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The Impact of Climate Change on Plant Productivity, Biodiversity and Ecosystem

Wendu Kebede Gemeda*

Ethiopian Forestry Development, Addis Ababa, Ethiopia

Abstract

Climate change is a pervasive and growing global threat to biodiversity and ecosystems .Climate change impacts are extremely effect on plant productivity by reducing water use efficiency, increase salinity, high temperature stress and disturbing the soil health. Climate change also affects biodiversity by changing the behavior, morphology, and phenological by reducing species abundance, distribution and biodiversity loss. Climate change impact on human wellbeing is measured by the ecosystem services alteration caused by climate-related biodiversity change. The Ecosystem services have vital play an important role in the balance of the natural ecosystem and social-economic development, are suffering from degradation caused by human activities and climate change. Ecosystems provide many services that are of significant economic benefit and play a crucial role in providing goods and ecosystem services. The threat of varying global climate not only impact on environment it also impact on food security.

Keywords: Biodiversity; Climate change; Ecosystem; Plant productivity

Introduction

Global agriculture is relying on a relatively small number of crop species, which have been bred to optimize productivity within a relatively narrow range of environmental variations [1]. Moreover, current food security has been achieved through large industrial agriculture, in which large farms often grow the same crops annually, using over amounts of pesticides and fertilizers that finally deplete soils, pollute water, cause nutrient loss, decrease biodiversity, and contribute to climate change. On top of the doubt regarding the future environmental impact of agriculture comes the looming threat to yield sustainability caused by climate change-induced variations in weather patterns. Predictions advise that on a global scale, an increase in land use of ~100 Mha with a tripling of international trade is required by 2050 to meet the future crop needs of 9.8 billion people, without causing any significant change in present cropped land area. Extreme weather events cause massive damage to crop production.

Living and non-living organisms, their ecosystems and climatic situations can be considered as dependent components of the world and their balance is essential for the existence of the world. Climate change is a persistent and growing global threat to biodiversity and ecosystems. Climate change affects specific species and the way they interact with other organisms and their habitats, which alters the structure and function of ecosystems and the goods and services that natural systems offer to society. As a primary anthropogenic activity, land-use changes could influence the ecosystem process through altering the physical properties of the land surface, such as the albedo, roughness, and evapotranspiration. Human societies could obtain well-being by improving the provision of ecosystem services, regulating the ecosystem services and the cultural ecosystem services, including food, freshwater provision, carbon sequestration, and landscape aesthetics that are wanted for human life.

Impact of climate change on biodiversity the organisms cope with changes in their environment is by altering their behavior or morphology. Behavioral replies to climate change can result from variations in temperature and manifest before changes at the population and species level, such as distribution changes or population declines. Differential alterations in phenology among interacting organisms could drive population declines through reduced reproductive success and/ or increased predation or competition. Climate change is driving large-scale shifts in species distribution, abundance, and reorganization of terrestrial and aquatic ecosystems Geographic range shifts are widespread across taxa and ecosystems.

Methodology

Objective

The objective of this paper is to review the impact of climate change on plant productivity, biodiversity and ecosystem.

All of the information has been collected from the secondary sources of data. All the data here in were compiled from documents (such as, published articles, and dissertations) including Google Scholars. The literature covers mostly the time between 2015 up to 2021, while a few review documents have been carefully selected from the preceding period to lay a foundation for the review.

Impact of climate change on plant productivity

Water use scarcity and drought

Water deficits pose a serious threat to crop productivity and food security in many parts of the world due to poor or erratic rainfall and depletion of groundwater reserves. Improvements in crop productivity under conditions of limited water availability are vital to meet global food demand. Climate change is predicted to increase the frequencies of droughts and floods, both of which will be problematic for food production. Water scarcity and drought are one of the enormous effects on plant growth and plant productivity.

