

Strategies for leading towards a Low-Carbon, Climate-Resilient Future of a Tier-II city in India: Case study of Bhopal

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Abstract

Bhopal, the capital city of Madhya Pradesh, faces growing urban challenges including rapid population growth, infrastructural demands, and climate change impacts. This paper presents a comprehensive analysis of Bhopal's climate action plans and strategies to transition towards a low-carbon, climate-resilient development pathway. Drawing from the Climate Smart Cities Assessment Framework (CSCAF) and greenhouse gas (GHG) emissions inventory, the paper evaluates Bhopal's current performance across key sectors such as energy, urban planning, mobility, water management, and waste management. It identifies critical gaps and areas for improvement, proposing actionable recommendations to enhance energy efficiency, promote renewable energy, conserve biodiversity, improve waste management, and build climate-resilient infrastructure. The paper underscores the importance of integrated, multi-sectoral approaches and citizen engagement in realizing Bhopal's vision of sustainable urban development.

Keywords: Low carbon footprint, Solar city, Energy efficient infrastructure, solid waste management, climate resilient

Introduction

Bhopal, known as the "City of Lakes," is a rapidly urbanizing metropolitan area in central India. Being the state capital and the district headquarters, Bhopal is situated in the Vindhya and Malwa plateau region (23 16'N, 77 22'E) and has a unique physiography with the Narmada valley in the central-east, Bhoj wetland towards the south-east, Berasia shrub forests in the west, upper and lower lake views, and various hill points. The city – also referred to as the 'city of lakes' – falls under the humid-tropical climatic zone, which contributes to its micro-climatic variabilities to a great extent. Located at 192 km from Indore and surrounded by significant tourist and trade destinations, the city is well connected by road, rail, and air routes.

According to the 2011 Census, the population of Bhopal city (the area under Bhopal Municipal Corporation) was 1,798,218, with 936,168 males and 862,050 females. The highest average elevation is 542m and the lowest elevation is 479m above mean sea level. Presently Bhopal municipal corporation has a population of 23,71,000, across 85 wards occupying a total area of 417.8 km². Its population density is 50 persons per hectare (PPH), which is quite less compared to the other cities of Madhya Pradesh. With a population of over 2.3 million and a decadal growth rate of 27.53%, the city faces increasing pressure on its urban infrastructure and growing concerns about climate change impacts. This paper examines Bhopal's efforts to advance city climate action and achieve low-carbon, climate-resilient development goals.

