A Review on Climate Change and Biodiversity: Impacts, Adaptations and mitigation strategies

**Abstract:**

Biodiversity has a very important role to play in climate change mitigation and adaptation. The good management of ecosystems such as wetlands and forests, remains an effective mitigation option given the high sequestration potential of natural systems. The permanence of carbon sinks is also tied to the maintenance or enhancement of the resilience of ecosystems. Major alterations in global weather patterns, increasing sea levels, and a rise in the frequency of extreme weather occurrences are all results of climate change brought on by human activity. This review synthesizes the latest scientific literature concerning the impact of climate change on global biodiversity, while also identifying and analyzing various adaptation and mitigation approaches that have been proposed or implemented. Global action must be swift and well-coordinated since these changes pose a threat to ecosystems, biodiversity, and human health. A shift in weather patterns over time that defines different parts of the world is known as global climate change. There is unanimous agreement among scientists that the globe is warming. The farming industry is especially fragile because of weather fluctuations that cannot be reversed. Consequently, it is upending global purchasing trends, particularly in nations where agriculture plays a major role in their output and economics. Increased flooding, dissolving glaciers and ice, and altered weather patterns are just a few of the effects of global warming that are already evident in many locations. Well-being of humans, availability of freshwater, and biodiversity are all being affected by climate change.

**Keywords**: climate change, flooding, weather pattern, biodiversity, global warming.

**Introduction:**

“Climate change is a long-lasting change in the weather arrays across tropics to polls. It is a global threat that has embarked on to put stress on various sectors” (Abbass et al., 2022; Ulises et al., 2023). “As climate change threatens the environment, ecosystem services – such as food and shelter, protecting communities from drought and floods, basis of traditional knowledge and innovations – will become even more important and valued. This report provides eight key messages by world-renowned experts in the fields of biodiversity and climate change to help us better understand how biodiversity and climate change interact and how we can best work together to achieve our common goals” (Griscom et al., 2017; Smith et al., 2024). “Climate change refers to long-term alterations in temperature, precipitation patterns, and other atmospheric conditions on Earth” (Dore, 2005). “Climate change has also put the integrity and survival of many species at stake due to shifts in optimum temperature ranges, thereby accelerating biodiversity loss by progressively changing the ecosystem structures. Climate variations increase the likelihood of particular food and waterborne and vector-borne diseases, and a recent example is a coronavirus pandemic. Climate change also accelerates the enigma of antimicrobial resistance, another threat to human health due to the increasing incidence of resistant pathogenic infections. Besides, the global tourism industry is devastated as climate change impacts unfavorable tourism spots” (Abbass et al., 2022). Primarily driven by human activities, such as the burning of fossil fuels, deforestation (Gorte & Sheikh, 2010), and industrial processes, climate change has led to a significant increase in greenhouse gas concentrations in the atmosphere.This results in global warming, which is characterized by rising average temperatures and an increase in the frequency and intensity of extreme weather events (Seneviratne et al., 2021). Climate change is a pressing global challenge with far-reaching implications for the environment, human health (Young et al.,2006), and socio-economic stability (McMichael, 2011). It leads to rising temperatures, extreme weather events, and shifting ecosystems, jeopardizing biodiversity and threatening the survival of numerous species. Additionally, climate change exacerbates existing inequalities by disproportionately impacting vulnerable communities, affecting food security, water resources, and public health. Economically, it incurs significant costs related to disaster management, infrastructure damage, and shifts in agricultural productivity. Ultimately, addressing climate change is crucial for ensuring a sustainable future, protecting natural resources, and promoting global security. Current and forecasted global climate variations. Global warming is important in the twenty-first century. changes at a worldwide level that have been experienced in recent times 65 years have passed. The United Nations Intergovernmental Panel on Climate Change (IPCC 2014) Fifth Assessment Report forecasts that continued emissions will contribute to more heating and changes in the climate system's components of environmental issues and the emissions of greenhouse gases. In consequence, a more challenging cycle of water with significant shifts in temperature, and transpiration, which contribute and moisture will occur (Middelkoop et al., 2001). Approximately 19 percent of the surface of the earth is comprised of tropical land zones, which represent an important proportion of the world's entire surface area (Peel et al., 2007). These regions, which are mostly affected by radiation from the sun, are roughly located between the Tropics of Leo and Capri. More than every other part of the tropics is impacted by sunlight in terms of the cycle of water (Latrubesse et al., 2005). A great deal of shifts in precipitation and evaporation is caused by behavior (Gu et al., 2007). The impact of global warming varies from place to place because of its degree or makeup. It is expected that some regions might experience an absence of drinking water, and others are going to experience greater amounts of inundation. Droughts and flooding happening more often as a result generate large-scale financial losses, such as decreased yields of crops (Abbaspour et al., 2009) and significant damage to infrastructure (Dang et al., 2016). The development and planning of forthcoming water-related laws and equipment so require forecasting what is anticipated in the flow of rivers under warming circumstances (Middelkoop et al., 2001). The fourth interim report released by the IPCC (IPCC 2007) says unequivocally that global warming is going to have an effect on every water cycle variable, especially temperatures, streamflow, flooding, drought, and both the quantity and the intensity of precipitation. A 100-decade global trend chart (1906–2005) shows a 0.74 °C rise in the global average temperature, according to (Huang et al., 2013). Higher evaporation, increased moisture in the air, and variations in rainfall are the consequences of this warming (Huang et al., 2013). A lot of research is looking at whether climate change could impact the upcoming stream flow of various rivers in different parts of the globe (lKara and Yucel 2015), for the greatest part of these investigations, Models of hydrology and climate were both used. The models of hydrology typically need to be calibrated first. using information regarding flow of streams that have been collected (Butts et.al., 2004). subsequently, the representations are used to create and simulate prospective climate data predicted flow of the river (Nijssen et al., 1997). At the end of what was anticipated and the data on streamflow observed in the past are compared and analyzed to estimate and evaluate the impact of warming temperatures fluctuation in the release of rivers. Biodiversity, the rich tapestry of life on our planet, is of paramount importance for the continued functioning and resilience of ecosystems (Berkes et al., 1994). At the heart of this significance lies the profound role biodiversity plays in maintaining essential ecosystem functions and the provision of vital services that support human well-being.

