

Environmental Degradation and Its Consequences on Global Biodiversity

Anil Kumar^{1*}, Deepika Ahuja², Chetna Sharma³, Shiya Thakur³, Joy Chopra³

¹Associate Professor, University Institute of Biotechnology, Chandigarh University, Gharuan, Mohali - 140413, Punjab, India.

²Assistant Professor, School of Allied and Healthcare Sciences, Centurion University of Technology and Management, Bhubaneswar, Odisha.

³B.Sc. Biotechnology, University Institute of Biotechnology, Chandigarh University, Gharuan, Mohali - 140413, Punjab, India.

Correspondence to Author:

Dr. Anil Kumar (anil_thakur840@yahoo.com)

Associate Professor, University Institute of Biotechnology, Chandigarh University, Gharuan, Mohali - 140413, Punjab, India.

Abstract

Environmental degradation is a critical global concern with extensive implications for ecosystems, human health, and sustainable growth. The effects of climate change, biodiversity loss, and pollution affect the livelihoods of community members dependent on agriculture, hence influencing their adaptive reactions and initiatives for sustainable development. This article examines the multifaceted causes of environmental degradation, including, urbanization, industrialization, deforestation, pollution, natural disasters, population growth, climate change, soil degradation, overpopulation, introduction of exotic species and landfills. It analyses the diverse consequences of environmental degradation, encompassing implications on human health, biodiversity loss, global warming, and ozone layer depletion. The article presents many options to address environmental deterioration, such as afforestation, pollution reduction, reduced fuel usage, methods for managing waste, water conservation, environmentally friendly methods, public awareness initiatives, social movements, and governmental laws. The review addresses the necessity for awareness regarding environmental safety, conservation, and mitigation strategies.

Keywords: Biodiversity, Environmental Degradation, Climate change, Global Warming, Deforestation

INTRODUCTION

Biodiversity refers to the diversity of life on Earth in all its manifestations. Biodiversity denotes the diversity of life present in an ecosystem, encompassing animals, plants, fungi, and microorganisms such as bacteria (Robinson et al., 2024). Each of these organisms and species coexists and interacts within intricate ecosystems. Numerous elements that we often overlook are supplied by robust ecosystems. Plants convert solar energy, rendering it accessible to various forms of life. Bacteria and other creatures breakdown organic matter into nutrients, fostering the formation of good soil for plant growth (Iqbal et al., 2023). Pollinators are essential for plant reproduction, hence guaranteeing food production. Plants function as significant carbon sinks and supply oxygen to terrestrial life forms (Katumo et al., 2022). Biodiversity provides clean air, clean water, fertile soil, and crop pollination. It aids in combating climate change and adaptation, while also alleviating the impacts of natural disasters (Ekardt et al., 2023). The extinction of a species can significantly impact the food chain due to the interactions of organisms within dynamic ecosystems. Environmental degradation refers to the decline of the environment resulting from the depletion of resources, including air, water, and soil, alongside the destruction of ecosystems and the extinction of wildlife (Chu and Karr, 2017). It is characterised as any modification or disruption to the environment that is either harmful or undesirable. Numerous factors can affect environmental change, such as economic growth, population growth, urban development, agricultural intensification, increased energy usage, and transportation. Environmental degradation may adversely affect human health (Raihan and Tuspekova, 2022). Toxic air pollutants may trigger respiratory disorders, including pneumonia and asthma, in those residing in contaminated regions (Shetty et al., 2023). Biodiversity is crucial for maintaining ecosystem equilibrium by combating contaminants, replenishing nutrients, safeguarding water sources, and regulating climate. The primary factors contributing to biodiversity loss include deforestation, climate change, overpopulation, and pollution (Shin et al., 2022). The ozone layer protects the Earth from harmful UV radiation. Chlorofluorocarbons and hydrochlorofluorocarbons in the

atmosphere contribute to the depletion of the ozone layer (Mmbando and Ngongolo, 2024). The depletion will let the infiltration of damaging radiation to the Earth (Bernhard et al., 2023).

