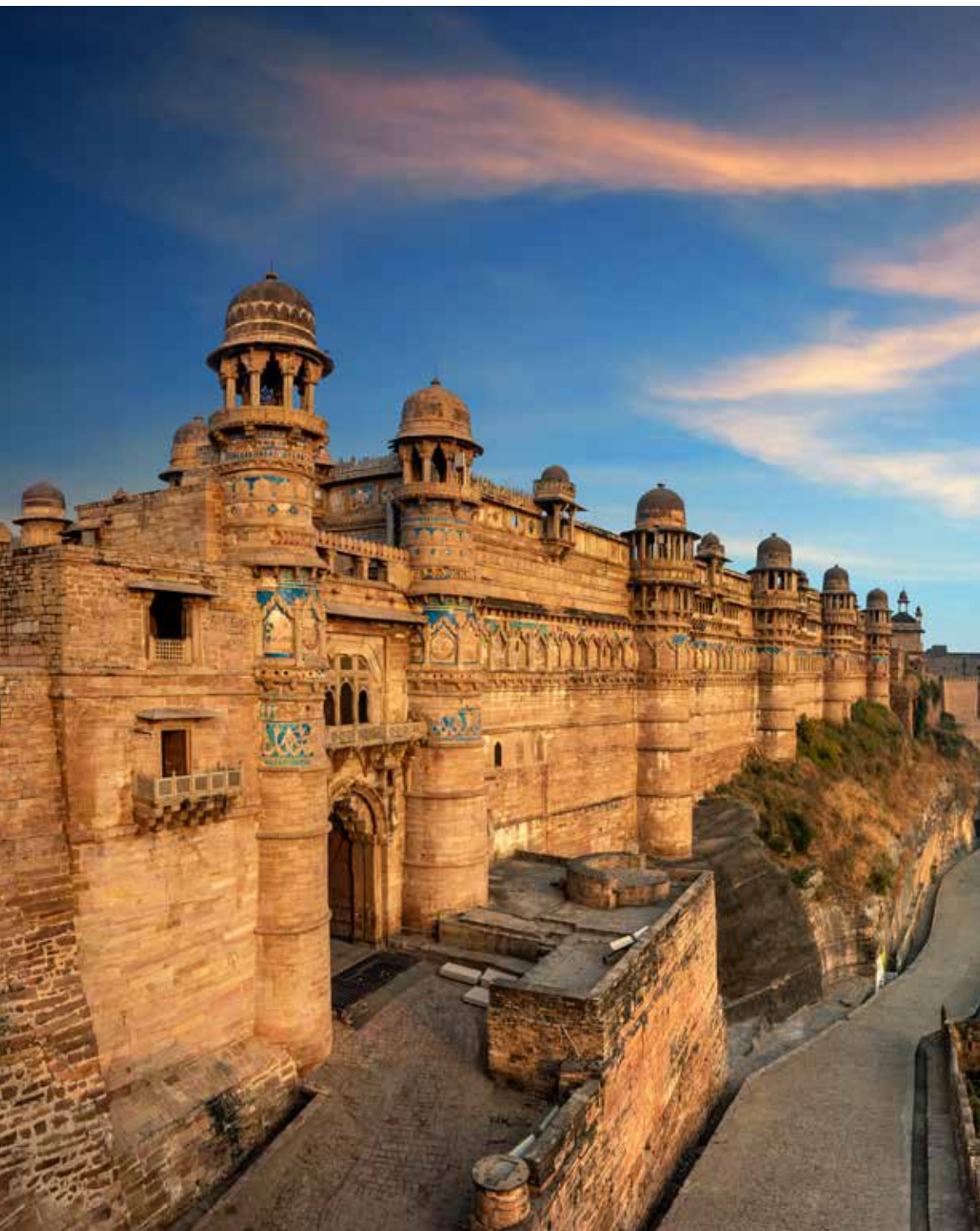




ADVANCING CITY CLIMATE ACTION IN MADHYA PRADESH

Towards a low-carbon, climate-resilient **GWALIOR**



Gwalior City Climate Action Plan

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Department of Environment, Government of Madhya Pradesh, 2023

DISCLAIMER

This document is prepared by WRI India in partnership with Environmental Planning & Coordination Organisation (EPCO), Department of Environment, Government of Madhya Pradesh to support Gwalior city in developing its Climate Action Plan. The data and information used for preparing this report have been sourced from Gwalior city, State Government departments, published sources of Government of India, etc. While due care has been taken to ensure authenticity of the data and other information used, any error in their accuracy or interpretation is absolutely unintentional.