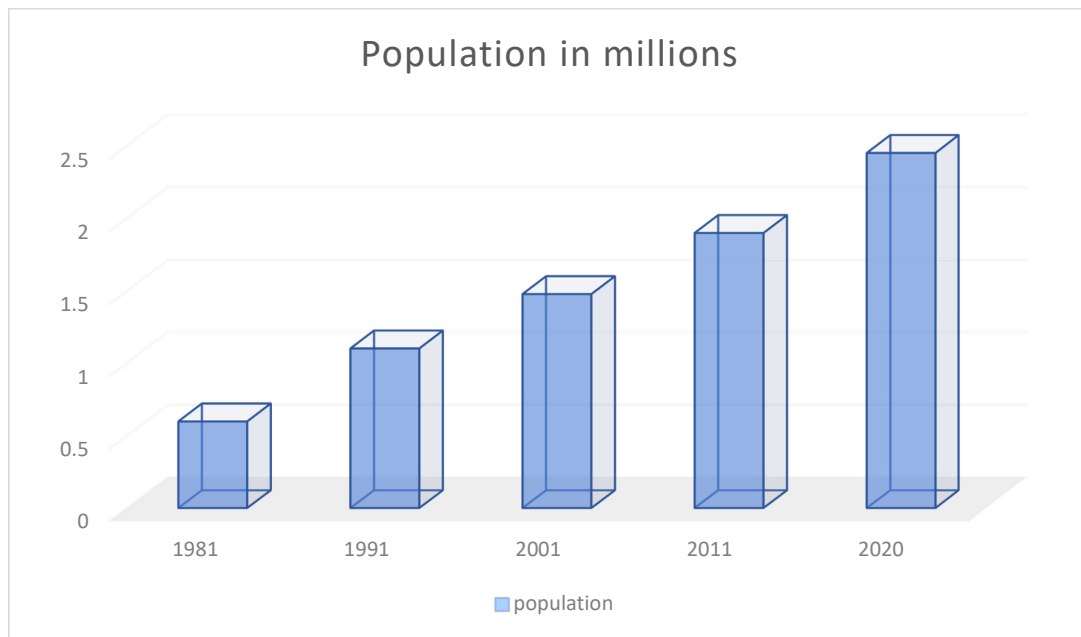


Fig:1 Decade wise population of Bhopal City [12]

Methodology

The research involves a comprehensive analysis of Bhopal's climate action plans, policies, and initiatives, drawing from various sources, including:

1. Climate Smart Cities Assessment Framework (CSCAF) evaluation
2. Greenhouse gas (GHG) emissions inventory
3. Smart City Proposal and development plans
4. Government reports and policy documents
5. Relevant academic literature and case studies

The analysis covers key sectors such as energy and green buildings, urban planning, green cover and biodiversity, mobility and air quality, water management, and waste management. It identifies current measures, challenges, and areas for improvement, proposing actionable recommendations to address gaps and enhance climate resilience. Following goals are to be fulfilled. [1,3]

Goal 1 Transform Bhopal into a solar city

- Promoting energy efficiency improvements and renewable energy use in MSMEs
- Piloting solar bus stops
- Exploring common solar PV projects for low-income community housing
- Installing solar water heaters and solar photovoltaic panels on rooftops of educational institutions

- Incentivizing installation of rooftop solar panels and solar water heaters in all new residential constructions.
- 100% RE-powered educational campuses • Green hospitals and hotels
- PPP engagement for efficient infrastructural distribution.

Goal 2 Sustainable & circular waste management economy in Bhopal

Innovative models for managing electronic waste in Bhopal

- Piloting fuel generation from plastic waste
- Connecting all the vegetable and fruit markets in the city with the proposed 200 TPD bio-CNG plant
- Upgrading waste collection and transportation infrastructure to electric vehicles
- Public-private partnership models for managing construction and demolition waste

Goal 3 Greening the transport sector in Bhopal

- Improving last mile connectivity of planned metro in Bhopal
- Piloting electric buses as part of Mybus (Bhopal BRTS)
- NMT focused street design guidelines for Bhopal
- Promoting electric two wheelers in Bhopal
- Fuel efficiency training and management for public and private bus operators
- Increasing the spatial network of Pollution Under Control (PUC) certificate and Ambient Air Quality (AAQ) Monitoring System stations in the city

Goal 4 Green & inclusive spaces in Bhopal

Engaging citizens in urban green cover conservation

- Promoting green terraces and kitchen gardens in residential buildings and schools
- Bioremediation for conserving the Bhoj wetland (upper and lower lakes)
- Institutionalizing a tree cell to prevent illegal logging and implementing policies for scientific transplantation and heritage tree protection
- Data, information, and awareness for biodiversity conservation.

Goal 5 Water-resilient Bhopal

- Developing and implementing a demand management plan for Bhopal city
- Developing and implementing an integrated flood and storm water management plan
- Implementing solar-powered sewage treatment plants.

Goal 6 Sustainable & climate-resilient infrastructure in Bhopal

Implementing measures to promote green buildings in Bhopal

- Promoting low-carbon, ECBC compliant development in the construction of government housing phase II & III under ABD, heritage development of Sadar Manzil and place making projects
- Promotion of green and cool roofs in residential projects/ colonies/apartments to reduce cooling demand.