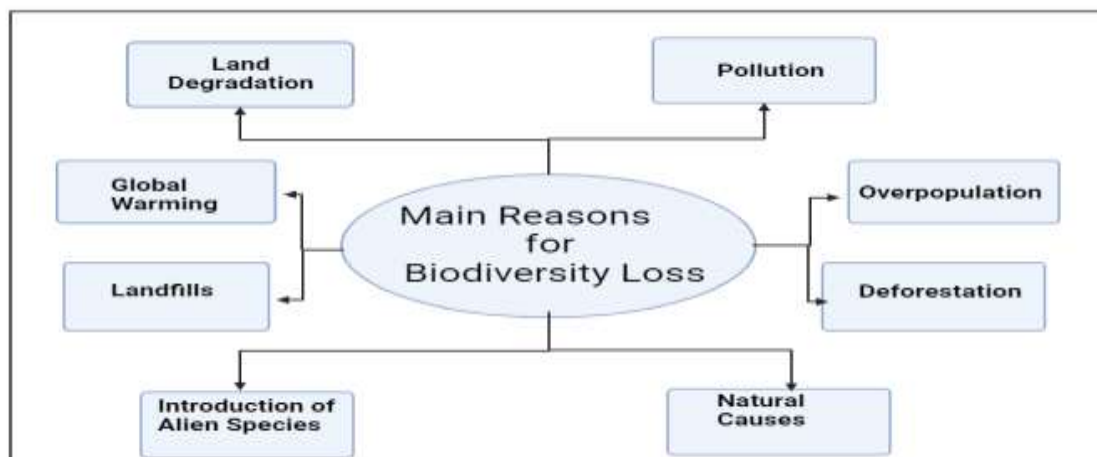


Figure 1. Main Reasons for Biodiversity Loss

Main reasons for biodiversity loss

Land degradation

Land degradation is a worldwide concern resulting from both natural and anthropogenic activities. Soil is a naturally occurring dynamic equilibrium of mineral constituents, organic matter, and microorganisms that has developed over thousands to millions of years. Human demands and improper land usage disturb this equilibrium, leading to soil degradation within a few years (Rahman, 2023). Land degradation, coupled with population growth and heightened demand for alternative land management products like biofuels, results in poverty, food insecurity, inadequate access to clean water, and heightened vulnerability to climate change and extreme weather events (Adenle, 2020) It results in disruptions to the surface soil that can modify topographical features and the arrangement of plant patches. Deforestation, desalination, waterlogging, desertification, wasteland, and soil erosion. Erosion plays a crucial role in chemical weathering by revealing unweathered minerals, hence facilitating mineral disintegration and soil development. Nevertheless, fast erosion resulting from deforestation or agricultural activities may impede this progress, diminishing our future soil supplies (Rothacker et al., 2018). The FAO projected that almost 2 billion individuals in the developing countries depend on biomass for their daily energy needs (Kumar et al., 2020).

Pollution

Pollution is the introduction of toxins into the natural environment due to human activity, resulting in adverse environmental changes. The three primary categories of pollution are atmospheric pollution, aquatic pollution, and terrestrial pollution.

Water pollution is a significant problem globally, especially in developing nations. Water constitutes approximately 71% of the Earth's surface, existing as groundwater and in oceans. Freshwater is a limited resource essential for agriculture, industry, and human survival. Increased demand for water in urban and rural settings, essential for human activities, will lead to groundwater scarcity. Water pollution may originate from natural or anthropogenic sources, with the source's geometry encompassing landfills, refuse dumps, septic systems, and subterranean tanks (Talabi and Kayode, 2019). Cholera epidemics in India have been linked to faecal contamination of water sources and open defecation (Muzembo et al., 2022). Nitrogen fertiliser undergoes biological conversion to nitrate, which exhibits excellent solubility in water. Moreover, soluble nitrate has significant mobility, rendering it unavailable for crop absorption, and when contaminants infiltrate drinking water supplies, fertiliser nitrates can pose severe health risks, particularly to young cattle and infants. (Akhtar et al., 2021)

Heavy metals resulting from industrial processing operations can be transported to adjacent rivers and lakes, adversely affecting the aquatic life and, ultimately, humans who consume the fish. Heavy metal toxicity can result in congenital anomalies, stunted growth, and possesses carcinogenic properties. High levels of dangerous contaminants in water make it unsuitable for drinking, bathing, cooking, or other uses (Masindi and Muedi, 2018). This results in a lowering of Biological Oxygen Demand, adversely affecting the flora and fauna of the rivers and causing fish mortality due to asphyxia. The Ganga River serves as a vital resource for almost 400 million individuals residing along its course, depending on it for

daily necessities including washing, livestock hydration, corpse disposal, sewage management, and industrial waste (Dwivedi et al., 2018).

The EPA estimates that around 300,000 industrial workers have pesticide-related acute illnesses and accidents annually, predominantly characterised by cholinergic symptoms from anticholinesterases and respiratory diseases due to airborne exposure. Air pollution is a contributing factor to environmental degradation, affecting both climate change and human health through heightened morbidity and mortality rates. The predominant sources of these pollutants are anthropogenic activities, including fossil fuel combustion, vehicular exhaust, and emissions from agriculture and industry. Nitrogen oxide, sulphur dioxide, volatile organic compounds (VOCs), dioxins, and polycyclic aromatic hydrocarbons (PAHs) are classified as hazardous air pollutants. Inhalation of air pollutants infiltrates the respiratory system, resulting in respiratory and cardiovascular diseases, reproductive and central nervous system dysfunction, and cancer (Ioannis et al., 2020).

