

Methods for Guiding a Tier-II Indian City Bhopal, towards a Low-Carbon, Climate-Resilient Future

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ABSTRACT: The urban center of Madhya Pradesh, Bhopal, is confronted with escalating urban challenges stemming from swift population expansion, infrastructural needs, and the repercussions of climate change. This article offers a thorough examination of Bhopal's strategies for climate action and its endeavors to shift towards a development trajectory that is both low-carbon and resilient to climate impacts. By leveraging the Climate Smart Cities Assessment Framework (CSCAF) and conducting a greenhouse gas (GHG) emissions inventory, this study assesses Bhopal's present performance in crucial sectors like energy, urban planning, transportation, water resource management, and waste management. It pinpoints crucial deficiencies and areas necessitating enhancement, while suggesting practical recommendations to ameliorate energy efficiency, advocate for renewable energy, preserve biodiversity, upgrade waste management practices, and construct green infrastructure resilient to climate adversities. The article underscores the significance of integrated, multi-sectoral methodologies and active citizen involvement in materializing Bhopal's vision of sustainable urban development.

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

INTRODUCTION

Bhopal, renowned as the "City of Lakes," is a swiftly developing metropolitan region in central India. Bhopal, recognized as an emerging Tier-II residential hub, serves as the capital of the Indian state of Madhya Pradesh and the administrative center of Bhopal district and division. Renowned as the "City of Lakes" due to its natural and artificial water bodies, Bhopal stands out as one of India's greenest cities. Divided into old and new Bhopal, the city accommodates various national institutions and installations, including ISRO's Master Control Facility, AIIMS Bhopal, and NIFT. Bhopal gained global attention following the tragic Bhopal disaster in 1984, caused by a gas leak at a Union Carbide India Limited plant. Since then, the city has been a focal point for protests and campaigns, drawing participation from worldwide supporters. Additionally, Bhopal is celebrated for its exquisite silver jewelry, intricate beadwork, and embellished velvet accessories. The city's population density stands at 50 persons per hectare (PPH), comparatively lower than other urban centers in Madhya Pradesh.

With a population exceeding 2.3 million and a decadal growth rate of 27.53%, Bhopal confronts mounting strain on its urban infrastructure and escalating apprehensions regarding climate change impacts. The crucial question pertains to achieving this transition in a

Tier-II city with a population of around 24 lakh, as India progresses towards a global platform. Conducting surveys with customers aims to gauge their awareness levels and assess their receptiveness to new concepts and innovations. Similarly, engaging with various developers through surveys seeks to evaluate their technical expertise and knowledge in green building construction within the residential real estate sector.

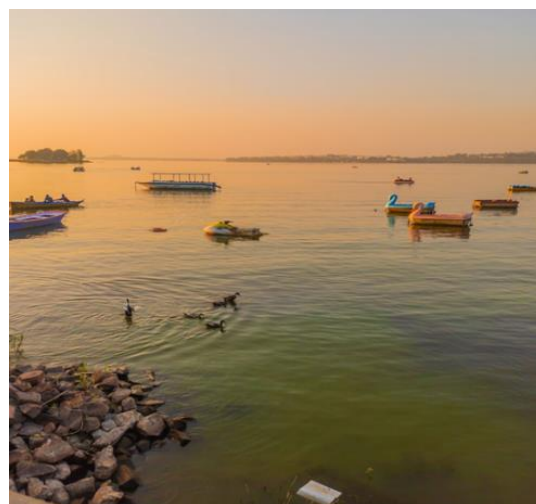


Fig. 1. Bhopal Upper lake (Source: School of planning and Architecture Bhopal).

Insights gathered from interviews with government officials shed light on the policies and regulatory framework concerning green buildings in residential real estate. The overarching query revolves around the awareness levels among developers and local government bodies. The attitudes of local government bodies will play a pivotal role in shaping the acceptance of new ideas and technologies. Various parameters of this article scrutinizes Bhopal's endeavors to propel city climate action and attain objectives of low-carbon, climate-resilient development (Urban Dev. Gov. M.P., 2019).

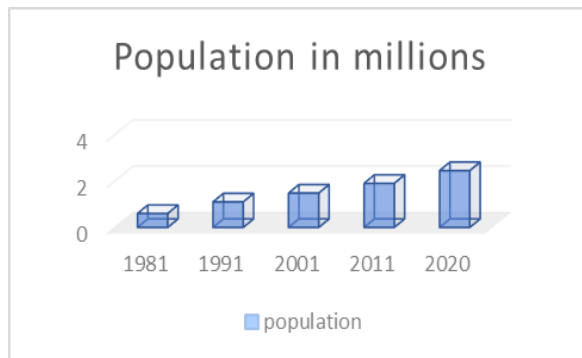


Fig. 2. Decade wise population of Bhopal City [India Census, 2011].

