

Climate Change Induced Food Scarcity: A Threat to Agricultural Sustainability

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ABSTRACT The manifestation of the devastating impacts of climate change is a threat to food security and it is producing severe and chronic hunger. Poor people are the most affected. Most of these poor people live in rural areas of most of the developing countries. They rely mainly on agriculture for both subsistence and major source of livelihood. The concern is that climate change is making food insecure. Prices of food have gone up drastically over and above what the poor can afford. To reduce hunger and poverty caused by the devastating impact of climate change, there should be intervention to stop the main contributor to global climate change which is the burning of fossil fuel that emits carbon dioxide. Against this backdrop, this paper advocates for emission reduction in order to save agriculture sector that is producing food for the world's well-being and livelihood.

INTRODUCTION

Various scientific evidences and reports from national and international spheres have confirmed that the issue of global climate change calls for major concern, necessary intervention and a rethink of how to protect and preserve agriculture and resources from this sector (Wackernagel and Rees 2013). This is against the backdrop that global warming and climate change are threatening agriculture and the impacts have started manifesting in form of food insecurity, hunger and poverty (Campbell et al. 2007). Scientific reports have confirmed that developing countries are feeling the impact more than developed countries (Bodansky 1993). This is because while the developed countries have the adapting capacities to cope, the developing countries do not, making them vulnerable whenever the impacts manifest (Adger et al. 2003). Food insecurity caused by the impact of climate change is also threatening other development projects and making them to be vulnerable and unsustainable (Godfray et al. 2010). Developing countries rely heavily on climatic resources for various social economic amenities and services and yet they do not have the wherewithal to cope with the extreme weather events (Durant et al. 2004). To this end, they become more vulnerable as the impact of climate change produces poverty and hunger (Schipper and Pelling 2006). These worrying situations are likely to worsen and people in developing

countries are likely to continue to remain in chronic abject poverty as a result of the devastating impact of climate change. To curtail these climate challenges, workable interventions are needed in order not to escalate an already climate tensed situation. These days, as a result of the impact of climate change, the rainfall is unpredictable and sometimes when it rains, it creates a huge flood which affects agricultural products and livelihood and makes people's situations and conditions worst (Heltberg et al. 2009). Other times, rain ceases which results in draught and lack of drinking water for the people and animal thereby causing severe hardship and hunger because the planted crops are being deprived of water to enable them germinate (Walker and Salt 2006).

Climate change is also seriously threatening food production and making it insecure (Bohle et al. 1994). According to Food and Agriculture Organisation (FAO 2008) food security is defined as a "situation when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Food security is looked at from the point of view of whether the means to buy food is available and sufficient (Maxwell and Smith 1992). Even if food is available, people still need to have the means to buy (Eriksen 2008). If this means are lacking, the people will not be able to buy food and become food insecure; as a result of this, hunger will definitely

set in. As Pretty et al. (2003) observed that “An adequate and appropriate food supply is a necessary condition for eliminating hunger. But increased food supply does not automatically mean increased food security for all.

Consequently, both quantity and quality are essential for food production and security (Barrett 2010). With devastating manifestation of impacts of climate change, all aspects of food production are being affected and this is impacting on other social economic goods and services (Kelly and Adger 2000). The changes in climate are also distorting the components of food chains which usually make food secure. These components are: food availability, food accessibility, food utilization and food system stability (von Braun 2009). Therefore, agriculture needs to be sustainable because of its importance as it produces the food people eat and provides job opportunities to a quite number of people especially the rural poor in the developing countries (Pretty et al. 2003).

Objectives

The paper examines the threats to food security as a result of various manifestations and impacts of global climate change. The impacts on agricultural sector and the consequential impacts that are now creating food insecurity and producing hunger especially in the rural areas of developing countries are also examined. The paper also analyses the plights of farmers who rely on food production as means of livelihoods but are now becoming more vulnerable due to the impact of climate change on the agricultural produce and animals.

METHODOLOGY

The study is based on qualitative research approach. By so doing, the study relies heavily on the existing literature relevant to the study. The study makes a modest contribution to bridging the knowledge gap in literature by analyzing what should be done to improve and strengthen food security in order to reduce hunger and poverty. Carbon emissions are the main reasons for global warming and climate changes as a result of human activities. To address this, the study looks at various existing strategic interventions put in place to reduce emissions and argues for immediate adoption.

