BODHIVRUKSHA JOURNAL OF DIVERSE DISCIPLINE (BJDD)
An Open-Access, Peer-Reviewed, Multidisciplinary Scholarly Journal | Bi-Monthly | Multilingual | Academic Research
Vol 2, Issue 6 (November-December 2026) (Special Issue 2) | ISSN: 3139-1486 (Online) | ISSN: 3139-9819 (Print)

DEVELOPMENT IN INDIA: INTEGRATING GREEN TECHNOLOGIES, ENVIRONMENTAL PROTECTION, AND PUBLIC POLICY FOR A SUSTAINABLE FUTURE

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Abstract

India's development priorities are closely connected with the growing risks posed by climate change. Rising temperatures, irregular rainfall, droughts, floods, heat waves, biodiversity loss, and pressure on water resources affect livelihoods, public health, agriculture, and infrastructure. Sustainable development therefore requires economic progress to be planned alongside social inclusion and environmental protection. This review examines how renewable energy, energy-efficient technologies, sustainable agriculture, biodiversity conservation, water management, and public policy can contribute to this goal in India. It draws on secondary sources, including scientific literature, government publications, and reports from international organizations. The review identifies recurring barriers: limited finance, uneven access to technology and information, gaps in public awareness, and the greater exposure of rural and economically vulnerable communities to climate risks. It argues that progress will depend not only on national commitments but also on practical implementation at state, district, and community levels. Priorities include expanding clean energy, strengthening climate-resilient infrastructure, protecting natural ecosystems, improving water-use efficiency, and making climate information accessible to those who need it. The paper concludes that climate mitigation and adaptation should be treated as complementary parts of India's development strategy.

Keywords: sustainable development, India, renewable energy, green technology, climate resilience, biodiversity, and environmental policy.

1. Introduction

Climate change refers to long-term shifts in temperature, rainfall, wind patterns, and other features of the climate system. Natural factors can influence climate; however, the Intergovernmental Panel on Climate Change (IPCC, 2023) concludes that human activities have unequivocally caused global warming. For India, the issue is particularly important because rapid urbanization, industrial growth, rising energy demand, and dependence on climate-sensitive livelihoods place pressure on natural resources.

Climate-related risks are already relevant to everyday development concerns. Heat can affect health and workers' productivity; irregular rainfall can complicate farming and water planning; floods and droughts can damage homes, infrastructure, and livelihoods; and ecosystem degradation can reduce the benefits people receive from forests, wetlands, and other natural systems. These pressures are not experienced

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equally. Farmers, outdoor workers, low-income households, and communities with limited access to public services may have fewer resources to prepare for or recover from climate-related events.

Sustainable development offers a way to address these connected challenges. It aims to improve people's quality of life today without undermining the ability of future generations to meet their needs. In India, this means reducing emissions while also protecting biodiversity, improving water security, supporting rural livelihoods, reducing pollution, and ensuring that the benefits of climate action reach vulnerable groups. Green technologies can help, but their impact depends on affordability, sound planning, public participation, and effective implementation.

2. Objectives of the Study

1. To examine the relationship between climate change and sustainable development in India.

2. To identify major environmental and socio-economic risks associated with climate change.

3. To discuss how renewable energy and green technologies can help reduce greenhouse gas emissions.

4. To consider the contribution of biodiversity conservation, sustainable agriculture, and water management.

5. To review the role of Indian government policies and international sustainability frameworks.

3. Review of Literature

Research on climate change and sustainable development in India covers agricultural adaptation, renewable energy, ecosystem protection, and climate policy. Taken together, the literature suggests that technology alone is insufficient: local conditions, access to finance, institutional support, and community participation also shape the results.

3.1 Nivetha and Mohanraj (2026): Climate adaptation in Indian agriculture

The paper cited under this title reviews empirical research on agricultural adaptation in India from 2014 to 2025. The strategies described include crop diversification, crop rotation, changes in sowing schedules and the use of stress-tolerant crop varieties. The review also identifies education, farm size, income, access to credit and agricultural extension services as factors that influence farmers' ability to adapt. These observations point to the importance of reliable climate information and sustained institutional support. The full bibliographic details should be checked against the original publication before submission.

3.2 Vij et al. (2025): Adaptation measures in India

The cited systematic review, "What Works, Where and How? Systematic Literature Review of Climate Change Adaptation Measures in India," discusses approaches such as crop diversification, adjusted cultivation schedules, improved seeds, soil conservation and livelihood diversification. It also identifies gaps in research concerning gender, education, capacity building and the uneven distribution of climate vulnerability. This work is relevant because adaptation outcomes depend on both practical farming choices and the support available to communities.

