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ROLE OF ECO-FRIENDLY PLANTS IN CLIMATE CHANGE MITIGATION

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ABSTRACT
Eco-friendly plants play a vital role in mitigating climate change by enhancing carbon sequestration, improving ecosystem resilience, and regulating atmospheric greenhouse gases. As global temperatures continue to rise due to increased emissions of CO_2, CH_4, and N_2O, nature-based solutions have gained prominence as sustainable mitigation strategies. According to the Intergovernmental Panel on Climate Change (IPCC), terrestrial vegetation absorbs nearly 30% of anthropogenic CO_2 emissions annually, highlighting the significant contribution of forests, grasslands, and wetlands to global carbon budgets. Trees with high biomass potential such as mangroves, eucalyptus, and neem sequester substantial carbon over long periods, while shrubs and grasses stabilize soil and enhance carbon storage in deeper soil layers. Wetland plants also support methane regulation by improving water filtration and fostering anaerobic microbial activity. Eco-friendly plants further mitigate climate-related impacts through shading, evapotranspiration, and microclimate regulation, reducing urban heat islands and lowering energy demands in cities. In agriculture, climate-resilient species contribute to sustainable farming by improving soil fertility, conserving water, and reducing dependence on chemical inputs. Despite these benefits, challenges such as deforestation, invasive species, and climate-induced water scarcity limit plant-based mitigation effectiveness. Strengthening policy frameworks, promoting community-led plantations, and expanding urban green infrastructure can maximize the potential of eco-friendly plants in global climate strategies. Overall, eco-friendly plants represent a cost-effective, accessible, and ecologically sustainable solution to climate change mitigation.

KEYWORDS: Eco-friendly plants; Carbon sequestration; Climate change mitigation; Sustainable ecosystems; Nature-based solutions.

1. INTRODUCTION
Climate change represents one of the gravest challenges to the planet, with far-reaching environmental, social, and economic impacts. Rising global temperatures, more frequent and severe extreme weather events, melting glaciers, sea-level rise, and shifts in precipitation patterns threaten biodiversity, food security, and human livelihoods. According to the National Academies, ecosystems already absorb a substantial portion of anthropogenic carbon dioxide emissions, acting as natural carbon "sinks" but human activities such as deforestation and land-use change are undermining this capacity. Given the scale of the crisis, nature-based solutions have emerged as a crucial, complementary pathway alongside technological mitigation. These solutions involve protecting, restoring, and sustainably managing ecosystems to address climate change in conjunction with other societal challenges. The World Bank estimates that nature-based solutions could deliver up to 37% of the cost-effective carbon mitigation needed by 2030 to meet the goals of the Paris Agreement. By leveraging ecosystem functions, such as carbon sequestration, water regulation, and biodiversity support, these approaches not only reduce greenhouse gas concentrations but also enhance resilience, protect human well-being, and support sustainable development(Zuma et al., 2023). In this context, eco-friendly plants refer to plant species including trees, shrubs, grasses, and aquatic vegetation that contribute positively to ecosystem health, biodiversity, and climate regulation. These plants perform key ecological services such as carbon storage in biomass and soils, stabilization of soils to prevent erosion, and purification of air and water. Through their natural processes, they enhance ecosystem resilience, mitigate climate-related risks, and provide habitat for wildlife. When thoughtfully selected and managed, eco-friendly plants become powerful agents of nature-based mitigation, helping to address climate change in a way that is sustainable, cost-effective, and aligned with broader ecological goals (Saha et al., 2024).

2. MECHANISMS THROUGH WHICH PLANTS MITIGATE CLIMATE CHANGE

Carbon Sequestration: Plants serve as major carbon sinks by absorbing atmospheric CO_2 through photosynthesis and storing it in their biomass, roots, and surrounding soils. Forest ecosystems alone sequester about 7.6 billion tons of CO_2 annually, according to the Intergovernmental Panel on Climate Change (IPCC). Soils also play a crucial role in long-term carbon storage. Deep-rooted species increase carbon deposition in soil layers, enhancing soil organic carbon and slowing carbon release.