Global Warming

Climate change is currently inducing severe droughts, water scarcity, intense fires, rising sea levels, flooding, melting polar ice, catastrophic storms, and diminishing biodiversity. Climate change impacts ecosystems by altering average conditions and variability, along with accompanying changes including heightened ocean acidification and elevated atmospheric CO₂ levels (Yadvinder et al., 2020).

The effects of climate change will vary by location, with global surface temperatures projected to increase by 0.3 to 1.7 degrees Celsius under the lowest emissions scenario and by 2.6 to 4.8 degrees Celsius under the highest emissions scenario. The Himalayan-Hindu Kush mountain range and the Tibetan Plateau in Central Asia have been adversely affected by global warming, resulting in the loss of 509 glaciers over the past 50 years and a local temperature increase of 1.5 °C. In 2018, a substantial ice mass detached from Greenland's Helheim Glacier (Arora, 2019). Rising global temperatures, resulting in elevated sea levels, climatic disruption, and desertification, are associated with adverse effects on human health and agricultural output (Braun, 2020). Due to mosquitoes being temperature-dependent vectors of diseases, the prevalence of these diseases in endemic regions is anticipated to increase (Lim et al., 2021). It is also linked to a rise in the frequency of droughts, floods, and storms, along with an increase in bug populations, leading to food scarcity and adverse effects on agriculture.

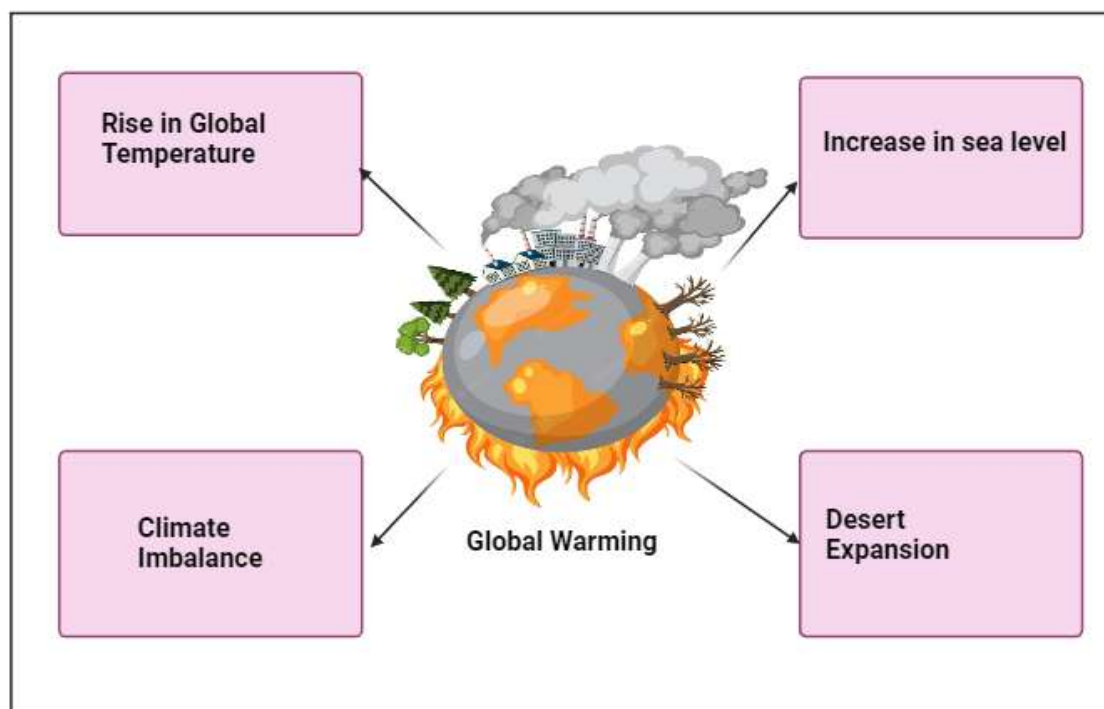


Figure 2. Impacts of Global warming on Environment.

