ORGANIC FARMING IN AFRICA

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Preface

This special treatise has been painstakingly put together on the subject matter "**Organic Farming in Africa**". The book is very unique in the sense that it provides ample information on several areas of organic agriculture in relation to the tropical African region of the world. The 'tropics' refers to the region of the planet Earth that is near to the equator and between the Tropic of Cancer in the northern hemisphere and the Tropic of Capricorn in the southern hemisphere. However, the book lays more emphasis on the continent of Africa. Africa is only second to Asia in size and population of about 1.1b people. At present the continent accounts for just 1.2 million hectares of land under certified organic agriculture corresponding to 3% of world organic agriculture land.

Globally, organic agriculture became a prominent movement in the last two decades as the proponents mounted massive advocacy on it as a socially and environmentally friendly and sustainable agro-food production system. Consequently, the global market has been increasing steadily and it reached 72b US$ in 2013. However, Africa is yet to prominently feature as a key player and significant contributor to the global organic market. One of the major reasons why organic agriculture is still lagging behind in the tropics could be attributed to paucity of relevant textbooks and learning materials that can fast track the adoption of this relatively new production system by the present and future practitioners. Furthermore, organic agriculture is yet to be properly mainstreamed into the curricula of majority of the higher educational institutions (HEIs) in the tropics.. This has resulted in the lull of activities in the sector among agriculture graduates who find it difficult to pursue organic agriculture as a business. Although, there are relatively encouraging organic trade investments in East Africa. The current Ecological Organic Agriculture Initiative (EAO-I) is being coordinated by the African Union Commission (AUC) and its

Kingdom. Pp22.

Inckel, Mi De Smet, P; Tersmette, Tald Veldkamp, T (2005). Preparation and Use of Compost. Agrodok-Series Number 8, CTA: 6-56.

Patterson *et al* (2002). Integrated Waste management Board: Compost Maturity and Nitrogen Release Characteristics in Central Coast Vegetable Production.

Chapter 12

ORGANIC AGRICULTURE AND CLIMATE CHANGE

Fayinminnu, O.O., O.O. Fadina and A.F. Ogundola

Introduction

Agriculture provides the primary source of livelihood for more than 60% of the population in sub-Saharan Africa and about 40–50% in Asia and the Pacific (Inubushi *et al.,* 2001). Agriculture is highly dependent on climate conditions and it is therefore subject to change and variability, with obvious impacts on food security (FAO, 2007). Changing environmental conditions such as rising temperatures, changing precipitation patterns and an increase of extreme weather events seriously affect agricultural productivity (FAO, 2007). The Fourth Assessment Report of the Inter-governmental Panel on Climate Change (IPCC), revealed that greenhouse gas (GHG) emissions from the agricultural sector account for 10–12% of the total anthropogenic annual emissions of CO_2, CH_4 and N_2O (IPCC, 2007). This amount includes only direct agricultural emissions; emissions due to the production of agricultural inputs such as nitrogen fertilizers, synthetic pesticides and fossil fuels used for agricultural machinery and irrigation were not included.

Changes in carbon stocks as a result of land use change caused by some agricultural practices were not taken into account, e.g. clearing of primary forests. Emissions by deforestation due to land conversion to agriculture, mostly CH_4 from livestock raising, biomass burning and wet cultivation practices and N_2O from the use of synthetic fertilizers accounted (Andrasko *et al.,* 2007) for the global GHG emissions, which can be additionally allocated to agriculture. N_2O are the most important source of agricultural emissions, NH_3 and NO_3 emissions are nitrogen leakage into rivers and coastal zones. Thus, agriculture production practices emit as high as 17-32% and 38% of global anthropogenic emissions (Bellarby *et al.*, 2008; Smith 2007), at least one-quarter of global anthropogenic GHG emissions. A report by the International Food Policy Research Institute (FAO, 2007) warned that climate change if not checked would have major negative effects on agricultural productivity.

It was predicted that crop productivity is projected to decrease for even local temperature increases (1-2°C) in many developing countries, at lower latitudes, especially in the seasonally dry and tropical regions and this would increase the risk of hunger (FAO, 2007). The rise in temperature would produce adverse impacts on agriculture in tropical areas, where it is the primary source of livelihood for more than 60% of the population in sub-Saharan Africa and about 40–50% in Asia and the Pacific (Inubushi *et al.*, 2001; IPCC, 2007). By 2050, all agroecosystems of the world, including temperate areas are expected to be affected by climate change as reported by IPCC (2007). Therefore, there are strong needs for ecosystems designs in order to cope with stress and adapt to change so as to facilitate food security and sustainable livelihoods in sub Sahara Africa.

Climate change would cause yield declines for most important crops and result in additional price increases for the world's staple food such as rice, wheat, maize and soybeans (Smith *et al.*, 2008; Smith and Lenhart, 1996). The threats of climate change would include; likely increase of extreme weather conditions, increased water stress and drought, and desertification, as well as adverse health effects (extreme heat and increased spread of diarrhoeal and infectious diseases, such as malaria). These adverse effects may over stretched if adaptation fail into destabilization and security risks, including loss of livelihoods, malnutrition, forced migration and conflicts (IPCC 2007; Lobell *et al.*, 2008).