Regulation of Greenhouse Gases (CO_2, CH_4, N_2O): Wetland plants such as reeds, mangroves, and marsh species regulate methane (CH_4) emissions by maintaining water balance and supporting microbial communities that oxidize methane. Vegetated ecosystems also help reduce nitrous oxide (N_2O) emissions by improving soil structure and reducing fertilizer dependency.

Cooling Effects (Shade and Evapotranspiration): Plants reduce surface and air temperatures through shade provision and evapotranspiration, a natural cooling process where water is released from leaves. Urban tree cover can reduce local temperatures by 2–8°C, helping mitigate urban heat islands.

Soil Conservation and Erosion Control: Plant roots bind soil particles, preventing erosion from wind and water. Vegetation cover increases soil stability, reduces runoff, and enhances water infiltration.

Improving Air Quality Through Pollutant Absorption: Plants improve air quality by absorbing pollutants such as ozone, particulate matter, nitrogen oxides, and sulfur dioxide. Urban vegetation can remove up to 25% of airborne particulate matter annually (Kodadi et al., 2025)(Ahmad & Iqbal, 2025).

Table 1: Categories of Eco-Friendly Plants, Their Ecological Functions, Examples, and Climate Mitigation Benefits.

Sr.No	Plant Category	Ecological Function	Examples	Climate Mitigation Benefits
1	Trees	Carbon sequestration, soil stabilization	Mangroves (*Rhizophora spp.*)	High carbon storage, coastal protection
2	Trees	Shade, evapotranspiration	Eucalyptus (*Eucalyptus spp.*)	Urban cooling, carbon sequestration
3	Trees	Nitrogen fixation	Neem (*Azadirachta indica*)	Soil fertility improvement, carbon storage
4	Shrubs	Soil stabilization	Lantana (*Lantana camara*)	Reduces erosion, moderate carbon storage
5	Shrubs	Habitat for pollinators	Hibiscus (*Hibiscus spp.*)	Biodiversity support, ecosystem resilience
6	Grasses	Carbon storage in roots	Bamboo (*Bambusa spp.*)	Rapid growth, soil carbon accumulation
7	Grasses	Soil conservation	Miscanthus (*Miscanthus sinensis*)	Deep root carbon sequestration, erosion control
8	Aquatic Plants	Water purification	Water hyacinth (*Eichhornia crassipes*)	Nutrient absorption, improved water quality
9	Aquatic Plants	Wetland carbon storage	Seagrass (*Posidonia spp.*)	Blue carbon sequestration, methane regulation
10	Urban Green Plants	Urban cooling	Green roofs, street trees	Heat island mitigation, air purification
11	Urban Green Plants	Air quality improvement	Platanus (*Plane trees*)	Particulate matter absorption, CO_2 capture
12	Agroforestry Species	Soil fertility enhancement	Gliricidia (*Gliricidia sepium*)	Nitrogen fixation, carbon storage
13	Agroforestry Species	Crop productivity	Tectona (*Teak*)	Microclimate regulation, biodiversity support
14	Drought-Resistant Plants	Water conservation	Millets (*Panicum spp.*)	Reduced irrigation needs, resilient cropping
15	Mixed Community Plantations	Ecosystem restoration	Native multi-species forests	Biodiversity, carbon sequestration, flood protection

3. CATEGORIES OF ECO-FRIENDLY PLANTS

Trees (High Carbon Sinks): Trees are among the most powerful eco-friendly plants when it comes to climate mitigation. Their large biomass trunks, branches, leaves, and deep roots enables long-term carbon storage. Species such as mangroves (e.g., *Rhizophora* spp.) are particularly effective: they store "blue carbon" in their saturated soils and can sequester more carbon per hectare than many terrestrial forests. Eucalyptus trees are another example: fast-growing, with high wood density and deep root systems, they can accumulate significant biomass quickly. Neem (*Azadirachta indica*) and other native or nitrogen-fixing tree species can provide both carbon storage and co-benefits like soil fertility improvement (Yadapadithaya et al., 2022).

Shrubs and Grasses: Shrubs and grasses often grow faster than trees, making them valuable for rapid biomass accumulation and soil stabilization. Bamboo, though technically a grass, is one of the most efficient carbon-sequestering species due to its rapid regrowth and dense root network. Perennial grasses (for example, *Miscanthus sinensis*) contribute significantly to soil organic carbon because their extensive root systems deposit carbon deep into the soil. Shrubs can also act as windbreaks and provide erosion control while sequestering carbon(Panicker, 2024).