LITERATURE REVIEW

The study encompasses an exhaustive analysis of Bhopal's climate action blueprints, regulations, and undertakings, drawing insights from a spectrum of sources including: 1. Evaluation under the Climate Smart Cities Assessment Framework (CSCAF) 2. Compilation of greenhouse gas (GHG) emissions inventory 3. Examination of the Smart City Proposal and developmental schemes 4. Scrutiny of governmental reports and policy manuscripts 5. Relevance of academic literature and illustrative case studies (Potbhare *et al.*, 2009). The assessment spans across pivotal sectors like energy conservation and sustainable structures, urban planning, greenery coverage and biodiversity, transportation systems and air quality, water resource management, and waste disposal. It pinpoints prevailing initiatives, hurdles, and areas necessitating enhancement, while proposing pragmatic recommendations to bridge gaps and fortify climate resilience. The forthcoming objectives are to be achieved (Gupta *et al.*, 2019).

Goal 1: The objective is to metamorphose Bhopal into a solar city through various initiatives such as enhancing energy efficiency and utilizing renewable energy in MSMEs, introducing solar bus stops, implementing solar PV projects for low-income community housing, and installing solar water heaters and photovoltaic panels on educational institution rooftops. Encouraging the installation of rooftop solar panels and water heaters in new residential constructions is crucial. Educational campuses are targeted to be 100% RE-powered, while green practices are to be adopted in hospitals and hotels. Public-Private Partnerships (PPPs) are to be engaged

for efficient infrastructural distribution (Gogoi and Giri 2017).

Goal 2: The goal is to enhance the transport sector in Bhopal by improving the last mile connectivity of the planned metro, introducing electric buses in the Mybus system (Bhopal BRTS), implementing street design guidelines focused on Non-Motorized Transport (NMT), promoting electric two-wheelers, providing fuel efficiency training to bus operators, and expanding the spatial network of Pollution Under Control (PUC) certificate and Ambient Air Quality (AAQ) Monitoring System stations (Satya *et al.*, 2016).

Goal 3: The target is to develop a city which can fulfil its entire water requirements without depending on any other external resource. This requires a systematic management plan for the city by setting up solar-powered sewage treatment plants.

RESULTS AND DISCUSSIONS

Bhopal has initiated steps towards transitioning into a "solar city" by undertaking projects like rooftop solar installations, energy audits, and street lighting projects. However, renewable energy sources fulfill only a minute fraction of the city's energy demand, emphasizing the urgency of accelerating the adoption of clean energy technologies. Recommendations have been put forth to enhance energy efficiency, incentivize rooftop solar installations, and enforce green building codes to diminish energy consumption and emissions. A significant portion of street lighting has already been upgraded to LED and energy-efficient systems, showcasing the city's commitment to promoting green buildings. Furthermore, several buildings have received construction approval for complying with the Energy Conservation Building Code (ECBC) and Eco Niwas Samhita (ENS) standards (Gehlot and Shrivastava 2022).

6. 5MW solar rooftop energy projects have been established in the urban area as part of the city's solar energy initiative together with lake front solar.

Areas of enhancement

1. Enhancing the reduction of transmission and distribution losses from 28% as recorded in 2019.

2. Augmenting the power generation from Renewable Energy sources, which currently stands at 0.05%.

3. Advocating for and embracing green buildings. Urban Planning, Green Cover, and Biodiversity

1. Bhopal has witnessed a substantial decline in green cover, plummeting from 92% in 1977 to a mere 7% in 2021, thus necessitating immediate conservation endeavors.

2. Various measures have been introduced in the city such as Miyawaki plantations, biodiversity parks, and the establishment of a city biodiversity index to safeguard its ecological resources.

3. Recommendations encompass fortifying the enforcement of green space preservation policies, restricting development around delicate zones like the Bhoj wetland, and encouraging public participation in urban green initiatives.

Areas of enhancement

The city should oversee the impact of biodiversity strategies. There is a necessity to monitor, revise, and integrate the disaster management plan into departmental schemes.

Mobility and Air Quality

1. Bhopal has implemented measures like the Clean Air Action Plan, public bike-sharing systems, and blueprints for electric buses and metro rail.

2. Nevertheless, obstacles persist, including a scarcity of clean fuel vehicles, insufficient public transportation coverage, and the imperative for institutional capacity development.