OBSERVATIONS AND DISCUSSION

Insights from the Existing Literature

Except the opinions strongly held by some climate denials and sceptics, it is generally accepted that global climate change is real and that it is impacting negatively on the atmosphere, the environment and the ecosystems (Harris 2010). Adger et al. (2003) have observed that *“the world’s climate is changing and will continue to change into the coming century at rates projected to be unprecedented in recent human history. The risks associated with these changes are real but highly uncertain. Societal vulnerability to the risks associated with climate change may exacerbate ongoing social and economic challenges, particularly for those parts of societies dependent on resources that are sensitive to changes in climate. Risks are apparent in agriculture, fisheries and many other components that constitute the livelihood of rural populations in developing countries.”* Campbell et al. (2007) admonished that the impact of global climate change is not trivial but huge and has started manifesting in different dimensions *“although the consequences of global climate change may seem to be the stuff of Hollywood—some imagined, dystopian future—the melting ice of the Arctic, the spreading deserts of Africa, and the swamping of low lying lands are all too real.”* The erratic changes in the global climate has brought about various challenges and has drastically increased the vulnerability of farmers, especially in most developing countries as they are unable to predict or forecast the weather accurately using their indigenous knowledge (Moorhead 2009). Although the developed countries are not immune to the devastating and unpredictable weather events because there are consistent impacts of global climate change manifesting also in the developed countries as there have been reports of droughts, outbreaks of fire, heavy rainfalls and many more natural disasters (Turner and Clifton 2009), Moorhead (2009) points out that *“agriculture on which we all depend for our food is under threat from climate change. There is no doubt that systems worldwide will have to adapt, but while consumers may barely notice the impact of climate change in developed countries, millions of people in developing countries face a very real and direct threat to their food security and livelihoods.”*

Developing countries are feeling the heat in almost all areas of life as food insecurity and hunger remains endemic, particularly in Africa (Rosegrant and Cline 2003). Explaining the impact of climate change on food and other social economics well beings of the poor people in the rural Africa, Balogun et al. (2013) observe that *“the significance of this variability is clear when we consider that in sub-Saharan Africa, agricultural production accounts for up to 90% of food needs. Socio-economic conditions and the adverse impact of unpredictable weather on the agricultural production of communities in sub-Sahara Africa have long been recognized as an important cause of malnutrition in the region.”* The rural poor are affected by high costs of food and majority is unemployed hence, they leave below the poverty level because they do not have the means to purchase food. The combination of all these lacks make them vulnerable resulting in hunger and chronic poverty (Barrett et al. 2002). Furthermore, the bizarre weather events are having destructive impacts on all human endeavours and are also destroying vital ecosystems, infrastructure, property, and people’s livelihoods and sometimes the damages caused are irredeemable (Thompson 2013).

What needs to be done is for the international community to join hands and fight global climate change by reducing emissions and provide assistance to the developing countries that are feeling the huge impacts of global climate change (Victor 2004). The problem of food scarcity caused by the impact of climate change is threatening the survival of vulnerable people in the rural Africa and it has thrown a lot of these people into hunger and abject poverty because the majority of them are peasant farmers who solely rely on agriculture and farming as sources of livelihood and existence (Pfeiffer 2006). Pursuant to this, international community and the policy makers are enjoined to refocus on sustained food security by incorporating green agriculture as a solution to several of these challenges, including hunger, poverty, unemployment and environmental degradation (Sha Zukang 2012).

Therefore, there is need to pursue development that will also incorporate the issue of food security in order to address poverty (Maxwell 1990). This approach will promote sustained food security described by Maxwell

(2009) as *“the meaning and measurement of food insecurity; structural reform of food systems; improved targeting; the future of food aid; and the strengthening of rural and urban safety nets.”* In order to implement this, a strong institution that will carry out the task is inevitable. India has made a milestone in this regard by designing and establishing a crop insurance scheme to absorb the impact of climate change should it manifest (Mills 2007). All efforts in this regard should be channeled toward promotion of food security by enabling people to engage in economic activities that will create wealth and lead to technological progress. This intervention is playing an important role in supporting Indian farmers through the losses incurred during drought years (de la Fuente 2007). Literature has confirmed that the crop insurance is working in India, this needs to be emulated by other developing countries as part of their adaptive measure to protect farmers, increase food production and reduce poverty caused by climate change (Linnerooth-Bayer and Mechler 2006).

It is important to point out that while scientific reports have shown different threats caused by climate change (Carpenter et al. 2008), the list is not closed because new climate threats are also emerging and presenting new challenges (Brown et al. 2007). This is the reason why there should be a collective action to combat the surge. If this is not taken into consideration, the impact of climate change might affect progress in human development achieved over the last decade and slow down or even reverse economic growths successes recorded by some of the developing countries (Daily and Ellison 2002).

Speranza (2010) argues that *“while it is conceded that managing climate risks is a major challenge of today and for the future, the high dependence of the economies and rural people upon rain fed agriculture, the prevalence of poverty and food insecurity, and limited development of institutional and infrastructural capacities make coping with natural climate variability a perennial challenge.”* To this end, Endfield and Tejedo (2006) indicate that in the past several decades, the numbers of extreme weather events particularly in sub-regions and the numbers of people affected by droughts and floods have grown dramatically and disposed them of their means of livelihood and sometimes loss of life. Undoubtedly, with the devastating

scenarios of the manifestations of the impacts of climate change, it is apt to say categorically that indeed climate change poses a grave threat to human existence and ecosystems (Varner 2002). Combating climatic emissions now is the most viable response to the threats (Shearman and Smith 2007).