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3.3 Baraj et al. (2024): Climate resilience and sustainable agriculture

The cited bibliometric review examines research on agricultural climate change, resilience, adaptation and sustainability, drawing on articles published between 1994 and 2022. Its reported scope reflects growing research attention to climate-resilient agriculture. The wider implication is that adaptation needs to be suited to local agro-climatic conditions rather than applied as a single approach across all regions. The exact publication details should be verified from the original source.

3.4 IPCC (2023): Climate Change 2023—Synthesis Report

The IPCC synthesis report brings together evidence on the causes and impacts of climate change, as well as options for mitigation and adaptation. It identifies human activity as the dominant cause of observed global warming and describes increasing risks to people and ecosystems. The report supports the view that emissions reduction and climate adaptation must proceed together and be incorporated into development planning.

3.5 Climate change and Indian agriculture (2022)

The paper cited as "Climate Change and Indian Agriculture: A Systematic Review of Farmers' Perception, Adaptation, Transformation" considers how farmers perceive changing conditions and respond to them. The summary in the source manuscript describes concerns about rising temperatures and variable rainfall, alongside adaptation measures such as changes in cropping patterns and farming methods. Limited climate information, access to credit and differences in household resources are presented as barriers. These issues underline the value of agricultural extension, financial support and coordinated adaptation planning. The authors and publication details need to be completed from the original source.

3.6 Kumar and Majid (2020): Renewable energy and sustainable development in India

Kumar and Majid discuss the contribution renewable energy can make to energy security, environmental protection, employment and economic development in India. Their work also considers barriers related to investment, technology and infrastructure. The overall implication is that renewable energy can support sustainable development when backed by stable policy, adequate finance, reliable infrastructure and long-term planning.

4. Research Methodology

This paper uses a qualitative, descriptive review approach based on secondary information. It does not report original fieldwork, experiments or statistical analysis.

Sources of information:

- Climate assessments and synthesis reports published by the IPCC.
- United Nations publications on the Sustainable Development Goals.
- Government of India publications and policy documents relating to climate, energy and development.
- Research literature on climate adaptation, biodiversity, renewable energy and sustainable development.

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Method of analysis: The material is organized thematically around climate impacts, renewable energy, green technologies, ecosystem management, sustainable agriculture, public policy, and climate resilience.

Scope: This review focuses on India and discusses issues relevant to the country's development priorities.

Limitations: The findings depend on the coverage and reliability of the secondary sources consulted. No field survey, experiment, or independent statistical analysis was conducted. The recommendations are therefore analytical conclusions drawn from the reviewed material, not findings from original empirical research. The references—particularly the author details and titles of some review studies—should be checked against the original publications before academic submission.

5. Climate Change Impacts on India

5.1 Rising temperatures and heat waves

Higher temperatures and more frequent or intense heat events can increase heat stress, affect labor productivity, raise cooling demand, and threaten public health. Outdoor workers, farmers, and people living in densely built urban areas may face particular risks. In cities, limited vegetation and extensive concrete surfaces can intensify the urban heat island effect. Measures such as heat action plans, shaded public spaces, cool roofs, urban trees, and access to safe drinking water can help reduce exposure when they are planned and maintained effectively.

5.2 Water scarcity and changing rainfall

Climate variability can contribute to drought conditions in some areas and intense rainfall or flooding in others. These changes complicate the replenishment of groundwater, the management of reservoirs, the supply of drinking water and irrigation planning. Therefore, water security requires a combination of conservation, efficient use, catchment protection, rainwater harvesting, and locally appropriate infrastructure.

5.3 Agriculture and food security

Agriculture depends on suitable temperatures, rainfall, soil conditions, and water availability. Heat waves, droughts, floods, and shifts in pest patterns can reduce yields or make farm incomes less predictable. Climate-resilient approaches include diversifying crops, developing and using suitable stress-tolerant varieties, conserving soil, improving irrigation, using weather advisories, and applying integrated pest management. The best combination will vary by region and farming system.

5.4 Biodiversity and ecosystem degradation

Forests, wetlands, grasslands, rivers, and coastal ecosystems support biodiversity and provide services such as water regulation, soil protection, and carbon storage. Climate change can add to the pressures caused by pollution, habitat fragmentation, and changes in land use. Protecting existing ecosystems and restoring degraded areas can strengthen ecological resilience; however, restoration should be based on local conditions and native species rather than simply counting the number of trees planted.