***Corresponding author:** WenduKebede Gemeda, Ethiopian Forestry Development, Addis Ababa, Etiopia E-mail: Wendu33GK@gmail.com

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Salinity stress

Salinity stress is an important yield-limiting factor that poses a significant threat to agriculture worldwide. Salinity is considered as one of the leading limiting factors responsible for growth and production decline of agricultural crops throughout the world principally in arid and semiarid regions [3,4]. Furthermore, it is strongly evident that higher concentration of salts' ions in soil negatively effects on plant growth and productivity the uptake of other necessary ions which plants require for several metabolic and enzymatic activities.

High temperature stress

Climate change-led rises in local and global temperatures pose a significant threat to plant growth and crop production. Heat stress can damage all stages of plant growth from germination to reproduction, limiting the productivity of major staple food crops. The plant reproductive organs and processes leading to seed set are very vulnerable to increasing temperatures. The current information and understanding of the molecular mechanisms that contribute to this temperature sensitivity are ably discussed by, who summarize them regulation of male and female reproductive organ development and fertilization, together with heat-induced abnormalities at flowering.

Impact of climate change on biodiversity

Behavior and morphology change

One way that organisms cope with changes in their environment is by changing their behavior or morphology. Behavioral responses to climate alteration can result from changes in temperature and manifest before changes at the population and species level, such as distribution changes or population decrease. Behavioral responses include seeking shade or refuge, altering feeding times, changing site use, and shifting circadian or circannual rhythms (e.g., hibernation, migration. Morphological changes commonly entail changes in body size, For example, increasing summer temperatures have been associated with reduced body size and increased wing length in North American migratory birds. The relative impact of climate change versus other stressors fluctuates depending on the species or ecosystem. Diverse biological communities and functioning ecosystems are critical to maintaining the ecosystem services that support human well-being.

Phenological change

Phenology, or the seasonal timing of frequently biological events, is a critical part of ecological relationships, and a primary indicator of species responses to climate change. Although changes in phenology are well familiar, trends are far from homogenous, a result of high variability in climate drivers and phenological responses across habitat kinds. Phenological shifts in marine and aquatic habitats are less well known in comparison to terrestrial systems, largely due to difficulty detecting and tracking aquatic organisms. Nonetheless, there have been perfect directional shifts in the timing of seasonal aquatic and marine abiotic drivers, including earlier transitions from winter to spring temperatures and previous ice melting and runoff increase. Marine phytoplankton can respond rapidly to such abiotic changes, resulting in change of timing of phytoplankton blooms, which in turn can make a mismatch with secondary consumers and alteration the food web structure. Differential shifts in phenology among interrelating organisms could drive population declines through reduced reproductive success and/or increased predation or competition.

Geographic range shifts

Climate change is driving widespread shifts in species distribution, abundance, and reform of terrestrial and aquatic ecosystems Geographic range shifts are broad across taxa and ecosystems. Northern Hemisphere birds, for example, are decreasing in abundance along species' southern and minor elevational range edges. Marine organisms have also demonstrated range shifts, in some cases at more quickly rates than in terrestrial systems and at pace with climate velocities. Arctic marine environments are experiencing fluctuations to sea ice cover, increasing temperatures, and ocean acidification, resulting in range shifts for marine fish, arthropods, and marine mammals.

Biodiversity loss

Globally, biodiversity is being gone and increasingly threatened through a range of anthropogenic actions. The Convention of Biological Diversity defines biodiversity loss" as "the long-term or permanent qualitative or quantitative reduction in components of biodiversity and their potential to provide goods and services, to be measured and managed at global, regional and national levels. The most important famous drivers behind the current loss of biodiversity are habitat modification, overexploitation, climate change, invasive alien species, and chains of extinction, known collectively as the evil five biodiversity threats;. Even if it is difficult to disentangle the effects of climate change from other anthropogenic stressors for a range of species, consequently, forecasts may provide insights into the multiple components of climate change and their relative distribution fears to global biodiversity. The current threat from habitat destruction, land use change or fragmentation, and gradually population growth interacts with climate change in a nonlinear way so that the negative impacts are higher than expected on biodiversity.

