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Effect of Climate Change on Food Security

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Abstract
Climate change has negative impacts on all four facets of food security: food supply, food quality, food consumption and food stability. It has an effect on human health, livelihoods, food processing and distribution systems, as well as on increasing buying power and consumer movements. Its effects can be short-term, arising from increasingly regular and more severe extreme weather conditions, and long-term, owing to rising temperatures and precipitation levels. Emissions of greenhouse gasses (GHGs) lead in global warming and climate change. The extent to which advanced countries are adding to GHG pollution is not well established. It has also been argued that climate change will have a significant effect on food processing processes and that food security may be affected by rising climate change. It seems, though, that work on climate change and food security has always been one-sided; climate change has been described as a source of food scarcity and not as food protection mechanisms have escalated the climate change problem. The goal of this paper is therefore to have a more informed perspective and a clearer understanding of the impact of climate change on food security by objectively analyzing the specific danger posed to the dimensions of food security.

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I. Introduction

Climate change happens in a number of forms, ranging from increased seasonal variation and incremental changes in temperature and precipitation to increased frequency and severity of weather events. Climate change has already been a widespread phenomenon. However, it is only in recent years that foreign organisations, non-profit groups, national organisations, companies and individuals have paid attention to this issue. As the formal President of the United States of America, Mr. Barrack Obama, warned, climate change is no longer a question of the future, but rather a threat that "would shape the contours of this century more profoundly than any other" (The Straits Times, 2014). Climate change is defined as the following:

“Climate change that can be detected (e.g. by way of statistical tests) by changes in the mean and/or variation of its products, and that lasts for a prolonged period of time, usually decades or prolonged. This refers to any change in temperature over time, whether due to weather or human activities (IPCC. Climate Change 2007).”

Climate change has only led to an increase in the world average daily surface air levels, but also to a rise in the volume of ambient greenhouse gasses (GHGs) (Misra, 2014). Global mean temperatures have been recorded to have risen by 0.74 degrees Celsius over the last 100 years and the Gangtori glacier, one of the largest glaciers in the Himalayas, is steadily disintegrating at 12–13 m per year (Misra, 2014; Khandekar, 2015). The effects of climate change, such as the loss of water supplies and the increase in global air temperature, have produced conditions for a reduction in agricultural productivity. It therefore, in effect, contributes to global food inflation and food shortages in developing countries, where the poor suffer tremendously as they are unable to pay high food prices (Misra, 2014).

According to the Food and Agricultural Organisation of the United Nations (FAO), there are about 795 million undernourished people worldwide, with poor nutrition accounted for almost 45 per cent of children under 5-years of age per year. A further 13.5% of the populations of developed countries were undernourished due to lack of nutritional availability; nutritional stability; and/or economic and physical access to food (FAO, 2015). Such results are predicted to be further compounded by the growth in world population, which is estimated by the United Nations to rise by 2.4 billion by 2050 (UNDESA Report 2015). Population growth, combined with rising urbanization and increasing environmental issues such as pollution and deforestation, will have adverse consequences on food production, distribution and consumption. In fact, the failure of food suppliers to satisfy the needs of the population will raise food prices. This, along with the increased incidence of climate-related disasters and more climate change worldwide, will intensify the food security challenge faced by already at-risk individuals/populations as well as the global community. Food security is thus understood as:

"A condition that occurs where all people have, at all times, physical, social and economic access to adequate, secure and nutritious food that satisfies their nutritional requirements and their food preferences for active and balanced living (FAO, 2015)."

In addition, with the latest adoption of the climate agreement adopted at the Paris Climate Conference (COP 21) aimed at reducing global temperature increases to far below two degrees Celsius, more focus has been paid to greening campaigns and potential ways of intervention to minimize their greenhouse emissions (BBC News: COP21, 2016). New types of eco-friendly food processing processes such as the Rice Intensification System (SRI) have expanded, which can dramatically minimize GHG emissions relative to traditional methods of agriculture (Uphoff and Dazzo, 2016). Nevertheless, despite these sustainable methods of food production, the FAO reported in 2014 that GHG emissions from agriculture, forestry and fisheries had almost doubled in the last 50 years. This number is projected to rise by a further 30% by 2050 if little is done to reduce it (FAO, 2016). It can therefore be seen that, before transitioning to new types of sustainable and eco-friendly systems, more awareness and understanding of the consequences of traditional practices is required to ensure that the improvements contribute to positive and practical outcomes.