Findings and Discussion

Energy and Green Buildings

1. Bhopal has taken steps towards becoming a "solar city," with initiatives like rooftop solar installations, street lighting projects, and energy audits.
2. However, renewable energy sources currently meet only 0.05% of the city's energy demand, highlighting the need for accelerated adoption of clean energy technologies.
3. Recommendations promoting energy efficiency improvements, incentivizing rooftop solar installations, and implementing green building codes to reduce energy consumption and emissions have been given.
4. 37.35% of street lighting is LED and energy efficient, City is promoting green buildings.
5. Six Energy Conservation Building Code (ECBC) /Eco Niwas Samhita (ENS) compliant buildings have obtained construction approval through 2019-20.
6. 5MW solar rooftop energy projects have been set up in the city as part of the city's solar energy project with lake front solar. [2,5]

Areas of improvement

1. Reducing transmission and distribution losses from 28% in 2019.
2. Increasing power generation from Renewable Energy sources (0.05% currently).
3. Promoting and adopting green buildings.

Urban Planning, Green Cover, and Biodiversity

1. Bhopal has experienced a significant reduction in green cover, from 92% in 1977 to 7% in 2021, necessitating urgent conservation efforts.
2. The city has initiated measures like Miyawaki plantations, biodiversity parks, and a city biodiversity index to protect its ecological assets.
3. Recommendations include strengthening implementation of green space conservation policies, curtailing development around sensitive areas like the Bhoj wetland, and promoting citizen engagement in urban greening initiatives.
4. More than 18% of the municipal area is under green cover, plantation has been done in places at various locations like Bhopal Water and Land Management Institute.
5. Ankur program – where citizens are awarded for tree plantation – has been launched in the state and Pradhan Mantri Awas Yojana (PMAY) has been linked to it.

6. Bhopal has initiated a city level biodiversity management committee, which has calculated its city biodiversity index, developed a people's biodiversity register and identified measures within the green and blue master plan to increase biodiversity. [13]

Areas of improvement

1. City should monitor the impact of the biodiversity strategies.
2. There is a need to monitor, update & mainstream the disaster management plan within departmental plans.

Mobility and Air Quality

1. Bhopal has implemented initiatives such as the Clean Air Action Plan, public bike-sharing systems, and plans for electric buses and metro rail.
2. However, challenges persist, including limited clean fuel vehicles, inadequate public transportation coverage, and the need for institutional capacity building.
3. The paper suggests increasing the uptake of clean fuel vehicles, expanding the public transportation network, and strengthening air quality monitoring and enforcement mechanisms.
4. 18% of buses run on CNG, even Metro is under construction
5. Clean Air Action Plan of the city is in place and under implementation. Simultaneously monitoring daily air quality index levels and making it public is a common practise
6. 215 low floor buses are in use, 275 more planned as of 2022. Plans of electrifying public bike sharing system- 94 stations installed with 480 cycles in operation and currently 30000+ users registered Placemaking projects in certain areas such as New Market, Subhash school area, Alkpuri park, etc are under construction.

Areas of improvement

1. Increasing the number of public buses, because only 0.09 buses are available per 1000 population.
2. Increasing the Non-Motorised Transport (NMT) coverage of road length (15.56% currently).
3. Increasing uptake of clean fuel vehicles (less than 15% of shared mobility vehicles run on clean fuels)

Water Management

1. Bhopal has undertaken efforts to increase water harvesting, introduce consumer metering, and implement dual piping systems for water conservation.
2. Challenges include high non-revenue water (20-30%) and low wastewater recycling and reuse (<5%).
3. Recommendations include reducing water losses, increasing wastewater treatment and reuse, and developing integrated flood and stormwater management plans.