Overpopulation

The swift population growth in a nation such as India jeopardises the environment via agricultural expansion and intensification, unrestrained urbanisation and industrialisation, and habitat degradation. The swift rise in population exerts pressure on natural resources, leading to environmental deterioration

(Weber and Sciubba, 2019). The enhancement of medical services has led to a reduction in the mortality rate, hence increasing life expectancy. An increase in population directly correlates with heightened need for sustenance, apparel, and housing. Additional acreage is necessary for food cultivation and to accommodate millions of individuals. This results in deforestation, loss of biodiversity, resource extraction, and ecosystem devastation, all of which contribute to environmental degradation (Bologna and Aquino, 2020). Elevated population growth rates lead to heightened population density, a rise in the number of individuals residing beneath the poverty threshold, and intensified pressure on natural resources, hence exacerbating environmental degradation through the over-exploitation of these resources.

Landfills

Landfills adversely affect the ecology and diminish the aesthetic appeal of the city. Landfills are situated within urban areas because to the substantial volume of waste generated by residences, industries, factories, and healthcare facilities. Landfills risk the health of the environment and the residents in proximity. By 2025, global waste is projected to nearly double to 2.2 billion tonnes annually, with virtually every city worldwide failing to meet waste reduction objectives. Municipal solid waste was typically disposed of in landfills and/or open dumpsites (Vaverková, 2023). The incineration of landfills produces a repugnant odour and causes considerable environmental harm. Besides methane, landfills emit carbon dioxide, water vapour, and minor quantities of oxygen, nitrogen, hydrogen, and non-methane organic molecules. These gases are contaminating the atmosphere and contributing to climate change (Kumar et al., 2020). Landfills generate a toxic mixture referred to as leachate, formed when waste experiences biological and physicochemical transformation. Leachate is very toxic and contaminates soil and groundwater (Thakur et al., 2019). Contemporary landfills must be established with engineering techniques for the disposal of trash in specially designed and safeguarded cells on the ground surface or within excavated areas of the land.

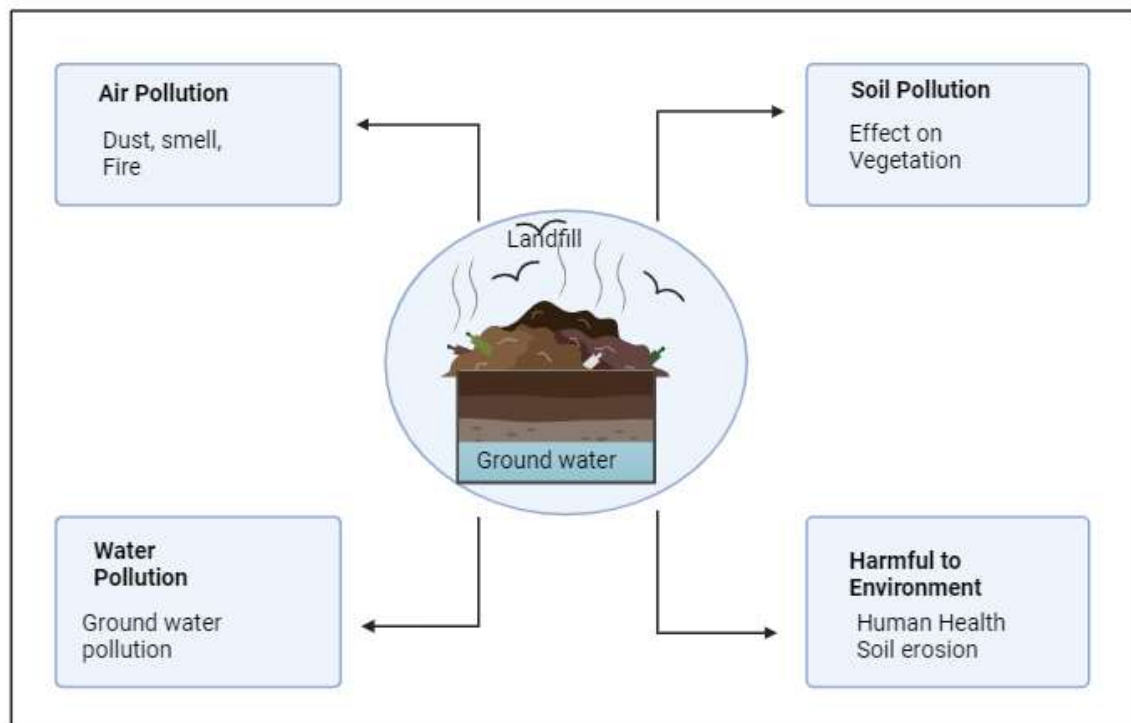


Figure 3. Impacts of Landfills on the Environment

Deforestation

Forests offer a diverse array of ecosystem services, encompassing local livelihoods and socioeconomic development resources such as food, timber, and water, in addition to global ecological and economic functions including ecosystem integrity, biodiversity, carbon dynamics, and climate regulation. Forests constitute a nation's paramount asset, supplying raw materials for modern industries, timber for construction, and habitat for diverse fauna and microorganisms. Deforestation refers to the eradication

