International Journal of Research in Agricultural Sciences
Volume 8, Issue 4, ISSN (Online): 2348 – 3997

Review Article: Climate Change Impact on Farming Components

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Date of publication (dd/mm/yyyy): 05/09/2021

Abstract – **Global climate change is largely the result of human activities such as burning fuel, agricultural practice, deforestation, industries and etc. It has been resulting significant impact on agriculture, water sources, food security and human health especially in African countries. So, the objective of the review was to explore the cause of climate change, its impact on farming components and food security, management strategies and present updated information. The sectors like crop, livestock, fisheries, aquatic culture, forestry ecosystem and food systems are sensitive to weather and directly affected by climate change. Since the 1980s, 10% of yield declines globally for cereal crops in every 1°C warming specifically for wheat, rice and maize in 6, 3.2 and 7.4% percent respectively. Regarding livestock, the climate change affect animal growth, reproduction, metabolic activity, milk production and reduce feed resources for animals. The challenge of climate change in all sectors exacerbates food insecurity, and need mitigation as well as adaptation practice to reduce or alleviate its impact. In summary, as the earth will continue to warm considerably more over the next few decades to centuries there should be technological or policy changes to reduce emission and alleviate further globally averaged warming.**

Keywords – **Climate, Food Security, Aquaculture, Mitigation, Adaptation.**

I. INTRODUCTION

Climate change refers to significant changes in global temperature, precipitation, wind patterns and other measures of climate that occur over several decades or longer [1]. It poses a pressing threat to food security and rural livelihoods worldwide, but climate impacts and needed responses can be highly region-specific [2]. By the end of this century CO_2 emission in combination with other changes in the atmosphere, will make earth warmer by an average of 1.8 °C to 4.0 °C [3]. IPCC [4] also reported by the end of the 21st century, temperature expected to rise by 3-5 °C, and CO_2 to reach 1415-1910 ppm. Recently, [5] reported that surface is warming by considering the temperature change from the period of 1889 to 2019 and also figure out that earth's average surface air temperature has increased by about 1 °C (1.8 °F) since 1900.

Now a day, the worldwide heavy rainfall, floods, drought, forest fires, occurrences and spread of new diseases, new strains of pathogens and viruses, and higher incidences of insect pests are direct indications of drastic environmental changes globally [6]. The magnitude and rate of climate change would determine the extent of damage and number of systems affected. Water resources, agriculture and forestry and marine systems, human settlements, and human health are human systems sensitive to climate change. [7] and [8] pointed out that agro-ecosystems which includes pasture and cropland covers nearly 40% of earth's land surface are increasingly vulnerable to mean climate changes, its variability and extremes.

Climate changes have been resulting significant impact on farming components like crop and livestock production, water sources, food security and human health especially in African countries [9]. Wheeler and Braun [10] also reported that agriculture is inherently sensitive to climate variability and change, as a result of either natural causes or human activities. Particularly, crop and livestock production system which play major role in agricultural sector in developing nations are adversely affected by the changing climate. Stated that if green house gas emissions and climate change continue by the year 2100 there will be yield decline in the production of major cereal crops (20–45% in maize, 5–50% in wheat and 20–30% in rice) [11]. Similarly, world population is expected to reach 9.7 billion by 2050 which would magnify the pressure on agricultural lands to meet the growing food demands already affected by the impact of climate change [12]. The increasing demand of food due to ever growing population have resulted in intensive agricultural practices including use of agro-chemicals, livestock production, exploitation of water resources etc. These agricultural activities further aggravated the climate change by the release of green house gas (GHG). Besides, the unchecked rate of deforestation imbalances the natural process of carbon cycle by hindering forest function as sink for the increasing CO_2 and this has major impact on agricultural production.

It is clear that the fast pace of climate change will have far reaching impact on agro-ecosystems and their productivity. Improving knowledge of the impact of climate change on different agricultural practices, food security and the adaptation strategies to fight climate change are of vital importance. Also it is high time that we prepare ourselves for the up-coming challenges so as to combat the impact of climate change and ensure food security not only for humans but other living beings as well. The objective of this paper is to explore the cause of climate change, its impact on agriculture and food security, adaptation and mitigation strategies to the changing climate. Scientific information is a crucial component for society to make informed decisions about how to reduce the magnitude of climate change and how to adapt to its impacts. Hence, the review also intended to provide updated useful information for scientists, decision makers, educators and policy makers who are interested in understanding the impacts of climate change on agriculture and food security.

