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Review on Impacts of Climate Change on Agriculture

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Abstract

Climate change exerts profound effects on agriculture via many interrelated mechanisms, constituting a substantial hazard to global food security and the economic well-being of farmers across the globe. The ramifications of these changes are becoming progressively apparent and are anticipated to exacerbate in the ensuing years. Ethiopia is classified among the least developed nations globally; however, it has experienced a noteworthy trajectory of economic expansion and a significant decrease in poverty levels in recent years, characterized by an average GDP growth rate of 10.1 percent for two decades, alongside an approximate GDP per capita growth rate of 8 percent. The regulatory services pertinent to the mitigation of climate change that the agricultural sector may furnish encompass the comprehensive diminution of greenhouse gas emissions. The aims of the review are (i) To determine how climate change affects agricultural productivity, (ii) To determine the economic and food security impact of climate change, and (iii) Contribute to the agriculture strategy system adaptation and mitigation.

Keywords: Climate change, Agriculture, Food security, Mitigation, Adaptation

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1. INTRODUCTION

Climate change refers to any significant change in the signature patterns of typical weather conditions of an area, region, or the entire earth, either due to natural variability and/or as a result of human activity, projected over comparable periods, which may be observed over tens, hundreds, or perhaps millions of years. Changes in climatic conditions are expressed in terms of

Radiative forcing (In the earth-atmosphere system, radiative forcing is a measure to express the influence of a factor in transforming the incoming and outgoing energy balance (Stocker et al., 2013).

Concerns about climate change are global and real. As all communities try to adapt to the challenges of their local climate, they are today sensitive to its variations. Third World countries, particularly Africa are threatened by the predicted effects of climate change because of their economic dependence on climate for development whose backbone is agriculture. There is strong evidence from the World Meteorological Organization (WMO), Intergovernmental Panel on Climate Change (IPCC), and United Nations Environmental Program(UNEP) that the observed increases in greenhouse gases particularly Carbon dioxide (CO2) may lead to global warming, sea level rise and space-time changes in climatic zones and seasons on the globe (Khaoma & Ngaira, 2007).

Reports have predicted that SSA is one of the regions that would have the most severe impacts of climatic change. The increasing climatic variability brought about by the increase in extreme weather events, global warming, seawater, and rainfall deficit would have serious implications for food production and availability in the region. Climate change has threatened the food security in SSA. The climatic change would significantly affect the livelihood patterns, the ability to access food, and the socio-economic lives of the majority of the people in the region (Chijioke et al., 2011).

The least developing countries and people receive the effect of climate change first and will suffer the most as these nations are more susceptible to the negative effects of climate change which would affect productivity and human health (Akram & Abdul, 2015). Ethiopia is one of the least developing countries in the world, but recently Ethiopia had a remarkable track of record growth and reduction in poverty in recent years, with GDP growth averaging 10.1 over two decades, about 8 percent GDP per capital growth (Ketema & Negeso, 2020). However, Ethiopia is heavily dependent on rain-fed agriculture. The physical location and landscape coupled with little adaptive capacity necessitate a high vulnerability to adverse impacts of climate change; due to these, the country faces drought in different periods due to climate changes that directly affect agricultural output (International Monetary Fund, 2016). This makes the country face different droughts causing problems in different periods that lead to chronic food shortage and food insecurity for long periods (Gebreegziabher et al, 2011).

The largest known economic impact of climate change is upon agriculture because of the size and sensitivity of the sector. Warming causes the greatest harm to agriculture in developing countries primarily because many farms in the low latitudes already endure climates that are too hot (Mendelsohn, 2008).

An integrated view of agriculture combines the provision of food and fiber with additional functions and services to the extent that an ecosystem service approach has been proposed as the future of land evaluation. The regulating services relevant to climate change mitigation that agriculture might provide include the overall reduction of emissions of greenhouse gases (Dominati et al., 2016). The goals of this review are The assess the impact of climatic change on agriculture and to evaluate agricultural productivity, the economic and food security impact of climate change, and agriculture strategy system adaptation and mitigation.