Aquatic Plants (Wetland Species & Water Purification); Aquatic and wetland plants including mangroves, marsh grasses, and seagrasses are critical for "blue carbon" ecosystems. These plants sequester carbon not just in their biomass, but also in underlying sediments, where anaerobic (oxygen-poor) conditions slow decomposition and lock carbon away for long periods. In addition to carbon storage, they help purify water by filtering nutrients and pollutants, enhancing water quality in coastal and freshwater systems (Nanjundan & Thomas, 2024).

Urban Green Plants (Rooftop & Street Vegetation): Urban vegetation trees, shrubs, and groundcover planted along streets, in parks, or on rooftop gardens plays a key role in mitigating urban heat islands, improving air quality, and storing carbon. Studies have shown that species like Eucalyptus camaldulensis in greenbelts can store significant above-ground biomass carbon even in cities. Urban green plants also reduce energy demand (by cooling) and provide ecosystem services that enhance quality of life in densely populated areas(El-Bichri et al., 2024).

Agroforestry Species (Climate-Smart Agriculture): Agroforestry integrates trees, shrubs, and perennial plants into agricultural systems, combining ecological and economic benefits. Trees in agroforestry (such as Tectona grandis, eucalyptus, or nitrogen-fixing species like *Gliricidia*) sequester carbon in their biomass and roots, while leaf litter and root turnover enrich soil organic carbon. Additionally, agroforestry systems like alley cropping, silvopasture, and home gardens improve soil fertility, enhance biodiversity, and increase farmers' resilience to climate variability (Ahirwar et al., 2020).

4. CASE STUDIES AND GLOBAL EXAMPLES

Reforestation and Afforestation Initiatives

Large-Scale Afforestation in Asia (South Korea / China / India): Several countries have implemented large government-led afforestation and reforestation programs for climate mitigation. A report by the Climate & Land Use Alliance highlights how South Korea, China, and India have used large-scale forest expansion to sequester carbon. These efforts illustrate that ambitious tree-planting, when tied to national carbon accounting, can make a major contribution to mitigation.

Billion Tree Tsunami (Pakistan): In Khyber Pakhtunkhwa, Pakistan, the "Billion Tree Tsunami" project restored degraded land and forests. This community-inclusive afforestation drive not only increased forest cover, but also improved ecosystem resilience and created green jobs showing how large-scale tree planting can align with socio-economic development goals (Almalki et al., 2023).

Mangrove Restoration Projects

Community Mangrove Restoration in Bangladesh: Under the Community-Based Adaptation to Climate Change (CBACC) program, local communities planted nearly 9,650 hectares of mangroves in four coastal districts using a "Forest, Fish, Fruit" (FFF) model that also supports fish nursery ponds. This not only strengthens coastal protection, but also enhances livelihoods while sequestering carbon.

Gazi Bay, Kenya (Mikoko Pamoja): In Gazi Bay, a community-led mangrove project (Mikoko Pamoja) has protected 117 ha of forest and involves nearly 500 local participants. The initiative also sells carbon credits through a Payment for Ecosystem Services (PES) mechanism, linking local conservation efforts with global climate finance.

Thor Heyerdahl Climate Park, Myanmar: This large-scale restoration project aims to plant millions of mangrove trees in the Ayeyarwady delta, regaining lost mangrove cover and storing significant carbon over decades.

Balabac, Palawan, Philippines: WWF's mangrove restoration there is helping regenerate degraded coastal areas. Wetlands International is scaling science-based restoration across the Philippines, integrating community livelihood goals with ecological resilience(Gerona-Daga & Salmo III, 2022) (Rodríguez-Rodríguez et al., 2021).

Urban Green Infrastructure Successes

Buffelsdraai Community Reforestation, South Africa: In Durban, the Buffelsdraai Landfill Site reforestation project planted over 500,000 indigenous trees around a large landfill, converting a degraded area into a carbon-absorbing forest buffer. This restored ecosystem also provides biodiversity benefits and helps the local community adapt to climate risks.