At the most fundamental level, biodiversity underpins the basic ecological processes that sustain life on Earth. The diverse interactions between species, from producers to consumers and decomposers, are the driving force behind crucial functions such as nutrient cycling (Hättenschwiler et al., 2005), soil formation, primary productivity, and water purification. This intricate web of relationships ensures the proper functioning of ecosystems, as a more diverse community is better equipped to withstand and recover from disturbances (Palmer et al., 1997). Higher levels of biodiversity often correlate with increased ecosystem stability, allowing these natural systems to adapt and thrive in the face of change. Moreover, biodiversity provides a wide array of essential services that directly support human societies and economies (Haines-Young et al., 2010). These ecosystem services include the provision of food, fiber, and fuel; the regulation of water and climate; and the opportunities for recreation and cultural enrichment. Many species, particularly in areas of high biodiversity, also hold the potential to yield valuable goods and services, such as medicinal compounds and ecotourism revenue. The loss of biodiversity can disrupt the flow of these vital services, with far-reaching consequences for human well-being.

This review examines the literature on numerous sectorial pieces of evidence that affect the environment internationally to emphasize the socio-scientific aspects of the implications of climate change. Notwithstanding the fact that this review offers a comprehensive analysis of climate change and its severe effects on various industries that are extremely dangerous to the world's agriculture, biodiversity, health, economy, forestry, and tourism, it also aims to provide some workable preventative measures and mitigation strategies that can be adopted as viable alternatives to withstand the effects of climate change. There is much discussion on the societal ramifications of erratic weather patterns as well as other impacts of climate change. With a particular emphasis on its economic, social, and environmental elements, this research reviews a number of global sustainable mitigation strategies and adaptation tactics.

**Methods**

The collected literature on flow of streams and its measurement is accessible via the internet indexes and keywords like streamflow, stream discharge, velocity-area method, formed narrowing, constricted flow methods, current meters, timed volume method, float method, dilution gauging, trajectory method, weir method, flume method, water resource tracking, and sustainable water recognition and supervisors. The selection of articles was based on how well they addressed "Global Climate Change Impacts, adaptation, and sustainable mitigation measures" and how pertinent they were to the study's stated goals. We had 49 items to employ in our inquiry when the process was complete. A systematic review of all 49 is the next stage.   
Articles that investigate and deconstruct the study issues as well as additional elements like the settings, procedures, and theoretical frameworks that underlie the investigations. Furthermore, this study looks at linked subjects, creating new research opportunities. The study looked at research problems and potential future directions to comprehend the findings of studies on climate change and its effects on various businesses.