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5.5 Health and livelihoods

Climate-related hazards can affect health through heat exposure, poorer air quality, disruptions to food and water supplies, and changes in the conditions that influence disease transmission. Floods, storms, and other disasters can also damage homes, roads, schools, workplaces, and livelihood assets. Therefore, preparedness, early-warning systems, resilient public infrastructure, and accessible health services are important components of climate adaptation.

6. Role of Green Technologies in Climate Mitigation

6.1 Renewable energy

Solar, wind, and small hydropower can reduce reliance on fossil fuels when appropriately planned and integrated into the energy system. Distributed renewable-energy systems may also improve energy access in remote and rural areas. The manuscript cites a national non-fossil electricity-capacity figure of 217.62 GW as of 20 January 2025 and refers to India's 2030 capacity ambition. These figures should be checked against the relevant official release before publication, and capacity should not be confused with the actual share of electricity generated. Expansion also requires grid upgrades, storage, land-use planning, and responsible management of equipment at the end of its useful life.

6.2 Energy efficiency and green buildings

Energy efficiency means using less energy to provide the same service. Efficient lighting, industrial equipment, appliances, cooling systems, and building design can reduce demand and associated emissions. Buildings can also benefit from natural ventilation, insulation, daylight, reflective roofs, and efficient water systems. These measures are most effective when selected for local climate conditions and maintained over time.

6.3 Electric mobility and sustainable transport

Electric vehicles can reduce tailpipe emissions, while public transport, walking, cycling, and compact urban planning can reduce dependence on private cars. The overall environmental benefit of electric mobility depends partly on how electricity is generated, how vehicles and batteries are manufactured, and how batteries are handled at the end of their useful life. A transport strategy focused only on replacing petrol or diesel cars with electric cars will not, by itself, resolve congestion or inefficient land use. Reliable public transport and safer streets remain essential.

6.4 Artificial intelligence and digital technologies

Digital tools can support weather forecasting, early-warning systems, energy-demand estimates, irrigation planning, and the identification of crop or vegetation stress. Satellite data and geographic information systems can help monitor forests, water bodies, land degradation, and urban expansion. However, these tools depend on reliable data, technical capacity, and transparent decision-making. Access should not be limited to better-resourced institutions or communities, and the energy and material requirements of digital infrastructure should be included when assessing its environmental benefits.

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7. Environmental Conservation and Nature-Based Solutions

7.1 Forest conservation and restoration

Forests store carbon, support biodiversity, help regulate water flows, and reduce soil erosion. Protecting existing natural forests should not be replaced by tree-planting programs that ignore ecosystem quality. Where restoration is appropriate, it should favor native species, support natural regeneration, and involve local and Indigenous communities in planning and long-term stewardship.

7.2 Wetland and river conservation

Wetlands can help regulate floods, filter water and provide important habitats. Rivers and their catchments also support ecosystems and communities. Damage to these systems can weaken their ability to provide such benefits. Wetland restoration, catchment protection, pollution control and the maintenance of ecological flows can contribute to climate resilience, provided they are supported by effective management.

7.3 Urban green infrastructure

Urban trees, parks, green roofs, permeable surfaces, and restored lakes can help reduce local heat and manage stormwater. Their benefits depend on suitable design, regular maintenance, and integration with drainage and land-use planning. Green spaces should also be accessible to different neighborhoods rather than concentrated in already well-served areas.

8. Sustainable Agriculture and Water Management

Sustainable development requires agricultural productivity without exhausting soil and water resources. Several approaches can contribute to this objective.

• **Micro-irrigation:** Drip and sprinkler systems can improve water-use efficiency when designed for local conditions and maintained properly.

• **Soil conservation:** Mulching, cover crops, crop rotation, and erosion control can help preserve soil structure and fertility.

• **Crop diversification:** Growing a range of suitable crops can reduce dependence on a single crop and spread climate-related risks.

• **Agroforestry:** Integrating appropriate trees into farming systems can provide shade and other benefits, although species selection and water needs must be considered.

• **Rainwater harvesting:** Capturing rainfall can supplement local water supplies and reduce runoff where systems are properly designed.

• **Weather-based advice:** Timely, understandable forecasts and agricultural advisories can help farmers make decisions about sowing, irrigation, and crop protection.