II. Causes of Climate Change

Nearly 200 nations and about 97% of climate scientist witnessed that human activity is causing climate change [13, 14]. Also reported that scientists know that recent climate change is largely caused by human activities from an understanding of basic physics, comparing observations with models, and fingerprinting the detailed patterns of climate change caused by different human and natural influences [5]. Calculations using climate models have been used to simulate what would have happened to global temperatures if only natural factors were influencing the climate system and yield little surface warming, or even a slight cooling, over the 20th century and into the 21st [5]. These scholars also indicated that human-induced climate change is long-term which could last for decades, while natural factor cause short-term climate variation. However, [13] pointed out that some observers claim that climate change is not a man-made phenomenon, blaming factors such as solar cycles (variations in the amount of energy reaching the Earth from the sun) or volcanic activity for recent increases in temperature. Also reported that greenhouse gas emissions (methane and nitrous oxide) from livestock sector have been contributing to the changing climate and pointed that gases mainly come from enteric fermentation, manure storage and feed production [15]. The scholars reported that emission feed production and processing, enteric fermentation and manure storage account 45, 39 and 10% of the livestock sector respectively.

Greenhouse gases emitted to atmosphere due human activities and other factors make the surface much warmer by absorbing and emitting heat energy in all directions and then cause climate change. When the concentration of GHG is too high, too much heat is trapped, and the earth’s temperature rises outside the range of natural variability. There are many GHG namely Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Black carbon (soot, PM) and Fluorinated gases (PFCs, HFCs NF3 and SF6) with emission rate of 82, 10, 5, >1 and >5% [16]. The gases emissions have been growing since the Industrial Revolution and were 60% higher in 2014 than they were in 1990 [17]. The primary sources of year-on-year GHG emissions are the "burning of fossil fuels (coal, oil and gas), with important contributions from the clearing of forests, agricultural practices, and other activities [18]. Human activities currently emit an estimated 10 billion tons of carbon each year, mostly by burning fossil fuels [5]. Fossil fuel consumption for electricity and heat production generates about 25% of total GHG emissions, industry 21%; transportation 14%, other energy 10%, buildings 6%, while agriculture, forestry and other land uses contribute the remaining 24% of total GHG emissions [19].

III. Impact of Climate Change On

Crop Production

Climate variations affect crop production in several regions of the world, with negative effects more common than positive, and developing countries highly vulnerable to further negative impacts [20]. Reported that increased temperature and rainfall are positive for the crop yield, and the precipitation is more important for crop yield than the temperature [21]. However, [22] and [23] pointed out that crop yield increases in response to increasing temperature reach a peak though further increases in temperature result in decreases in yield. The climate and crop production trends showed that since the 1980s, 10% of yield declines globally for cereal crops in every 1 ^{0}C warming, except in high latitude countries [24]. Reported that climate change is estimated to have already reduced global yields of maize and wheat by 3.8% and 5.5% respectively [24]. Also pointed out that for every 1 ^{0}C of average warming there will be global yield decline for wheat, rice and maize in 6, 3.2 and 7.4 percent respectively [25]. Further complicating the interactions of crop production and climate is the potential for increased climate variability in the form of extreme events of flood and drought [26].

Pointed that temperature above 29 ^{0}C for maize are commonly modeled to decrease yields through accelerated growth or direct tissue or enzyme damage [27]. Recent empirical analysis of over 20,000 maize trials in Africa found that each degree day above 30 ^{0}C reduced the final yield from 1% to 1.7% for optimal rain-fed and drought conditions, respectively [23]. By the end of the twenty-first century, the multi model mean (MMM) of growing season temperatures in Iowa is projected to increase by more than 5 ^{0}C, and maize yield is projected to decrease by 18%. By the late twenty-first century, MMM growing season precipitation in southeastern Australia is projected to decrease by 15%, temperature is projected to increase by 2.88–4.5 ^{0}C, and wheat yields are projected to decline by 70% [27].