Another concern is that the scientific evidence on how climate change has become a serious threat to agricultural production and agricultural systems worldwide is disturbing and it is a major concern to the governments of the world and the international community. (Dimes et al. 2008). Christian-Smith (2012) has admonished that if measures are not put in place to mitigate and adapt to the climate change, the future is bleak as people will face even greater challenges and the coping systems may not solve the problem unless there is drastic action taken now to combat the climatic emissions. The study conducted by Parrrt et al. (2009) for World Food Programme revealed that climate change will act as a multiplier of existing threats to food security, make natural disasters more frequent and intense, land and water more scarce and difficult to access, and increases in productivity even harder to achieve, thereby creating unbearable hunger and poverty. The implications of these are that people who are poor, are food insecure and are malnourished will become more immense and the poor will become chronically poorer (Sasson 2012).

Therefore, the need for constant assessment of the impact and effects of global climate change on agriculture and food production should be top priority of most of the governments in order for food to be secured and hunger curtailed (Schneider and Root 1996). The governments in the developing countries should be more proactive in this regard considering the fact that they are the most vulnerable to global climate change (Patwardhan and Semenov 2007). As part of the solution, scientific literature has shown that investment in agricultural research and demonstration has high rates of success in terms of returns and poverty reduction (Diao et al. 2008). The model in India is a good example of positive strategic intervention. India has invested hugely on research on climate crop and also established climate crop insurance. These interventions were done in order for the agricultural sector to cope with the negative impact of climate changes. This model is

sustaining food production and food security in India. The positive impact on the rural poor farmers is huge because they are able to produce enough food for sustenance and for commercial purposes. As a result of this, the farmers' standard of living is being improved because of the gains and profits from the sales of agricultural products. (Nath and Behera 2011).

ADAPTING FOOD PRODUCTION TO CLIMATE CHANGE

The fight against climate change through adaptive measures in order to have food security and sustainability needs to be approached from all angles. This is because global climate change is threatening human existence as a result of its impacts on food and agricultural sector. Schneider and Root (1996) indicate that *"the need to anticipate outlier events and assign them subjective probabilities suggests emphasis on interdisciplinary research associations. The desire to reduce societal vulnerability to such events suggests the need to build adaptive management and diverse economic activities into social organizations. The effectiveness of adaptation responses to anticipated climatic changes is complicated when consideration of transient changes, regional disturbances, large unforeseeable natural fluctuations and surprises are considered. Slowing down the rate of disturbances and decreasing vulnerability are advocated as the most prudent responses to the prospect of human-induced climatic changes."* (Schneider and Root 1996).

A multifaceted approach to solving the problem of climate induced food scarcity and hunger is suggested by Godfray et al. (2010) *"the effects of climate change are a further threat. But the world can produce more food and can ensure that it is used more efficiently and equitably. A multifaceted and linked global strategy is needed to ensure sustainable and equitable food security."* Managing the risks through all available means is now inevitable in order to continue to live in the world free of threats of negative impacts of climate change. Against this backdrop, Heltberg et al. (2009) pointed out that *"Societies have a long record of adapting to climate risks and climate changes. Household asset portfolios and livelihood choices are shaped by the need to manage climatic risks,*

especially in rural areas and for low-income households. Even so, climate events continue to bring devastation. Recent evidence and predictions indicate that climate changes are accelerating and will lead to wide-ranging shifts in climate variables. There will be changes in the mean and variance of rainfall and temperature, extreme weather events, food and agriculture production and prices, water availability and access, nutrition and health status. The most adverse impacts are predicted in the developing world because of geographic exposure, reliance on climate sensitive sectors, low incomes, and weak adaptive capacity. Socio-economic impacts, though generally not well understood, are likely to be profound and will impact humans through a variety of direct and indirect pathways. The indirect risks are often hard to predict they are the consequences of consequences but could have the worst impacts."

Sub-Saharan Africa faces a lot of climatic challenges hence a lot needs to be done in order to curtail vulnerability on the continent (Ellis 2005). The continent is experiencing huge magnitude of poverty, food insecurity, environmental and health challenges and the level of poverty is appalling (Booth et al. 1999). Therefore, for purposes of sustainable livelihood, development plan should take into consideration the issues surrounding food security, hunger and poverty alleviation (Buchanan-Smith and Maxwell 1994). Applying the principles of sustainable development in support of sustainable food production and security will be one of the ways of solving the problem of the impact of the global climate change on agricultural sector (Pretty 2008). Climate change is likely to make matters worse with increases in rainfall variability being predicted (Mendelsohn and Dinar 1999). The ability of agricultural communities and agricultural stakeholders to cope better with the constraints and opportunities of current climate variability must first be enhanced for them to be able to adapt to climate change and the predicted future increase in climate variability (Twomlow 2008).