Agriculture today faces the challenge of having to adapt and respond to climate change and reduce GHG emissions (IPCC 2007). This challenge could be faced by Organic agriculture, in adapting to climate change and also reducing GHG emissions. Organic agriculture enhances biodiversity, protects the fragile soils and improves the nutritional quality of food (El-Hage Scialabba and Muller Lindanlauf, 2010). It ensures high standards of animal welfare and provides increased employment in rural areas. Organic agriculture at the same time reduces fossil fuel energy use, cuts nutrients and pesticide pollution and stops potentially harmful pesticide residues entering our food chain (El-Hage Scialabba and Muller Lindanlauf, 2010). There is a need to emphasise on the mitigation and adaptation of climate change in relation to organic agriculture as a result of reducing environmental pollution.

Impacts of Organic Agriculture Practices on Climate Change and the Environment

Organic agriculture, a holistic production management system, that avoids use of synthetic fertilizers, pesticides and genetically modified organisms (GMO), minimizes pollution of air, soil and water, and optimizes the health and productivity of interdependent communities of plants, animals, people and environment at large' The Codex Alimentarius Commission (2001). Organic agriculture has well established practices that simultaneously mitigate and combat climate change, builds resilient farming systems, reduce poverty, securing local food supplies and thereby improve food security. Organic agriculture is able to quickly, affordably and effectively sequesters carbon in the soil (Pimentel *et al.*, 2005).

In addition, organic agriculture makes farms and people more resilient to climate change, mainly due to its water efficiency, can withstand extreme weather events and lower risk of complete crop failure (El- Hage Scialaaba and Hattan, 2002). On the other hand, conventional agriculture relies on fossil fuel based chemical nitrogen (N) fertilizers and herbicides manufactured in energy intensive factories transported to farms. Millions of tonnes of carbon are emitted from the ongoing conversion of habitats. For example, supply of soya to intensive livestock operations and the destruction of rainforest for export beef production. The production and transport of external inputs, such as chemical fertilizer and concentrate feed contributed significantly to emissions of CO_2 and N_2O in agricultural sector and in the manufacturing process (Eyhorn, 2007; EFIMA, 2005).

Organic agriculture is widely recognized for its environmental sustainability. A study by the Asian Development Bank (Andrasko *et al.*, 2007) recommended organic agriculture for its climate-friendly and resilient farming practices. FAO has specified organic agriculture as a promising way for agriculture to mitigate and adapt to climate change (FAO, 2007). Organic agriculture replaces highly soluble synthetic chemical nutrients with naturally occurring nutrients in manure, compost and leguminous plants because the organic agriculture uses 60 to 70% less N input than conventional agriculture (Niggli *et al.*, 2009).

The diversity of crops grown in an organic system, planted at different times in the year make organic agriculture more stable in uncertain weather conditions (Smith and Lenhart, 1996). Organic crops tend to have deeper and denser roots and scavenge nitrogen and other nutrients more efficiently than non-organic crops (Zhang and Li, 2003). Organic agriculture increases soil fertility and stability, optimises water use, diversifies crops and incomes, thereby building resilience to climate change, achieving high yields under difficult conditions and creating new local markets (Badgley *et al.*, 2007).

Organic agriculture incorporates significant amounts of organic matter, avoids bare fallows and generally has a higher proportion of grasslands within farming systems (Khan *et al.*, 2007). Chemical fertilizers and herbicides inhibit the natural biological activity of the soil that drives the formation of compounds that encase and effectively store carbon (IPCC, 2007). There are some indications that the higher the application of chemical inputs, the greater the amount of soil carbon lost, as CO_2 as the soil fractions are less stable. However, this is only part of the reason that organic agriculture sequesters more CO_2 than conventional systems. Compost, followed by farmyard manure and legumes has the most efficient conversion of carbon into soil carbon (Niggli *et al.*, 2008). In comparison, arable crop residues are relatively poor at forming soil carbon which tends to be rapidly mineralised.

Mitigation of Climate Change in relation to Organic Agriculture in the environment

Mitigation involves concepts and science underlying the main organic agriculture practices that reduce the greenhouse gases (GHG) emissions (IFOAM, 2006, IPCC, 2006; Niggli *et al.*, 2008). The following mitigation aspects which are simple and will be able to reduce GHG emissions in the environment are hereby discussed and the potential in organic agriculture is shown in Table 1.

Soil Organic Carbon: Organic Agriculture has a significant contribution in this aspect. Organic agriculture utilizes organic fertilisers, fertility building leys with cover crops, green (legumes) and animal manures, crop residues and compost to build soil organic matter, minimize nutrient loss and maximize productivity (IFOAM, 2006). These enhance the production of soil organic matter by maintaining and increasing soil organic carbon in agricultural systems as reported by Smith *et al.*, (2008), Leifeld and Fuhrer (2010) and Chirinda *et al.*, (2010a). Soil carbon build-up is stimulated by the additional biomass that returns to the soil from organic fertilizers, which is absent when using chemical fertilizers (Drinkwater and Wagoner 1998; Pimentel *et al.*, 1995). These practices also contribute to the build-up of a healthy soil structure (greater aeration, increased porosity and higher organic matter content), which facilitates complete crop failure (El- Hage Scialaaba and Hattan, 2002). On the other hand, conventional agriculture relies on fossil fuel based chemical nitrogen (N) fertilizers and herbicides manufactured in energy intensive factories transported to farms. Millions of tonnes of carbon are emitted from the ongoing conversion of habitats. For example, supply of soya to intensive livestock operations and the destruction of rainforest for export beef production. The production and transport of external inputs, such as chemical fertilizer and concentrate feed contributed significantly to emissions of CO_2 and N_2O in agricultural sector and in the manufacturing process (Eyhorn, 2007; EFIMA, 2005).