Sponge City / LID in Guangxi, China: Low-impact development (LID) designs used in "sponge city" projects such as bio-retention areas, sunken green spaces, and permeable pavements — help manage stormwater and reduce urban flooding, while enhancing vegetation and ecological services.

Miyawaki Urban Forests in India: The Miyawaki method, which builds very dense native-forest patches in small urban areas, is increasingly used in Indian cities to improve green cover rapidly, sequester carbon, and boost biodiversity. For example, in Kolkata, schoolchildren planted over 5,000 saplings of 53 species (Gatt et al., 2022).

Community-Led Plantation Projects in Developing Countries

Indus Delta, Pakistan: WWF-Pakistan worked with coastal communities to restore mangrove cover in the Indus Delta by replanting mangroves at household scale across several villages, combined with sustainable crab harvesting. This project not only boosts carbon storage, but also supports food security and sustainable income.

Trillion Tree Campaign (Global): The global "Trillion Tree Campaign," supported by Plant-for-the-Planet and UNEP, mobilizes reforestation projects around the world, especially in developing nations, to contribute to climate mitigation and ecosystem restoration(Brown & Gabrys, 2025).

Key Lessons and Insights

Community involvement is crucial: Many successful restoration projects (e.g., in Bangladesh, Kenya, and Pakistan) rely heavily on local communities for planting, maintenance, and benefit sharing. Synergy between mitigation and livelihoods: Initiatives such as mangrove restoration not only sequester carbon, but also support fisheries, food security, or ecotourism. Sustainable financing: Carbon credit schemes (e.g., Mikoko Pamoja) or global campaigns (Trillion Tree Campaign) help link local restoration to global climate finance. Adaptation and resilience: Nature-based projects provide multiple benefits beyond carbon capture such as flood control, storm protection, and urban cooling making them especially valuable in climate-vulnerable regions(Brown & Gabrys, 2025).

5. ROLE OF PLANTS IN SUSTAINABLE AGRICULTURE

Enhancing Soil Fertility and Biodiversity

Eco-friendly plants play a central role in improving soil fertility by enriching soil organic matter, enhancing nutrient cycling, and promoting beneficial microbial activity. Leguminous plants, such as clover, *Gliricidia sepium*, and *Sesbania*, fix atmospheric nitrogen through symbiotic rhizobium bacteria, reducing the need for external nitrogen inputs. Deep-rooted species increase soil aeration and help redistribute nutrients from deeper layers to the surface. Increased plant diversity also supports ecological stability by providing habitat for pollinators, natural predators of pests, and soil organisms essential for nutrient turnover. In diversified cropping systems, biodiversity improves resilience against pests, diseases, and climate stressors(Hamzah Saleem et al., 2022).

Reducing Reliance on Chemical Fertilizers

By enhancing natural soil fertility, eco-friendly plants significantly reduce dependency on synthetic fertilizers. Cover crops such as mustard, rye, and vetch suppress weeds, fix nitrogen, and prevent nutrient leaching. Green manure crops, when incorporated into the soil, release essential nutrients gradually, supporting sustainable nutrient availability. This minimizes environmental problems linked to excessive fertilizer use, such as soil acidification, groundwater contamination, and nitrous oxide emissions. In addition, organic mulching with plant residues helps retain nutrients and improves soil structure, further reducing the need for chemical inputs(Iqbal et al., 2020).

Conserving Water Through Drought-Resistant Species

Drought-resistant plants such as millets, sorghum, moringa, aloe vera, and certain native grasses play a key role in sustainable agriculture by ensuring productive yields under limited water availability. These species have adaptive traits such as deep root systems, reduced transpiration rates, and water-efficient metabolism (e.g., CAM or C_4 pathways). Integrating drought-tolerant plants into cropping systems helps conserve water, reduces irrigation demands, and enhances climate resilience, particularly in arid and semi-arid regions(Soomro et al., 2025).

Agroecology and Eco-Friendly Farming Systems

Agroecology promotes the integration of ecological principles into agricultural practices, emphasizing biodiversity, soil health, and low external inputs. Eco-friendly plants are fundamental components of agroecological systems such as agroforestry, intercropping, crop rotation, permaculture, and conservation agriculture. Trees in agroforestry systems provide shade, control erosion, add organic matter, and store carbon, while intercrops optimize resource use by maximizing light, water, and nutrient efficiency. These approaches not only boost productivity but also improve ecosystem resilience, biodiversity conservation, and long-term sustainability(Rosero et al., 2020).