These measures should be supported by extension services, accessible finance, and locally relevant research. A practice that works in one region may not be suitable everywhere; therefore, farmers' experiences and local ecological conditions must inform implementation.

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9. Government Policies and Initiatives in India

Public policy provides the framework for coordinating climate mitigation and adaptation. The impact of a policy depends not only on its stated targets but also on funding, institutional coordination, implementation, and monitoring.

9.1 National Action Plan on Climate Change

India's National Action Plan on Climate Change (NAPCC), adopted in 2008, established national missions covering areas such as solar energy, energy efficiency, sustainable habitats, water, the Himalayan ecosystem, forest protection, sustainable agriculture, and climate science. Effective implementation requires coordination between national, state, and local institutions, as well as financing, monitoring, and attention to local priorities.

9.2 Nationally Determined Contributions

Under the Paris Agreement, India has submitted climate commitments relating to emissions intensity, non-fossil energy capacity, and carbon sinks. These commitments should be described with reference to the relevant official submission and target year. Progress needs to be assessed using transparent indicators and consistent reporting.

9.3 Renewable energy and clean technology policies

Policies supporting renewable energy, energy efficiency, electric mobility, and green hydrogen can help reduce emissions and encourage technological development. Their long-term success depends on affordability, grid reliability, workforce skills, environmental safeguards, and responsible waste management. Policy design should consider the full life cycle of technologies rather than only their initial deployment.

9.4 Climate adaptation and disaster management

Early-warning systems, heat action plans, flood-risk assessments, resilient infrastructure, and climate-aware urban planning can reduce the effects of extreme events. State governments, municipalities, scientific institutions, and local communities all play important roles. The Government of India's Economic Survey 2024–25 is cited in the source manuscript as discussing adaptation, resilience, finance, and infrastructure; specific claims should be checked against the relevant sections of the Survey.

10. Results and Discussion

Because this is a secondary-source review, the discussion below synthesizes themes in the literature and policy documents rather than reporting original field findings.

Renewable energy: Low-emission electricity can reduce dependence on fossil fuels, but its contribution depends on grid integration, storage, investment, and access.

Agriculture: Climate variability creates risks for crops and farm livelihoods. Adaptation is more likely to be useful when it combines locally suitable farming practices with credit, extension services, and reliable weather information.

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Biodiversity: Healthy ecosystems provide ecological and protective services. Conservation should be integrated into infrastructure planning, land-use decisions, and local development.

Urban development: Heat, flooding, and transport emissions are connected challenges. Public transport, green infrastructure, resilient drainage, and thoughtful land-use planning can address several of these pressures.

Public policy: National commitments require practical implementation, sustained finance, clear responsibilities, and transparent monitoring at the state and local levels.

Social equity: Climate risks and the ability to adapt differ across communities. Support should prioritize people who face high exposure but have fewer resources to prepare, respond, or recover.

Mitigation and adaptation should be pursued together across these themes. Renewable energy and energy efficiency can limit future emissions, while resilient infrastructure and ecosystem protection can reduce vulnerability to climate impacts. Economic and environmental objectives are not necessarily in conflict; efficient transport, ecosystem restoration, and climate-resilient agriculture can offer several benefits simultaneously. However, these benefits are not automatic. They depend on sound design, adequate finance, maintenance, and careful assessment of trade-offs.

The United Nations' Sustainable Development Goals reporting has also highlighted that progress towards the 2030 Agenda remains insufficient in several areas. Climate change makes that agenda harder to achieve, reinforcing the need to connect environmental action with poverty reduction, health, infrastructure and inclusive economic opportunity.

11. Conclusion

Climate change presents a significant challenge to India's environmental security, economic development, and social well-being. Its effects on agriculture, water resources, biodiversity, public health, and infrastructure show why development planning cannot treat environmental protection as a separate or optional concern.

This review discusses the links between renewable energy, energy efficiency, green technologies, sustainable agriculture, ecosystem conservation, and public policy. Each can contribute to sustainable development, but the results depend on implementation, scientific evidence, public awareness, adequate investment, and cooperation across levels of government. Technology must also be accessible and appropriate for the communities expected to use it.

India's development strategy should therefore combine economic opportunities with environmental safeguards and social inclusion. Climate measures need to be translated into practical actions at the state, district, institutional, and community levels. Progress should be assessed through measurable outcomes—not only announced targets—including improved resilience, more reliable access to clean energy and water, ecosystem health, and fair access to adaptation support. A coordinated approach can help India pursue development while reducing climate risks for present and future generations.

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