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Chemical Nitrogen Fertilizers: Strong indications had shown that synthetic fertilizers can lead to losses of soil organic matter (Klan *et al.*, 2007; Malvaney *et al.*, 2009). One percent (1%) of global fossil energy consumption is used for chemical nitrogen fertilizers. Organic agriculture does not contribute to this emission as no chemical nitrogen fertilizers are used (El-Hage Scialabba and Muller Lindanlauf, 2010). Organic systems are based on lower nitrogen inputs, closed nutrient cycles and combined animal and plant production needs to be accounted for especially on the accounting of GHG emissions from farming system (Muller, 2012). Nitrogen input stems from N fixing leguminous plants and application of compost and manure are used. Biological N fixation itself is not a source of N_2O emission (Rochette and Janzen, 2005). The report of Moller and Stinner (2009) revealed that soil incorporation of N-rich plant residues from legume crops can lead to high emissions of N_2O. However, more research is needed to determine the relative performance of chemical and organic fertilizers with relationship to life cycle emissions and interactions of soil carbon levels.

Fossil Energy: Pimentel *et al.*, (2005) and Pimentel (2006) reported the amount of fossil energy use in organic agriculture as 20-30% (crop farms, per ha: based on corn and soya bean) to 50% (livestock per kcal meat protein: organic grass - fed beef against conventional grass-fed beef) which was lower than conventional agriculture. The lower energy used in organic farms largely because industrial fertilizers and pesticides are not used thereby avoiding energy inputs for their production (Lampkin, 2007). Organic farming systems use less fossil energy on a per hectare and per unit of food produced basis than conventional farming system (Schader *et al.*, 2011). In some cases (e.g potatoes) where yields of organic farms are lower, the energy input per unit output can also be higher (Cormack and Metcalfe, 2000). Weed control is another aspect in organic systems where the tillage increasing needs and corresponding energy consumption pose problems. However, averagely the increased machinery use requires less energy, than needed for fertilizer production (Cormack and Metcalfe, 2000).

Paddy Rice Production: Methane from paddy rice field accounts for 11% global agricultural GHG emissions which influenced the cropping systems. The main influencing factors are cultivars, organic amendments and drainage (Neue *et al.*, 1996). While organic amendments increase emissions the drainage reduces the emission (Yang and Chang 2001). Organic systems add more organic amendments but adding amendments in the times of drainage could avoid higher emissions (Xu *et al.*, 2000; Cai and Xu, 2004). As organic systems do not use herbicides, the aquartic weeds have the tendency to be present in organic rice paddies and weeds have an additional decreasing effect on methane (Inubushi *et al.*, 2001). Generally, there are adverse effects of organic paddy production on methane emissions due to organic fertilization.

Limited External Inputs: The use of synthetic inputs like mineral fertilizers and chemical pesticides are banned in organic agriculture (El-Hage Scialabba and Muller Lindanlauf, 2010). Chemical fertilizers and herbicides inhibit natural biological activity of the soil that drives the formation of compounds that encase and effectively store carbon. The energy used for the chemical synthesis of nitrogen fertilizers, which are totally excluded in organic systems, represent up to 0.4–0.6 Gt CO_2 emissions (FAOSTAT, 2009; EFMA, 2005). This is as much as 10% of direct global agricultural emissions (El-Hage Scialabba and Muller Lindanlauf, 2010) and around 1% of total anthropogenic GHG emissions. Calculated total primary energy burden of conventional wheat production in the UK was allocated by 56% to mineral fertilizers and by 11% to pesticides (Williams *et al.*, 2006). Pimentel (2006) calculated similar results for corn in USA, 30–40% for fertilization and 9–11% for plant protection for wheat and corn. These emissions are avoided by organic agriculture. Reduced use of synthetic fertilizers is believed to result to lower yields per land unit, depending on the level of intensity of the previous management systems.

A review by Badgley *et al.*, (2007) calculated the average yield losses under organic management for developed countries of 0-20% and for developing countries, an increase in yield or hardly any yield reduction. In low external inputs system especially in arid or semi arid areas, organic yields always improve to 180 % (Pretty, 2002; Blaise, 2006). Higher yields in low external inputs systems are mainly achieved by the application of manure from integrated livestock production, composting and diversification. Organic yields also depend on availability of other organic nitrogen sources where there is less or no integrated livestock. However, in an appropriate agroforestry system lower yields are compensated by producing other food stuff and goods (Daniels *et al.*, 1999; Rice and Greenberg 2000).