3. The document proposes enhancing the adoption of clean fuel vehicles, extending the public transportation grid, and reinforcing air quality monitoring and enforcement mechanisms.

4. Currently, 18% of buses operate on CNG, while the Metro system is in the construction phase.

5. The city has a functioning Clean Air Action Plan and regularly monitors the air quality index levels, making this information accessible to the public.

6. There are 215 low floor buses in operation, with plans for an additional 275 by 2022. Efforts to electrify the public bike-sharing system are underway, with 94 stations installed, 480 cycles in operation, and over 30,000 registered users. Placemaking projects are being developed in specific areas like New Market, Subhash school area, and Alkpuri park.

Areas of enhancement. Boosting the number of public buses, as there are only 0.09 buses available per 1000 residents. Expanding the coverage of Non-Motorised Transport (NMT) along roadways (currently at 15.56%). Increasing the utilization of clean fuel vehicles (less than 15% of shared mobility vehicles operate on clean fuels).

Water Management. Bhopal has initiated endeavors to enhance water harvesting, introduce consumer metering, and implement dual piping systems for water preservation. Challenges encountered encompass a high percentage of non-revenue water (20-30%) and limited recycling and reuse of wastewater (<5%). Recommendations put forth involve the reduction of water losses, enhancement of wastewater treatment and reuse, and the formulation of comprehensive flood and stormwater management strategies (Zhang *et al.*, 2019).

Bhopal has made notable advancements in waste management, such as implementing door-to-door waste collection, establishing composting and material recovery facilities. However, challenges persist in the extraction of methane from landfills and sewage treatment plants, as well as in improving waste transportation infrastructure. Exploring waste-to-energy solutions, upgrading waste collection vehicles, and expanding the bio-methanation capacity for organic waste are suggested in the literature.

The integration of waste pickers and the complete collection of segregated household waste at the doorstep have been officially sanctioned in Bhopal. Furthermore, the city boasts a 96% recycling rate for wet waste through four composting pits and provides

six material recovery facilities for processing dry waste. Moreover, a 100 TPD plant processes all construction and demolition waste, utilizing it in low-lying areas and for paving blocks.

Improvement areas include the capture of methane gas from scientific landfills and sewage treatment plants, as well as the enhancement of waste transport infrastructure, requiring an additional 41 vehicles for garden and construction waste collection (Jain *et al.*, 2024).

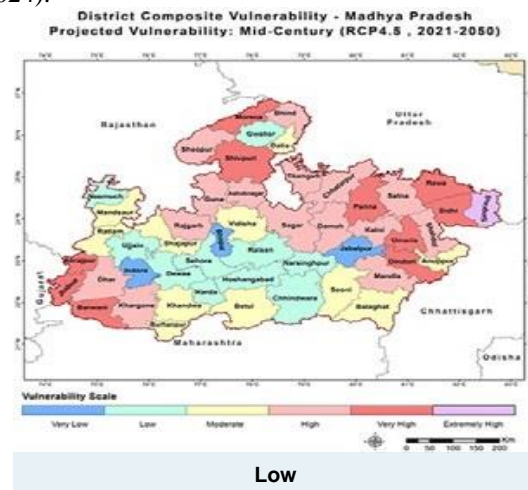


Fig. 3. Composite Vulnerability.

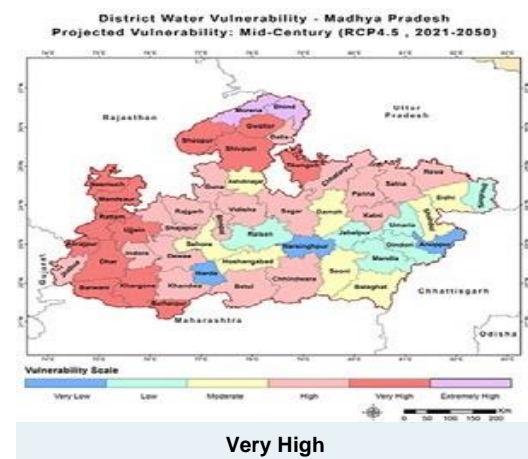


Fig. 4. Water Resource Vulnerability.

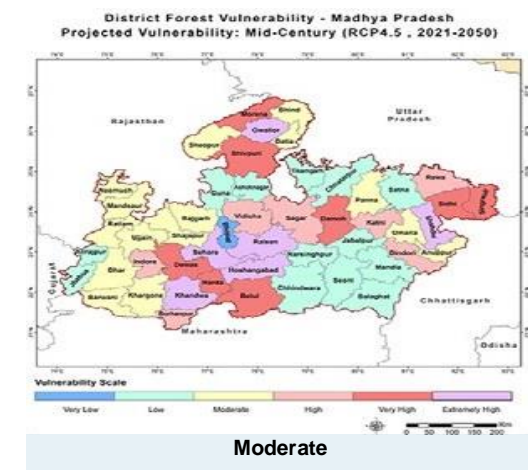


Fig. 5. Forest Vulnerability.

