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Effects of Climate Change on Agriculture and Food Security: Climate Smart Mitigation Strategies

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Abstract

*There are many climate resilient and climate smart technologies and case studies that farmers can adopt to mitigate the effects of climate change , this review aims to highlight and discuss some of them using case studies. The effects of climate change are currently being felt in all spheres of life but effects are more severe in the agricultural sector. Climate variability and changes are setback to vital development such as food security, which results from poor yield, making most farmers to diversify into other live hood activities to the detriment of agriculture which is under serious strain resulting from climate change and these effects are anticipated to worsen with time. Literature materials on climate change, climate resilience and climate smart solutions were assembled along with case studies from outside Nigeria, they were thereafter **reviewed** and discussed Innovations, Technologies and case studies such as climate -livestock and market project in East Africa, climate insurance project in Kenya ,Pest Risk Information System (PRISE) ,the soil carbon recuperation project, , index thresh hold for weather factors and the climate smart agricultural practices of 33 countries launched as COP24, where highlighted .It was concluded that the effect of climate change on the farmers are majorly from drought, increased outbreak of crop, livestock and fish diseases, insect infection and damage to crops while increase in cost of production and household spending, reduction of farm and none farm income, loss of harvest and increase in crime and insecurity were the other non farm effects and that climate change resilience and climate smart practices can greatly help in mitigating the effects of climate change. It was recommended that farmers should adopt digital and climate smart climate change mitigation technologies, government should provide agricultural input to farmers with a view to providing solutions to the incidence of pests and diseases resulting from climate change and advice farmers on appropriate strategies to cope with climate change such as climate resilient strategies and also provide farmers with ICT devices to promote climate smart practices*

Keywords: *Climate Change, Climate Smart, Case Studies, Digital, , Mitigation . Technology*

Introduction

The issue of Climate change is a front burner in the policies and programmes of many governments the world over (Igene *et al*, 2023) The effects of climate change are currently being felt in all spheres of life but effects are more severe in the agricultural sector (Olorunfemi *et al.*,2020). This is so because agricultural production performance and live hood are on the priority lists of governments policies and programmes, no doubt, climate variability and changes are setback to vital development such as food security, which results from poor yield, making most farmers to diversify into

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other live hood activities to the detriment of agriculture which is under serious strain resulting from climate change and these effect are anticipated to worsen with time.

Banmeke *et al*. (2017) pointed out that the intergovernmental panel on Climate Change (IPCC, 2001) defines climate change as statistically significant variation caused by human and non-human activities that last for decades or longer. Deforestation oil spills and gas flaring are example of non-human causes. This definition showed that It is caused by human activities and by uncontrollable natural circumstances. It poses significant threat to the highly industrialized and less industrialized worlds. It has also been reported that third world or developing countries are more vulnerable to the effect of climate change, despite the fact that developed counties emit the most carbon and other high-level industrial waste. West African sub region would also be more vulnerable. Individual farmers, fishermen and other rural dwellers and city dwellers are the most vulnerable group Climate change is having a profound impact on global food systems, with far-reaching consequences on Agriculture and food security. Rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events are affecting the productivity, distribution, and quality of essential food sources (IPCC, 2019).

Climate change negatively affect the over all survival of human race and other living organism on the surface of the earth because the life of all living organism depends on water, humidity air, and soil for survival. Air Pollution caused by the emission of gases from factories vehicle, domestic use of firewood, etc.. significantly affect the ozone layer, thereby leading to reduced pacification, humidity and increase in the concentration of carbon dioxide on the earth, which in turn leads to poor agricultural production and hence food insecurity There are many climate resilient strategies and climate smart innovations that farmers can adopt to mitigate the effects of climate change which this review aims to highlight and discuss, using case studies.

In aquatic ecosystems, warming waters and ocean acidification are altering fish populations and disrupting fisheries, with many species shifting their ranges polewards or to deeper waters in response to changing conditions (Perry *et al.*, 2018). This can have cascading effects on the livelihoods of communities dependent on fishing and aquaculture (FAO, 2020).

Similarly, livestock production is being impacted by heat stress, changes in pasture quality and availability, and increased disease transmission, pest attacks, leading to reduced productivity and economic losses for farmers (Herrero *et al*., 2016).

Crop production is also being affected, with rising temperatures and altered precipitation patterns impacting yields, growing seasons, and crop quality (Schmidhuber *et al.*, 2007). Increased frequency of extreme weather events, such as droughts and floods, can further exacerbate these impacts (Lesk *et al*., 2016).

This paper will examine the effects of climate change on Agriculture, with focus on the implications for global food security and sustainability.

Methodology

Literature materials on climate change, climate resilience and digital as well as climate smart solutions were assembled along with case studies from outside Nigeria, they were thereafter reviewed and discussed

The impacts of climate change on fish population/production

The impacts of climate change on fish populations are multifaceted and far-reaching, with significant consequences for the health, productivity, and sustainability of marine ecosystems.

