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The Potential Role of Biodiversity Conservation in Climate Change Mitigation: A Review

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Abstract: This review paper aims to compile relevant information on the potential of biodiversity conservation in climate change mitigation. The global climate change is the result of the concentration of greenhouse gases: dominantly of carbon dioxide, methane and nitrous oxide emitted into the atmosphere. The root causes for these emissions are the natural phenomenon and human-induced activity in which high pressure poses on the environment from human-driven. Evidence from previous study indicates that biodiversity components are widely influenced under climate change and at the same time, the conservation of biodiversity potentially mitigates the effect of the global climate change. As a result, there is a beneficial and adverse effect type of co-existence of two ecological components (i.e. the living and non-living) in this interaction. Biodiversity has the potential to mitigate climate change as they reduce and stabilize atmospheric greenhouse gas concentrations. Thus, in such mitigation process, Forestry and Agricultural practices contribute a lion's share based on their potential to absorb and store carbon from the atmosphere, reduce deforestation and biodiversity degradation, and provide bio-energy products that substitute for fossil energy. Therefore, the global community should be needed to done in collaboration on biodiversity conservation to improve climate change mitigation potential of biological diversity.

Keywords: Biodiversity, Carbon Dioxide Emissions, Climate Change, Global Warming, Greenhouse Gas

1. Introduction

The world greenhouse gas (GHG) emissions have roughly doubled since the early 1970s and could rise by over 70% during 2008-2050. The critical increment observed and will be predicted is the result of power generation (26%), industry intensification (19%), transportation service (13%), and deforestation and forest degradation (17%) of total emissions [1]. However, natural processes and human-induced factors are the primary causes for the concentration of GHG, climate change, and biodiversity losses respectively [2, 3]. Therefore, climate change and biodiversity loss are predicted as the two major environmental challenges of the 21st century [4, 5]. Moreover, the relationship between biodiversity and climate change is both directions type of relationship because of their effect-benefit type of two interacting components [6]. Climate changes affect biodiversity, and at the same time, biodiversity plays a significant role in climate change mitigation in addition to other ecosystem services they provide [6-8]. For this interaction details, the Convention on Biological Diversity has adopted an Ad Hoc Technical Expert Group (AHTEG) on Biodiversity and Climate Change in 2001. The technical group clarifies three important points: 1) the possible negative impacts of climate change on biodiversity; 2) identify the role of biodiversity in climate change mitigation; and 3) identify opportunities for achieving climate change and biodiversity co-benefits [9].

The Conservation of biodiversity during rapid climate change is now a priority of biodiversity for climate change mitigation, in addition to other uses [7]. Therefore, climate change mitigation through carbon sequestration potential of biodiversity has been a high priority in the scientific, governmental, and civil society in the last few years [8]. In these mitigation processes, the forestry, agriculture, and agroforestry sectors play a crucial role as they have the potential to stabilize atmospheric CO_2 concentrations between 450-550 ppm at the end of the 21st century under proper management of biodiversity resources [3]. Nabuurs *et al*. report that forest management plays a critical role in climate change mitigation through emission reduction and carbon sequestration. He also reports that forest diversity and its mitigation potential were under the influence of climate change [10]. As per revised literature, little attention was given to the investigation of the potential of biodiversity component in climate change mitigation in separate from its adaptation potential. Therefore, it is mandatory to deal out the relationship between climate change and biodiversity, impacts of climate change on biodiversity, and the potential of biodiversity conservation in climate change mitigation.

2. The Global Climate Change

Climate change is a long-term change shift in the statistics of the weather as mean temperature and precipitation [11]. The atmospheric greenhouse gas (GHG) concentrations released from carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorine compounds such as sulfur hexafluoride (SF_6), hydrofluorocarbon (HFCs), and perfluorocarbon (PFCs) are the root causes for global climate change [12]. The global temperature projection predicts an increase in global average temperatures between 1.5°C and 6°C by the end of the present century. This increment is due to natural factors such as volcanic eruption, crustal movements, changes in rainfall patterns, sea levels, and rates of glacial retreat that aggressively accelerated by anthropogenic factors from the mean temperatures of bout 0.7°C since the mid-1800s [13].