The efforts to be made are therefore to ensure stability in food production and agricultural through coping intervention. According to Pretty (2003) agricultural sustainability connotes "what do we understand by agricultural

sustainability? Systems high in sustainability are making the best use of nature's goods and services whilst not damaging these assets." The need for coping for purposes of agricultural stability is significant in view of the fact that the "world still faces a persistent food security challenge. There are an estimated 790 million people lacking adequate access to food, of whom 31% are in east and south-east Asia, 31% in South Asia, 25% in Sub-Saharan Africa, 8% in Latin America and the Caribbean, and 5% in North Africa and near east. A total of 33 countries still have an average per capita food consumption of less than 2200 kcal per day (Pretty 2003)."

Pursuant to this, the risks and vulnerability of the farmers and all role players and stake holders in agriculture will reduce if they incorporate adaption strategy as part of their tactics and planning to these evolving climatic risks (Osman-Elasha et al. 2006). In Sudan, "there are examples of development and environmental management strategies employed by rural populations of Sudan that have increased the resilience of communities for coping with drought and its effects. These examples provide models that could be applied to increase drought resilience more widely in Sudan. They can also provide lessons to guide adaptation to climate change, projections of which indicate the potential for a more arid climate and more frequent drought." (Osman-Elasha et al. 2006:2). An example of how effective response to climate change impact was implemented in one of the areas in Sudan is given thus "in response to these devastating conditions that prevailed in the area, a Carbon Sequestration strategy was initiated in 1992 covering 17 villages within. The aim of the project was to implement a simple model of community-based natural resource management to prevent over-exploitation and degradation of marginal lands and rehabilitate rangelands for the purpose of carbon sequestration. It also sought to encourage biodiversity preservation, reduction of dust storms, and reduction of the risks of production failure in this drought-prone area by providing alternatives for sustainable production. To ensure the success and sustainability of this approach, the project provided for increasing numbers of livelihood alternatives to diversify local production systems and improve the socio-econom-

ic conditions, leading to decreased out-migration and population stability. In essence, the project included both mitigation and adaptation outcomes." (Osman-Elasha et al. 2006: 6-7).

Taking action as exemplified above should be the norm in order to curtail and compact the impact of climate change on the rural poor. This should be emulated and lessons should be learnt from this by other countries in Africa. Inaction will compound the existing problem with regards to the threats of climate change. Interventions in various ways would curtail the threats if not totally curb them. Thus so far, according to Food and Agriculture Organization of the United Nations (FAO 2008) *"agriculture is a source of climate change but also a solution to climate change if adequate sustainable production measures are adopted that hold substantial mitigation potential, and that contribute to adapt agriculture and food production systems to extreme events, raising temperatures, and increasing CO₂ concentration."* FAO (2008) indicated that, in order to adapt to climate change, *"farmers will need to broaden their crop genetic base and use new cultivars and crop varieties. They will need to adopt sustainable agronomic practices such as shift in sowing/planting dates, use of cover crop, live mulch and efficient management of irrigation and reduce the vulnerability of soil based agricultural production systems through the management of soil fertility, reduced tillage practices and management of the cycle of soil organic carbon more efficiently in grasslands and cropping systems."*

The threats of food insecurity caused by the impact of climate change are real and manifesting in different dimensions, in order to tackle these threats and preventing hunger and poverty, it requires the support of everybody from different backgrounds and disciplines (Warner et al. 2012). As indicated, most of the farmers in developing countries live in the rural areas, while some of them have benefitted from modern technology for farming, others have not. They still use indigenous knowledge to adapt and cope with the changes in the climate. Therefore, tackling the problem of the impact of the climate change on agricultural sector, hunger and poverty will require the combination of both modern and best traditional knowledge and practices of farming (Heltberg and Ashwill 2013). This will be of

immense benefit to the smallholders' farmers in the developing countries farming in the remote rural isolated areas (Pretty 1999).

REDUCING CLIMATE INDUCED POVERTY THROUGH INNOVATIVE INTERVENTIONS

Pragmatic sustainable research is important as a means of diffusing and applying new technology and systems to agricultural productivity in order to adapt to the impact of climate change and combat food insecurity and hunger (Bartel 2010). Schipper and Pelling (2006) assert that *"reducing losses to weather-related disasters, meeting the Millennium Development Goals and wider human development objectives, and implementing a successful response to climate change are aims that can only be accomplished if they are undertaken in an integrated manner."*

Climate change is a serious risk to poverty reduction and threatens to undo decades of development efforts and gains made so far, (Newell and Jenner 2009). What needs to be done in Africa to improve agricultural production is, according to Bartel (2010) ensure *"incremental improvements in processes, products, inputs, or equipment that are needed to adapt existing technologies to the local environment in ways that enhance productivity and lower costs. The ability to adapt, therefore, is a significant step in technological empowerment, which over a period of time, can lead to the creation of knowledge generation capabilities amongst actors that are demand-driven rather than simply those that aim to replicate the successes of other regions of the world."*

Technological inputs are therefore important in order for the developing countries to attain the Millennium Development Goals of sufficiency of food for all, eradication of hunger and poverty (Jarosz 2011).