**Climate change and agriculture:**

Agriculture is a major industry that both significantly contributes to and is negatively impacted by climate change, as it is ultimately held responsible for 20% of all GHG emissions. Agribusiness output and other agro-environmental and climatic parameters are significantly impacted by precipitation extremes, such as floods, droughts, and forest fires (Chivangulula et al., 2023). Furthermore, the excessive dependence on limited resources, which leaves agriculture vulnerable to devastation globally, is what fuels the fire. Given that climate change is having a significant impact on food and water supplies (Zhang et al., 2024), the decline in agriculture poses a threat to farmers' standard of living and is thus a significant contributor to poverty (Hazell & Wood, 2008). Elevated temperatures will have significant detrimental effects on agricultural growth, rendering global food output very vulnerable to these patterns of temperature change. According to the IPCC (2022), during the past few millennia, airborne GHG concentrations have risen to previously unheard-of levels. N2O, CO2, and CH4 are examples of GHGs. Climate change is the result of a combination of two different factors: human activity and natural events (Seneviratne et al., 2012). Additionally, it has been projected that the average global temperature may increase by 1.1 to 3.7 degrees Celsius by the end of the twenty-first century. investigated the potential effects of climate change on agriculture, which has already occurred between 1960 and 2000, when there was a 0.25 ◦C increase in global temperature. This caused changes in precipitation patterns, and the effects on agriculture are calculated using cross-sectional and crop simulation data, temperature, precipitation, and CO2 response functions.

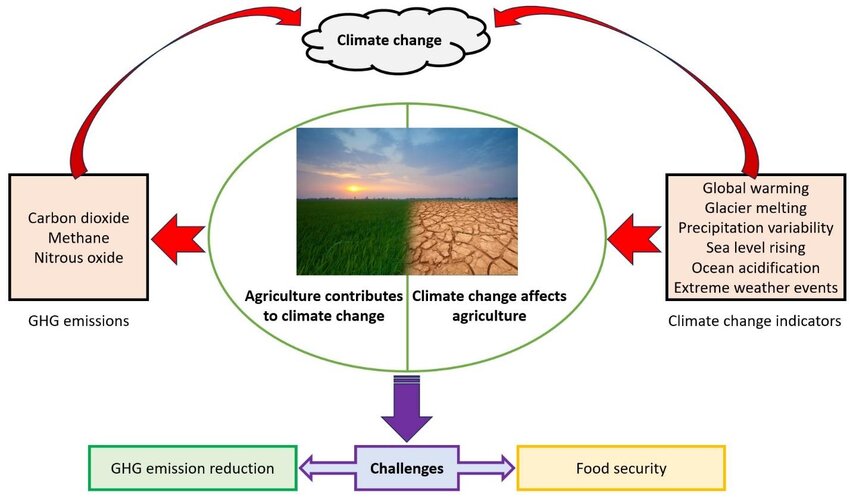


Fig:1 Linkage between climate change and agriculture

Source: Raihan, (2023)

**Mitigation:**

In addition to government action, consumer cooperation is necessary to mitigate global climate change. analysis of qualitative data revealed several structural, behavioural, and cognitive barriers to voluntary mitigation. Economic development and output are significantly impacted by the climate. Climate change is causing environmental authorities worldwide to become more concerned due to its effects on economic growth. Analysis indicates that different regions of the world might see an impact on the agriculture sector. The focus of research has switched to comprehending the potential effects of climate change on farming in other locations and creating plans to adjust to these modifications (Gleditsch, 2021). “In order to develop adaptation and mitigation strategies for the conservation of biodiversity during climate change it is necessary to 1) understand the impacts of climate change on biodiversity, 2) understand the problems associated with the implementation of policies promoting the conservation of biodiversity during climate change, and 3) highlight key areas for action, both to address gaps in our understanding of the potential impacts of climate change and to develop the necessary levels of communication between scientists and policy-makers. Mitigation policies attempt to limit further changes in global climate and either focus on reducing the emission of greenhouse gases through, for example, more efficient energy use or cleaner energy production, or on enhancing greenhouse gas sinks” (Brooker et al., 2007).