of trees to accommodate further residential and industrial development. Deforestation accounts for 17-20% of global greenhouse gas emissions, potentially intensifying the severity of air storms (Duguma et al., 2019). The reduction of forest cover releases carbon into the environment, contributing to environmental damage. It accelerates soil erosion, resulting in nutrient depletion and diminished soil fertility, a rise in river sedimentation, and a heightened frequency of droughts (Bhattacharya et al., 2015). Urbanization-induced deforestation and forest fragmentation result in elevated temperatures and the proliferation of vector-borne diseases (Ortiz et al., 2021). Governmental and nonprofit organisations should promote conservation techniques, including reforestation, area closure, agroforestry practices, and participatory watershed management, to mitigate soil loss in the study region. the terrestrial surface.

Introduction of exotic species.

Invasive alien species include non-indigenous flora, fauna, diseases, and other organisms that can inflict economic or environmental damage or adversely affect human health (Ljubojević, 2023). They adversely affect biodiversity, resulting in the loss or extinction of native species through competition, predation, or pathogen transmission, along with the disruption of local ecosystems and ecosystem services (Rodolfo Gentili et al., 2021). Indigenous flora can function as pollutant absorbers and significantly enhance carbon sequestration. Extensive research conducted over the past three decades has demonstrated that invasive alien species (IAS) adversely affect native biodiversity, impacting genetic, ecological, and landscape levels (Lazzaro et al., 2020).

Currently, biological invasions are regarded as primary factors contributing to biodiversity loss and species extinctions in major plant and animal groups globally. Nevertheless, contemporary intensive agriculture aimed at ensuring food security has considerably facilitated the proliferation of invasive species, adversely affecting agriculture (Montagnani C et al. 2022). Ecosystem services and human health are compromised, leading to perilous vector-borne diseases (Clow, 2017). Invasive alien species exacerbate poverty and hinder development by impacting agriculture, forestry, fisheries, and natural systems, which are essential to the livelihoods of individuals in poor nations.

Natural causes

Humans are not only responsible for environmental degradation and biodiversity loss. Climate-related hazards, particularly droughts, floods, and storms, exert the most substantial influence on the environment and lead to considerable economic losses. Natural calamities, like avalanches, earthquakes, tsunamis, hurricanes, and wildfires, can devastate local flora and fauna, hindering their survival in affected areas. Floods introduce non-native creatures into new environments, resulting in significant problems for local habitats and health. Occhipinti, 2021. Natural causes of environmental degradation, such as floods, result in tidal waves that displace reptiles and insects. Land degradation significantly exacerbates the increasing effects of floods and droughts on both populations and ecosystems (Fasihi et al., 2021).

Conservation and Mitigation Strategies

National parks serve as one of the most effective means to safeguard the environment and preserve biodiversity, especially for endemic and endangered species (Fernandes et al., 2024). In terms of biodiversity conservation, forests are seen as essential habitats for biological diversity and as instruments for their preservation through the sustainable management of their resources (Muigua and Kariuki, 2022). International environmental law has significantly influenced India's constitutional provisions concerning environmental protection and equitable development (Kaur, 2024). Indigenous knowledge has been acknowledged as an essential element in biodiversity conservation. Traditional ecological practices, informed by the intimate connection between indigenous communities and their surroundings, provide sustainable approaches that enhance modern conservation initiatives, examining the significance of indigenous knowledge in biodiversity preservation, assessing its advantages and possibilities for incorporation into current environmental management (Dawson et al., 2021).

Need for awareness on environment safety

- Preserve water and refrain from the overexploitation of natural water sources.
 - Avoid littering or disposing of rubbish in unsuitable locations.
 - Engage in discussions regarding the ramifications of environmental degradation with others. The government can utilise economic incentives and punitive measures to promote afforestation.
 - Refrain from littering or discarding waste in inappropriate locations.
- Strict legislation must be enacted to regulate water pollution caused by individuals and the disposal of refuse and industrial waste into rivers.

- Procedures for the prevention of oil leaks must be implemented.
- Prior to discharging chemical waste into rivers and streams, it must be converted into innocuous biodegradable chemicals. By raising awareness of the causes and hazards of environmental degradation
- Enhancing machinery for more efficient fuel combustion and implementing suitable ventilation systems in every kitchen to mitigate the gases produced by burning wood, coal, and oil.
- Establish vehicle regulations and construct the vehicle to ensure complete fuel combustion within the engine.
- Afforestation control - the planting of trees should occur in parks and public spaces.