About WRI India

WRI India is a research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

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Source: Gwalior Smart City Development Corporation Ltd.

**GULSHAN BAMRA (IAS)
PRINCIPAL SECRETARY**



Department of Environment
Government of Madhya Pradesh
Mantralaya, Vallabh Bhawan, Bhopal

Preface

No evidence is required to prove that climate is changing and that too because of increased human activities which have serious repercussions on economic development and natural resource management. Various recent extreme weather events in Madhya Pradesh, urban flooding, and untimely rains have shown that developing localised mitigation and resilience strategies is the need of the hour.

Paris Agreement 2015 and Glasgow Pact 2021 have shown the commitments from the international communities for reducing or mitigating GHG emissions, however to resolve this global issue, there lie the local solutions at sub-national level, district level and city level. Hon'ble Prime Minister of India has also launched the LiFE Movement which emphasizes on change in the lifestyle and behavioural patterns of living. He has stressed on reduce, reuse and recycle concepts as also on the circular economy to be an integral part of our lifestyle and for sustainable development. Concept of inclusivity is also very much integrated with this movement.

We in Madhya Pradesh are also committed to addressing the challenge of climate change in order to pursue the state's development goals in a sustainable manner.

Taking the cue from Ministry of Housing & Urban Affairs (MoHUA) as part of Climate Smart Cities Assessment Framework, the preparation of Climate Action Plans (CAPs) of all the 7 smart cities of MP by State Knowledge Management Centre on Climate Change (SKMCCC), EPCO and WRI India are steps towards making the local authorities equipped with strengths for tackling the challenge of climate change. The city level GHG inventorisation also helps in quantifying the actions to reduce the CO₂ emissions and offsetting the current emissions.

The City level Climate Action Plans (CAPs) for all the 7 smart cities have been drafted after wide consultations and participation with city experts so as to bring all the stakeholders on board and make their say.

I appreciate the efforts of EPCO and WRI India for taking the lead in preparing the City level Climate Action Plans.

These CAPs have flagged important issues which require attention and are expected to be implemented by the local authorities & SPVs.



(Gulshan Bamra)



Foreword

As extreme weather events unfold across the globe, the climate crisis has reached our doorstep. While India is on track to achieve the Nationally Determined Contributions, the State of Madhya Pradesh (MP) is determined to lead India's fight against this impending crisis by policy-governance reforms and inculcating a climate action culture in the society. With MP's complex urban challenges and increasing climate risks and disasters, sustained actions ensuring cities to prepare for and develop the ability to thrive in the varying climate is crucial. In MP, the rising urban population has created a reason to be concerned about climate change, and therefore the interventions at the city level are deemed important.

In this connection, the Climate Smart Cities Assessment Framework (CSC-AF) issued by Ministry of Housing & Urban Affairs (MoHUA) plays an important role in devising the appropriate actions to keep our cities safe from the adverse impacts of climate change. This brings an opportune time to integrate the concerns of climate change into our on-going program & policies and achieve the goal of low carbon development with inclusive growth.

It has been a very good opportunity for EPCO to join the LiFE movement launched by Hon'ble Prime Minister of India during Glasgow CoP. All the concepts of LiFE have been tried and addressed in the cities while developing the plans.

It is also important for us to develop well researched strategies specific to the cities to respond effectively to the possible impacts of climate change. To address these challenges, City level Climate Action Plans (CAPs) have been developed by State Knowledge Management Centre on Climate Change, EPCO in association with WRI India. The CAPs have highlighted key concerns and strategies for actions as per the indicators outlined in the CSCAF.

I would like to acknowledge the efforts of EPCO professionals and WRI India team for their commendable work. I would also like to extend my gratitude towards UADD, all the SPVs and other stakeholders for extending their support to formulate these plans and providing necessary data and information to make these plans more robust.


(Mujeebur Rehman Khan)



Acknowledgements

Environmental Planning and Coordination Organization (EPCO) is grateful to Mr Gulshan Bamra, Principal Secretary, Government of Madhya Pradesh, Environment Department; Mr Mujeebur Rehman Khan, Executive Director EPCO; and other team members from EPCO for their continuous support and guidance at various stages of developing the inclusive-climate action plan for Gwalior city.

