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Impacts of Climate Change on the Forest Ecosystems in Ethiopia

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Abstract: Climate change is one of the world's greatest challenges and creates new constraints for forest ecosystem. Geographic distribution of host trees and their associated insects and pathogens are already affected by climate changes with anticipated increases in pest impacts both by native and invasive pests. Forests and trees throughout the world are increasingly affected by factors related to global climate change. Climate greatly shapes forest's species composition, structure, productivity, disturbance regimes, water yield, nutrient retention, wildlife habitat and availability of goods and services. Climate change also influences the timing, frequency, and magnitude of disturbances on forest ecosystem which in turn may worsen many of the threats to forests, such as pest outbreaks, fires, human development, and drought. Forest insects are the group of the greatest importance, including species detrimental to forest health. The effects of climate change on forest insects may be reflected in their distribution, phenology and number of generations and indirectly through impact on their natural enemies. Climate changes have direct and indirect effect on the expansion and productivity of forests through changes in temperature, rainfall, weather and alternative interrelated factors. Moreover, elevated levels of carbon dioxide have an impression on plant growth. The increasing temperature and drought have negative impacts on forest species diversity also as ecosystem goods and services to humanity. As atmospheric carbon dioxide increases over the next century, it is expected to become the first or second greatest driver of global biodiversity loss in which many diversity exist in forest ecosystem will be lost. The paper summarizes the impacts of climate change on forest ecosystems and reviewed scientifically by reading different credible books, articles and journals, comprehensive scientific explanations regarding impacts of climate change on forest ecosystem and each resource is well offered in the reference section.

Keywords: Climate Impacts, Forest Insects, Forest Management, Global Warming, Phenology

1. Introduction

Climate change is one in all the world's greatest challenges. Despite variety of uncertainties, scientific evidence has led to a general consent that climate change is happening and is profoundly influenced by human activity. There is no doubt that, climate changes can intrinsically affect forest ecosystems and the impacts may be both positive and negative: some areas and some species are increases in growth, while others experiences reduced growth and increased mortality [1]. Severe global climate change causes deforestation, which may result to desertification, while at the same time this deforestation is additionally a serious driver of climate change [19]. Recent changes in global and regional climate are now well documented and generally show an increment in average annual temperature, more extreme hot days, and more episodic and intense precipitation events [14].

Climate change could alter the frequency and intensity of forest disturbances such as insect outbreaks, invasive species, wildfires, storms and these disturbances can reduce forest productivity which in turns change the distribution of tree species or shift their range or die out [3]. The currently ongoing decline in biodiversity threatens the ability of forest ecosystems adapt to changing climate and because of this; species may no longer be adjusted to the set of environmental conditions in a given region [2]. The majority of studies on climate change impacts on forest ecosystem have focused on direct effects of climate change that is effects of changes in temperature and precipitation on biodiversity [11]. The

ongoing climate change is mainly expected to have a significant impact on world's biomes, with forest ecosystems especially vulnerable to these changes. The effect of climate change on forests is indirect through its impact on different tree species of diverse ecological requirements and direct through its impact on all living components of the forest ecosystems. Although increasing forest vulnerability with sustained global warming (Rising in global temperature associated with increasing evaporative demand, frequency, intensity, and duration of droughts in many semi-arid regions) is generally supported, particularly in water limited areas, there are few direct sources of information to quantify the magnitude of climate change impacts [10].

2. Literature Review

2.1. Impacts of Climate Change on the Forest Productivity and Health

Climate change is already affecting the geographic distribution of forest ecosystems (host trees) as well as their associated insects and pathogens by disrupting evolved life history traits and causing phonological mismatches with anticipated increases of both native and invasive pest impacts [7]. Although native forests are adapted to some level of disturbance, all forests today face the main stress in the form of climate change, air pollution and invasive pests along with deforestation and increasing demand for forest resources [5]. Climate change can exacerbate invasions of forest pests as well as impacts of native pests and many of these invasions have caused substantial forest damage, economic impacts and losses of ecosystem goods and services provided by trees [17]. Widespread, catastrophic impacts on productivity and tree survival resulting from periodic outbreaks of insects and pathogens may reduce the amount of absorbed photosynthetic active radiation, the carbon uptake, the stored carbohydrates and nitrogen remobilization, thus reducing overall productivity and stem growth [18]. Disturbances may also indirectly influence forest productivity by changing forest structure and composition and directly by killing trees and or through more subtle effects of disturbances on productivity [15].