**Climate change effects on biodiversity**

The world's biodiversity is suffering greatly as a result of climate change, which is one of the main drivers of species extinction. Numerous climatic conditions have been demonstrated to have a substantial correlation with the dynamics of species on a global scale (Manes et al., 2021). The speed and intensity of climate change are causing changes in the ranges of freshwater, marine, and terrestrial creatures that may live in their respective habitats.   
The quantity and distribution of species, migration patterns, activity schedules, and the use of microhabitats are only a few of the many aspects of ecosystem health that are impacted by changes in average climate regimes (Allan et al., 2021). The range of a species is often determined by its tolerance of biological interactions, environmental stressors, and dispersion restrictions. This is extremely important since everyone is impacted by climate change. Climate change-induced species translocation has the potential to decrease net ecosystem productivity and carbon storage over time (Baldrian et al., 2023). Among the frequent disturbances that have been reported are impacts on marine and terrestrial production, the formation of marine communities, and the protracted invasion of toxic cyanobacteria bloom (Nwosu et al., 2023).

**Conclusions:**

"The majority of the warming observed over the last 50 years is attributable to human activities," according to the IPCC's Third Assessment Report, which was released in 2001. Thus, humans can somewhat, but not entirely, reduce the effects of climate change and GHG emissions.

Climate change has the potential to have a substantial impact on human health, with direct consequences like heat stress and flooding as well as indirect ones like altered disease transmission and malnutrition as a result of increased competition for water and crop resources. As the earth heats, it alters the epidemiology of infectious diseases, increases the prevalence of vector-borne illnesses, and affects mortality through poor health, especially in the summer months among the elderly.

It is mentioned how crucial it is for adaptation and mitigation to work together. Research to determine the ideal balance between adaptation and mitigation is likewise becoming more and more demanded. Focusing only on adaptation or mitigation is insufficient; the best durable effects come from combining the two.

Human and environmental resilience is impacted by climate variability in addition to other anthropogenic and natural stresses. Another scary possibility is a lack of food security, which might lead to inferior food products, higher costs, and inefficient supply networks. Storms, flash floods, droughts, and severe precipitation are just a few of the climatic conditions that pose a threat to forests around the world. Their extinction, on the contrary hand, is a boon to humanity. There is no doubt that the susceptibility scale of the world's areas varies, but proper mitigation and adaptation methods can help decision-makers design efficient policies to address its effects.