2. The concept of climatic change

Climate refers to a long-term variation in the atmospheric condition of a specific region or region, and climate change means a gradual change in the climate system both by natural and artificial causes. Climate change is caused by the change in each component of the climate system such as the atmosphere, hydrosphere, biosphere, cryosphere, and lithosphere, or by complicated interactions among those components. The causes of climate change are largely divided into natural causes and artificial causes. Natural causes include changes in solar activity, volcanic eruption, sea water temperature, ice cap distribution, westerly waves, and atmospheric waves. On the other hand, artificial causes include carbon dioxide emission from industry and agricultural production activities, deforestation, acid rain, and the destruction of the ozone layer by Freon gas, with global warming by the increase of greenhouse gases as the representative (Kim, 2010). Climate change is one of the most defining concerns of today's world and has greatly reshaped or is in the process of altering the earth's ecosystems. Although climate change has been a constant process on earth, but in recent times, approximately the last 100 years or so, the pace of this variation has increased manifolds. Due to anthropogenic activities, the average temperature has raised by 0.9 °C since the nineteenth century, mainly due to greenhouse gas (GHG) emissions in the atmosphere. As per estimates, this rise is expected to be 1.5 °C by 2050 or maybe even more, the way deforestation is occurring, GHG emissions are increasing and soil, water, bodies, and air are being polluted (Arora, 2019).

3. The concept of agriculture

The term Agriculture is derived from two Latin words ager or agri meaning soil and culture meaning cultivation. Agriculture is an applied science that encompasses all aspects of crop production including horticulture, livestock rearing, fisheries, forestry, etc.

Agriculture is defined in the Agriculture Act (1947), as including 'horticulture, fruit growing, seed growing, dairy farming and livestock breeding and keeping, the use of land as grazing land, meadow land, osier land, market gardens and nursery grounds, and the use of land for woodlands where that use ancillary to the farming of land for Agricultural purposes.

Agricultural sector is indispensable to the country's economic growth, food security, employment generation and poverty alleviation particularly, at the rural level. It contributes 19.2 percent to the GDP and employs around 38.5 percent of the labour force. More than 65-70 percent of the population depends on agriculture for its livelihood. The agricultural growth rate has been constrained by shrinking arable land, climate change, water shortages, and large-scale population and labour shifts from rural to urban areas.

Sustainable agriculture has progressed over the last ten years, from a focus primarily on a low-input, organic farming approach with a major emphasis on small fruit or vegetable production farms, often referred to as Low Input Sustainable Agriculture, to the current situation, where sustainability is an important part of mainstream animal and plant production units. Agriculture programs involve a wide range of tasks, such as protecting natural resources, improving environmental quality, and ensuring farm productivity. One rapidly evolving technique that can reduce the use of external inputs, conserve the agricultural environment, and boost economic returns is the use of Geographic Information Systems technology to direct the application of fertilizers, insecticides, and herbicides(Wagner, 1999).

4. The impact of climatic change on agriculture

Climate change poses one of the gravest risks to mankind as it affects a wide variety of socio-economic activities, important to world food security. Agriculture is one of the most important sectors vulnerable to climate change. Agricultural production is sensitive to climate change, and food security is sensitive to agricultural production. Climate abnormalities such as perpetual droughts, floods, heat waves, and rainfall failure can have devastating consequences for agricultural production and the impacts could be immediately transmitted to food security and human livelihoods (Ferede T et al., 2013).

Agricultural production is carried out through the selection of crops suitable for the climate of a specific region and the application of proper farming methods. Therefore, agriculture is a climate-dependent bio-industry with notable regional characteristics. Regional characteristics refer to the ecosystem characteristics determined by the climate of the region. Climate change disturbs the agricultural ecosystem, resulting in changes in agricultural climatic elements such as temperature, precipitation, and sunlight, while further influencing the arable, livestock, and hydrology sectors (Kim, 2010).

Temperature and soil moisture determine the length of the growing period and the crop`s development and water requirements. Higher temperatures will shorten the freeze periods, promoting cultivation in marginal croplands. However, in arid and semi-arid areas higher temperatures will shorten the crop cycle and reduce crop yields (IPCC, 2007b).

