climate Research, 11, 65-74.

Yohannes Gebre Michael and Mebratu Kifle 2009. Local innovation in climate change adaptations by Ethiopian pastoralists, Addis Ababa, Ethiopia.

****