We extend gratitude to Commissioner, Urban Administration and Development Department (UADD) for facilitating the plan development process and providing necessary guidance. We also are grateful to Commissioner, Gwalior Municipal Corporation and Chief Executive Officer of Gwalior Smart City Development Corporation Limited for constant support in providing valuable city level inputs and facilitating data collection across all departments and parastatal agencies. We would also like to thank all officers and city experts from concerning line departments and external agencies who contributed to the development and refinement of this plan through timely provision of data and valuable insights during stakeholder consultations.

EPCO would like to thank World Resources Institute (WRI) India, especially Mr Madhav Pai, CEO, Dr OP Agarwal, Senior Advisor and Former CEO, Ms Ulka Kelkar, Director, Climate Program for providing technical support to EPCO and Gwalior city, which played a key role for developing this plan.

We would also take this opportunity to appreciate the efforts made by the study team Mr Saransh Bajpai, Mr Prateek Barapatre, Ms Ramya MA, Ms Faiza Solanki and Ms Avni Agrawal for providing their expertise to assist in the research and development of the climate action plan.

Lastly, we would like to thank the internal reviewers from WRI India including Ms Marie Duraisami, Ms Sumedha Malaviya, Mr Dhilon Subramanian, Ms Azra Khan, Ms Chaitanya Kanuri and Ms Sahana Goswami for providing valuable feedback to strengthen the sectoral strategies in the plan

(Lokendra Thakkar)

Coordinator,
State Knowledge Management
Centre on Climate Change, EPCO



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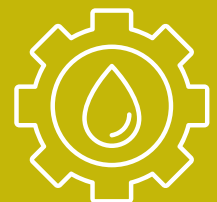


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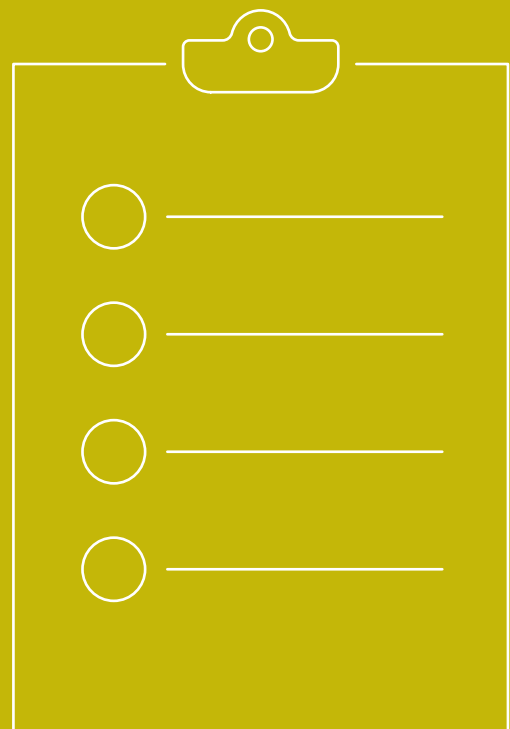
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Abbreviations