Crop Diversification: By abstaining from synthetic input use, organic agricultural systems cannot but adapt to local environmental conditions (El-Hage Scialabba and Muller Lindanlauf, 2010). Therefore, species and varieties are chosen for their adaptability to the local soil and climate and their resistance to local pests and diseases (IPCC, 2007). Organic farmers prefer not to use uniform crops and breeds and opt for more robust traditional species, which they tend to conserve and develop. Growing different assemblages of crops in time and space seeks to enhance the agro-ecosystem resilience to external shocks such as extreme weather events or price variation (Smith and Lenhart, 1996) on which are all risks most likely to increase as the climate changes (Smith *et al.*, 2007). Diverse cropping systems in developing countries do not only rely on cash crops but also on food crops for house hold consumption. These systems also make more efficient use of available nutrients, with improved productivity and economic performance, which is of high importance in times of limited nutrients and financial constraints (Zhang and Li, 2003).

Restoration of Degraded Land: About 70% of the land in dried area is assumed to be degraded (Dregne and Chou 1994). Organic farming practices such as crop rotation, cover crops, manuring and application of organic amendments are recommended strategies. These are to restore degraded soil (Blanco and Lal, 2007) and hence improve the livelihoods of rural population affected by climate change. Edwards (2007) reported that agricultural productivity was doubled by soil fertility techniques through agroforestry, application of compost and introduction leguminous crops into the crop sequence in one of the most degraded soils in Ethiopia in Tigray Province. By restoring soil fertility, yields were increased to a much greater extent than using synthetic mineral fertilizers. Restoration of soil has a huge mitigation potential by increasing soil carbon sequestration. The total mitigation of potential of restoration of degraded land is estimated as 0.15Gt (Smith *et al.*, 2008).

Table 1: Mitigation potential of organic agriculture on climate change in the environment.

Source of GHG	Share of Total Anthropogenic GHG Emissions	Impacts Optimized Organic Management	Remarks
Direct emissions from agriculture	10-12%		
N_2O from soils	4.2%	Reduced	Higher Nitrogen use efficiency
Methane (CH4) from enteric fermentation	3.5%	Opposed effects	Increased by lower performance and lower energy concentration in the diet but reduced by lower replacement rate and multi-use breeds.
Biomass burning	1.3%	Reduction	Burning avoided according to organic standards
Paddy rice	1.2%	Opposed effects	Increased by organic amendments but lowered by drainage and aquatic weeds
Manure handling	0.8%	Equal	Reduced methane emissions but no effect on N_2O
Direct emissions from forest clearing for agriculture	12%	Reduction	Clearing of primary ecosystems restricted
Indirect Emissions			
Mineral fertilisers	1%	Totally prohibited	Prohibited use of mineral fertilizers
Food chain	?	Reduction	Inherent energy saving but still inefficient distribution systems
Carbon sequestration		Enhanced	Increased soil organic matter

Source: *El-Hage Scialabba and Muller Lindanlauf, 2010*

Adaptation of Climate Change in relation to Organic Agriculture in the environment

Adaptation actions involve those necessary to restore the resilience of the eco-systems and their productivity to enable sustainable economic development when faced with adverse effects of climate change (IFOAM, 2006, IPCC, 2006; Niggli *et al.*, 2008). The following adaptation actions in restoring the eco systems are discussed with the potential in organic agriculture shown in Table 2.

Low risk farming strategy of external inputs: Organic agriculture lowers toxicity, reduced input lower costs and increase competitiveness of this farming system economically hence price premium may be realised. Organic agriculture is an alternative to industrial production inputs (i.e mineral fertilizer and agrochemicals) to decrease pollution (El-Hage Scialaabba and Muller Linderlauf 2010). Fayinminnu (2010) demonstrated and reported that crude cassava water extract (organic pesticide) as a natural herbicide was a lower cost input and did not contribute any pollution concern in the environment. It was also reported by Fayinminnu *et al.*, (2013) that using crude cassava water extract as a natural herbicide lowers toxicity and could control weeds of cowpea as an alternative to synthetic industrial production input. Due to low cost of inputs in organic farming, there is effective insurance against crop failure and reduction as reported by El-Hage Scialaabba and Hattam (2002), Eyhorn (2007). It also improves natural resources processes and environmental services (El-Hage Scialaabba and Muller Linderlauf, 2010). There is also increase in coping capacity of farms which reduces the risks indebtedness. Therefore organic agriculture is a viable alternative for the poor farmers.

Soil Organic Matter: Reganold *et al.*, (1987) reported that soils under organic management can capture and store water better than soils of conventional cultivation. Organic cultivation is less prone to extreme weather conditions such as drought, flooding and water logging (El-Hage Scialaabba and Muller Linderlauf,

2010) which are expected to be frequent under climate change (Ahmed *et al.*, 2009). Organic farming systems have been shown to reduce soil erosion, increase aggregate stability and stimulate soil biological activity (Siegrist *et al.*, 1998; Lampkin 2007).

Biodiversity of species: Organic agriculture uses a greater level of diversity among crops (Eyhorn, 2007), crop rotation and production practices which improve ecological and economical stability than convectional, industrialized agriculture which is often based on monocultures. Enhanced biodiversity as well as resilience to adverse effects of climate change are among the benefits of organic agriculture (Eyhorn, 2007). This reduces pest outbreaks and severity of plant and animal diseases (IPCC, 2007), while also improving utilization of soil nutrients and water (Smith *et al.*, 2011). El-Hage Scialaabba and Muller Linderlauf (2010) also reported the means of biodiversity as farm diversification (polycropping) which involves agroforestry and integrated crop and livestock and use of local varieties and breeds (IPCC, 2007). The impacts of biodiversity in the environment had shown risk splitting (pests and diseases), enhanced use of nutrient and energy flows, resilience to climate variability and savings on capital intensive seeds and breeds (El-Hage Scialaabba and Muller Linderlauf, 2010).