The emission of global greenhouse gas increases up to 70% between 1970 and 2004 due to human activities. For example, CO_2 emissions have grown at about 80% (28% between 1990 and 2004) and accounted for 77% of total emissions in 2004. Energy supply (145%), transport (120%), industry (65%), and emissions from deforestation, biomass burning, decay of biomass from logging and deforestation, decay of peat and peat fires (40%) are among the main contributors for these emissions [6]. The global emissions are still increasing and are highly fluctuating environmental conditions which affect biodiversity and the whole ecosystem services [2, 13]. The IPCC Special Report on Climate Change and Land report that Agriculture, Forestry and Other Land Use (AFOLU) activities contributed to 13% of CO_2, 44% of methane (CH_4), and 82% of nitrous oxide (N_2O) from global GHGs emissions by human activities globally, representing 23% (12.0+/-3.0 $GtCO_2eyr^{-1}$) of total net anthropogenic emissions in the year 2007-2016 [14].

3. Relationship Between Climate Change and Biodiversity

Climate change and biodiversity are closely interlinked, and change in one component will affect the other [15]. However, many studies indicate climate change has been one of the world's threats to biodiversity, and there is a prediction that climate change will be the second most threat to biodiversity next to habitat alteration in 2100 [4]. Climate change affects biodiversity at all levels of biological organization –from organisms to the biome. Climate change widely affects genetic variability, species distributions, abundance, richness and diversity, reproduction time, migration events, and frequency of pest and disease outbreaks [16-18]. It also alters the entire ecosystem with all biodiversity living there [19]. Again, these effects (i.e. change in biodiversity) may also continue to contribute to increases in future global climate change. Global climate change affects ecosystem functioning and biodiversity and is also stabilized by biodiversity resources. For example, the degradation of biodiversity can directly reduce the continuous flow of ecosystem services and functions such as carbon sequestration potential of biodiversity, and further climate change [20]. Climate change is a rapidly increases stress on ecosystems by enhancing the effects habitat fragmentation, loss and conversion, over-exploitation, invasion of alien species, disease and pests, and interrupted seasonal cycles and changes in human-nature interactions [9, 15, 19].

4. Climate Change Mitigation Potential of Biodiversity

Climate change mitigation refers to a measurement activities undertaken to control or reduce the concentration of atmospheric greenhouse gases through the reduction of human-induced emissions or enhancing the absorption capacity (sequestration) from the atmosphere [21, 22]. The total mitigation potential of biodiversity may depend on factors such as emissions levels, availability of technology, enforcement, and incentives [21]. According to [20, 23] reports, mitigation as an effort made to reduce the negative impacts and enhance positive impacts of climate change on biodiversity and ecosystem functioning achieved through biodiversity conservation, restoration and management for the purpose of absorption of carbon in order to reduce the emitted atmospheric greenhouse gas. Carbon sequestration, enteric fermentation, manure and fertilizer management and shifting human dietary trends are also parts of the climate mitigation potential [24]. As sub-component of biological diversity, agriculture and forestry application is a powerful land use practice in achieving the goal of stabilization of atmospheric concentrations between 450-550 ppm CO_2 at the end of 21 century. Such practices include the reduced deforestation and degradation of tropical forests (REDD), sustainable forest management (SFM) and forest restoration (FR), agroforestry, and agricultural soils [3]. The Intergovernmental panel for climate change has also reported traditional agroforestry as an option land use system to reduce emissions and enhance sinks of greenhouse gases [6].

4.1. Forest Mitigation Potential

Forests contain a substantial proportion of the world's terrestrial biodiversity. The potential in global carbon cycling and reducing the concentration of atmospheric greenhouse gas makes this resource unique among the earth's biodiversity [25]. There is past, present and predicted evidence concerning the potential of forest resources in climate change mitigation as they sequester carbon and provide products substitute fossil fuels and other energy sources contributed to the emissions of greenhouse gases [26]. In sequestration process, carbon is absorbed and stored in leaves, branches, trunks and roots of trees and forest soils. On the other hand, unless properly managed, forests are also a net source for carbon emissions because of deforestation and forest degradation [27].