Until recently, the majority of estimates of the impact of climate change on the food and agriculture sector centered on the consequences for food production and global supply, with less concern for the negative impact of development and industrialization on agriculture (especially fossil fuels and how biofuel can be gradually replaced). This paper takes a wider perspective and discusses the causes of climate change (major activities causing climate change) which is basically emission of greenhouse gases (GHGs) and how climate change limits productivity with no farm mechanization in place.

II. Materials and Methods

This paper employed various qualitative approaches in understanding various activities causing climate change, basically, emission of greenhouses gases; adverse impact of technology and industrialization on farming most especially fossil fuel and how it can be gradually substituted by biofuel. Lastly, how climate change limits productivity with no farm mechanization in place. In order to gain a better insight of activities causing climate change, impact of technology and industrialization (fossil fuel) on farming, we have resolved to employ both content and discourse analysis in order to gather the information needed for this research. These unobtrusive forms of methodology enabled us to sieve out helpful information that would have been otherwise obstructed by geographical restrictions, through the analyzing of a wide database of research papers and books on the topics of climate change, agricultural production systems and food security.

Content analysis, a robust examination of relevant materials was used for capturing and observing trends or patterns found in climate change, agricultural production systems and food security. Through the employment of content analysis, various variables proposed by scholarly and academic journals as responsible or related to climate change and food security were also identified. Besides, the researcher also consulted and juxtaposed the analysis with other soft sources such as newspaper and Internet reports. In our examination, we analyzed the various findings in academic journals and research papers. This analysis helped to sieve out relevant information on effect of climate change on food security through the use of reasoning and analytical thinking. Along with content analysis, discourse analysis was also used for studying text linguistics, i.e., phonology, style and organization, in academic research papers. Through the deconstruction of texts, implicit or hidden contents in academic research papers were made more obvious, thereby helping in one's understanding on effect of climate change on food security. A combination of both content and discourse analysis was necessary to capture the complex dynamics contribution of fossil fuel to climate and how it affects agriculture in general.

III. Research Findings

3.1. Activities causing Climate Change and how it affects Food Security

Overall, climate scientists believe the main cause of the recent global warming pattern is human expansion of the "greenhouse effect" of warming resulting from the trapping of heat from Earth to space (US: Department of Agriculture Research Report, 2013).

In practice, the rate at which energy is obtained from the sun and the rate at which it is lost to space determine the Earth's equilibrium temperature and climate (Jessica and Law, 2007). This energy is spread across the globe by waves, ocean currents, and other processes that influence the environment of different regions. Indicators that can influence the environment are referred to as climate forcings or "driving structures" (Inter-Government Committee on Climate Change, 2007; Ibrahim, 2013). These include mechanisms such as fluctuations of solar radiation, changes in Earth's orbit, shifts in greenhouse gas concentrations, etc. There are a number of climate change feedbacks that can either magnify or raising the initial impact. Many areas of the climate system, such as oceans and ice caps, react gradually in response to climate influences, while others respond more rapidly. Force systems can be either "internal" or "external." Internal driving structures are natural processes within the climate system itself (e.g., thermohaline circulation) (Inter-Government Commission on Climate Change, 2007). External driving processes may be either normal (e.g., shifts in solar output) or anthropogenic (e.g., elevated greenhouse gas emissions). Whether the initial forcing mechanism is internal or external, the climate system's response may be rapid (e.g., sudden cooling due to airborne volcanic ash reflecting sunlight), slow (e.g., thermal expansion of warm ocean water) or a combination (e.g., sudden loss of albedo in the Arctic Ocean as sea ice melts, followed by more gradual thermal expansion of water). The climate system will then react unexpectedly, but the complete response to forcing processes could not be completely established for centuries or even longer (ISDR, 2008).

Again, some gasses in the atmosphere block the heat from leaking out. Lengthy-gasses that remain semi-in the atmosphere, which do not respond physically or chemically to temperature changes, are described as "strengthening" climate change, while gasses such as water that respond physically or chemically to temperature changes are described as "feedbacks" (Ibrahim, 2005; Jessica and Law, 2007). Greenhouse gasses, or gasses that contribute to the greenhouse effects, include: Water vapor, Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O) and Chlorofluorocarbons (CFCs).