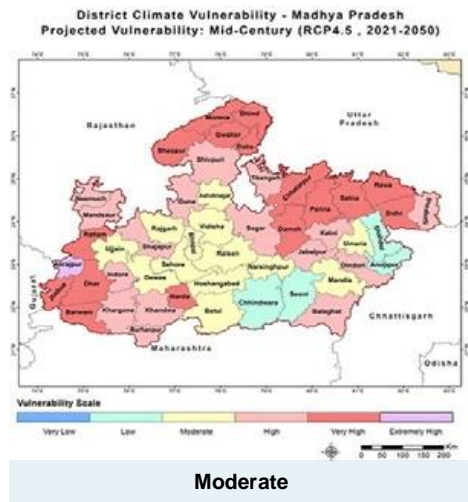


Fig. 6. Climate Vulnerability.

(Source: Directorate of Town and Country Planning)

RESULTS AND DISCUSSION

GHG emissions from activities within the city boundary are a significant concern, with stationary energy accounting for 56% and transportation for 28% of the total emissions. The waste and wastewater sector contributes 16% to the emissions, projected to rise by 18.6% by 2025 and 40% by 2030 compared to 2019 levels. Solar panels shall be installed over the institutional and educational buildings (Jain *et al.*, 2024).

Bhopal hosts prestigious research and academic institutions like ISRO's Master Control Facility, National law academy, and Maulana Azad National Institute of Technology, offering potential for renewable energy adoption through solar water heaters and rooftop solar panels. For instance, RGPV has installed Solar panels. Bhabha University has installed a 100-kW solar power plant to reduce reliance on non-renewable energy sources, producing 500 kWh daily and cutting carbon emissions by 136 tonnes annually. Additionally, incentivizing the installation of solar panels and water heaters in new residential constructions is recommended.

Subsidies: The Diu Smart City, among a limited number of cities, offers its residents an installation subsidy ranging from Rs. 10,000 to Rs. 50,000 for the installation of a 1-5 kW capacity roof solar PV system. Evidence suggests that this initiative has contributed to a yearly reduction of power tariffs by 10-15%. Moreover, the Karnataka State Government provides a rebate of 50 paise per unit up to Rs. 50 monthly for the installation of solar water heaters (SWH). In addition, Pune offers a 5% tax rebate for one energy efficiency initiative, such as SWH, composting, or rainwater harvesting (RWH).

Mandate: As per the PM Surya Bijli Yojna the central government is providing subsidies to the residential owners for installing solar panels. A maximum subsidy of 78000 INR is being provided to 1 crore residential house owners. Hence everyone shall take advantage of this.

CONCLUSIONS

The burgeoning development across various realty sectors has led to a notable surge in property prices in Bhopal. Notably, prices in prime locations have witnessed a significant increase due to the real estate growth in the city. The residential sector has seen the emergence of both luxury villas and affordable housing options, diversifying the housing landscape in Bhopal. With the property market in Bhopal gaining traction and national developers showing interest in the city, there is a growing focus on realty development. As the city transitions through a dynamic phase of real estate growth, the need for residential green building development becomes increasingly evident. Cooperation among all stakeholders involved in the process can pave the way for feasible residential green buildings in Bhopal. By considering the insights presented in this project report, the vision of establishing green homes in Bhopal can undoubtedly be realized. Bhopal has made significant strides towards addressing climate issues within the city; however, substantial obstacles remain in achieving its goal of fostering low-carbon, climate-resilient development. The study underscores the necessity for holistic, cross-sectoral strategies, collaboration among stakeholders, and active involvement of citizens to bridge the identified gaps and effectively execute the proposed recommendations. Embracing sustainable practices in energy, urban planning, transportation, water management, and waste disposal can guide Bhopal towards a more resilient and sustainable future (Gehlot and Shrivastava 2022). It is crucial for the concept of green buildings to be widely embraced by stakeholders, with the government considering the provision of subsidies to encourage broader adoption among the public.

FUTURE SCOPE

The study can be applied over the other Tier-II and Tier-III cities of India and hence the details of making them sustainable can be evaluated. The important factors for making these cities eco friendly can also be explained. Further suggestions and details of obstructions in developing a sustainable city can be explained.

Conflict of Interest. None.

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