Agricultural Sustainability and Food Security

What needs to be done in order to attain food sustainability is well captured in an elaborate analysis of Pretty (2008) thus *"Concerns about sustainability in agricultural systems centre on the need to develop technologies and practices that do not have adverse effects on environmental goods and services, are acces-*

sible to and effective for farmers, and lead to improvements in food productivity. New approaches are needed that will integrate biological and ecological processes into food production, minimize the use of those non-renewable inputs that cause harm to the environment or to the health of farmers and consumers. Make productive use of the knowledge and skills of farmers. Dividends can come from making the best use of the genotypes of crops and animals and the ecological conditions under which they are grown or raised. Agricultural sustainability suggests a focus on both genotype improvements through the full range of modern biological approaches and improved understanding of the benefits of ecological and agronomic management, manipulation and redesign. Sustainable agriculture outcomes can be positive for food productivity, reduced pesticide use and carbon balances.”

Accordingly, “if food poverty is to be reduced, then it is important to ask who produces the food, who has access to the technology and knowledge to produce it, and who has the purchasing power to acquire it? Modern agricultural methods have been shown to be able to increase food production, yet food poverty persists. Poor and hungry people need low cost and readily available technologies and practices to increase food production. A further challenge is that this needs to happen without further damage to an environment increasingly harmed by existing agricultural practices.” (Pretty 2003).

Because the situation requires multi solutions approaches, Barrett et al. (200) have suggested an idea of food for work thus “food-for-work (FFW) programmes have been widely heralded as a means of providing self-targeting transfers coupled with investment in public goods...with an attempt at distilling some useful rules of thumb as to when, how and why FFW can serve effectively as short-term insurance, a longer-term rehabilitation and development intervention, or both. famine; food aid; poverty; public employment programmes; transfers” (Barrett et al. 2002).

All these measures and strategies canvassed are geared toward addressing these complex problems and challenges of food insecurity. Approaching the problems from multifaceted opportunities to harness new innovations will

therefore require out-of the-box solutions such as new technologies, institutions, policies, and higher investments in agriculture (Lybbett and Sumner 2010).

Tools and approaches are now available that allow for a better understanding, characterization and mapping of the agricultural implications of climate variability and the development of climate risk management strategies specifically tailored to stakeholders’ needs (Smit and Wandel 2006). Developing countries are therefore enjoined to take advantage of these by investing money earned from natural resources exploitation on agriculture (Onwuekwe 2006).

Using Agricultural Biodiversity to Increase Productivity

A blend of agricultural diversity that will integrate and use all aspects of agricultural variability including ecosystems will be source of viability and sustainability for food growth and production (Nellemann 2009). Javis et al. (2008) describe agricultural biodiversity as “*variability of crops and their wild relatives, trees, animals, microbes and other species that contribute directly or indirectly, to food production. But climate change is threatening the existence of species as they are now shrinking and decreasing on a daily basis*” (Javis et al. 2008).

Indigenous knowledge has also proven to confirm the effectiveness and viability of agricultural variability (Tripp R 1993). The findings of the study conducted by Olatokun and Ayanbode (2008) revealed that “*the majority of the rural women were farmers and illiterates but have vast knowledge of traditional medicine. There was an extensive use of oral indigenous knowledge in various domains: culture transfer and preservation, food security, saving and lending money, population control, childcare and so on but its greatest impact was in the area of food production.*” This is peculiar to most of the rural farmers in sub-Saharan Africa and it is a useful example of how to use indigenous knowledge to adapt and cope with the variations in the climate. This approach serves as a potential mode to change lives and sustain our world by diversifying livelihoods, increasing the resilience and sustainability of production systems and by providing access to a diverse and nutritious diet (Verchot et al. 2007).