While there are several reasons influencing climate change, the key factor often cited as the cause of deteriorating climate conditions is the rise in greenhouse gas pollution in the atmosphere. The increased accumulation of GHGs in the atmosphere is expected to trap more heat on Earth, resulting in an increase in global mean temperatures (Thomas and López, 2015). Climate change has negative consequences on both habitats and human populations as it raises the occurrence of flooding, droughts and other environment-related events that have the ability to impact farmlands, livestock and livestock production, which are important for agricultural purposes (Gould and Lewis, 2009). In order to better understand the effect of climate change on food security, this paper will focus on three factors described as having the most significant impact on agricultural production: water, soil and crops (Lal, 2013). These three aspects are critical to recognizing the effect of climate change on food security as the most important and necessary components of food production.

i. Water

Similar to soil supplies, water bodies are also limited and vulnerable to waste, deforestation, eutrophication and climate change (Lal, 2013). The United Nations Department of Economic and Social Affairs (UNDESA) estimated in 2014 that current climate change conditions would result in nearly half the world's population living in high-water stress areas by 2030. The changing climate is altering the hydrological processes, impacting the consistency and quantity of water (Lal, 2013). Water availability is affected by climate change as it is likely to decrease or cause changes in temperature and precipitation in some regions of the world (Kang *et al*., 2009). Variations in rainfall and temperature can potentially cause crop failure, particularly for crops requiring high temperatures and rainfall conditions, such as rice.

As pointed out earlier, climate change influences the drying-rewetting cycles of the soil, thus increasing the N quality of the soil. The above, in addition, impacts water resources as nitrates from soil seep into freshwater supplies and change the distribution of nutrients in water bodies. Increased concentration of N in water bodies can contribute to eutrophication. Eutrophication is a mechanism in which the accumulation of nutrients in the water body leads to an increase in floating plant populations and plankton (Feuchtmayr *et al*., 2009). In fact, improved development of floating plant populations is also encouraged by cooler water sources due to climate change, which stimulates and prolongs the growing season. Increased growth of aquatic plant communities can have a detrimental impact on underwater plant communities, as the sunlight required for these plants to photosynthesize is obscured and absorbed by plants floating on the water. To order to grow, these floating plant populations compete with underwater plants and other marine animals for the nutrients in the water bodies.

The failure of underwater plant populations to photosynthesize, breathe and consume the necessary nutrients could ultimately lead to the death of these plants. Deaths in underwater plant species may change the chemical balance of water sources due to a rise of oxygen content of water bodies, as plants are no longer able to consume oxygen and convert it to carbon dioxide by the respiration cycle. The above, in effect, upsets underwater ecology, as marine animals that rely on these food plants are also affected by changes in the food chain. Animals who are unable to turn to alternate sources of food can either die or have nutritional shortages due to changes in their nutritional uptake. As a result, increased nitrogen concentration in water sources and cooler water temperatures have led to an increase in floating plant species at the detriment of submerged marine plant diversity. In fact, the high accumulation of GHGs in the environment, along with the reckless dumping of contaminants in water sources, has altered the quality of water, contributing to ocean acidification and hypoxia, which would affect the production and efficiency of fisheries and aquaculture in many ways (Porte *et al*., 2014).

ii. Soil

Soil resources are small, unevenly dispersed and vulnerable to soil abuse, mismanagement and climate change degradation (Lal, 2013). Climate change, i.e. high concentrations of atmospheric carbon dioxide (400 ppm), along with rising air temperatures (2-4 C or higher) that persist for a longer period of time, will significantly affect soil properties and fertility, food quantity and quality, and environmental quality (Qafoku, 2015). This is because the Carbon (C) ozone cycle is complex and sensitive to climate change (Lal, 2013). In addition, increased weathering of rocks and minerals in soils is caused by elevated concentrations of atmospheric CO_2 (400 ppm), temperatures, strong runoff, heat waves and extended cycles of drought (Qafoku, 2015).