CONCLUSION

Currently, a significant environmental challenge is the destruction of ecosystems and the preservation of biodiversity. Depending on the severity of the destruction, certain ecosystems may never recuperate. Environmental degradation will result in the permanent extinction of flora and wildlife native to those places. The primary causes of environmental degradation in India are attributed to rapid population growth along with economic development. To alleviate future consequences, urban planners, industry, and resource management must confront the enduring environmental impacts of expansion. Trees may be cultivated in residential areas and educational institutions to mitigate air pollution and to motivate urban residents to reduce their carbon footprints by enhancing green coverage. The government must prioritise the treatment of household wastewater, and existing wastewater treatment facilities should be routinely monitored and maintained. India is a repository of biodiversity, hosting a diverse array of flora and recognised as one of the eight principal "Vavilovian" centres of origin and crop diversity. The Western Ghats encompass over 90 percent of the nation's higher plant species, rendering them very pertinent to traditional medicine. The maintenance of biodiversity is essential for sustaining ecological balance. The environmental degradation we inflict is currently unrecognised in economic and social metrics. This absence of "environmental value" has permitted us to over use "free" natural resources, which are not free. This has led to an excess of inexpensive products with very little life spans. There is a necessity to produce durable, recyclable items.

REFERENCES

1. AbdelRahman, M.A.E. An overview of land degradation, desertification and sustainable land management using GIS and remote sensing applications. *Rend. Fis. Acc. Lincei* 34, 767–808 (2023). <https://doi.org/10.1007/s12210-023-01155-3>
2. Ademola A. Adenle, Sandra Eckert, Oluwatola I. Adedeji, David Ellison, Chinwe Ifejika Speranza,
3. Human-induced land degradation dominance in the Nigerian Guinea Savannah between 2003 – 2018, *Remote Sensing Applications: Society and Environment*, 2020(19),100360.
4. <https://doi.org/10.1016/j.rsase.2020.100360>.
5. Rothacker, L., Dosseto, A., Francke, A. et al. Impact of climate change and human activity on soil landscapes over the past 12,300 years. *Sci Rep* 8, 247 (2018). <https://doi.org/10.1038/s41598-017-18603-4>
6. Talabi, A. and Kayode, T. (2019) Groundwater Pollution and Remediation. *Journal of Water Resource and Protection*, 11, 1-19. doi: 10.4236/jwarp.2019.111001.
7. Muzembo BA, Kitahara K, Debnath A, Ohno A, Okamoto K, Miyoshi SI. Cholera Outbreaks in India, 2011-2020: A Systematic Review. *Int J Environ Res Public Health*. 2022 May 8;19(9):5738. doi: 10.3390/ijerph19095738. PMID: 35565133; PMCID: PMC9099871.
8. Akhtar N, Syakir Ishak MI, Bhawani SA, Umar K. Various Natural and Anthropogenic Factors Responsible for Water Quality Degradation: A Review. *Water*. 2021; 13(19):2660. <https://doi.org/10.3390/w13192660>
9. Masindi V, Muedi KL. Environmental Contamination by Heavy Metals [Internet]. *Heavy Metals*. InTech; 2018. Available from: <http://dx.doi.org/10.5772/intechopen.76082>
10. Sanjay Dwivedi, Seema Mishra, Rudra Deo Tripathi. Ganga water pollution: A potential health threat to inhabitants of Ganga basin. *Environment International*. 2018 (17): 327-338.
11. <https://doi.org/10.1016/j.envint.2018.05.015>.
12. Ioannis M, Elisavet S, Agathangelos S and Eugenia B. Environmental and Health Impacts of Air Pollution: A Review. *Frontiers in Public Health*. 2020 (18): 1-20.
13. <https://www.frontiersin.org/articles/10.3389/fpubh.2020.00014>
14. Arora, N. Earth: 50 years challenge. *Environmental Sustainability* 2, 1–3 (2019). <https://doi.org/10.1007/s42398-019-00053-5>
15. Malhi Yadvinder, Franklin Janet, Seddon Nathalie, Solan Martin, Turner Monica G., Field Christopher B. and Knowlton Nancy 2020 Climate change and ecosystems: threats, opportunities and solutions *Phil. Trans. R. Soc. B* 375:2019010420190104
16. <http://doi.org/10.1098/rstb.2019.0104>
17. von Braun, J. (2020). Climate Change Risks for Agriculture, Health, and Nutrition. In: Al-Delaimy, W., Ramanathan, V., Sánchez Sorondo, M. (eds) *Health of People, Health of Planet and Our Responsibility*. Springer, Cham. https://doi.org/10.1007/978-3-030-31125-4_11