The concentration of CO_2 also has crucial impact on many crops. Higher concentration enhances the accumulation of biomass, increase yield and increase water use efficiency or decrease water consumption. According to [3], crop yields increase at 550 ppm CO_2 in the range of 10% to 20% for C3 crops (such as wheat, rice, and soybean), and only 0–10% for C4 crops such as maize and sorghum for under optimal condition. Though the nutritional quality of the crop grown under elevated CO_2 was not well understood, the protein concentration of some cereal crop and forage found lower [29]. The higher concentration of CO_2 also reduce water consumption rate of crop plants because of partial closure of stomata and decrease in the aperture of stomata. Reported that CO_2 enrichment increased potato tuber yield by 43%, decreased water consumption by

11% thereby increased the water use efficiency (WUE) by about 70% [30]. Similarly, [31] reported that 20% water consumption reduction and 8% yield increment for sugar beet experimentation under CO_2 enrichment.

Soil Water Balance and Crop Water Productivity

Soil water storage (SWS) is important for provisioning (e.g. crop production, water balance and plant-available nutrients) as well as regulating and supporting ecosystem services (e.g. water, nutrients, climate, flood and drought) [32]. Reported that climate change can affect both supply and demand for water in agriculture by changing the rain fall pattern and water compartment such as surface water and ground water, and crop water requirements [33]. Changes of precipitation patterns, both intra-annual and inter-annual, are likely to affect groundwater recharge rates, although there is a lot of uncertainty, as well as local variations related to these impacts [34]. The ground and surface water compartments could interact, as water stress on the latter could be transmitted to the former in the dry season.

Temperature rise and changing seasonal rainfall patterns could alter the probability of droughts and affect freshwater resources [35]. Indirect effects caused by increasing the atmospheric water demand, limiting evapo-transpiration due to water stress and reducing the soil water storage, could in turn lead to a decrease in crop yield [36]. Water productivity concerned with water saving irrigation is dependent on the groundwater level and evapo-transpiration [37]. Climate change can affect not only water availability, but also crop water requirements. Under climate change, current rain fed crops may require irrigation to maintain reasonable productivity, and current irrigated crops may have a larger or smaller irrigation requirement [38]. Production of either the same yield with less water resources or to obtain higher crop yields with the same water resources will increase water productivity [39].

Livestock Production

The changing climate is expected to have severe impact on livestock production systems across the world. The impact of climate change on livestock could be direct and indirect. Impact on animal growth, reproduction, metabolic activity, milk production, and disease occurrences are direct, while reducing water and pasture availability and other feed resources are considered indirect effect. Among the environmental variables affecting animals, heat stress seems to be one of the intriguing factors making animal production challenging in many geographical locations in the world [40].

Described that increased temperature, frequency and intensity of heat waves can affect livestock health by causing metabolic disruptions, oxidative stress, and immune suppression causing infections and death [41]. Similarly, he reported the alteration of the availability and quality of feedstuffs, drinking water, and survival and redistribution of pathogens and their vectors. Decline in quantity of pasture, rangeland, and forage crops production are widely mentioned as consequence of increased temperature and drought [42-44]. Also reported that climatic extremes and seasonal fluctuations in herbage quantity and quality will affect the well-being of livestock, and will lead to declines in production and reproduction efficiency [45].

Hot summer conditions, particularly when body temperature reaches 39.5°C disrupt several reproductive processes, resulting in a pronounced depression of conception rate in dairy cows worldwide [46]. Heat stress negatively affects milk composition and alters cheese making properties and merchandise value of milk thereby impact economy of producers and consumers [47, 48]. The heat stress also resulted economic losses to swine industry via reduced and inconsistent growth, decreased feed efficiency, decreased carcass quality (increased lipid deposition and decreased protein accretion), decreased reproductive performance (male and female pork) and increased mortality [49].

Forestry Ecosystem

Forest ecosystem is a natural unit consisting of all plants of which the main element is forest trees, animals and micro-organisms (biotic factors) in an area functioning together with all of the non-living physical (abiotic factors) factors of the environment. Forest land stores approximately 60% of the total carbon stock contained in terrestrial carbon pools [50]. Forests pull water from the ground and release water vapor through the leaves of the trees, generating atmospheric rivers of moisture that water crops thousands of kilometers away from where they stand [51]. However, Climate change strongly affects forest ecosystems by altering the growth, mortality and reproduction of trees. Effects of climate change on forest ecosystems mainly address the role of the latter with regard to carbon emission and sequestration [52]. It also alters the frequency and severity of natural disturbances in some forests; particularly fire, drought, species invasions, insect and disease outbreaks, and storms such as hurricanes are disrupting the structure, composition and function of forest ecosystem, community or population, and change resource availability or the physical environment. Stated that climate change can facilitate the range expansion of both native and exotic pests (insects and pathogens), or affect tree resistance to pests [53]. For instance, emerald ash borer (*Agrilus planipennis*) insect which was accidentally introduced to North America and western Russia resulted very serious impact as it kills virtually all native species of ash (*Fraxinus*), but minor pest in its native area northeast Asia. Beside, in Europe, the economic impact of the pine wood nematode (*Bursaphelenchus xylophilus*) has been estimated to reach 22 billion Euros by 2030 [54].