Although weathering has the ability to reduce carbon dioxide concentrations (by increasing the inorganic carbon (IC) pool in soils through carbonate mineral formation), it can also disrupt the balance between biotic and abiotic C cycles in soils (Qafoku, 2015). This disturbance affects the distribution of C to less stable soil pools; increasing mobilization of containment that could significantly alter soil microbial activity, plant productivity, soil life, and C and elemental cycling,[and] elementary balances in rivers, lakes and oceans "(Qafoku, 2015, p. 117). Changes in soil carbon dioxide concentrations affect soil organic matter content and soil quality, resulting in soil degradation. Soil degradation reduces agricultural output and the efficiency of inputs. Moreover, this decline in soil quality could increase the vulnerability of soil to degradation, including "crusting, compaction, accelerated erosion and salinization" (Lal, 2013, p. 10). Climate change thus leads to land-related effects, including "significant/dramatic changes in soil resources, surface water and groundwater quality, food (national) protection, water availability, human health, energy, agriculture, forests and habitats" (Qafoku, 2015, p. 114).

In fact, work has also shown that climate change triggers detrimental human and agro-ecosystem impacts and also food stability, as it raises the risk of climate-related events such as droughts, flooding and heat waves (Islam, 2013). This influences the drying-rewetting processes of the soil, which, in effect, directly affect the "microbial nitrogen (N) turnover rate in the soil by increasing the water content and the partial oxygen level" (Gschwendtner *et al*., 2014, p. 1).

iii. Crop

Climatic change has also raised the occurrence of environmental-related events such as flooding and droughts. Both have a strong negative effect on crop production and food security. Global temperature increases have resulted in flooding due to rising sea levels caused by the melting of glaciers and ocean expansion (Kibria, 2017). Sea-level rise (SLR) impacts food security and food production, as rising sea levels will lead to increased flooding and saltwater intrusions into land, wetlands and freshwater bodies (Kibria, 2017). SLR can result in crop failure when crops are submerged by floodwaters that prevent soil aeration. Salt water infiltration will also contribute to salinization and waterlogging, which causes soil erosion, leaving the soil affected unsuitable for agriculture.

It has been found that an SLR of 1.5m in Bangladesh will flood about 16% of the country's land area and make it unsuitable for rice production (Kibria, 2017). Droughts, many of which are caused by climate change, can lead to crop failure as the lack of water available for agricultural production causes crops to die. This is apparent in the significant drop in crop yields, i.e., maize yields in Italy and France decreased by 36% and 30%, respectively, during the extreme heat season in Europe in 2003 (Farmar-Bowers, 2013 p. 225). Droughts also have an impact on soil quality, as they can give rise to a decline in plant-available water capacity, rendering the land unsuitable for crop production. In relation, the rise in global temperatures caused by climate change could lead to an increase in weed growth and the consequent use of pesticides (Keating, 2013). With rising temperatures, crops are faced with more severe pest attacks and are more susceptible to diseases that threaten to wipe out harvests (Santra *et al*., 2014).

This is because rising temperatures typically provide more optimal conditions for disease-causing species and pests that will have adverse effects on crop growth as these factors affect the quality and quantity of crops (Santra *et al*., 2014). Researchers at the Indian Agricultural Research Institute have concluded that there will be a "loss of 4–5 million tons in wheat growth, with temperature rises per 1^0C during the growing season" (Mahapatra, 2014, p. 219). Climate change also impacts food security, because rising temperatures and conditions that are averse to crop production influence the quality and quantity of crops.

iv. How all three factors affect Food Security

The effect of water, land and crops on food security can be calculated using four components: food quality, economic and physical access to food, food usage and food resource stability. Nutrition quality refers to the actual nature of nutrition accessible for consumption; economic and actual access to food refers to the ability/resources to obtain food; the utilization of food refers to providing an "sufficient nutrient value of food and the capacity of the body to use it effectively;" and the security of food supplies refers to the need to ensure that enough food existsallthe time (Burke and Lobell, 2010, p. 14).

- Food Availability

If the soil lacks nutrients or is unable to sustain crop production, there will be a shortage of supply and, thus, availability of crops. Similarly, because the water was polluted due to the high acid content, the crops will die and the acidity of the water will destroy the crops. Moreover, the emergence of natural disasters such as floods and droughts impact food security, as drought inhibits crop growth and induces crop failure or delays in crop production, while floods cause crops to die or land to be unsuitable for agricultural purposes due to lack of fertile soil. Crops are vulnerable to changes in temperature and precipitation, and increasing global mean temperatures by 2^0C will destabilize agricultural activities and crop production cycles (Kang *et al*., 2009). In addition, food supply is also challenged as climate change, contributing to temperature variability, has the potential to contribute to a lack of local diversity and to a reduced quality of opportunities for both current and future generations (Úbeda *et al*., 2013).