4.1 The impact of crop productivity

Crops grown in any province are critical for the global food supply. Any changes in temperature, carbon dioxide (CO2) levels, and extreme weather conditions may profoundly impact crop yield. On the one hand, warmer temperatures may increase crop growth, but the same temperature could induce reduced yields. Crops tend to grow faster under warmer conditions. However, in some crops like grains, faster growth reduces the amount of time required by seeds to grow and mature which can reduce yields (i.e., the quantity of crop produced from a given amount of land) For a particular crop, any impact of increased temperature is known to depend on the specific optimal temperature required for the growth and reproduction of the crop. Although in some areas, an increase in temperature may benefit the kind of crops that are typically planted, but at the same time, if warming overshoots, a crop's optimum temperature, yield decline cannot be ruled out. Some of the possible impacts of climate change on crops are described under the following sections. (Krishnan et al., 2007).

At the national level, the simulation results suggest that crop production will be adversely affected during the coming four decades and the severity will increase over time. Production of teff, maize, and sorghum will decline by 25.4, 21.8, and 25.2 percent, respectively by 2050 compared to the base period. Climate change will also cause losses of 31.1 percent of agricultural GDP at factor cost by 2050. Climate change affects more the income and consumption of poor rural households than urban-rural non-farming households. The reduction in agricultural production will not be evenly distributed across agroecological zones, and will not all be negative (Solomon et al., 2021).

Changes in crop yields are the result of climate changes and any human mitigating responses (such as increasing fertilizer or water use or adoption of new crop varieties), while changes in acreage are affected by producers' expectations concerning changes in relative crop prices and per acre returns (Adams et al., 1999).

The pollination stage is one key moment in which temperature plays a major role; pollen release is linked to the growth of fruit, grain, or fiber. High temperatures during this time can diminish crop yields significantly and raise the chance of total crop loss. Plants that are exposed to high nighttime temperatures during grain, fiber, or fruit production have lower productivity and quality. These effects have already begun to manifest themselves; in 2010 and 2012, rising evening temperatures impacted crop production across the Corn Belt. Yield decreases

will become more common as the number of nights with high temperatures is expected to rise by as much as 30%. (Hatfield & Takle, 2014).

4.2 Impact on Livestock

Annual global consumption of meat is around 41.90 kg per person per year

2013 FAO. Apart from human consumption, the livestock industry produces several billion dollars worth of goods. Any climate changes may affect animals as well as the economy both directly and indirectly(Ghahramani & Moore, 2016).

- Under climate change, heat waves, which are likely to increase, may threaten livestock directly. It is reported that just one heat wave can create a loss of more than 5000 animals. Heat stress may influence animals both indirectly and directly. Progressively with time, heat stress can enhance disease susceptibility, reduce fertility, and reduction in the production of milk.
- Drought under climate change may imperil pasture and feed supplies by retracting the measure of quality forage available for grazing livestock.
- Climate change may likely enhance the invasion of pests and diseases, parasites, and insects that may significantly affect livestock. Warmer winters and the untimely inception of spring may consequently result in the easy survival of certain parasites and pathogens. In areas receiving increased precipitation, moisture-reliant pathogens are likely to flourish.
- Elevation in carbon dioxide (CO2) levels may increase pasture productivity but may also decline their quality. An increase in CO2 levels in the atmosphere may increase plant productivity on which livestock feed.

4.3 The impact of food security

Climate change poses one of the gravest risks to mankind as it affects a wide variety of socio-economic activities, important to world food security. Agriculture is one of the most important sectors vulnerable to climate change. Climate abnormalities such as perpetual droughts, floods, heat waves, and rainfall failure can have devastating consequences for agricultural production and the impacts could be immediately transmitted to food security and human livelihoods (Ferede T et al., 2013).

A range of supply and demand-side pressures affect food security, including economic conditions, market globalization, food safety and quality, land-use change, population change, disease, and poverty. Climate change is projected to have many effects on food security within the complex global food system. Aside from affecting agricultural production, rising temperatures, changing weather patterns, and an increase in the frequency of extreme weather events will have an impact on the spread of food- and water-borne diseases, as well as food trade and distribution. This means that food security is dependent not only on how climate change affects crop yields at the local and national level, but also on how climate change and changes in extreme events affect food processing, storage, transportation, and retailing, including transportation disruption and consumers' ability to purchase food. (Hatfield & Takle, 2014)

Food security is defined by the FAO in four dimensions: food availability, access to food, food supply stability, and food usage. Food availability – will be harmed by a drop in food production due to extreme events, changes in the suitability or availability of arable land and water, and the unavailability or lack of access to crops, crop varieties, and animal breeds that can be productive in conditions where pests and diseases have changed; Climate change events will decrease access to food by causing infrastructure damage and losses of livelihood assets, as well as a loss of income and employment prospects; Food supply stability - may be influenced by food price changes and a greater reliance on imports and food (FAO, 2008).