Described that fire is a major control of forest carbon balance and reduces the strength of forests carbon sinks as well as result loss of soil nutrients and affect available macronutrient concentrations [55]. Sharp increase in forest fires observed in temperate and boreal regions, with extensive and long-lasting wildfires in the US, Siberia, Australia and Europe by the year 2018 [56]. Gradual increase in temperature will affect the regeneration of tree species due to low soil moisture and competition with other species during the seedling stage.

Fisheries and Aquaculture

Fisheries, aquaculture and the associated post-harvest activities support millions of livelihoods and contribute significantly to food security and economic well-being in coastal zones. Climate change effects on aquaculture sustainability have gained considerable interest owing to the sector's significant contribution to global food security, nutrition, and livelihoods [57, 58]. [11] and [59] also reported that aquaculture has been the world´s fastest growing food production system in recent decades. However, climate change will impact fisheries and aquaculture via acidification, changes in sea temperatures and circulation patterns, the frequency and severity of extreme events, and sea-level rise and associated ecological changes [60, 61].

[62] and [63] reported that climate change directly influence the physical and physiology of finish and shellfish stocks in production systems, while indirectly by altering the primary and secondary productivity, and input supplies or by affecting product prices, fishmeal, and fish oil costs. Pointed that global marine primary production which controlling the energy and food available fish will decline by 6% ± 3% by 2100 due to climate change [63]. Climate change has higher effects on aquaculture producers in developing nations and poorer

economies compared with those in developed ones. Described that small-scale farmers will be more affected by climate change risks due to increased production costs in farm management and lack of support systems to recover from the effects compared to large-scale producers [64].

Global temperature with the predicted rise of 1.5 ^{o}C this century, increased mortalities of most fish, especially cold-water species, such as the Atlantic halibut, Salmon and Cod, and intertidal shellfish due to thermal stress [65]. Also described that rising water temperatures will lead to shifts in freshwater species' distributions and exacerbate existing problems in water quality, especially in those systems experiencing high anthropogenic loading of nutrients [20]. The metabolism and physiology, as well as feeding behavior and growth performance of most finfish and shellfish species are likely to be affected [66].

Ocean acidification (pH decrease) due to uptake of atmospheric CO_2 will have adverse effects on the growth, development, calcification, survival, and abundance of several aquatic species through water quality deterioration [67]. Moreover, the rise in ocean acidity reduces the availability of carbonate required for the construction of coral skeletons (Calcification) in shell-forming organisms, such as shrimps, mussels, oysters, or corals which potentially threatens marine aquaculture production [68. 69]. This could pose negative implications on the social and economic sustainability of aquaculture production. The rain fall will affect aquaculture production and sustainability in two directly opposite ways; increased rainfall (Flooding) and periods of low or no rainfall (Drought). Heavy rainfall will increase production risk such as losing fish from ponds during floods, invasion of ponds by unwanted species, and ponds damage resulting from infilling and washing away of walls [70]. The fish losses from ponds threaten the social and economic dimensions of aquaculture sustainability by lowering the economic gains of the producers and inducing poverty in communities.

Food Security

Food security is a situation exists 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 [71]. Today, 821 million people experience a shortage of food each day; while over twice that number face moderate food insecurity and this execrated by climate-related extreme events [72]. Food, from staple cereal grains to high protein legumes and oilseed crops, is central to human development and well-being [73]. However, climate is an important factor in agricultural productivity and its change affects all dimensions of food security (i.e., food availability, food accessibility, food utilization, and food systems stability) [74, 75]. Due to the recently emerging climate change-induced phenomena, food security is to be threatening everywhere [76]. Estimated that global agricultural productivity could be reduced by 15.9% and developing country experiencing a disproportionally larger decline of 19.7% [77]. According to [20] the temperature increases of 1.5 – 2.5 °C, approximately 20% – 30% of plant and animal species are expected to be at risk of extinction with severe consequences for food security in the developing countries. Developing nations, especially those in sub-Saharan Africa are more vulnerable to the effects of climate change [78]. Large portion of the Ethiopian population are affected by chronic and transitory food insecurity which is highly linked up to severe, recurring food shortage and famine, which is associated with recurrent drought (climate change) [79]. Evaluated present and future climate scenario impacts on food security and water availability in 2020 and 2070s and suggested some measures to enlarge potential crop production such as diversifying crops and expanding the rain fed and irrigated agriculture areas [80]. Anderson *et al.* [81] also pointed that adapting agriculture to climate change is t-

-he key to food security in the 21st century.