When mentioned earlier, climate change has the ability to modify the geographical distribution of some marine animals, such as oil sardines, due to higher temperatures in water bodies that make water conditions unsuitable for their continued survival. Such migration will increase the number of fisheries in these areas and thus increase jobs and food opportunities. Some may interpret the movement of fish to other regions in a positive light as it would increase food supply and physical access to food in those regions.

- Economic and Physical Access to Food

When crops fail due to climate-related hazards, farmers are unable to market their crops or raise money and help their families. Between 2003 and 2013, more than 1.9 billion people in developed countries were impacted by these disasters, resulting in an unprecedented half a trillion US dollars in losses (FAO, 2015). FAO reports that the "agricultural sector absorbs about 22 per cent of the overall economic impact of these disasters" which, in turn, affects its capacity to sustain food security. It is clear that the impacts of climate change are unequal. Poor (developing) countries are more affected by climate change and crop loss, primarily agricultural economies, compared to rich (developed) countries, because poor countries lack the resources and expertise to cope with these changes, i.e. the capacity to store enough food for their population in times of crisis.

In addition, farmers in developing countries frequently survive from one harvest to another, and the loss of one harvest may result in them losing all their savings. As such, they no longer have the financial means to purchase food or to produce food from their crop. This is especially the case in developing countries where policy funding for farmers is not as high as in developed countries. As a consequence, as crops fail, these farmers are often left without a safety net to recover from their losses or the opportunity to provide food for their families. It is projected that with increased climate change, the production of rice in the Philippines may fell as much as 75% by 2100 (Singh, 2013).

This decline may result in many Filipinos having to settle for food with little to no rice due to a shortage of rice and a lack of economic access to food. However, this issue can be minimized if the government intervenes and introduces climate change measures, i.e., expanded use of technologies for agricultural purposes, to help mitigate any major declines in rice production (Singh, 2013).

- Stability of Food Supply

Climate change impacts food stabilization due to changing anthropogenic conditions, drying-rewetting cycles and global mean temperatures that would influence livestock rearing and crop production. Some policymakers and farmers have turned to scientific innovations and improvements in the hope of reducing the effect of climate change on food security. However, there is a risk that technical developments used to alleviate the impacts of climate change will further intensify the problem of food security and climate change. Climate change is a complex issue and the full extent of its consequences is still unraveled today (FAO, 2015).

It remains to be seen if the technical advancements integrated into food production processes would also lead to reduced impacts on climate change and improved food security, as all of these advancements are still in their infancy. More work and time are also required to achieve a deeper understanding of these developments. Food security is not only affected by climate change, but also by other influences such as food distribution and transport. Climate change has often been reported to increase the frequency and intensity of climate-disasters, and this, in turn, affects food supply stability as food trade is hindered when aircraft and ships are grounded/docked due to poor visibility due to harsh weather conditions or access roads destroyed by earthquakes or floods. Instability of food supply is experienced mostly in developing countries that do not conduct stockpiling. These countries also lack the technical expertise and financial resources required by experts and engineers to help build infrastructure that can withstand the effect of natural disasters and storage conditions that allow food to be stored for a longer period of time (FAO, 2015). Food security is therefore impacted by the closing of major infrastructure and transport centers, such as airports/ports, or the collapsing of food storage buildings during such disasters. In addition, developing countries lack the financial resources and technological advances needed to help alleviate problems such as ocean acidification and soil salinization, to ensure the continued production and supply of food to their population.

3.2. Impact of Technology and Industrialization on Farming

Overall, climate scientists believe that the key source of the present global warming phenomenon is human acceleration of the "greenhouse effect" of radiation arising from the transfer of heat from Earth to space.