While it is recognized that the traditional coping mechanisms would not be adequate to produce enough food in view of the growing population, efforts should be geared toward the diffusion of technical innovations such as mechanized farming to complement indigenous methods and knowledge (Sharma et al. 2012). Commenting on the problems being faced in the agricultural sector, Sharma et al. (2012) said that *“across the world, the challenges facing the sector are immense: declining natural resources, smaller landholdings and lesser area for cultivation, erratic monsoons, climate change crisis, energy crisis, loss of biodiversity, weak extension machinery, rising input costs, inadequate storage infrastructure, high post-harvest losses, and lack of access to markets.”* Therefore, *“efforts should therefore be geared towards research and innovation on the breeding of new and adapted varieties as well as the preservation of traditional, locally adaptable varieties that can tolerate climate variability and are suitable for changed climatic conditions”* (Biringer et al. 2005). This can be done by developing innovative and practical technologies such as alternative cropping systems, conservation and precision agriculture sustainable forest management; and the application and improvement of technologies for more efficient use of inputs such as energy, fertilizer, water and seeds (Sayer and Campbell 2004). It is pertinent to point out that such technologies should be affordable and accessible for the rural poor in the developing countries if they are to make any meaningful impact in alleviating agricultural poverty (Graff et al. 2006). Graff et al. (2006) study is in support of affordable and accessible technologies and they express the view that *“while biotechnology innovation is concentrated in high income countries, international diffusion of innovations to improve the diet, health, and incomes of the poorest will be largely driven by innovators such as China and Brazil. Adoption of beneficial biotechnologies in these countries will increase as more transgenic versions of conventionally grown varieties become available and as costs decline, which in turn will depend upon regulatory approvals being needed only once for each transformation event and transaction costs for accessing technologies being minimized. Investments in higher education and intellectual property clearinghouse institutions can greatly facilitate technology transfer.”*

Becoming More Proactive and Prepared for the Manifestation of Climate Change Calamities

In most cases, the manifestations of the bizarre events are unpredictable, therefore those who engage in climate prone enterprises should be proactive and get prepared always to adapt to the manifestations of the devastating impacts of the climate change (Curry 2012). Farmers should therefore be sensitised on proactive management of the impact of climate change (Huq et al. 2004). For those in the rural areas, indigenous knowledge of weather forecasts is vital for farming and growing of crops (Nyong et al. 2007). Attesting to the useful and viable application of indigenous knowledge to the impact of the changing climate Nyong et al. (2007), point out that *“integrating mitigation and adaptation into climate change concerns is not a completely new idea in the African Sahel. The region is characterized by severe and frequent droughts with records dating back into centuries. The local populations in this region, through their indigenous knowledge systems, have developed and implemented extensive mitigation and adaptation strategies that have enabled them reduce their vulnerability to past climate variability and change, which exceed those predicted by models of future climate change.”* The following suggestions have been made for purposes of coping and adapting to the effects of the changing climate, *“knowledge and understanding of risks and who the victims are; monitoring and evaluation of the risks to ascertain and forecast; taking care of the poor of the poorest and ensuring food security and availability to them during disaster; linking all developments plans to climate change mitigation and adaptation, availing people on climate information and issues surrounding disasters to the community and decision makers, adequate provisions of financial resources and human resources for effective risk reduction is very important”* (Adger 2006).

CONCLUSION

The effects of climate changes are threatening food security and other agricultural activities. These are now producing hunger and chronic poverty. The people especially farmers in the rural developing countries are vulnerable

to the manifestations of all these disasters and calamities. The situation is exacerbated because they lack capacity to cope with the effects. This notwithstanding, there should be political will to address the problem. One of which is to enlist the support of the developing countries to curb climate change by slowing down and out rightly stopping carbon emissions resulting from burning of fossil fuel for energy used in powering and driving their industrial activities. The vulnerable rural farmers and poor need to be protected and empowered by providing them with technological innovations that will make their farming activities adapt to the effects of climate change. Indigenous knowledge has also proved to drive agricultural sustainability. A blend of indigenous knowledge and modern technology will be a viable option to enhance food security, increase food production, reduce hunger and poverty.

RECOMMENDATIONS

The effects of climate change are causing serious concern around the world. It is the talk of the town in virtually all parts of the world. This is because the manifestations are causing irredeemable damages to the movable and immovable. Talks should be translated into actions by ensuring that all activities causing or aggravating global climate change are drastically slowed down and with time, stopped.