Local and indigenous farmer knowledge: Indigenous and traditional knowledge are a key source of information on adaptive capacity, centred on the selective, experimental and resilient capabilities of farmers (Altieri and Koohafkan, 2008; Niggli *et al.*, 2008).Adaptive learning and crop development are seen as important sources of adaptation to climate change and variability in farming communities. Many farmers cope with climate change in different ways: by minimising crop failure through increased use of drought-tolerant local varieties, water-harvesting, extensive planting, mixed cropping, agroforestry, opportunistic weeding and wild plant gathering. Traditional knowledge (Altieri and Koohafkan, 2008; Niggli *et al.*, 2008),

coupled with the right investments in plant breeding, could yield new varieties with climate adaptation potential.
Other adaption actions include plant and animal breeding for improved drought and heat resistance, use of locally adapted varieties and optimised feeding practices to avoid heat stress for animals.

Table 2: Adaptation potential of organic agriculture on climate change in the environment

Objectives	Means	Impacts
Alternative to industrial production inputs (i.e mineral fertilisers and agrochemicals) to decrease pollution	Improvement of natural resources processes and environmental services (e.g soil formation, predation)	Reliance on local resources and independence from volatile prices of agricultural inputs (e.g mineral fertilizers) that accompany fossil fuel hikes.
In situ conservation and development of agrobiodiversity	Farm diversification (e.g polycropping, agroforestry and integrated crop/livestock) and use of local varieties and breeds	Risk splitting (e.g pests and diseases), enhanced use of nutrient and energy flows, and resilience to climate variability and savings on capital – intensive seeds and breeds.
Soil fertility	Nutrient management (e.g crop rotations, cover crops and manuring	Increased yields enhanced soil water retention/drainage (better response to droughts and floods), decreased irrigation needs and avoided land degradation.

Source: *El-Hage Scialabba and Muller Lindanlauf, 2010*

However, there are challenges facing organic agriculture in mitigation and adoption processes in reducing greenhouse gas (GHG) emissions in the environment (Muller *et al.*, 2012). These challenges include: **Lack of training, extension services and information** which are critical points that are needed to be available with institutional structures such as having market access. **Doubts of relevant yields and food security about organic agriculture** that, it cannot meet the world's food demands, primarily because of low yields and insufficient organic fertilizer. However, Badgley *et al* (2007) reported that recent research organic and other sustainable agriculture particularly in developing countries and arid regions can have considerable higher yields than the current used agriculture. More research is highly needed to increase knowledge in reducing the N_2O emissions with interactions of soil carbon contents, to improve the effects of organic paddy rice production and to develop strategies in reducing the methane emissions, to reduce emissions from mulching green manures and cover crops, sequestration of potential of above and below ground carbon input, adaptability of plants to environmental stress.

I suggest that, Environmentalists/Toxicologists should also focus on research using organic method(s) on how to reduce the emissions of toxicant radioactively gases. These include added new greenhouse gas (GHG), such as halocarbons (e.g chlorofluorocarbons) and hexafluoride (from anthropogenic activities), which contribute highly to the climate change in the environment.

Conclusion and Recommendations

Organic agricultural systems have an inherent potential to both reduce greenhouse gas (GHG) emissions release in the environment and to enhance carbon sequestration in soil. Organic agriculture has a strong potential for building resilience in the face of climate variability. Its capacity to contribute to the mitigation of climate change can be considered as an important benefit to its primary goal (soil productivity, food security, biodiversity and others) of sustainable land use. Organically managed systems contributed potentially to the careful management of nutrients which reduces N_2O emissions from soils which are the most relevant single source of direct GHG emissions from agriculture. Indirect GHG emissions are reduced in organic systems by avoidance of mineral fertilisers. Through the promotion of aerobic organisms and high biological activity in soils, the oxidation of methane is increased hence organic agriculture has the superior impact in reducing methane production in the environment. Agroforestry, a management system that integrates trees in landscaping is systematically applied in organic agriculture which holds biggest potential carbon sequestration in tropical countries. Absence of synthetic inputs in organic agriculture reduces toxicants, pollutants and produces a more favourable energy balance in the environment.

The relationship between climate change and agriculture is a two-way one; climate change in general, adversely affects agriculture and agriculture contributes to climate change in several major ways. In developing countries, some of the poorest people live and farm in subsistence farming, any minor changes in climate can have disastrous impacts on their lives and livelihoods. Agriculture releases into the atmosphere a significant amount of global anthropogenic greenhouse gas (GHG) emissions around 10-12% annually. Contaminants such as inorganic fertilisers and synthetic pesticides used in conventional agriculture are a major concern all over the world. The GHG includes CO_2, mainly from burning of fossil fuels and deforestation, CH4 from livestock raising, biomass burning and wet cultivation practices, and N_2O from the use of synthetic fertilisers. The challenge is therefore, to design an agriculture that adapts and responds to the changes in climate experienced, as well as reduces GHG, persistent pesticides which have accumulated up the food chain where top predators (e.g. humans) consume toxic dosages. This challenge could be met through organic agriculture which increases its ability to continue functioning when faced with unexpected events such as climate change. However, the objective of this paper therefore, is to overview the implications of organic agriculture on climate change in the environment, which restores the environmental balance and has none of deleterious effects on the environment.