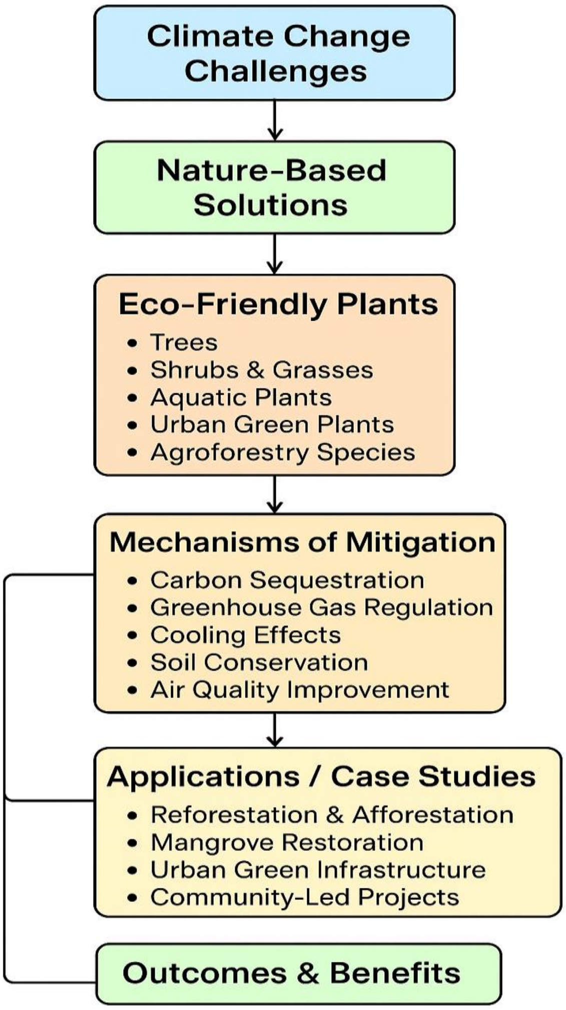

Figure No. 1: Role of Eco-Friendly Plants in Climate Change Mitigation.

6. CHALLENGES TO USING PLANTS FOR CLIMATE MITIGATION

Deforestation and Land-Use Change

Despite the promise of nature-based mitigation, ongoing deforestation and land-use change pose a major challenge. Forest loss remains a significant source of greenhouse gas emissions: deforestation accounts for a large share of the AFOLU (Agriculture, Forestry, and Land Use) sector's net CO_2 fluxes. Furthermore, even when afforestation efforts are made, carbon gains can be fragile. Carbon sequestration through vegetation and soil can be reversed by human activities (logging, land conversion) or natural disturbances like fires or pests. These dynamics underscore the difficulty of ensuring permanence: planting trees is not enough if they may later be cut or degraded (Eckardt et al., 2023).

Invasive Species Concerns

Introducing non-native plant species for climate mitigation can backfire. Some species originally intended for afforestation or restoration can become invasive, outcompeting native flora, reducing biodiversity, and destabilizing ecosystems. Climate change itself may exacerbate this risk: warming, disturbance, and shifting precipitation regimes can favor invasive species establishment.

Moreover, many policy and restoration frameworks do not sufficiently integrate invasive species management. The Invasive Species Advisory Committee (ISAC) has warned that failing to include control of invasives undermines climate adaptation goals. There are documented ecological costs too; for example, invasive plants such as *Mikania micrantha* and *Lantana camara* have been reported in forest ecosystems, disrupting native species composition and nutrient cycles(Fawzy et al., 2020).

Water Scarcity and Climate Stress on Plants

Water availability is a critical constraint on large-scale planting. In many regions suitable for afforestation, precipitation may not be sufficient to meet the water needs of new forests. Global modeling shows that 36% of potentially suitable afforestation areas lie in zones where rain only covers up to 40% of plants' water requirements. This can lead to increased water stress, competition for water with agriculture or human consumption ("green water grab"), and even dispossession of local communities. Additionally, extreme climate stress such as prolonged droughts or heatwaves may reduce survival rates of young trees or slow their growth, undermining carbon sequestration goals(Kwiatkowski et al., 2023).