ABD	Area-Based Development	GHG	Greenhouse Gas
ADB	Asian Development Bank	GI	Green Infrastructure
AHP	Affordable Housing in Partnership	GCTSL	Gwalior City Transport Services Limited
AI	Artificial Intelligence	GMC	Gwalior Municipal Corporation
AJAY	Atal Jyoti Yojana	GRIHA	Green Rating for Integrated Habitat Assessment
AMRUT	Atal Mission for Rejuvenation and Urban Transformation	GSCDCL	Gwalior Smart City Development Corporation Limited
BEE	Bureau of Energy Efficiency	GW	Gigawatt
BEMS	Building Energy Management Systems	HFAP	Housing For All Programme
BRTS	Bus Rapid Transit System	ICCT	International Council on Clean Transportation
C&D	Construction and Demolition	ICT	Information & Communication Technology
CAAQMS	Continuous Ambient Air Quality Monitoring System	IGBC	Indian Green Building Council
CBD	Central Business District	IMC	Indore Municipal Corporation
CGWB	Central Ground Water Board	IPT	Integrated Public Transport
CH₄	Methane	IT	Information Technology
CNG	Compressed Natural Gas	ITS	Intelligent Transportation System
CO₂	Carbon Dioxide	JNNURM	Jawaharlal Nehru National Urban Renewal Mission
COP	Conference of Parties	KPI	Key Performance Indicator
CORDEX	Coordinated Regional Downscaling Experiment	LCB	Low Carbon Building
CPCB	Central Pollution Control Board	LED	Light Emitting Diode
CPHEEO	Central Public Health and Environmental Engineering Organisation	LEED	Leadership in Energy and Environmental Design
CPWD	Central Public Works Department	LPCD	Litres per capita per Day
CSCAF	Climate Smart Cities Assessment Framework	LPG	Liquified Petroleum Gas
DEWATS	Decentralized Wastewater Treatment Systems	MC	Mid-century
DISCOMS	Distribution Company	MLD	Million Litres per Day
EC	End-century	MNRE	Ministry of New and Renewable Energy
ECBC	Energy Conservation Building Code	MOHUA	Ministry of Housing and Urban Affairs
EESL	Energy Efficiency Services Limited	MP	Madhya Pradesh
EPCO	Environmental Planning and Coordination Organisation	MPLADS	Member of Parliament Local Area Development Scheme
ESCO	Energy Service Company	MPPCB	Madhya Pradesh Pollution Control Board
EV	Electric Vehicle	MPPWD	Madhya Pradesh Public Works Department
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India	MPUVN	Madhya Pradesh Urja Vikas Nigam
FY	Financial Year	MPMKVVCL	MP Madhya Kshetra Vidyut Vitaran Company Limited
GCC	Gross Cost Contract	MPWRD	Madhya Pradesh Water Resources Department
GDP	Gross Domestic Product	MRF	Material Recovery Facility

MRV	Monitoring, Reporting and Verification	URDPFI	Urban and Regional Development Plans Formulation and Implementation
MSW	Municipal Solid Waste	US	United States
Mt	Metric Tonne	VGf	Viability Gap Funding
mt	Million tonnes	WHO	World Health Organization
MW	Mega Watt	WRI	World Resources Institute
N₂O	Nitrous Oxide	WTE	Waste to Energy
NDC	Nationally Determined Contribution	WTP	Wastewater Treatment Plant
NGO	Non-Government Organization	ZCB	Zero Carbon Buildings
NITI	National Institution for Transforming India		
NMT	Non-Motorized Transport		
NMV	Non-Motorized Vehicle		
NRW	Non-Revenue Water		
NUTP	National Urban Transport Policy		
PET	Polyethylene Terephthalate		
PHE	Public Health Engineering		
PMAY	Pradhan Mantri Awas Yojana		
PNG	Piped Natural Gas		
PPP	Public Private Partnership		
PSP	Private Sector Participation		
PT	Public Transport		
PV	Photo Voltaic		
RCP	Representative Concentration Pathways		
RE	Renewable Energy		
RTO	Road Transport Organization		
RWA	Resident Welfare Association		
RWH	Rainwater Harvesting		
SAPCC	State Action Plan on Climate Change		
SBM	Swachh Bharat Mission		
SCP	SMART City Proposal		
SDG	Sustainable Development Goal		
SHG	Self Help Group		
SKMCCC	State Knowledge Management Centre on Climate Change		
SPA	School of Planning and Architecture		
SPV	Special Purpose Vehicle		
STP	Sewage Treatment Plant		
SWH	Solar Water Heater		
SWM	Solid Waste Management		
TOD	Transit Oriented Development		
TPD	Tonnes per Day		
ULB	Urban Local Body		
UNESCO	United Nations Educational, Scientific and Cultural Organization		
UNFCCC	United Nations Framework Convention on Climate Change		

EXECUTIVE SUMMARY



Gwalior and its Vulnerability to Climate Change

Gwalior is the tourist capital of Madhya Pradesh — the fort being a notable attraction — and is among the eleven counter-magnet cities as defined by the National Capital Region Planning Board Act of 1985. More than half of Gwalior's land (54%) is under agricultural land use followed by residential land use (15%) and hills and hillocks (15%), recreational land use and scrub land (almost 2.5%), water bodies including lakes and rivers (less than 1%)¹.

The city has three major nuclei: Lashkar, Hazira and Morar. Most of Lashkar is the Maharaj Bada, and a major part of the ABD area for Gwalior's smart city project is in this area. Lashkar's 803 acres are bordered by the Swarnarekha river to its north and west, Jai Vilas palace to the north-east, Chattris on the east, and dense urban settlements to the south.