18. Lim, AY., Cheong, HK., Chung, Y. et al. Mosquito abundance in relation to extremely high temperatures in urban and rural areas of Incheon Metropolitan City, South Korea from 2015 to 2020: an observational study. *Parasites Vectors* 14, 559 (2021). <https://doi.org/10.1186/s13071-021-05071-z>
19. Bologna, M., Aquino, G. Deforestation and world population sustainability: a quantitative analysis. *Sci Rep* 10, 7631 (2020). <https://doi.org/10.1038/s41598-020-63657-6>
20. Weber H, Sciubba JD. The Effect of Population Growth on the Environment: Evidence from European Regions. *Eur J Popul.* 2018;35(2):379-402. Published 2018 Apr 9. doi:10.1007/s10680-018-9486-0
21. Vaverková MD. Landfill Impacts on the Environment—Review. *Geosciences.* 2019; 9(10):431. <https://doi.org/10.3390/geosciences9100431>
22. Chandan Kumar , Purnima Mishra , Nandani Singh , Ashish Kumar Pathak, 2020, Landfill Emissions and Their Impact on the Environment, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) Volume 09, Issue 08 (August 2020),
23. Swati, Thakur, I.S., Vijay, V.K., Ghosh, P. (2019). Scenario of Landfilling in India: Problems, Challenges, and Recommendations. In: Hussain, C. (eds) *Handbook of Environmental Materials Management*. Springer, Cham. https://doi.org/10.1007/978-3-319-73645-7_167
24. Duguma LA, Atela J, Minang PA, Ayana AN, Gizachew B, Nzyoka JM, Bernard F. Deforestation and Forest Degradation as an Environmental Behavior: Unpacking Realities Shaping Community Actions. *Land.* 2019; 8(2):26. <https://doi.org/10.3390/land8020026>
25. Bhattacharyya R, Ghosh BN, Mishra PK, Mandal B, Rao CS, Sarkar D, Das K, Anil KS, Lalitha M, Hati KM, et al. Soil Degradation in India: Challenges and Potential Solutions. *Sustainability.* 2015; 7(4):3528-3570. <https://doi.org/10.3390/su7043528>
26. Ortiz DI, Piche-Ovares M, Romero-Vega LM, Wagman J, Troyo A. The Impact of Deforestation, Urbanization, and Changing Land Use Patterns on the Ecology of Mosquito and Tick-Borne Diseases in Central America. *Insects.* 2021;13(1):20. Published 2021 Dec 23. doi:10.3390/insects13010020
27. Ljubojević M. Editorial: Invasive alien plant species: From the molecular to the economic approach. *Front Plant Sci.* 2023 Mar 30;14:1185567. doi: 10.3389/fpls.2023.1185567. PMID: 37063212; PMCID: PMC10101563.
28. Lazzaro, L., R., Bolpagni, G., Buffa, R., Gentili, M., Lonati, A., Stinca, A.T.R., Acosta, et al. 2020. "Impact of invasive alien plants on native plant communities and Natura 2000 habitats: State of the art, gap analysis and perspectives in Italy." *Journal of Environmental Management.* 274:111140. doi: <https://doi.org/10.1016/j.jenvman.2020.111140>.
29. Rodolfo Gentili, Urs Schaffner, Adriano Martinoli & Sandra Citterio (2021) Invasive alien species and biodiversity: impacts and management, *Biodiversity*, 22:1-2, 1-3, DOI: 10.1080/14888386.2021.1929484
30. Montagnani C, Gentili R, Brundu G, Caronni S, Citterio S. Accidental Introduction and Spread of Top Invasive Alien Plants in the European Union through Human-Mediated Agricultural Pathways: What Should We Expect? *Agronomy.* 2022; 12(2):423. <https://doi.org/10.3390/agronomy12020423>
31. Clow K.M. The influence of abiotic and biotic factors on the invasion of *Ixodes scapularis* in Ontario, Canada. *Ticks Tick-borne Dis.* 2017;8:554-563.
32. Occhipinti-Ambrogi A. Biopollution by Invasive Marine Non-Indigenous Species: A Review of Potential Adverse Ecological Effects in a Changing Climate. *International Journal of Environmental Research and Public Health.* 2021; 18(8):4268. <https://doi.org/10.3390/ijerph18084268>
33. Fasihi S, Lim WZ, Wu W, Proverbs D. Systematic Review of Flood and Drought Literature Based on Science Mapping and Content Analysis. *Water.* 2021; 13(19):2788. <https://doi.org/10.3390/w13192788>
34. Ferreira Fernandes, C.S., Alves, F. & Loureiro, J. Sustainable futures: from causes of environmental degradation to solutions. *Discov Sustain* 5, 63 (2024). <https://doi.org/10.1007/s43621-024-00242-1>
35. Muigua, Ph.D, Dr. Kariuki and Muigua, Ph.D, Dr. Kariuki, Boosting Biodiversity Conservation through Sustainable Forest Resources Management (February 18, 2022). *JCMSD Vol 8-1 2022*, Available at SSRN: <https://ssrn.com/abstract=4097656> or <http://dx.doi.org/10.2139/ssrn.4097656>
36. Kaur, Navdeep, The Impact of International Environmental Law on Constitutional Provisions of India Related to Environmental Protection and Sustainable Development (January 15, 2024). Available at SSRN: <https://ssrn.com/abstract=4697849> or <http://dx.doi.org/10.2139/ssrn.4697849>
37. Dawson, N. M., B. Coolsaet, E. J. Sterling, R. Loveridge, N. D. Gross-Camp, S. Wongbusarakum, K. K. Sangha, L. M. Scherl, H. Phuong Phan, N. Zafra-Calvo, W. G. Lavey, P. Byakagaba, C. J. Idrobo, A. Chenet, N. J. Bennett, S. Mansourian, and F. J. RosadoMay. 2021. The role of Indigenous peoples and local communities in effective and equitable conservation. *Ecology and Society* 26 (3):19. <https://doi.org/10.5751/ES-12625-260319>
38. Robinson J.K., Breed, A.C., Camargo A, Redvers N and Breed MF, Biodiversity and human health: A scoping review and examples of underrepresented linkages, *Environmental Research*, Volume 246, 2024, 118115. <https://doi.org/10.1016/j.envres.2024.118115>.
39. Iqbal B, Li G, Alabosh KF, Hussain H, Khan I, Tariq M, Javed Q, Naeem M, Ahmad N, Advancing environmental sustainability through microbial reprogramming in growth improvement, stress alleviation, and phytoremediation, *Plant Stress*, Volume 10, 2023, 100283.
40. <https://doi.org/10.1016/j.stress.2023.100283>.
41. Katumo DM, Liang H, Ochola AC, Lv M, Wang QF, Yang CF. Pollinator diversity benefits natural and agricultural ecosystems, environmental health, and human welfare. *Plant Divers.* 2022 Feb 3;44(5):429-435. doi: 10.1016/j.pld.2022.01.005. PMID: 36187551; PMCID: PMC9512639.
42. Ekardt, F., Günther, P., Hagemann, K. et al. Legally binding and ambitious biodiversity protection under the CBD, the global biodiversity framework, and human rights law. *Environ Sci Eur* 35, 80 (2023). <https://doi.org/10.1186/s12302-023-00786-5>
43. Chu EW, Karr JR. Environmental Impact: Concept, Consequences, Measurement. Reference Module in Life Sciences. 2017:B9780-12-809633-8.02380-3. doi: 10.1016/B9780-12-809633-8.02380-3. Epub 2016 Oct 31. PMCID: PMC7157458.