Ocean warming and acidification alter habitats and disrupt fish populations:

Ocean warming is causing shifts in species distributions, with many fish populations moving pole wards or to deeper waters in search of cooler temperatures (Perry *et a*l., 2018). This can lead to changes in community composition, reduced biodiversity, and altered food web dynamics (Cheung *et al*., 2010). Additionally, ocean acidification, resulting from increased absorption of CO2 by oceans, can impair fish growth, survival, and reproduction (Kroeker *et al*., 2013).

Changes in ocean currents and temperature affect fish migration patterns:

Altered ocean circulation patterns and temperature gradients can disrupt the migratory routes and schedules of fish populations, potentially leading to mismatches between fish and their prey or habitat (Edwards & Richardson, 2004). This can have cascading effects on fisheries and the livelihoods of communities dependent on them (FAO, 2020).

Increased disease and parasite spread due to warmer waters:

Warmer waters can facilitate the spread of disease and parasites among fish populations, further threatening their health and productivity (Harvell *et al.*, 2002). This can be particularly problematic for aquaculture operations, where disease outbreaks can have significant economic impacts (Stentiford *et al*., 2012).

The impacts of climate change on livestock

The impacts of climate change on livestock production are significant, with far-reaching consequences for animal health, productivity, and food security.

Heat stress reduces productivity and increases mortality:

Rising temperatures and increased frequency of heat waves can lead to heat stress in livestock, resulting in reduced productivity, decreased milk and meat production, and increased mortality (St-Pierre *et al*., 2003). Heat stress can also impair reproductive performance and fertility in livestock (Hansen, 2004).

Shifts in pasture quality and availability impact grazing:

Changes in precipitation patterns and increased frequency of droughts can alter pasture quality and availability, affecting

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grazing livestock (Herrero *et al*., 2016). This can lead to reduced feed quality, decreased animal growth rates, and increased supplementation costs (Craine *et al*., 2010).

Increased disease transmission due to changing weather patterns:
Climate change can alter the distribution and prevalence of disease-carrying insects, such as ticks and mosquitoes, increasing the risk of disease transmission to livestock (Gale *et al.,* 2010). Warmer temperatures can also facilitate the growth and survival of pathogens, further increasing disease risk (Lindsay *et al*., 2010).

Climate Change Impact on Crop Production
Climate change is significantly impacting crop production worldwide, posing a substantial threat to global food security.

Rising temperatures and altered precipitation patterns impact yields:
Warmer temperatures and changing precipitation patterns can lead to reduced crop yields, decreased water availability, and increased evapo-transpiration, resulting in lower productivity (Schmidhuber *et al.,* 2007). For example, a 1°C increase in temperature can lead to a 2-4% decline in wheat yields (Asseng *et al.*2015).

.Changes in growing seasons and weather extremes (droughts, floods) affect crop quality:
Shifts in growing seasons and increased frequency of extreme weather events, such as droughts and floods, can impact crop quality, leading to reduced nutritional value, increased contamination, and lower marketability (Lesk *et al.,* 2016). For instance, drought stress can reduce corn yields by up to 20% (Ciais *et al*., 2005).

Increased pest and disease pressure due to warmer temperatures:
Warmer temperatures can alter the distribution, prevalence, and severity of pests and diseases, leading to increased crop damage and reduced yields (Bebber *et al*., 2013). For example, warmer temperatures can increase the reproduction rate of aphids, a major pest of wheat, by up to 50% (Harrington *et al.,* 2001).

The Implications of Impact of Climate Change

- Reduced food availability and quality
- Economic losses for farmers and fisheries
- Negative impacts on human nutrition and health

Adaptation and mitigation strategies, such as sustainable agriculture practices, climate-smart aquaculture, and ecosystem-based management, can help minimize these effects and ensure food security in the face of climate change.

Case Studies of Climate Smart Mitigation Strategies
Digital technology is increasingly being used to bolster farmers climate-resilience in the face of weather uncertainly. A CTA- supported Climate Livestock and market project in east Africa, for instance, provides pastoralists with weather information- including potential rainfall, temperature and evapotranspiration. A cloud-based weather information system draws this data from a host of local weather station. Where it is then delivered directly to the pastoralist' mobile phones via SMS – allowing farmers to better plan for, and adapt to, changing weather and climate conditions. (Spore Magazine, 2018)

To mitigate the devastating impact of pest, estimated to cause around 40% of crop losses worldwide, researchers in the UK have developed a service that uses satellite and earth observation data to forecast the risk of pest outbreak. The pest Risk information service (PRISE) feeds information related to temperature, weather forecast and plant-pest lifecycles into a computer model that predict when an outbreak is likely. Farmers using the service receive an alert to their mobile phones when there is high risk of an outbreak, enabling them implement appropriate precautions, PRISE is currently being used in kenya, Ghana and Zambia, where it is hoped to improves yields and increase farm incomes by up to 20% . (Spore Magazine, 2019)