"Something significant happened on this planet around the year 1750AD, that is, INDUSTRIAL REVOLUTION, which led to the development of machines that have simplified man's many activities (agriculture, transport, war, etc.), and today, after more than a quarter of a century, the revolution has undeniably dramatically destroyed the very conditions that make life possible on this planet (IBY, 2013)"

In practice, the rate at which energy is obtained from the sun and the rate at which it is lost to space decide the Earth's equilibrium temperature and atmosphere. This energy is spread across the globe by waves, ocean currents and other processes that influence the environment of different regions (Miko, 2010).

The Intergovernmental Subcommittee on Climate Change (IPCC, 2007) outlined proof of climate change, its potential effects, and probable prevention and adaptation steps. Heat trapping by so-called greenhouse gases, the most powerful of which is carbon dioxide (CO_2), is changing the global atmosphere (IPCC, 2007). The bulk of emissions (57 per cent) of these gasses come from fossil fuel burning, with a further 17 per cent from erosion, organic matter degradation and peat (IPCC, 2007). Deforestation is mainly motivated by an increase in population, putting additional land under cultivation. The analysis of emissions by industry assigns about 14 per cent to agriculture and 17 per cent to forestry, but these statistics do not reflect other inputs from the food system to the post-farm market. Agriculture accounts for nearly 50 per cent of methane emissions (mostly from rice paddies and ruminant animals) and 70 per cent of nitrous oxide emissions (mostly associated with nitrogen fertilizer) (IPCC, 1996, pp. 49-53).

Climate change would have a direct effect on agricultural production and, as a result, on food security Agriculture systems have long evolved to gradual climate change and are expected to do so in the light of the predicted warming of the 21st century. However, climate change impacts on global agriculture have also had demonstrable adverse consequences on agricultural production (Lobell, Schlenker, and Costa-Roberts, 2011). Beyond these effects, the increasing occurrence of traumatic events is likely to be especially destructive. The linked incidents of the 2010 drought in Russia and the floods in Pakistan (Lau and Kim, 2011) have had global implications due to their effect on food prices. In particular, high food prices in the Middle East, which have partly arisen from Russian grain unavailability, along with other apparent social and political causes, have led to the political instability of many governments (Lagi *et al.*, 2011). While no particular weather occurrence, much less particular civil events, can be attributed exclusively to climate change, forecasts clearly forecast a rise in the incidence of extreme weather events (IPCC, 2007). Together, both combined sluggish impacts and significant local incidents will intensify the problem of achieving global food security.

Global diplomatic action to combat climate change has stalled. Many of the countries that signed the Kyoto Protocol of 1997 have made substantial strides in lowering greenhouse gas emissions, as have individual states in the U.S. and other cities around the world. For the two biggest emitters, China and the United States, the latest talks are likely to stay stagnant (Bodansky, 2011). In the lack of a large international consensus, business as normal prevails, with emissions increasing much higher than any of the IPCC's earlier predictions. Environmental change will significantly impact nutrition and general human well-being in the 21st century. In addition to other food security issues, climate changes on agriculture would bring upward pressure on food prices. Political measures to combat climate change by placing a price on greenhouse gas emissions, in particular from fossil fuel burning, would raise costs for fossil fuels and further effect on food security. Another problem is the transfer of cropland to biofuel production, which has created a near connection between oil prices and biofuels.

The vast glut of readily available fossil fuels and the correspondingly low energy costs that powered the Green Revolution were transient phenomena. Consequently, the inevitable maxima in the output of oil and coal, and ultimately natural gas, together with the reliance of global food supply on fossil fuels and the current demands for the output of biofuels in agriculture, present a formidable challenge to food security. Agriculture around the world relies, to varying degrees, on gasoline and diesel for mechanized agricultural equipment, on shipping materials to agricultural and ranch and supplying goods to the market, and on off-grid electricity for irrigation pumps. The production of ammonia-nitrogen fertilizers is highly dependent on natural gas. Agriculture depends on coal-fired electricity for irrigation, food production, preservation and cooking in many areas, especially in developing countries. In addition, fossil fuel inputs also lead to energy intensive phosphorous extraction, a vital commodity with minimal mineral supplies (Elser and Bennett, 2011). Fossil oil, natural gas and coal, which are the driving force behind industrial life, in particular contemporary global agriculture, have been deposited by volcanic processes over millions of years. Large-scale human production of coal has taken place for little more than 200 years; the timescale for oil and gas is no more than 100 years. Data is growing that the production of such non-commodities will hit its height in the coming decades, after which humanity will face the burden of food security. Peak performance should have come even earlier.