The Secretariat of the Convention on Biological Diversity report on Connecting Biodiversity and Climate Change Mitigation and Adaptation indicates that forestry land reduces emissions and increases carbon sequestration at an estimated range from 0.5-4 $GtCO_2$-eq per year [9]. Today, loss of biodiversity from deforestation and forest degradation could further diminish the ability of forests to provide sustainable multiple ecosystem services [25]. The Food and Agriculture Organization of the United Nations reports forests as climate change mitigation strategies in four major categories. These are: reducing emissions from deforestation; reducing emissions from forest degradation; enhancing forest carbon sinks; and product substitution for fossil fuel and other energy-intensive materials [22].

Reducing emissions from deforestation and forest degradation (REDD+) is an important mechanism to mitigate climate change by controlling the release of carbon into the atmosphere through maintaining the area under forest cover and promoting forest conservation and protection activities [22, 28]. $REDD^+$ generates substantial funds for developing countries that use to reduce forest degradation and restore or otherwise improve the management of forests to reduce greenhouse gas emissions and increase forest-based carbon sequestration. As a result, a net loss of forest area is less than a rate of deforestation, and there is decreasing from 7.8 million ha yr^{-1} in the 1990s to 4.7 million ha yr^{-1} during 2010-2020 [29].

The substitution of forest products for fossil fuel and other non-wood products is another mechanism that contributes to climate change mitigation. The use of wood to produce energy has two opportunities to reduce greenhouse gas emissions. These are the use of harvest residue for electrical power generation rather than allowing it to accumulate and decay on the site, and the substitution of woody biomass for fossil fuels [30]. Therefore, the harvested wood products have the potential to reduce greenhouse gas emissions through direct carbon storage, the substitution of non-renewable materials, and the increased availability of biofuels. According to Johnston and Radelof report, the global harvested wood products pool was a net sink of 335 M MT C (335 Mt of CO_2) in 2015 and it could grow to 441 M MT C (441 Mt of CO_2) by 2030 [31].

4.2. Agriculture Mitigation Potential

The expansion of agriculture has adverse and beneficial effects due to its emission and mitigation potential from the climate change perspective. When negatively seen, agricultural intensification contributed to land degradation and increasing emissions of greenhouse gases [3]. However, from a beneficial point of view, the diversity of agricultural practice is known by its mitigation potential of greenhouse gases. The climate change mitigation potential of agriculture is grouped into two major categories. These are carbon sequestration in soils and on-farm emissions reductions, and displacement of fossil fuels through the production of suitable bio-energy products such as ethanol, biogas, and methane [21].

4.2.1. Carbon Sequestration Potential of Agriculture

Agricultural management systems greatly determine the amount of CO_2 emissions to the atmosphere as well as sequestered in the soil [32]. For example, [9] reported agricultural land emissions reduction and carbon sequestration potential estimated to 1-6 $GtCO_2$-eq per year. However, this potential is influenced by factors such as design and implementation mode of the practice. Agriculture enhances carbon sinks through cropland management by zero tillage or store carbon to slow the amount of carbon released into the atmosphere by burning, tillage, and soil erosion [21]. Agriculture also increases organic matter inputs into the soils and increases soil organic carbon stocks [33]. In the practice, crop residues enhance soil fertility, improve soil structure, sequester carbon, and mitigate the greenhouse effect [32]. The Intergovernmental Panel on Climate Change projected total mitigation potential from agriculture (crop and livestock activities), and agroforestry as: 2.3-9.6 $GtCO_2e.yr^{-1}$ by 2050 [14]. Here, agroforestry made the largest contribution to this mitigation potential because of the potential to sequester carbon in both soil and biomass [33].

4.2.2. On-farm Mitigation Potential of Agriculture

On-farm mitigation potential of agriculture includes improved management of the primary sources of greenhouse gas emissions in agricultural sectors. These include the management of fertilizer application dominated by N_2O, enteric fermentation dominantly of CH_4, livestock manures mainly CH_4 and N_2O, rice cultivation which accounted for 13%, 40%, 16% and 10% of the greenhouse gas emissions from agriculture respectively and burning of surplus agricultural products [21, 33].