Impact of climate change on Ecosystems

The impact of climate change on ecosystem-level changes in response to climate change are due to direct impacts from changing climate drivers and interacting effects of species- and population-level responses. It focus on several key ecosystem-level characteristics and properties affected by climate change: primary production; species interactions and emergent properties, including biological invasions; and the impact of extreme events on ecosystem resilience. Due to prolonged droughts and flash floods brought about by extreme rainfall events with the changes of monsoon pattern, sea level rise and increasing temperatures affect essentially ecosystem services.

Primary productivity

Almost all life on Earth depends on primary producers, photosynthetic organisms that are the foundation of most food webs and are responsible for producing Earth's oxygen and regulating important components of carbon cycling and sequestration. Climate change has had erratic effects on primary production across spatial and temporal scales. Globally, terrestrial primary production increased during the late 20th and early 21st centuries due to the fertilizing effect of increasing atmospheric CO2, nutrient additions from human activities, longer developing seasonal time, and forest regrowth. Warming and increased atmospheric CO2 may also affect belowground biogeochemical processes, such as carbon and nitrogen cycling, which can affect terrestrial production. However, even in energy-limited forests, drought and extreme temperatures could limit of increase growth.

In marine and aquatic systems, phytoplankton is accountable for nearly all primary production and generates almost half of the total global primary production. Phytoplankton growth rates affect CO2 uptake from seawater and organic carbon export to the deep ocean,

and also impact fisheries productivity. In contrast, gradually reduced ice cover at higher latitudes raises sunlight availability to the ocean surface, increasing phytoplankton growing seasons and annual primary production. Understanding how these changes effect of the food web is crucial for maintaining sustainable fisheries [5].

Species interactions, emergent properties, and biological invasions

Variability in species' exposure and responses to climate change are primary drivers of changed species interactions. Emergent properties of ecosystems, including community features such as food-web structure and function that are mediated by species interaction, are altering as species shift their distributions and phenologies in response to climate impacts. Many non-native invasive species are opportunistic generalists that can take advantage of changing situations, colonize disturbed areas, and out-compete species, there by changing community composition, dominance, production, and increasing extinction danger in some cases.

Moreover, many non-native invasive plants species respond more positively than native plants to concentration CO2, nitrogen deposition, and temperature, likely increasing their competitiveness under extremely climate change. Stronger competitive capabilities will likely lead to higher non-native invasive plant abundance and declines of native species abundances and community diversity. Penetration of non-native species into natural communities has already negatively impacted biodiversity [6, 7].

Extreme events and ecosystem resilience

Climate change has changed the duration, magnitude, and frequency of extreme events, including droughts, forest fires, and heatwaves. Many of these actions have significant impacts on ecosystems and interact with other climate-driven alterations, reducing ecological resilience [8].

More extreme droughts and wildfires, driven by rising temperatures and altered precipitation patterns, affect ecosystem structure and function, particularly in forested ecosystems. Drought weakens tree defenses, increasing susceptibility to other disturbances, including insects, pathogens, invasive species, While drought impacts have direct long-term consequences, drought facilitated disturbances can result in more instant changes to forest ecosystem structure and function. Increased storm intensity can affect ecosystems and human communities through extreme flooding, erosive waves, and higher storm surge, making recovery from extreme events more challenging. Rising ocean temperatures have also led to periods of extraordinarily warm conditions across the globe, known as marine heatwaves. Increasing ocean temperatures are driving widespread coral bleaching, contributing to coral cover loss, impacting fish communities, and increasing exposure of nearby shores to waves [9].

Ecosystem services

Diverse biological communities and functioning ecosystems are critical to maintaining ecosystem services that support human well-being. Therefore, climate change impacts to species, populations, and ecosystems affect the accessibility and delivery of ecosystem services, including changes to provisioning, regulating, supporting, and cultural services.