Organic agriculture is a common alternative to traditional methods in the developing world, which is already engaged in intensive farming. Gomiero, Pimentel and Paoletti (2011) offer the following concept in a significant distinction between organic and traditional cultivation. "Organic agriculture refers to an agricultural method that increases soil productivity by optimizing the productive use of natural resources, while avoiding the use of agrochemicals, the use of GMOs and other synthetic compounds used as food additives. Organic agriculture depends on a variety of agricultural methods focused on natural cycles which aims at mitigating the environmental effects of the food sector, ensuring the long-term viability of the land which reducing the usage of non-renewable energy. "According to some critics, organic agriculture cannot feed the planet. Nonetheless, Gomiero *et al.*, (2011) give a more nuanced view, illustrated by the challenge in making reasonable distinctions between traditional and organic farming. Studies vary in how they describe network limits, e.g. including or removing indirect energy costs, leading to large differences in the resulting figures. In comparison, each of these analyses rely on single crops and evaluate results for only a few years. While traditional agriculture primarily depends on monocultures, organic farming thrives on multi-cycles of rotating and changing crops. However, long-term patterns, especially in soil fertility— in which the two processes experience opposite effects — are not expressed in short-term investigations. The authors record that organic farming is superior to virtually every aspect of environmental success, especially energy efficiency. Productivity statistics are mixed, with yields usually higher for traditional agriculture by about 20%, but with variations between developed countries, where organic yields tend to be smaller, and emerging countries, where they tend to be higher. Given the recent decades of study and innovation in traditional agriculture, the probability that organic yields may be equal or better balanced by equivalent innovation in capital needs careful consideration.

Demand for renewable liquid fuels has contributed to the conversion of cropland to biofuel production, resulting in a strong correlation between oil prices and agricultural prices. Advocates such as Collins and Duffield (2005) are positive about the potential of modern U.S. agriculture to fulfill global food demands and to make a substantial contribution to biofuel production. Sustainability analysts Giampietro and Mayumi (2009) claim, however, that biofuels (at least those derived from agricultural crops) reduce food supply, increase CO_2 emissions and delay rural production. Addressing the wider issue of fulfilling a significant fraction of human energy needs with biomass, Smil (2010) opposes the concept of an insufferable interference into the essential workings of the biosphere. Smil does not directly discuss either crop residues or grass as potential biofuel sources, but its general energetic review highlights the fear that widespread extraction of such non-biological resources will impede the required recycling of nutrients. Recognizing the effect of oil prices on food prices and the instability of food markets, Koning and Mol (2009) call for new mechanisms to regulate food and energy markets.

3.3 Limitations in Productivity, Farm Mechanization and Climate Change

Agriculture is typically the primary sector that relies mainly on climate change (Mendelsohn and Dinar, 2009). The choice of optimal crops and the choice of optimum planting and harvesting times depend directly on the weather conditions prevailing in each area. This suggests that the impending climate change due to the rise in greenhouse gasses would have a significant effect on crop growth and output and, ultimately, on farmers ' incomes.

Climate uncertainties, leaf erosion, gully erosion, frequent floods, destruction of biodiversity, degradation of agricultural land and a general reduction in agricultural yields are now normal norms in developing countries, including Nigeria. All of these are both direct and indirect consequences of climate change and affect the entire 179 m population of Nigeria, whose main occupation is agriculture, which, prior to the discovery of oil, accounts for about 80 per cent of the country's GDP and currently accounts for 90 per cent of non-earnings (Ibrahim, 2013).

Agriculture is basically a man-made supplement to natural ecosystems and is dependent on weather and climate. In northern Nigeria, drought in April and May, which is agreed as natural, prevents timely land preparation and tillage. It further slows the sowing and delivery of seeds, as well as the transplantation of other crops (Maimaje, 2010). As the drought extends to early June, all fields are killed and harvests become very low. Inadequate rains from July to October have caused severe misery to the entire country. This phenomenon is further exacerbated by the fact that most major irrigation schemes are moribund (Oluwasola *et al.*, 2011). Growing climatic fluctuations are potential risks in these drought-prone regions, as well as some of the main risk averse factors. It pushes farmers to focus on low-input and low-risk technology (Oluwasola *et al*., 2011).