4.2.3. Bio-energy Production

Bio-energy production is the production of energy from biomass in the form of solid, liquid and gaseous fuels for a wide range of uses, including transport, heating, electricity production, and cooking. This product substitutes the utilization of fossil fuel, which is one of the major contributors of greenhouse gas. Thus, agro-biodiversity mitigates climate change by providing potential substituting product to fossil fuels in energy utilization.

5. Conclusion

Global climate change is more accelerated due to the emissions and concentration of atmospheric greenhouse gases such as CO_2, CH_4, and N_2O. The emissions may be natural, anthropogenic, or from both factors. Climate change is a global threat to biodiversity conservation. However, the relationship between climate change and biodiversity is a matter of two sides of the same coin because of their co-benefits and co-adverse type relationship ecosystem processes. Climate change negatively affects biodiversity and at the same time, biodiversity also plays a crucial role in the stability of climate change variables. Therefore, the conservation of biodiversity at different levels including forestry, agriculture, and agroforestry sectors play critical role in climate change mitigation.

References

[1] OECD. (2008). Climate Change Mitigation: What Do We Do? Organisation for Economic Co-operation and Development. 35pp.

[2] UNEP. (2007). Global Environment Outlook (GEO-4). Environment for development. United Nations Environment Programme, Nairobi, Kenya.

[3] Tubiello, F. (2012). Climate change adaptation and mitigation: challenges and opportunities in the food sector. Natural Resources Management and Environment Department, FAO, Rome.

[4] Sala, O. E., Chapin, F. S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Henneke, L. F., *et al*. (2000). Global Biodiversity Scenarios for the Year 2100. *Science,* 287: 1770-1774.

[5] Maljean-Dubois, S & Wemaere, M. (2017). Climate Change and Biodiversity. Elisa Morgera et Jona Razzaque. Biodiversity and Nature Protection Law, III, Edward Elgar Publishing, Elgar Encyclopedia of Environmental Law series, 978-1-78347-424-0.

[6] IPCC. (2007). Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Metz, B., Davidson, O. R., Bosch, P. R., Dave, R & Meyer, L. A. (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[7] 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.

[8] Diaz, S., Hector, A & Wardle, D. A. (2009). Biodiversity in forest carbon sequestration initiatives: Not just a side benefits. *Current Opinion in Environmental Sustainability*, 1: 55–60.

[9] Secretariat of the Convention on Biological Diversity (2009). Connecting Biodiversity and Climate Change Mitigation and Adaptation. Key Messages from the Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change.

[10] Nabuurs, G. J., Masera, O., Andrasko, K., Benitez-Ponce, P., Boer, R., Dutschke, M., Elsiddig, E., Ford-Robertson, J., *et al*. (2007). Forestry. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Metz, B., Davidson, O. R., Bosch, P. R., Dave, R & Meyer, L. A. (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[11] Rajeshwar, R. G., Prabhakar, M., Venkatesh, G., Srinivas, I & Sammi, R. K (Eds.). (2018). Agroforestry Opportunities for Enhancing Resilience to Climate Change in Rainfed Areas, ICAR - Central Research Institute for Dryland Agriculture, Hyderabad, India. 224pp.

[12] Omann, I., Stocker, A & Jäger, J. (2009). Climate change as a threat to biodiversity: An application of the DPSIR approach. *Ecological Economics*, 69 (1): 24-31.

[13] Hughes, L., Howden, M & Zethoven, I. (2003). Biodiversity and climate change: workshop aims and background. In: Howden, M., Hughes, L., Dunlop, M., Zethoven, I., Hilbert, D & Chilcott, C. (eds): Climate Change Impacts On Biodiversity In Australia, Outcomes of a workshop sponsored by the Biological Diversity Advisory Committee, 1–2 October 2002, Commonwealth of Australia, Canberra.

[14] IPCC. (2019). IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems. Summary for Policymakers. Intergovernmental Panel on Climate Change.

[15] Slingenberg, A., Braat, L., van der Windt, H., Rademaekers, K., Eichler, L & Turner, K. (2009). Study on understanding the causes of biodiversity loss and the policy assessment framework. Final Report: ECORYS Research and Consulting.