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**References:**

1. Dore, M. H. (2005). Climate change and changes in global precipitation patterns: *Environment international*, *31*(8), 1167-1181.
2. Gorte, R. W., & Sheikh, P. A. (2010). Deforestation and climate change.
3. Seneviratne, S. I., Zhang, X., Adnan, M., Badi, W., Dereczynski, C., Luca, A. D., ... & Allan, R. (2021). Weather and climate extreme events in a changing climate.
4. Young, O. R., Berkhout, F., Gallopin, G. C., Janssen, M. A., Ostrom, E., & Van der Leeuw, S. (2006). The globalization of socio-ecological systems: An agenda for scientific research. *Global environmental change*, *16*(3), 304-316.
5. McMichael, A. J. (2011). *Climate Change and Health: Policy Prorities and Perspectives* (pp. 15-pp). Chatham House.
6. Raihan, A. (2023). A review of the global climate change impacts, adaptation strategies, and mitigation options in the socio-economic and environmental sectors. *Journal of Environmental Science and Economics*, *2*(3), 36-58.
7. Middelkoop, H., Daamen, K., Gellens, D., Grabs, W., Kwadijk, J. C., Lang, H., ... & Wilke, K. (2001). Impact of climate change on hydrological regimes and water resources management in the Rhine basin. *Climatic change*, *49*, 105-128.
8. Peel, M. C., Finlayson, B. L., & McMahon, T. A. (2007). Updated world map of the Köppen-Geiger climate classification. *Hydrology and earth system sciences*, *11*(5), 1633-1644.
9. Latrubesse, E. M., Stevaux, J. C., & Sinha, R. (2005). Tropical rivers. *Geomorphology*, *70*(3-4), 187-206.
10. Gu, J., Goetschalckx, M., & McGinnis, L. F. (2007). Research on warehouse operation: A comprehensive review. *European journal of operational research*, *177*(1), 1-21.
11. Huang, P., Xie, S. P., Hu, K., Huang, G., & Huang, R. (2013). Patterns of the seasonal response of tropical rainfall to global warming. *Nature Geoscience*, *6*(5), 357-361.
12. Kara, F., & Yucel, I. (2015). Climate change effects on extreme flows of water supply area in Istanbul: utility of regional climate models and downscaling method. *Environmental Monitoring and Assessment*, *187*, 1-18.
13. Butts, M. B., Payne, J. T., Kristensen, M., & Madsen, H. (2004). An evaluation of the impact of model structure on hydrological modelling uncertainty for streamflow simulation. *Journal of hydrology*, *298*(1-4), 242-266.
14. Nijssen, B., Lettenmaier, D. P., Liang, X., Wetzel, S. W., & Wood, E. F. (1997). Streamflow simulation for continental‐scale river basins. *Water Resources Research*, *33*(4), 711-724.
15. Berkes, F., Folke, C., & Gadgil, M. (1994). Traditional ecological knowledge, biodiversity, resilience and sustainability. In *Biodiversity conservation: Problems and policies. Papers from the Biodiversity Programme Beijer International Institute of Ecological Economics Royal Swedish Academy of Sciences* (pp. 269-287). Dordrecht: Springer Netherlands.
16. Hättenschwiler, S., Tiunov, A. V., & Scheu, S. (2005). Biodiversity and litter decomposition in terrestrial ecosystems. *Annu. Rev. Ecol. Evol. Syst.*, *36*(1), 191-218.
17. Palmer, M. A., Ambrose, R. F., & Poff, N. L. (1997). Ecological theory and community restoration ecology. *Restoration ecology*, *5*(4), 291-300.
18. Haines-Young, R., & Potschin, M. (2010). The links between biodiversity, ecosystem services and human well-being. *Ecosystem Ecology: a new synthesis*, *1*, 110-139.
19. Chivangulula, F. M., Amraoui, M., & Pereira, M. G. (2023). The drought regime in southern africa: a systematic review. *Climate*, *11*(7), 147.
20. Zhang, L., Wang, S., Liu, L., Shad, N., & Summers, J. K. (2024). *Mitigating Global Climate Change: Enhancing Adaptation, Evaluation, and Restoration of Mountain Ecosystems*. BoD–Books on Demand.
21. Hazell, P., & Wood, S. (2008). Drivers of change in global agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*(1491), 495-515.
22. Seneviratne, S., Nicholls, N., Easterling, D., Goodess, C., Kanae, S., Kossin, J., ... & Zwiers, F. W. (2012). Changes in climate extremes and their impacts on the natural physical environment.
23. IPCC. (2022). Climate Change 2022: Mitigation of Climate Change, the Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, New York, USA.
24. Gleditsch, N. P. (2021). This time is different! Or is it? NeoMalthusians and environmental optimists in the age of climate change. Journal of Peace Research, 58(1), 177-185.
25. Manes, S., Costello, M. J., Beckett, H., Debnath, A., Devenish-Nelson, E., Grey, K. A., ... & Vale, M. M. (2021). Endemism increases species' climate change risk in areas of global biodiversity importance. Biological Conservation, 257, 109070.
26. Allan, J. D., Castillo, M. M., & Capps, K. A. (2021). Stream ecology: structure and function of running waters. Springer Nature.
27. Baldrian, P., López-Mondéjar, R., & Kohout, P. (2023). Forest microbiome and global change. Nature Reviews Microbiology, 21, 487-501.
28. Nwosu, E. C., Brauer, A., Monchamp, M. E., Pinkerneil, S., Bartholomäus, A., Theuerkauf, M., ... & Liebner, S. (2023). Early human impact on lake cyanobacteria revealed by a Holocene record of sedimentary ancient DNA. Communications Biology, 6(1), 72.
29. Smith, P., Arneth, A., Barnes, D. K., Ichii, K., Marquet, P. A., Popp, A., ... & Ngo, H. (2022). How do we best synergize climate mitigation actions to co‐benefit biodiversity?. Global Change Biology, 28(8), 2555-2577.
30. Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., ... & Fargione, J. (2017). Natural climate solutions. Proceedings of the National Academy of Sciences, 114(44), 11645-11650.
31. Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H., & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environmental science and pollution research, 29(28), 42539-42559.
32. Brooker, R., Young, J. C., & Watt, A. D. (2007). Climate change and biodiversity: impacts and policy development challenges–a European case study. The International Journal of Biodiversity Science and Management, 3(1), 12-30.
33. Ulises, Ramírez-Sánchez Hermes, Fajardo-Montiel Aida Lucia, García-Guadalupe Mario Enrique, and Ulloa-Godínez Héctor Hugo. 2023. “Climate Change and Its Impacts on Biodiversity in Mexico”. Asian Journal of Environment & Ecology 20 (4):29-54. https://doi.org/10.9734/ajee/2023/v20i4446.