4.4 The impact of economic

Impacts on production have immediate economic and social consequences at numerous scales, including on the farm and in the food chain. Changes in agricultural earnings, food markets, prices, trade patterns, and investment patterns are all possible outcomes of climate change. They can cause a spike in the price of agricultural commodities (food and feed) at the national level, affecting the economic and social standing of the entire population, especially in nations where food accounts for a significant portion of the household budget. This has macroeconomic consequences for agriculture-dependent countries where agriculture contributes significantly to GDP and/or employment. Climate change has the potential to stymie agricultural development by deterring

investment. Climate shocks that affect a large volume of global production or a key area in terms of global markets have global implications for markets: (1) quantity and price effects, resulting in increased market tension; and (2) impacts on bilateral contracts and/or import/export behavior, resulting in trade disruption (Gitz et al., 2016).

The majority of model forecasts of climate change-related food price impacts indicate future increases, albeit the magnitude and locations vary significantly between models and climate change scenarios. Increases in food prices are caused by population growth and increased earnings, which boost demand, as well as negative supply implications from climate change(Nelson et al., 2010).

The FAO claims Droughts, floods, and hurricanes destroy crops, livestock, and fish resources, as well as agriculture, livestock, and fishing/aquaculture infrastructure and productive assets like irrigation systems, livestock shelters, docks, and landing and post-harvest facilities, lowering overall food production capacity. Market access, trade, and food supply can be disrupted, resulting in lower income, depleted savings, eroded livelihoods, and increased hunger. Disasters, on the other hand, lead to ecosystem deterioration and loss, such as increased soil erosion, decreased rangeland quality, and soil salinization. As a result of increased environmental degradation, the supply of goods and services decreases, as do economic opportunities and life options (McGuire, 2015).

5. Climate change adaptation and mitigation agricultural system

5.1 Climate change adaptation in agricultural systems

Adaptation is the “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates, harm or exploits beneficial opportunities” (Lesnikowski et al., 2011)

Adaptation is central to many proposed strategies for reducing the negative impacts of climate change. Factors commonly cited as exacerbating household vulnerability in Ethiopia include drought, commodity price fluctuation, crop pests, and death and illness of family members(Calvo & Dercon, 2005).

Adaptation methods that have been implemented or are in the process of being implemented include the following: Changing eating habits by cutting down on the number of meals per day, restricting food, and eating wild food Building infiltration ditches around homes, growing grass cover, terrace farming, trenching, mulching, and tree planting are all examples of soil conservation techniques. Planting fungal disease-prone crops during low-rainfall seasons, or even dry seasons, is a good idea. By selling or slaughtering excess livestock, the overall livestock population can be reduced. Using agroforestry to protect a variety of native species keeping smaller cattle, cross-breeding, and zero-grazing Traditional forest-conservation measures are being adopted. Genetic resources conservation, Drought-tolerant, early-maturing crop development and promotion Solar and hydropower are two examples of renewable energy sources. Increasing the number of agricultural extension agents and Promoting agricultural goods' value-added, storage, and post-harvest techniques (Nzuma et al., 2010)

5.2. Climate change mitigation in agricultural systems

Climate change is exacerbated by agriculture and land-use change (deforestation). Agriculture, which includes cropland, pasture, animal production, and forestry, according to the IPCC Fourth Assessment Report, accounts for 13 and 17 percent of total human greenhouse gas emissions, respectively. Other emissions related to agriculture, such as fertilizer production (accounted under industry), food supply (transport and industry), packaging (waste), and cooling and heating (accounted under industry) are not included in this contribution to energy supply(FAO, 2008)