It is therefore recommended that, appropriate policy support, implementing national, regional and international action plans on organic agriculture and climate change should be implemented in GHG inventories. This will be beneficial in terms of climate adaptation and mitigation. Government and Non-government Organizations (NGOs) need to promote programs (awareness) on education about the basic concept of organic (eco-friendly) farming and also global warming, which will ensure long-term food security and environmental safety.

References

Ahmed, S.A., Diffenbaugh, N.S., Hertel, T.W. (2009). Climate volatility deepens poverty vulnerability in developing countries. Environmental Research Letters 4:034004.

Altieri, M.A. and Koohafkan, P. (2008). Enduring farms: Climate change, smallholders and traditional farming communities. TWN Environment and Development Series 6. Third World Network, Penang.

Andrasko, K., Benitez-Ponce, P., Boer, R., Dutschke, M., Elsiddig, E., Ford-Robertson, J., Frumhoff, P., Karjalainen, T., Krankina, O., Kurz, W., Matsumoto, M., Oyhantcabal, W., Ravindranath, N.H., Sanz Sanchez, M.J., and Zhang, X. (2007). Forestry. In B. Meencestz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer, (eds). Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Badgley, C., Moghtader, J., Quintero, E., Zakem, E., Chappell, M.J., Aviles-Vazquez, K., Samulon, A., Perfecto, I.(2007). Organic agriculture and global food supply. Renewable and Food Systems 22:18.

Bellarby, J., Foereid, B., Hastings, A. and Smith, P. (2008). Cool farming: Climate impacts of agriculture and mitigation potential. Greenpeace International, Amsterdam.

Blaise, D. (2006).Yield, boll distribution and fibre quality of hybrid cotton as influenced by organic and modern methods of distribution. Journal of Agronomy and Crop Science 1992:248-256.

Blanco, H. and Lal R. (2008). Chapter 15: Restoration of eroded and degraded soils. In Principles of Soil Conservation and Management. Springer Dordrecht, Netherlands.

Cai, Z.C. and Xu, H. (2004). Options for mitigating CH4 emissions from rice field in China. In Y Hayashi (ed.). Material Circulation through Agro-Ecosystems in East Asia and Assessment of its Environmental Impact.

NIAES Series 5, Tsukuba, Japan.p.45-55.

Chirinda,N., Olesen,J.E., Porter, J.R., Schjonning, P.(2010a).Soil properties, crop production and greenhouse gas emissions from organic and inorganic fertilised –based arable cropping systems. Agriculture Ecosystems andEnvironment139:584-594.

Codex Alimentarius Commission (2001). Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods. First Revision. Joint Food and Agriculture Organisation (FAO) and World Health Organisation (WHO) Food, Standards Program, Rome, Italy. Available at Web site http://www.codexalimentarius.net/ (October 2009).Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. aspx#anchor (accessed 7 October 2009).

Cormack, W. and Metcalfe, P., (2000). Energy Use in Organic Farming Systems, Defra Final Project Report Defra.

Daniels, S., Mack, R., and Whinney, J. (1999). Considerations for the Sustainable of Production Cocoa. Organic Commodity Project, Cambridge, MA, USA.

Dregne, H.E. and Chou, N.T. (1994). Global desertification dimensions and costs. In H.E. Dregne (ed.). Degradation and Restoration of Arid Lands. Texas Technical University, Lubbock, USA.

Drinkwater, L.E. Wagoner, P. (1998): Legume-based cropping systems have reduced carbon and nitrogen losses. Nature: International weekly journal of science Vol. 396: 262-265.

Edwards, S.(2007). The impact of compost use on crop yields in Tigray, Ethiopia. Institute for Sustainable Development (ISD). In proceedings of International Conference on Organic Agriculture and Food Security. FAO. Rome, Italy [on line] ftp://ftp.fao.org/paia/organicag/ofs/02-Edwards.pdf Accessed 15/10/2009.

El Hage Scialabba, N. and Hattam, C.(2002). Organic Agriculture, Environment and Food Security. Rome: FAO (On line) http//www.fao.org/docrep/005 /y4137e/

y4137e00.htm Accessed 27/07/11

El Hage Scialabba, N. and Muller-Lindenlauf M (2010). Organic agriculture and climate. Renewable Agriculture and Food Systems: 25(2): 158-169.

European Fertilizer Manufactures Association (EFMA). (2005). Understanding Nitrogen and Its Use in Agriculture. EFMA, Brussels, Belgium.

Eyhorn, F (2007). Organic Farming for Sustainable Livelihoods in Developing Countries: The Case of Cotton in India. Inaugural dissertation der Philosophisch-naturwissenschaftlichen Fakultat Universitat Bern Zurich:VDF Hochschulverlag AG.