III. Mitigation and Adaptation Strategies

Mitigation is devoted to reduce the impacts of climate change, while adaptations aim to cope with the impacts of climate change or improve the capacity of defense and resilience. Pointed that mitigation addresses the degradation rate of climate change, adaptation deals with weakening the adverse impacts of climate change [82]. Both strategies share common goal, namely to reduce the impacts of climate change from a long-term perspective and ensure sustainable development of human society.

Mitigation action lowers the green house gas (GHG) concentrations via reducing emissions and adding carbon sinks, to meet the objective of reducing the pace of climate change and frequency of extreme events [83]. Mitigation activities can broadly be grouped into five main areas: Efficient use of energy (reducing system waste); use of renewable energies (such as solar, bio-fuels, wind, and ocean thermal exchange); carbon sequestration through enhanced sinks (e.g., reforestation and afforestation); reduced sources of emissions through land use management; and macro-engineered carbon capture and storage [84]. [85] and [86] reported that global climate change mitigation goals cannot be met without the inclusion of forests, reducing deforestation, reforestation and improved forest management. As forests already remove around 25% of the anthropogenic carbon emissions added to the atmosphere each year [87], and could provide an additional 30% of the mitigation needed by 2030 [88]. Studied the climate change impacts on irrigation requirements and concluded that mitigated climate can reduce by about 40% impacts on agricultural water requirements in comparison to unmitigated climate [89].

IPCC [20] reported that climate adaptation aims to (i) avoid or minimize the harmful effects of climate change and (ii) benefit from the potential opportunities associated with climate change. The strategy include investments in flood risk control, introduction of new crop varieties, investment in more efficient irrigation and resource-saving technologies, adoption of sustainable forest management, investment in early warning and information sharing systems, soil and water conservation, livelihood diversification, and insurance. Described that genetic improvement for heat tolerance livestock is effective to achieve a permanent change in an animal's tolerance to heat. Mitigation and adaptation actions could have synergy and negative effect in climate change management. For instance, the synergies of land-use and forestry sectors, the reforestation to prevent flooding and erosion sequester carbon [91]. In contrast, dam construction for preventing sea water encroachment, raises the consumption of steel and cement, which are higher carbon emission goods. Improving capacities, providing higher access to climate services, including local-level early warning systems, and expanding the use of remote sensing technologies are high-return investments for enabling effective adaptation and mitigation responses [25].

IV. Future Climate Change

Major advances in the observations, theory, and modeling of Earth's climate system have been made by scientists and these have enabled them to project future climate change with increasing confidence. Nevertheless, several major issues make it impossible to give precise estimates of how global or regional temperature trends will evolve decade by decade into the future. The issues are the difficulty of predicting how much CO_2 human activities will emit, complexities of how climate feedbacks operate and the effects of an underlying trend in temperature can be modulated by natural variability. Taken together, all model projections indicate that Earth will continue to warm considerably more over the next few decades to centuries. If there were no technological or policy changes to reduce emission trends from their current trajectory, then further globally averaged warming of 2.6 to 4.8 °C (4.7 to 8.6 °F) in addition to that which has already occurred would be expected during the 21st century.

V. Conclusion

Climate change brings serious negative impacts on agricultural systems and food security at the global, regional, and local level. Climate change can reduce yield of agricultural product (crop, livestock, fish and etc) and disrupt food availability, reduce access to food, and affect food quality. The elevated temperature, flooding risk, green house gas emission (Carbon dioxide (CO_2), Methane (CH4), Nitrous oxide (N2O), Black carbon (soot, PM) and Fluorinated gases, PFCs) due to human activities result climate change. The climate change is aggravating and continuing to hinder all development sectors and looking for innovative solution both in technology and policy strategies is mandatory.

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