Climate change mitigation is a human intervention aimed at reducing greenhouse gas sources or increasing sinks. Climate change mitigation is a worldwide duty. Agriculture and forestry, in theory, have a lot of potential for reducing GHG emissions. By 2030, the IPCC forecasts that agriculture's global technological mitigation potential (excluding forestry and biomass-based fossil fuel offsets, and including all gasses) will be between 5 500 and 6 000 Mt CO2-equivalent per year, with 89 percent of that coming from carbon sequestration in soils. At the national level, assessing mitigation possibilities remains a key tool for defining priorities(IPCC, 2007)

Natural resource mitigation should concentrate on the five key sectors of livestock, forestry, rangeland, agriculture, and fisheries. Forest-related measures such as reducing deforestation and forest degradation and increasing afforestation and reforestation, as well as forest management interventions to maintain or increase forest carbon density, and efforts to increase carbon stocks in wood products and enhance fuel substitution, are all traditional mitigation options in the agricultural sector.

A collection of proposed approaches for reducing GHG emissions from agricultural ecosystems, along with their apparent benefits in reducing individual gas emissions (mitigative impact) and a scientific confidence assessment that the proposed strategy can reduce overall net emissions including 1) farmland management, which includes agronomy, nutrient management, tillage/residue management, water management (irrigation, drainage), rice management, agroforestry, and land-use change. 2) Grazing land management/pasture enhancement (e.g., increased grazing intensity, fertilization), nutrient management, fire management, and species introduction (including legumes) 3) Organic soil management to prevent wetlands from being drained. 4) Erosion control, organic amendments, and nutrient amendments for degraded land restoration (Marland et al., 2003).

6. Conclusion

Climate change, the outcome of "Global Warming" has started to reveal its consequences worldwide. The primary determinant of agricultural productivity is "climate" which bears a direct impact on global food production. Although the life cycle of grain and oilseed crops is likely to progress more rapidly; but with increasing temperatures and variable rainfall, crops may start to experience failure, particularly under low and variable precipitation patterns. Climate change is one of the most defining concerns of today's world and has greatly reshaped or is in the process of altering the earth's ecosystems. Although climate change has been a constant process on earth, but in recent times, approximately the last 100 years or so, the pace of this variation has increased manifolds.

Land degradation is resulting in mass migrations and as per a report published by the United Nations Environment Programme in 2017, 500 million hectares of farmland have been abandoned due to drought and desertification resulting in major social and environmental constraints. Extreme drought conditions, frequently occurring due to climate change, exacerbate the productivity of crops by causing nutrient immobilization and salt accumulation in soils making them dry, unhealthy, saline, and finally infertile. Soil and oceans are the biggest sinks of CO2, thus by increasing the soil organic matter and subsequent enhancement in yield or planting of perennial crops or through planned agro-forestry can result in decreasing the levels of GHGs, helping in combating the climate change and simultaneously resulting in reclamation of marginal or degraded lands. Agriculture might serve as a mitigation solution through carbon (C) sequestration in soil, in tree biomass, and reducing greenhouse gas (GHG) emissions. Increased C is beneficial for some soil structures and functions, improving the use of water and in turn crop adaptation.

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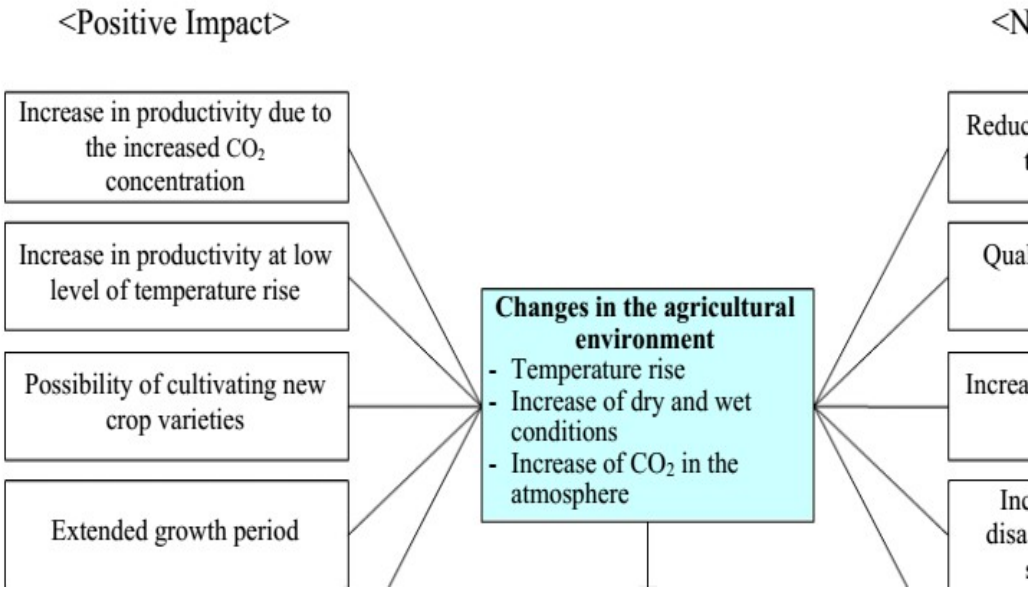