2.2. Forest Disturbance Due to Impacts of Climate Change

Forest disturbances are sensitive to climate changes and natural disturbances, such as fires, insect outbreaks and wind throws, which are an integral part of ecosystem dynamics in forests around the globe. These change mediated increase in disturbances which could exceed the ecological resilience of forests, resulting in long-lasting altered ecosystems or shifts to non-forest ecosystems as tipping points are crossed [16]. Disturbances disrupt the structure, arrangement and function of an ecosystem, community or population and alter resource accessibility or physical environment. In doing so, they form heterogeneity on the landscape, foster diversity across a wide variety of guilds and species and initiate ecosystem regeneration or reorganization. Disturbance regimes have altered profoundly in numerous forest ecosystems in the recent years, with climate being a protruding driver of disturbance change. An increase in disturbance occurrence and severity has been documented over large parts of the world, for instance, for fire, insect outbreaks, and drought. Such changes of disturbance regimes have the potential to strongly impact the ability of forests to deliver ecosystem services to society. Climate change prompted shifts in plant species distributions are altering the features of biomes (ecosystems with the same dominant plant life forms), changing structure and ecosystem functioning [6].

2.3. Effects of Climate Change on Forest Regeneration

Climate changes such as high range of temperature shift and high variation in water availability (which causes threshold shifts in species regeneration niches) can limit the regeneration capacity of tree species. This is because tree seedlings are very susceptible to climate change; for instance, Eucalyptus forest of Australia was shown that, tree species regeneration affected at both the landscape level and site level in future decades by raising temperature in the range of 1.0–4.5°C and reducing precipitation by 3 to 25% [19]. Average annual rainfall (abiotic), as well as ecosystem complexity, density, species richness, and diversity (over story), were found to be the most influential factors for the density and diversity of natural regeneration and thus a reduction in precipitation, especially drought, can limit the regeneration potential and composition of plants because almost all species are very susceptible to environmental factors at the seedling stages [8].

2.4. Impacts of Climate Change on Forest Growth, Mortality and Wildfire

Globally, Climate changes have large impacts on forest ecosystem. Today the magnitude of climate change impacts are increased and expanded into persistent infestations in habitats that previously had rarely been affected (previously unexposed habitats) with new (i.e. native) species associations [13]. The tree and forest growth rate is significantly correlated with climate and Climate change impacts on environment brings a reduction in the distribution and abundance of forest species, especially endemics, which may even result in their global extinction [12]. Climate change might causes modifications of frequent and intensified forest wildfires, insects' outbreaks, pathogens and extreme events such as high winds, which are more important than the direct impact of higher temperatures and elevated carbon dioxide in the forestry [9].

Recent regional increases in tree mortality rates and incidents of forest die-back have been linked to increasing temperatures, indicating that a potentially significant source of biotic feedbacks to global climatic changes may already be happening. Increases in trees mortality with temperature might be accredited to two broad and non-mutually exclusive mechanisms: (I) increasing drought stress on trees resulting from temperature-induced increases in climatic water deficit

(here after "deficit": an index of evaporative demand that is not met by available water, hence drought stress) or (ii) temperature-induced increases in the reproduction, survivorship, and effectiveness of insects and pathogens that kill trees [4]. Climate change is a leading cause of forest degradation through fire suppression, land use change, and species invasions which in turn contributing to changes in forest productivity in some regions [6].

3. Conclusion

Recent scientific evidence has led to a general consensus that climate change is occurring and is profoundly influenced by human activities. Globally, climate change is already affecting the geographical distribution of host trees and this increasingly impacts forest ecosystems through the world both positively and negatively. Expanding international trade has facilitated invasions of numerous insects and pathogens into new regions with anticipated increases in pest impacts on forest ecosystem by both native and invasive pests. The threats posed to forest ecosystems by invasive pests and climate changes are serious but, climate change can ultimately facilitate the range expansion of both native and exotic pests (insects and pathogens) which affect tree resistance to pests due to wide spread phenomenon. Climate change affect forests and their functioning, such as forest productivity and health, forest growth, forest regeneration and it also causes forest disturbance such as fires, insect outbreaks and wind throws which could exceed the ecological resilience of forests, resulting in long lasting altered forest ecosystems.

4. Recommendation

The evidence presented from this review shows that climate change is having considerable and widespread impacts on forest ecosystem health worldwide and as a result on the forest sector. Wide spread calls exist to ensure the persistence of many species and related forest ecosystem. Nevertheless, majority of recommendations in the published journal literature lack adequate specificity to direct this action. Most of the Literatures discussed only the impacts of climate change on forest and related ecosystem rather than discussing the solution for it. Fair amount of information is already available concerning the impacts (constraint) of climate change on the world's forest species and ecosystems, but much more is needed. Further studies on management strategies of forest ecosystem's pests, diseases and invasive species need to be developed for the future to assist forest managers and policy-makers. There is also a need for alternative practices to reduce subsequent vulnerability of forests ecosystem to climate change impacts, such as planting genetically tolerant trees identified through breeding programs, environmental impact assessment, reducing pollution from different sources, sustainable utilization of human and non-human resources and giving public awareness.

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