FAOSTAT. (2009). FAO Statistical Database Domain on Fertilizers: ResourcesSTAT-Fertilizers. Food and Agriculture Organisation of the United Nations (FAO) Rome, Italy. Available at http://faosat.fao.org/site/575/default.aspx#anchor (accessed 7/10/2009)

Fayinminnu, O.O. (2010). Crude cassava water extract as natural post emergence herbicide and effects on growth, yield and food composition of cowpea (Vigna unguiculata (L) Walp) Ph.D thesis Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria. pp 205.

Fayinminnu O.O., Fadina O.O., Adedapo A.A. (2013). Efficacy study of Bulk Source of Crude Cassava Water Extract as a post emergence in cowpea (Vigna unguiculata (L) Walp) production. The Lesotho Journal of Agricultural Sciences Vol. 3 No 1 pp 61-75.

Food and Agriculture Organisation (FAO) of the United Nations (FAO). (2007). Adaptation to Climate Change in Agriculture, Forestry and Fisheries: Perspective, Framework and Priorities. FAO, Rome, Italy. Food and Agriculture Organisation of the United Nations FAO R., (2007). Report on International Conference On Organic Agriculture and Food Security Rome 3-5 May 2007 Rome: FAO.

Giovannucci, D. (2005) Organic Agriculture and Poverty

Reduction in Asia. IFAD Office of Evaluation. International Fund for Agricultural Development IFAD, Rome, Italy.

International Federation of Organic Agriculture Movement (IFOAM) 2006. `Mitigation and Adaptation to Climate Change. The role of Organic Agriculture.` IFOAM side event to the 24th Session of the Subsidiary Bodies, Bonn, Germany, May 24, 2006. http://regserver.unfccc.int/seors/reports/archive.html?session_id=SB 24. Accessed 12/02/2009

Intergovernmental Panel on Climate Change (IPCC). (2007). Summary for policymakers. In M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van derLinden, and C.E. Hanson (eds). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK. p. 7–22.

IPCC (Intergovernmental Panel on Climate Change). (2007). Synthesis report. In O.R.D. Metz, P.R. Bosch, R. Dave, and L.A. Meyer (eds). Fourth Assessment Report: Climate Change 2007. Cambridge University Press, Cambridge, UK. Intergovernmental Panel on Climate Change (IPCC)(2007). Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

International Labour Organisation (ILO). (2007). Employment by sector. In: Key Indicators of the Labour Market (KILM). 5th ed. International Labour Organisation (ILO), Geneva, Switzerland. Available at Web site http://www.ilo.org/public/english/employment/strat/ (October 2009).

Inubushi,K., Sugii, H., Nishino,S., and Nishino, E. (2001). Effect of aquatic weeds on methane emission from submerged paddy soil. America Journal of Botany

88(6):975-979.

Khan, S. A.; Mulvaney, R. L.; Ellsworth, T. R., and Boast (2007), C. W. The Myth of Nitrogen Fertilization for Soil Carbon Sequestration. Journal of Environmental Quality. 2007 Oct 24; 36(6):1821-1832.

Lampkin, N. (2007). Organic Farming`s Contribution to Climate Change and Agricultural Sustainability. Welsh Organic Producer Conference, 18th October 2007.

Leifeld, J. and Fuhrer, J. (2010). Organic Farming and Carbon Sequestration: What Do We Know About The Benefits? AMBIO: A Journal of the Human Environment 39:14.

Lobell, D.B., Marshall, B.B., Telbadi, C., Manstradrea, M.D., Falcon, W.P., Naylor, R.L. (2008). Prioritizing climate change adaptation needs for food security in 2030. Science 319:607-610.

Moller, K. and Stinner W. (2009). Effects of different manuring systems with or without biogas digestion on soil mineral nitrogen content and on gaseous nitrogen losses (ammonia, nitious oxides). European Journal of Agronomy 30:1-16Mulvaney,R., Khan, S. and Ellsworth, T. (2009). Synthetic Nitrogen Fertilisers Deplete Soil Nitrogen: A Global Dilemma for Sustainable Cereal Production. Journal of Environmental Quality38:2295-2314.

Muller, A., Olesen, J., Davis, J., Smith, L., Dytrtova, K., Gattinger, A., Lampkin, N., Niggli, U (2012). Reducing Global Warming and Adapting to Climate Change: The Potential of Organic Agriculture. Working Paper Draft Version 11/04/2012.

Neue, H. U., Wassmann, R., Lantin, R.S., Alberto, M.C.R., Aduna, J.B. and Javellana, A.M. (1996). Factors affecting methane emission from rice fields. Atmospheric Environment 30:1751-1754.

Niggli, U., Fließbach, A. and Hepperly, P. (2008). Low Greenhouse Gas Agriculture: Mitigation and Adaptation Potential of Sustainable Farming Systems. FAO, Rome.

Niggli, U., Fließbach, A., Hepperly, P. and Scialabba, N. (2009). Low Greenhouse Gas Agriculture: Mitigation and

Adaptation Potential of Sustainable Farming Systems. Geneva: International Trade Centre FAO, April 2009. 2009. ftp://ftp.fao.org/docrep/fao/

Olesen, J.E., Schelde, K., Weiske, A Weisbjerg, M.R., Asman W.A.H. and Djurhuus, J. (2006). Modelling greenhouse emissions from European conventional and organic dairy farms. Agriculture, Ecosystems and Environment112:207-220.