Shunning new technologies to achieve full benefits during favorable seasons is slowing disaster recovery. Government investment in poverty reduction in these high-risk areas of northern Nigeria is often lost due to ongoing climate change effects, further crippling development efforts and exacerbating poverty (Ibrahim, 2013). Subsistent farmers, who make up more than 75% of the agricultural community and consider adapting to climate change a costly choice due to the investment required, default to disposing or mortgaging their properties and ultimately emigrate.

High heavy rainfall, as predicted in the southern part of the country, has resulted in increased flooding and sedimentation of floodplains, rendering them less competitive. Invasive salinity due to rising sea levels has further degraded marginal farming areas (Maimaje, 2010). Certain risks to adverse impacts of climate change in some developed countries include those visible in water management and reserves (dwindling), transport (unreliable), the spatial limits of agro-ecosystems, as well as species diversity and production (changing). Certain non-economic services, such as wildlife, air quality and water quality, are also impacted by negative climate change impacts. For example, many of these countries are decreasing plant supplies, as traditional herbalists now have inferior alternatives to them (Ibrahim, 2005). The migratory trend of fish populations has changed significantly, even as the capture has decreased. Prominent animal species, such as rats, reptiles, birds and fish, and other aquatic animals, which have been the main source of nutrition for millions of people, are at risk.

Research, technology and engineering will play a vital role in the development of more food by producing plant varieties with better characteristics, as well as by improving the inputs required to make agriculture more competitive. FAO describes mechanization as "the use of machines, tools and equipment to accomplish agricultural production" (FAO, 2013). They can all be operated by means of manual, animal or engine (fossil fuel or electrical) control. In fact, agricultural mechanization reflects a technical transition by the use of non-human forms of power to carry out agricultural operations.

According to the UN FAO, more than one third of agricultural products in developing countries were wasted due to poor farming practices, post-harvest management, storage and processing methods. The lack of appropriate grain storage technologies contributes to losses of up to 20-30%, particularly due to post-harvest pests. This means that more than one third of the resources used in this process are also lost. (Tefera and Abass, 2012) argue that food waste and loss is a major and increasingly urgent problem and particularly acute in developing countries, where food loss reduces incomes by at least 15% for 470 million smallholder farmers and downstream value chain players, most of whom are among the 1.2 billion people in food insecurity. They also point out that global food waste and depletion absorbs a quarter of global freshwater and a tenth of agricultural land for unconsumed produce. In 2050, the world's population will reach 9 billion, adding 2 billion additional mouths to feed. (Tefera and Abass, 2012) caution that unless food shortages are reduced, food demand in developed countries would have to rise by an additional 70%, requiring an investment of $83 billion per year. Mechanizing agriculture will lead to increased agricultural productivity, economic development and food security only if agricultural mechanization is made more available and efficient.

IV. Conclusions

Climate change has important consequences for agriculture and food security, posing new threats and obstacles and exacerbating emerging problems from local to global rates. Energy used (fossil fuel burning) and pollutants emitted during production processes can worsen the climate change problem. Changing production practices to implement more environmentally sustainable manufacturing methods is simpler relative to tackling the effect of climate change on food security, which includes not only economic but also political considerations.

Climate change will affect all facets of the food security of vulnerable groups as well as the various components of food systems. In the planet, industrial growth and pollution are the most significant sources of increased CO_2 production from fossil fuels, and this rise is one of the causes of global climate change. The contribution of population growth between 2000 and 2010 was more or less the same as the previous three decades, although the contribution of economic growth rose substantially.

Measurement of CO_2 emissions from soils of various land use programs allows an understanding and precise evaluation of soil conservation strategies to reduce GHG emissions. In our research, soil CO_2 emissions were greatly impacted by various land-use processes. Decomposition and mineralization of soil organic matter is the primary sources of CO_2 pollution. The soil itself may serve as a source or sink of CO_2, depending on the management or land use regime put on it. Land-use structures that also disrupt and expose the organic matter of the soil to decomposition and mineralization are likely to release more GHGs. It is also important to remember that the reasons identified for climate change and lack of food security in this study are minimal and there are a wide variety of other reasons that can or may contribute to climate change and affect food security, such as political unrest and economic interests.

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