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REFERENCES

- Adger WN 2006. Vulnerability. *Global Environmental Change*, 16(3): 268-281.
- Adger WN, Huq S, Brown K, Conway D, Hulme M 2003. Adaptation to climate change in the developing world. *Progress in Development Studies*, 3(3): 179-195.
- Balogun OL, Yusuf SA, Ayantoye K 2013. The threats of climate change: Implication for food crisis in sub-Sahara Africa. *Sustainable Food Security in the Era of Local and Global Environmental Change*, 1: 85-98.
- Barrett CB 2010. Measuring food insecurity, *Science*, 327: 825-834.
- Barrett CB, Holden S, Clay DC 2002. Can food-for-work programmes reduce vulnerability? From <<http://www.econstor.eu/handle/10419/52759>> (Retrieved on June 9, 2013).
- Barrett CB, Holden S, Clay DC 2002. Can food-for-work programmes reduce vulnerability? From <<http://www.econstor.eu/handle/10419/52759>> (Retrieved on April 19, 2013).
- Bartel C 2010. Enhancing food security in Africa through science, technology and innovation. From <<https://atdforum.org>> (Retrieved on April 4, 2013).
- Biringer J, Guariguata MR, Locatelli B 2005. *Biodiversity in a Changing Climate: A Framework for Assessing Vulnerability and Evaluating Practical Responses to Climate Change*. Jakarta, Indonesia: CIFOR Publishers.
- Bodansky D 1993. United Nations framework convention on Climate Change: A commentary. *Yale Journal of International Law*, 18: 451-466.
- Bohle HG, Downing TE, Watts MJ 1994. Climate change and social vulnerability: Toward a sociology and geography of food insecurity. *Global Environmental Change*, 4(1): 37-48.
- Booth D, Leach M, Tierney A 1999. Experiencing poverty in Africa: perspectives from anthropology. From <<http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/6168.pdf>> (Retrieved on July 4, 2012).
- Brown O, Hammill A, Mcleman R 2007. Climate change as the 'new' security threat: implications for Africa. *International Affairs*, 83(6): 1141-1154.
- Buchanan-Smith M, Maxwell S 1994. Linking relief and development: An introduction and overview. *IDS Bulletin*, 25(4): 2-16.
- Campbell KM, Gullledge J, McNeill JR, Podesta J, Ogden P, Fuerth L, Woolsey R J, Lennon AT, Smith J, Weitz R, 2007. The age of consequences: the foreign policy and national security implications of global climate change. From <<http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA473826>> (Retrieved on March 19, 2013).
- Carpenter KE, Abrar M, Aeby G, Aronson RB, Banks, Bruckner A, et al. 2008. One-Third of Reef-Building Corals Face Elevated Extinction Risk from Climate Change and Local Impacts. *Science*, 321(5888): 560-563.
- Christian-Smith J 2012. *Water and Agriculture-A Twenty-First Century US Water Policy*, 2012. London, UK: Oxford University Press.
- Curry J 2012. Conservative perspectives on climate change: Part II. From <<http://judithcurry.com/2012/06/07/conservative-perspectives-on-climate-change-part-ii/>> (Retrieved on September 4, 2013).

- Daily G, Ellison K 2002. *The New Economy of Nature: The Quest to Make Conservation Profitable*. Washington, USA: Island Press.
- de la Fuente A 2007. Private and Public Responses to Climate Shocks. From <https://hdr.undp.org/en/reports/global/hdr2007-2008/papers/de%20la%20Fuente_Alejandro_2007a.pdf> (Retrieved on August 4, 2012).
- Diao X, Headey D, Johnson M 2008. Toward a green revolution in Africa: What would it achieve, and what would it require? *Agricultural Economics*, 39(1): 539-550.
- Dimes J, Rao KPC, Shapiro B, Shiferaw B, Twomlow S 2008. Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? *Agriculture, Ecosystems and Environment*, 126(1): 24-35.
- Durant RF, Young-Pyong C, Byungseob K, Seongjong L 2004. Toward a new governance paradigm for environmental and natural resources management in the 21st century? *Administration & Society*, 35(6): 643-682.
- Ellis F 2005. Small Farms, Livelihood Diversification, and Rural-Urban Transitions: Strategic Issues in Sub-Saharan Africa. From <<http://portal.iri.columbia.edu/C80BD74C-6628-40C5-907D-6C6F7475BE16/FinalDownload/DownloadId>> (Retrieved on November 8, 2011).
- Ericksen PJ 2008. Conceptualizing food systems for global environmental change research. *Global Environmental Change*, 18(1): 234-245.
- FAO 2008. Food and Agriculture Organization of the United Nations. Joint FAO/WHO Activities on Risk Assessment of Microbiological Hazards. From <http://www.who.int/foodsafety/micro/jemra/meetings/call_data_formula_08.pdf> (Retrieved on March 8, 2012).
- Godfray H CJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, Pretty J, Robinson S, Thomas SM, Toulmin C 2010. Food Security: The Challenge of Feeding 9 Billion People. *Science*, 327(5967): 812-818.
- Graff G, Roland-Holst D, Zilberman D 2006. Agricultural biotechnology and poverty reduction in low-income countries. *World Development*, 34(8): 1430-1445.
- Harris PG 2010. *World Ethics and Climate Change: From International to Global Justice*. Edinburgh, UK: Edinburgh University Press.
- Heltberg R, Siegel PB, Jorgensen SL 2009. Addressing human vulnerability to climate change: Toward a 'no-regrets' approach. *Global Environmental Change*, 19(1): 89-99.
- Heltberg R, Ashwill M 2013. Is there a community-level adaptation deficit? From <<https://openknowledge.worldbank.com/handle/10986/16329>> (Retrieved on May 1, 2014).
- Huq S, Reid H, Konate M, Rahman A, Sokona Y, Crick F 2004. Mainstreaming adaptation to climate change in Least Developed Countries (LDCs). *Climate Policy*, 4(1): 25-43.
- Jarosz L 2011. Defining world hunger: Scale and neoliberal ideology in international food security policy discourse. *Food, Culture and Society: An International Journal of Multidisciplinary Research*, 14(1): 117-139.
- Jarvis A, Upadhyaya H D, Gowda C L L, Agrawal P K, Fujisaka S, Anderson B 2008. Climate Change and its Effect on Conservation and Use of Plant Genetic Resources for Food and Agriculture and Associated Biodiversity for Food Security. From <<http://oar.icrisat.org/5810/>> (Retrieved on October 4, 2012).
- Kelly PM, Adger WN 2000. Theory and Practice in Assessing Vulnerability to Climate Change and Facilitating Adaptation. *Climatic Change*, 47(4): 325-352.
- Linnerooth-Bayer J, Mechler R 2006. Insurance for assisting adaptation to climate change in developing countries: A proposed strategy. *Climate Policy*, 6(6): 621-636.
- Lybbett T, Sumner D 2010. Agricultural Technologies for Climate Change Mitigation and Adaptation in Developing Countries: Policy Options for Innovation and Technology Diffusion. From <<http://dspace.cigilibrary.org/jspui/handle/123456789/29144>> (Retrieved on September 9, 2012).
- Maxwell S 1990. Food Security in Developing Countries: Issues and Options for the 1990s. *IDS Bulletin*, 21(3): 2-13.
- Maxwell S, Smith M 1992. Household Food Security: A Conceptual Review. From <<http://www.ifad.org/53FE3F08-53AC-44AE-9913>> (Retrieved on November 7, 2013).
- Mendelsohn R, Dinar A 1999. Climate change, agriculture, and developing countries: Does adaptation matter? *Oxford Journals*, 14(2): 277-293.
- Mills E 2007. Synergisms between climate change mitigation and adaptation: An insurance perspective. *Mitigation and Adaptation Strategies for Global Change*, 12(5): 809-842.
- Moorhead A 2009. Climate Change, Agriculture and Food Security: A Strategy For Change. From <<http://cgspace.cgiar.org/handle/10568/33395>> (Retrieved on June 1, 2013).
- Nath PK, Behera B 2011. A critical review of impact of and adaptation to climate change in developed and developing economies. *Environment, Development and Sustainability*, 13(1): 141-162.
- Nellemann C 2009. The Environmental Food Crisis: The Environment's Role in Averting Future Food Crises: a UNEP Rapid Response Assessment From <<http://books.google.co.za/books?hl=en&lr&id=BO6d5mBc42cC&oi=fnd&pg=PA9&dq=20%20Rapid%20Response%20Assessment&f=false>> (Retrieved on March 11, 2012).
- Nyong A, Adesina F, Osman Elasha B 2007. The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitigation and Adaptation Strategies for Global Change*, 12(5): 787-797.
- Olatokun WM, Ayanbode OF 2008. Use of indigenous knowledge by rural women in the development of Ogun State: agriculture and food production. *Indilinga African Journal of Indigenous Knowledge Systems*, 7(1): 47-63.
- Onwuekwue C B 2006. Reconciling the scramble for foreign direct investments and environmental pru-