The area deals with issues like congestion and lack of green spaces, but as an important trade hub, it will be necessary to ensure that a robust public transport system connects it to all major nodes of the city. Currently, throughout the ABD area, there is a lack of green open spaces right down to the neighbourhood level. The drainage system is encroached upon by construction; this, combined with the concreting of the Swarnarekha riverbed — which reduces percolation of rainwater — can lead to flooding. This indicates a need for a regulated wastewater management system¹.

According to EPCO's Vulnerability Assessment Report, there is a very high risk of decreasing availability of water, increasing crop water stresses, and increase in

frequency of extreme events like floods and droughts in the Representative Concentration Pathways (RCP) 4.5 mid-century and end-century scenarios. The city faces an extremely high forest vulnerability in the RCP 4.5 mid-century scenario; this reduces slightly to very high risk as per end-century projections. In terms of climate, the city faces a very high climate vulnerability in the RCP 4.5 mid-century risk projections, with a very high risk of decrease in average annual rainfall, increase in intensity of precipitation, and rise in heat index.

As part of the Smart Cities Mission, the Housing and Urban Affairs ministry's Climate Smart Cities Assessment Framework (CSCAF) aims to provide a roadmap to combat climate change through mitigation and adaptation measures while planning city-level development actions and policies. CSF-AF has five themes — energy and green buildings; urban planning, green cover and biodiversity; mobility and air quality; water resource management; and waste management — with 28 indicators among them.

WRI India is supporting EPCO and the MP government's departments of Environment and Urban Development and Housing as a technical partner, in planning adaptation and mitigation strategies and building a city climate action plan (CAP). The CAP is informed by the cities' greenhouse gas emissions profiles and vulnerability assessments. After reviewing data submitted by cities, the CAP identifies existing gaps in addressing future climate risks and recommends key action points across the CSC-AF's five thematic areas. It also proposes an institutional framework necessary to implement the recommendations.

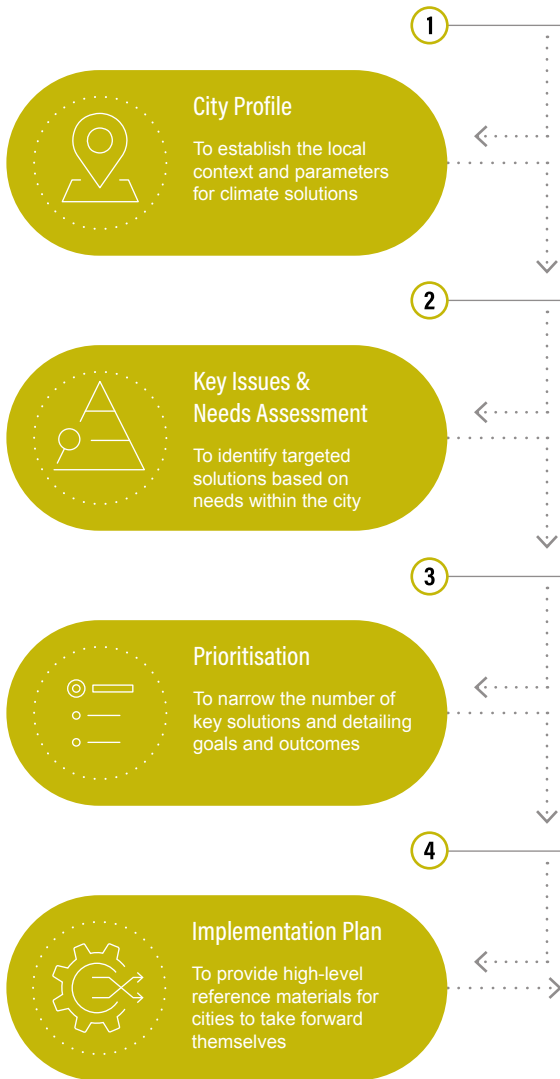
Climate Action Planning Process

WRI India adopted a four-pronged approach to prepare the Climate Action Plan:

- First, in February 2020, a planning-cum-launch workshop was organized in Bhopal with state and city officials, academicians and civil society organizations to apprise them of the relevance of developing a climate action plan and gather insights on the climate risks and development challenges faced by urban areas in MP.
- This was followed by a review of secondary literature to identify the city's vision and key sectoral priorities and develop a climate profile and greenhouse gas inventory for the city. This along with the vulnerability assessment by EPCO was used to identify climate risks and propose actions.
- Next, a stakeholders consultation workshop was organized in Gwalior, in September 2021, with participation from city officials, sectoral experts and civil society representatives, to present the preliminary findings and seek inputs on the goals and actions proposed.
- The final CAP provides prioritized sectoral actions, an implementation plan, and a governance mechanism for effective coordination and monitoring of implementation.