Waste Management

1. Bhopal has achieved significant progress in waste management, including door-to-door waste collection, composting facilities, and material recovery facilities.
2. Challenges remain in capturing methane from landfills and sewage treatment plants and enhancing waste transportation infrastructure.
3. The paper suggests exploring waste-to-energy solutions, upgrading waste collection vehicles, and increasing the capacity for bio-methanation of organic waste.
4. Bhopal city has authorized and integrated waste pickers and 100% of segregated domestic waste is collected at doorstep.
5. 96% of the wet waste is recycled in the city using four composting pits. • Six MRFs (material recovery facilities) for dry waste processing have been provided.
6. 100% C&D waste is being processed in a 100 TPD plant and used in low lying areas and paving blocks. [14,15]

Areas of improvement

1. Capturing of methane gas from scientific landfill and sewage treatment plants. There is a need for more waste transport infrastructure, 41 new vehicles for collecting garden waste and construction and demolition waste are needed.
2. GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary). Stationary energy contributes 56% to the city's total emissions, followed by 28% from transportation. Waste and wastewater sector contributes 16% to the total emissions.
3. The emissions are projected to increase by 18.6 % by 2025 and 40% by the end of the decade till 2030 compared to the baseline emissions of 2019. This creates an urgent need for the city to implement measures presented in the report for achieving its vision of low carbon and climate resilient development. [16]

Conclusions

Identified Actions for Bhopal

Action 1: Promote energy efficiency improvements and renewable energy use in MSMEs

Action 2: Pilot solar bus stops

Action 3: Explore common solar PV projects for low-income community housing

Action 4: Install solar water heaters and solar photovoltaic panels on rooftops of educational institutions

Bhopal is home to some of the nationally renowned research facilities and academic institutions including ISRO's Master Control Facility, All India Institute of Medical Sciences Bhopal, National law academy, Maulana Azad National Institute of Technology and School of Planning and Architecture (SPA) along with 200 other engineering, management and medical institutions. These educational buildings in Bhopal have the potential to use renewable energy for their daily heating purposes by installing solar water heaters and generating clean energy

by installing rooftop solar panels. For example, Bhabha University in Bhopal has set up a 100-kW solar power plant in the campus to reduce its dependence on non-renewable forms of energy. The plant produces an average of 500 kWh a day and reduces carbon footprint by 136 tonnes annually

Action 5: Incentivize installation of rooftop solar panels and solar water heaters in all new residential constructions

Subsidies: Few cities like the Diu Smart City offers all its residents an installation subsidy of Rs 10,000-50,000 for installing a 1-5 kW capacity roof solar PV. It is observed that this helped reduce power tariffs by 10-15% each year. Karnataka State Govt provides rebate of 50 paise per unit up to Rs 50 per month for installing SWH. Pune also provides a 5% tax rebate for one energy efficiency initiative out of SWH, composting or RWH

Mandate: Bhopal can mandate all new buildings to have solar water heaters. This should be included in the building by-laws. BESCOM in Bengaluru requires developers to install solar water heaters in dwellings with a floor space of 600 ft², i.e., 56 m², or above. The mandatory solar thermal capacity is linked to room size and increases based on the interior space available. - Awareness training workshops for resident welfare associations and large-scale distributors on benefits of implementing solar rooftop, available incentives, etc. - Collaborating with NGOs or research students working in the energy space to develop a Do-It Yourself (DIY) solar tool: a step-by-step guidance to consumers on how to install solar PV, available financing subsidies, application process and policies. A similar tool was developed by an NGO in Bangalore which has been used by nearly 15000 citizens. This tool can also include a 24x7 helpline number for citizens to call and clarify doubts on the installation process.

Further following points must be noticed

- 1) Bhopal has taken notable steps towards city climate action, but significant challenges persist in achieving its vision of low-carbon, climate-resilient development.
- 2) The research highlights the need for integrated, multi-sectoral approaches, stakeholder collaboration, and citizen engagement to address the identified gaps and implement the proposed recommendations effectively.
- 3) By adopting sustainable practices across energy, urban planning, mobility, water, and waste management, Bhopal can pave the way towards a more resilient and sustainable future.
- 4) The green buildings concept shall be widely accepted by the stake holders. Also, government shall plan to provide subsidies so as to promote people.

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