Lack of Awareness and Policy Support

Although the benefits of nature-based solutions (NbS) are well-documented, there is often insufficient policy prioritization. Coordination among ministries, agencies, and sectors can be weak, leading to fragmented implementation of restoration or planting programs. Funding is another major barrier: only a small fraction of climate finance is directed toward nature-based solutions. For example, just 1.5% of public international climate finance reportedly supports NbS for adaptation in developing countries. Moreover, there is a lack of standard metrics and long-term monitoring frameworks, making it difficult to track, validate, and scale up nature-based projects. At the community level, lack of ecological knowledge and limited awareness among local stakeholders (farmers, landowners) can hinder the adoption of native species and sustainable planting practices(Kwiatkowski et al., 2023).

7. FUTURE PROSPECTS AND POLICY RECOMMENDATIONS

The role of eco-friendly plants in climate change mitigation can be significantly enhanced through strategic integration into national and regional climate action plans. Policymakers should prioritize the inclusion of forests, wetlands, and urban green spaces in carbon accounting and mitigation frameworks to ensure measurable climate benefits. Promoting community-based reforestation programs empowers local populations, enhances stewardship, and ensures the long-term sustainability of planted ecosystems. Expanding urban green infrastructure including street trees, green roofs, and pocket parks not only sequesters carbon but also mitigates urban heat islands, improves air quality, and enhances public well-being. Furthermore, investing in research on climate-resilient plant species will identify drought-tolerant, fast-growing, and multi-benefit species suitable for diverse ecosystems. Together, these strategies can strengthen the contribution of nature-based solutions, making plant-based climate mitigation a sustainable, cost-effective, and socially inclusive component of global climate action(Zhang & Hayashi, 2023).

8. CONCLUSION

Eco-friendly plants play a critical role in mitigating climate change by sequestering carbon, regulating greenhouse gases, conserving water, and supporting biodiversity. Their integration into forests, agricultural systems, wetlands, and urban areas enhances ecosystem resilience while providing multiple co-benefits, including soil fertility, air purification, and climate adaptation. Sustainable ecosystem management through reforestation, agroforestry, and urban greening ensures that these benefits are maintained over time. To maximize impact, policymakers, researchers, and communities must collaborate, prioritize native and climate-resilient species, and implement science-based strategies. Collective action is essential to harness the full potential of plants as a natural, cost-effective solution to climate change.

9. REFERENCES

1. Ahirwar, N. K., Singh, R., Chaurasia, S., Chandra, R., & Ramana, S. (2020). Effective role of beneficial microbes in achieving the sustainable agriculture and eco-friendly environment development goals: a review. *Front. Microbiol*, *5:* 111–123.
2. Ahmad, A., & Iqbal, T. (2025). *Multifaceted Benefits of Basil (Ocimum spp.): Agriculture, Culinary, and Medicinal Uses*.
3. Almalki, F. A., Alsamhi, S. H., Sahal, R., Hassan, J., Hawbani, A., Rajput, N. S., Saif, A., Morgan, J., & Breslin, J. (2023). Green IoT for eco-friendly and sustainable smart cities: future directions and opportunities. *Mobile Networks and Applications*, *28*(1): 178–202.
4. Brown, D., & Gabrys, J. (2025). Community-led landscape regeneration: A review of and framework for engagement in restoration initiatives. *Ambio*, 1–18.
5. Eckardt, N. A., Ainsworth, E. A., Bahuguna, R. N., Broadley, M. R., Busch, W., Carpita, N. C., Castrillo, G., Chory, J., DeHaan, L. R., & Duarte, C. M. (2023). Climate change challenges, plant science solutions. *The Plant Cell*, *35*(1): 24–66.
6. El-Bichri, F.-Z., Sobhy, I., Bouchefra, I., Benhamou, B., & Chehouani, H. (2024). Building a sustainable future: evaluating eco-friendly materials for energy efficiency and climate change mitigation. *Advances in Building Energy Research*, *18*(2): 156–179.
7. Fawzy, S., Osman, A. I., Doran, J., & Rooney, D. W. (2020). Strategies for mitigation of climate change: a review. *Environmental Chemistry Letters*, *18*(6): 2069–2094.
8. Gatt, Y. M., Andradi-Brown, D. A., Ahmadia, G. N., Martin, P. A., Sutherland, W. J., Spalding, M. D., Donnison, A., & Worthington, T. A. (2022). Quantifying the reporting, coverage and consistency of key indicators in mangrove restoration projects. *Frontiers in Forests and Global Change*, *5:* 720394.
9. Gerona-Daga, M. E. B., & Salmo III, S. G. (2022). A systematic review of mangrove restoration studies in Southeast Asia: Challenges and opportunities for the United Nation's Decade on Ecosystem Restoration. *Frontiers in Marine Science*, *9:* 987737.
10. Hamzah Saleem, M., Usman, K., Rizwan, M., Al Jabri, H., & Alsafran, M. (2022). Functions and strategies for enhancing zinc availability in plants for sustainable agriculture. *Frontiers in Plant Science*, *13:* 1033092.
11. Iqbal, A., Hamayun, M., Shah, F., & Hussain, A. (2020). Role of plant bioactives in sustainable agriculture. In