Provisioning services

Climate-induced changes in provisioning services, the material goods that people obtain from ecosystems and biodiversity can have deep effects on human economies and well-being. Surface water scarcities are likely in dry years in some locations. Increasing stream temperatures also affect water quality. These fluctuations will stress water supplies, potentially increasing water treatment costs. Alterations in water supply, along with other climate change impacts, can change agricultural production. Droughts and other extreme events can minimize crop yield and quality, with production declines projected for several important crop species as temperatures increase. In freshwater systems, increasing stream temperatures will negatively affect some harvested species. Water, food, wood and other goods are some of the material benefits people get from ecosystems called ´provisioning services [10].

Regulating services

Biodiversity and ecosystems provide important regulation services, such as sequestering carbon, moderating the effects of extreme events maintaining soil and air quality, and controlling disease spread. Coastal wetlands are highly productive ecosystems that store carbon. Climate change is affecting the ability of ecosystems to provide this service as species ranges abundances, and habitat conditions shift. For example, Aedes mosquitoes, which transmit diseases such as dengue, are expanding their geographic distribution increasing disease risk. Maintaining the quality of air and soil, providing flood and disease control, or pollinating crops are some of the 'regulating services' delivered by ecosystems. They are often unseen and therefore mostly taken for granted. When they are injured, the resulting losses can be substantial and difficult to restore.

Supporting services

The combination of higher nutrient loading and increasing temperatures is increasing the frequency, duration, and extent of cyanobacteria responsible for damaging algal blooms, which can negatively impact human and animal health. Providing living spaces for plants or animals and sustaining a diversity of plants and animals, are 'supporting services' and the basis of all ecosystems and their services. Ecosystems provide living spaces for plants and animals; they also keep a diversity of complex processes that support the other ecosystem services. Some habitats have an exceptionally high number of species which makes them further genetically variation than others these are known as 'biodiversity hotspots.

Cultural services

Cultural services are the non-material benefits that people obtain from biodiversity and ecosystems, such as cultural identity, recreation, and mental and physical health. Despite their importance to human wellbeing, cultural services have been under deliberate compared to other ecosystem services. There is growing evidence that human health benefits from exposure to natural ecosystems; conversely, climate-driven extremes such as increased temperatures and storms can decline mental and physical human health. The non-material benefits people gain from ecosystems are called 'cultural services'. They include aesthetic inspiration, cultural identity, sense of home, and spiritual experience related to the entire natural environment. Typically, opportunities for tourism and for recreation are also regarding within the group. Cultural services are intensely interconnected with each other and often connected to provisioning and regulating services.

Conclusion and Recommendations

This review is more focus on the effect of climate change on plant productivity, biodiversity and ecosystem. Climate change is a pervasive

and growing risk to biodiversity, ecosystems, and ecosystem services. Climate changes are shocking the world by hampering agriculture and its products. Poisonous gases and Industrialization cause global warming, which ultimately disturbs the world's environment. Climate change has destructive effects on plant growth and yield. Abiotic stresses are the major type of stresses that plants decline growth. Climate change impacts the extremely effect on individuals, populations, and species through changes in behavior and morphology, phenology, and range shifts, and at the ecosystem level through changes in species interactions, primary production and emergent properties, and extreme events. Ecosystems and biodiversity underpin important services to people, thus these changes impact provisioning, regulating, supporting, and cultural services, with implications for human wellbeing. The effect of climate change on biodiversity are made up continuously, often predicting fast paced extinction of species, loss of natural habitats, and moves in the distribution and abundance of species. Pressures on biodiversity can push ecosystems beyond what might be termed "safe functioning space.

It could be recommended that the researcher in all worlds should be working on how they could mitigate and adapted the climate change in biodiversity, ecosystem and agriculture. Climate change are extensive impact on plant productivity, biodiversity and ecosystem. Analyze the effects of climate change, in particular in centers of origin and diversification of genetic resources of relevance to food and agriculture, to inform national conservation strategies. Promote the collection and ex situ conservation of genetic resources for food and agriculture most threatened by climate change, and most potentially useful in adaptation. Thus, the researchers should carrying out their research on development varieties of crop plants which can successfully grow under conditions of drought stress, water scarcity, heat stress and higher levels of water and soil salinity, as well as being inherently resilient to certain diseases and pests.

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