Figure 1. Potential impacts of global warming on the agricultural sector

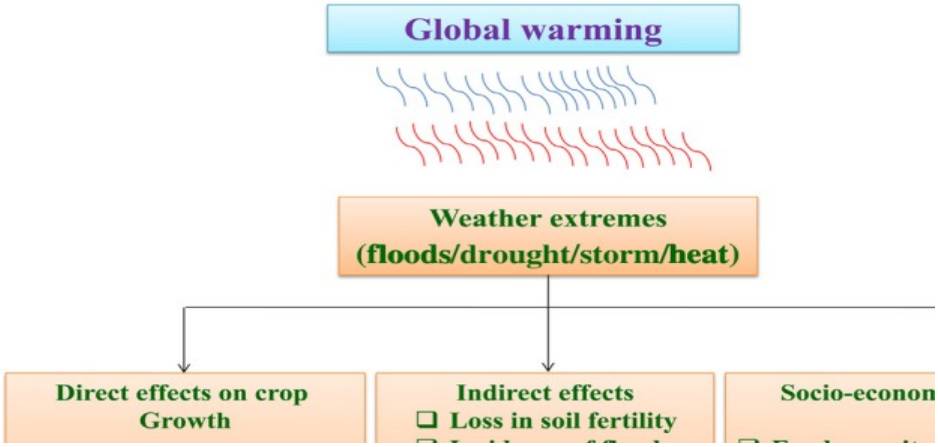

Figure 1: impact of climate change crop on agriculture

Figure 3: the impact of crop production on climate change

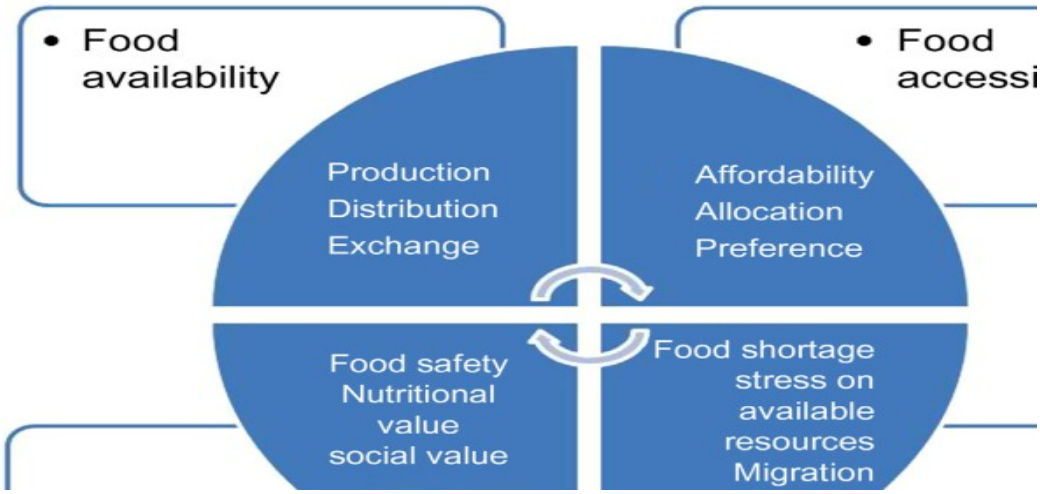

Figure 4: Core dimensions of food security under risk due to climate change