Environment, climate, plant and vegetation growth (pp. 591–605). Springer.

12. Kodadi, S. K., Manimekalai, K., Rabeek, S. M., Kalme, S. U., & Nathsharma, S. K. (2025). Nanotechnology And Green Nanomaterials: Modern Eco-Friendly Sustainable Approach For Combating The Environmental Effects Of Climate Change. *International Journal of Environmental Sciences*, *11*(12s): 238–254.
13. Kwiatkowski, C. A., Pawłowska, M., Harasim, E., & Pawłowski, L. (2023). Strategies of climate change mitigation in agriculture plant production—A critical review. *Energies*, *16*(10): 4225.
14. Nanjundan, P., & Thomas, L. (2024). AI as Sustainable and Eco-Friendly Environment for Climate Change. In *AI for Climate Change and Environmental Sustainability* (pp. 1–18). CRC Press.
15. Panicker, T. V. (2024). Adopting eco-friendly technologies for a sustainable environment. *Ecology, Environment and Conservation*, *30*: S322–S326.
16. Rodríguez-Rodríguez, J. A., Mancera-Pineda, J. E., & Tavera, H. (2021). Mangrove restoration in Colombia: Trends and lessons learned. *Forest Ecology and Management*, *496:* 119414.
17. Rosero, A., Granda, L., Berdugo-Cely, J. A., Šamajová, O., Šamaj, J., & Cerkal, R. (2020). A dual strategy of breeding for drought tolerance and introducing drought-tolerant, underutilized crops into production systems to enhance their resilience to water deficiency. *Plants*, *9*(10): 1263.
18. Saha, P., Gunturi, A., Barman, A., Patel, S., Roy, S., Roy, A., Sen, S., & Roy, P. (2024). Agroforestry: An Eco-friendly Strategy for Reducing and Adapting to Climate Change. In *Agroforestry Solutions for Climate Change and Environmental Restoration* (pp. 261–279). Springer.
19. Soomro, S., Boota, M. W., Guo, J., Li, Y., Qin, H., Ahmad Meahrayen, M., Hu, C., Gu, J., & Chen, J. (2025). Drought management for long-term water sustainability and resilience. *Marine and Freshwater Research*, *76*(5): MF24210.
20. Yadapadithaya, P. S., Naik, P., & Nayak, K. (2022). Implementation of Environment-Friendly Strategies for Energy Conservation and Mitigation of Climate Change–A Holistic Approach in Mangalagangotri Campus. *Journal of Sustainability Perspectives*, *2*: 209–218.
21. Zhang, J., & Hayashi, Y. (2023). Policy recommendations and future challenges. In *Transportation Amid Pandemics* (pp. 453–460). Elsevier.
22. Zuma, M., Arthur, G., Coopoosamy, R., & Naidoo, K. (2023). Incorporating cropping systems with eco-friendly strategies and solutions to mitigate the effects of climate change on crop production. *Journal of Agriculture and Food Research*, *14:* 100722.