Soil Carbon
Eight steps to recuperate soil carbon stock have been published by climate change and agricultural scientist in the nature journal the amount of carbon in soil is over twice the amount of carbon stored in trees and other Biomass; However, one third of the worlds soil are already degraded, which constrains agricultural production and add high levels of CO_2 to the atmosphere. The steps are therefore intended to help mitigate against climate change and boost soil fertility and include promoting best practices for storing carbon, such as the incorporation of cover crops and crop residues. The steps will also inform the next Koronivia joint work on agriculture climate meeting , which focuses on soil carbon.(Spore Magazine, 2018)

Climate 'Smartness'
The climate-smart agricultural practice and technologies of 33 countries across Africa, Asia and Latin America have been assessed in a report launched as COP24. Developed by the international center for tropical Agriculture and the World Bank, bringing the concept of Climate- Smart Agriculture to life evaluates, categories and rates some 1,700 climate-smart combinations. This informative report aims to build the resilience of the world's 500 Million Small holder farmers by outlining which site-specific interventions work under different circumstances. The report finds that the 'smartest' farming technique by region are silvopasture (the cultivation of trees and pasture), intercropping and use of biogas in Latin America, Africa and Asia, respectively (Spore Magazine, 2019)

Weather and climate is also being employed across Africa to provide farmers with index-based insurance. The Dutch Environmental Analysis and Remote Sensing organization uses data gathered from meterological satellites to develop 'index thresholds' for specific climate factors.in Uganda for example, when evapotranspiration – a reliable indicator of plant growth – fall below the calculated threshold farmers in the insured area are automatically compensated without having to file a claim.

Boosting rural resilience with climate risk management.

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. To foster greater climate resilence among farming communities, in 2016 the CGIAR Research program on climate change, Agriculture and food security (CCAFS) launched the 4 year Rwanda climate services for Agriculture (RCSA) programme. Supported by USAID, RCSA aims to improve the supply, communication and use of climate-related services across Rwnada.

RCSA is building on an existing initiaitve through which Rwanda's National Meteorological Agency combines data from local, ground- based weather stations from across the country, with rainfall and temperature statellite data. The satalites data, which extends 30-50 years into the past, also provides a historical source of information that aloows stakeholders to better understand long-term climate trends. This information is then compiled into 'Maproom' -a freely accessible database of climate data. Providing information on trends in termperature and rainfall across time and at national, regional and district scales.

To improve the dissemination of climate information, and enhance farmers' ability to utilize the data themselves, RCSA has adopted the participatory integrated climate services for Agriculture (PICSA) approach that focuses on supporting small scale farmers in their planning and decision- making. PICSA begins with an initial workshop, where farmers evaluate their current farming strategies with reference to the risk identified using maproom data. Trainers and extension staff use a seasonal forecast to update the risk identified during the first evaluation, and guide farmers to decide on any adjustment for the coming season.

Farmers participation in PICSA helps identify and support differing needs across Rwnada divers agro-ecology. But the approach has also proven effective at scale, with an estimated 75,000 farmers across the country having received in PICSA, as of April 2018. The project has also developed a network of trained farmers who are able to pass on their knowledge in the use of climate information to other farmers within their community.

Automated Irrigation

A prototype irrigation system that prevent the over watering of crops has been developed in kenya. The automated irrigation Manager system, created by scientist as Jomo Kenyatta University of Agriculture and Technology (JKUAT), can decrease a farms water usage by more than 25%. The technology uses 6cm sensors to read soil water levels and can be calibrated to adjust the water supply according to the moisture requirement of different crops. Pumps linked to the sensors feed water into the ground when moisture level drop below that needed by the plant. According to Wycliffe Obwoge, a JKUAT agronomist, the method also allows for the precise and economic applications, and boost crop yields by more than 50%.

Conclusion and Recommendations

Conclusion

The effects of climate change on Agriculture are drought, increased outbreak of crop, livestock and fish diseases, insect infection and damage to crops, shortage of pasture ,

Other effects are increase in cost of production and household spendings, reduction of farm and none farm income, loss of harvest , increases in crime , increased insecurity.

Adaptation and mitigation strategies, such as sustainable agriculture practices, climate-smart aquaculture, and ecosystem-based management, can help mitigate the effects of climate change and ensure food security .

.Climate cha nge resilience and climate smart practices can greatly help in mitigating the effects of climate change

Recommendations

Farmers should be willing to adopt digital and climate smart mitigation technologies to reduce vthe effects of climate change on agriculture.

Government should provide farmers with needed facilities such as irrigation facilities to help reduce the effect of drought.

And also, should provide agricultural input to farmers with a view to providing solutions to the incidence of pests and diseases resulting from climate change

Advice farmers on appropriate strategies to cope with climate change., such as climate resilient strategies and also provide farmers with ICT devices to promote climate smart practices

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