[16] Hens, L & Boon, E. K. (2005). Causes of Biodiversity Loss: a Human Ecological Analysis. Human Ecology Department, VrijeUniversiteitBrussel, Laarbeeklaan, Brussels, Belgium.

[17] Rawat, U. S & Agarwal, N. K. (2015). Biodiversity: Concept, threats and conservation. *Environment Conservation Journal,* 16 (3): 19-28.

[18] WWF. (2020). Living Planet Report 2020: Bending the curve of biodiversity loss. Almond, R. E. A., Grooten, M and Petersen, T. (Eds). WWF, Gland, Switzerland.

[19] Palita, S. K. (2016). Climate Change and its Impact on Biodiversity. Conference Paper ·September 2016, Central University of Orissa, Odisha.

[20] Hisano, M., Searle, E. B & Chen, H. Y. H. (2018). Biodiversity as a solution to mitigate climate change impacts on the functioning of forest ecosystems. *Biol. Rev.* 93: 439–456.

[21] Rosegrant, M. W., Ewing, M., Yohe, G., Burton, I., Huq, S & Valmonte-Santos, R. (2008). Climate Change and Agriculture Threats and Opportunities. Climate Protection Programme for Developing Countries. Eschborn, Germany.

[22] FAO. (2013). Climate change guidelines for forest managers. FAO Forestry Paper No. 172. Rome, Food and Agriculture Organization of the United Nations.

[23] Mant, R., Perry, E., Heath, M., Munroe, R., Väänänen, E., Großheim, C & Kümper-Schlake, L. (2014). Addressing climate change. Why biodiversity matters. UNEP-WCMC, Cambridge, UK.

[24] Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T & Woznicki, S. A. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. *Climate Risk Management,* 16: 145–163.

[25] Parrotta, J. A., Wildburger, C & Mansourian, S. (eds.). (2012). Understanding Relationships between Biodiversity, Carbon, Forests and People: The Key to Achieving REDD+ Objectives. A Global Assessment Report. Prepared by the Global Forest Expert Panel on Biodiversity, Forest Management, and $REDD^{+}$. IUFRO World Series Volume 31. Vienna. 161 pp.

[26] Mishra M and Singh, S. P. (2009). Indigenous community participation in India. In: Bodegom, V., Jan, A., Savenije, H and Wit, M. (eds). Forests and Climate Change: adaptation and mitigation. Tropenbos International, Wageningen, The Netherlands. xvi + 160 pp.

[27] Broadhead, J. S., Durst, P. B & Brown, C. L. (2009). Climate change: Will it change how we manage forests? In: Bodegom, V., Jan, A., Savenije, H & Wit, M. (eds). Forests and Climate Change: adaptation and mitigation. Tropenbos International, Wageningen, The Netherlands. xvi + 160 pp.

[28] Sharma, V., Chand, H., Rai, N & Prasad, M. (2017). Carbon sequestration in forest ecosystem and methods for its evaluation. *Van Sangyan*, 4 (12).

[29] FAO & UNEP. (2020). The State of the World's Forests 2020. In brief. Forests, biodiversity and people. Rome. https://doi.org/10.4060/ca8985en.

[30] Malmsheimer, R. W., Heffernan, P., Brink, S., Crandall, D., Deneke, F., Galik, C., Gee, E., Helms, J. A., *et al*. (2008). Forest Management Solutions for Mitigating Climate Change in the United States. *Journal of Forestry,* 106 (3): 115-171.

[31] Johnston, C. M. T & Radeloff, V. C. (2019). Global mitigation potential of carbon stored in harvested wood products. *PNAS,* 116 (29): 1-6.

[32] Jat, M. L., Dagar, J. C., Sapkota, T. B., Singh, Y., Govaerts, B., Ridaura, S. L., Saharawat, Y. S., Sharma, R. K., *et al*. (2016). Climate Change and Agriculture: Adaptation Strategies and Mitigation Opportunities for Food Security in South Asia and Latin America. *Advances in Agronomy*, 137: 127-235.

[33] Richards, M., Arslan, A., Cavatassi, R & Rosenstock, T. (2019). Climate change mitigation potential of agricultural practices supported by IFAD investments. An ex ante analysis. International Fund for Agricultural Development (IFAD).