Pimentel, D. (2006). Impacts of Organic Farming on the Efficiency of Energy Use in Agriculture. An Organic Center State of Science Review. [on line] http://organic.insightd.net/profiles/ENERGY_SSR.pd. Accessed 01/06/11

Pimentel, D., C. Harvey., P. Resosudarmo, K. Sinclair, D. Kurz, M. Mcnair, S. Crist, L. Shpritz, L. Fitton, R. Saffouri, and R. Blair (1995). Environmental and economic costs of soil erosion and conservation benefits. Science, 267:1117–1123.

Pimentel, D., Hepperly, P., Hanson, J., Douds, D., and Seidel, R. (2005). Environmental, energetic and economic comparison of organic and conventional farming systems. Bioscience 55:573–582.

Pretty, J.N., Noble, A.D., Bossio, D., Dixon, J., Hine, R.E., Penning Vries F.W.T., Morrison, J.I.L. (2006). Resource Conserving Agriculture Increases Yields In Developing Countries. Environmental Science and Technology 40.

Reganold, J., Elliot, L., Unger, Y (1987). Long term effects of organic and conventional farming on soil erosion. Nature 330: 3.

Rice, R.A., Greenberg, R. (2000). Cacao cultivation and the cultivation of biological diversity. Ambio 29(3):167-173.

Rochette, P., and Janzen, H.H. (2005). Towards a reversed coefficient for estimating N_2O emissions from legumes. Nutrieny Cycling in Agroecosystems 73:171-179.

Ruser, R., Flessa, H., Schiling, R., Besse, F., and Munch, J.C (2001). Effects of crop-specific field management and N fertilization and N20 emissions from a fine loamy soil.

Nutrient Cycling in Agroecosystems 59:177-191.

Schader,C., Stolze, M. and Gattinger, A. (2011 in press)`Environmental performance of organic agriculture` in Boye, J. and Arcand, Y. (eds.) Green Technologies in Food Production and Processing, New York Springer.

Shibata, M. and Terada, F. (2010). Factors affecting methane production and mitigation in ruminants. Animal Science Journal 82:8.

Siegrist, R.L., Lowe, K.S., Murdoch, L.D., Case, T.L., Pickering, D.A. and T.C. Houk (1998). Horizontal Treatment Barriers of Fracture-Emplaced Iron and Permanganate Particles. NATO/CCMS Pilot Study Special Session on Treatment Walls and Permeable Reactive Barriers. EPA 542-R-98-003. May 1998.

Smith, J., Wolfe,M., Woodward, L., Pearse, B., Lampkin, M. (2011). Organic Farming and Biodiversity: A review of the literature. Organic Centre Wales, Aberystwyth:Wales.

Smith, J.B and Lenhart,S.S (1996). Climate change adaptation policy options. Climate Research 6:193-201.

Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., McCarl, B., Ogle, S., O'Mara, F., Rice, C.,Scholes, R.J., Sirotenko, O., Howden, M., McAllister,T., Pan, G., Romanenkov, V., Schneider, U., Towprayoon, S., Wattenbach, M., Smith, J.U. (2008). Greenhouse gas mitigation in agriculture. Philosophical Transactions of the Royal Society.

Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., McCarl, B., Ogle, S., O'Mara, F., Rice, C.,Scholes, R.J., Sirotenko, O. (2007). Agriculture. Climate Change 2007: Mitigation. Contribution of Working Group 111 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Smith, K.A., McTaggart, I.P., Dobbie, K.E. and Conen, F. (1998). Emissions of N20 from Scottish agricultural soils as a function of fertilizer N. Nutrient Cycling in Agro-ecosystems 52:123-130.

UNEP-UNCTAD Capacity-building Task Force on Trade, Environment and Development (2008): Organic Agriculture and Food Security in Africa. Geneva and New York: United Nations: http://www.unctad.org/en/docs/

Williams, A.G., Audsley, E., and Sandars, D.L. (2006). Determining the Environmental Burdens and Resource Use in the Production of Agricultural and Horticultural Commodities. Main Report Defra Research Project IS0205 Cranfield University, Bedford and the Department of Environment, Food and Rural Affairs (Defra) [on line] http://www.silsoe.cranfield.ac.uk and www.defra.gov.uk Accessed 15/10/2009.

Xu,H., Cai, Z.C., Jia, Z.J. Tsuruta, H., (2000). Effect of land management in winter crop season on CH4 emission during the following flooded and rice growing period. Nutrient Cycling in Agroecosystems 58:327-332.

Yang, S.S and Chang S.L. (2001). Effect of green manure amendment and flooding on methane emission from paddy fields. Chemosphere –Global Change Science 3:41-49.

Zhang, F., and Li, L. (2003). Using competitive and facilitative interactions in intercropping systems enhance crop productivity and nutrient use efficiency. Plant and Soil 248:305-312.

Zollitsch, W., Kristensen, T., Krutzinna, C., MacNaeihde, F., Younie, D., (2004). Feeding for Health and Welfare: The Challenge of Formulating Well-Balanced Rations in Organic Livestock Production In: Vaarst M., Roderick, S., Lund, V., Lockeretz, W. (Eds.). Animal Health and Welfare in Organic Agriculture. CAB. International. pp 329-356.

The Book

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Editor

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