- dence - A developing country's nightmare. *Journal of World Investment & Trade*, 7: 113:125.
- Osman-Elasha B, Goutbi N, Spanger-Siegfried E, Dougherty B, Hanafi A, Zakieldeen S, Sanjak A, Atti HA, Elhassan HM 2006. Adaptation strategies to increase human resilience against climate variability and change: Lessons from the arid regions of Sudan. From <<http://www.iaaccproject.org>> (Retrieved on August 4, 2012). [B]Parry M, Evans A, Rosegrant MW, Wheeler T 2009. *Climate Change and Hunger: Responding to the Challenge*. Viola, Italy: WFP Publishers.
- Patwardhan A, Semenov S 2007. Assessing Key Vulnerabilities and the Risk From Climate Change. From <<http://ensembles-eu.metoffice.com/c80bd74c-6628-40c5-907d-pdf>> (Retrieved on April 4, 2011).
- Pfeiffer DA 2006. *Eating Fossil Fuels: Oil, Food and the Coming Crisis in Agriculture*. Gabriola Island, Canada: New Society Publishers.
- Pretty J 1999. Can Sustainable agriculture feed Africa? New evidence on progress, processes and impacts. *Environment, Development and Sustainability*, 1(3-4): 253-274.
- Pretty J 2008. Agricultural Sustainability: Concepts, Principles and Evidence. From <<http://rstb.royalsocietypublishing.org/content/363/1491/447.short>> (Retrieved on December 19, 2012).
- Pretty JN, Morison JIL, Hine RE 2003. . Reducing food poverty by increasing agricultural sustainability in developing countries. *Agriculture, Ecosystems & Environment*, 95(1): 217-234.
- Rosegrant MW, Cline SA 2003. Global food security: Challenges and policies. *Science Journal*, 12(302): 1917-1919.
- Sasson A 2012. Food security for Africa: An urgent global challenge. From <<http://www.agricultureandfoodsecurity.com/content/1/1/2>> (Retrieved on February 4, 2013).