44. Raihan A, Tuspekova A, Dynamic impacts of economic growth, energy use, urbanization, agricultural productivity, and forested area on carbon emissions: New insights from Kazakhstan, *World Development Sustainability*, Volume 1, 2022, 100019. <https://doi.org/10.1016/j.wds.2022.100019>.
45. Shetty SS, Deepthi D, Harshitha S, Sonkusare S, Naik PB, Kumari S, kumar H. Environmental pollutants and their effects on human health, *Heliyon*, Volume 9(9), 2023, e19496.
46. <https://doi.org/10.1016/j.heliyon.2023.e19496>.
47. Shin YJ, Midgley GF, Archer ERM, Arneth A, Barnes DKA, Chan L, Hashimoto S, Hoegh-Guldberg O, Insarov G, Leadley P, Levin LA, Ngo HT, Pandit R, Pires APF, Pörtner HO, Rogers AD, Scholes RJ, Settele J, Smith P. Actions to halt biodiversity loss generally benefit the climate. *Glob Chang Biol*. 2022 May;28(9):2846-2874. doi: 10.1111/gcb.16109. Epub 2022 Feb 27. PMID: 35098619; PMCID: PMC9303674.
48. Mmbando, G.S., Ngongolo, K. Environmental & health impacts of ultraviolet radiation: current trends and mitigation strategies. *Discov Sustain* 5, 436 (2024). <https://doi.org/10.1007/s43621-024-00698-1>
49. Bernhard, G.H., Bais, A.F., Aucamp, P.J. et al. Stratospheric ozone, UV radiation, and climate interactions. *Photochem Photobiol Sci* 22, 937-989 (2023). <https://doi.org/10.1007/s43630-023-00371-y>