ES Figure 1: CAP development process (Source: WRI India)

INTENDED OUTCOME OF THE STEP



ENGAGEMENT OVERVIEW

- 1** City climate context workshop
 - Stakeholder consultations to identify:**
 - Priorities and brainstorm main challenge areas for emissions reduction across sectors
 - Climate risks for resilience priorities
 - On-going initiatives
- 2** Desk review and CSCAF performance analysis
 - Review of secondary literature to:**
 - Understand current performance levels
 - Understand status of on-going initiatives
 - Develop bucket list of solutions
 - Draft report on city climate action for stakeholder consultation
- 3** Stakeholder engagement
 - Stakeholder consultations to:**
 - Assess societal, equity and spatial inclusion in the proposed solutions
 - Align with current and future priorities
 - Identify synergies with state and national level solutions
- 4** Dissemination workshop
 - Finalized city climate action plan:**
 - Climate vision and strategy for cities
 - Inclusive solutions
 - Prioritized actions across the sectors
 - Implementation plan

Baseline Assessment

A baseline assessment was conducted through an analysis of the climate smart cities assessment framework, greenhouse gas inventory development, and a vulnerability assessment.

| Climate Smart Cities Assessment

Gwalior scores well in waste management, but requires significant improvement in the other areas, especially mobility and air quality (the city is one of the most polluted cities in India²).

ES Table 1: CSCAF 2.0 Scores for Gwalior (Source: CSCAF 2.0 submission by Gwalior city)

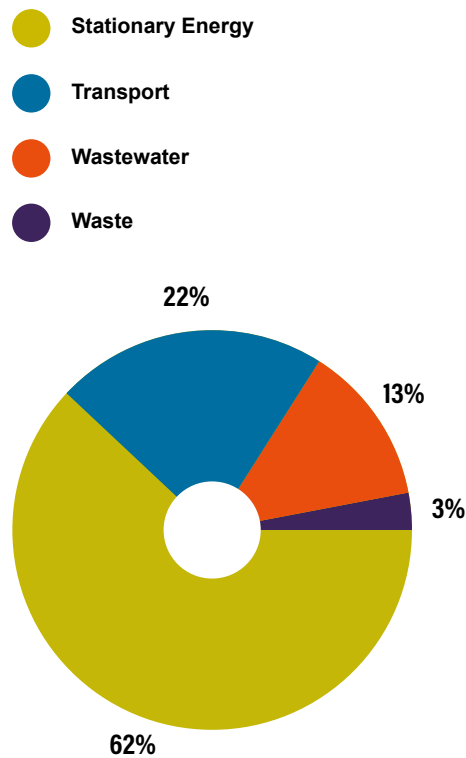
Overall Score as per CSCAF 2.0	Energy and Green Buildings	Urban Planning, Green Cover and Biodiversity	Mobility and Air Quality	Water Management	Waste Management
★★	★★	★★	★	★★	★★★★★
CSCAF 2.0 Score	2275	117	43	200	486
Current measures being undertaken in the city	<ul style="list-style-type: none"> Promoting restoration and adaptive reuse of heritage buildings like heritage building precinct near Urvai gate at Gwalior fort and Old collectorate Gorkhi palace³. A goal of meeting at least 20% of total power demand from renewables⁴. Solar panels on public buildings³. Increasing LED streetlights on a PPP basis³. 	<ul style="list-style-type: none"> GIS Mapping of open spaces and water bodies. Linking Pradhan Mantri Awaz Yojana to the Ankur program, which rewards citizens for tree plantation. 82% of the municipal area is under tree cover. Has a disaster management cell. A plan for a 50-hectare forest and zoological park near KSR hospital⁵. Maintains 520 gardens and parks⁶. 	<ul style="list-style-type: none"> Five multi-level parking locations identified³. Three continuous ambient air quality monitoring stations; two continuous emissions monitoring stations⁵. 6067 LPG vehicles and 6981 CNG vehicles registered in the city; six CNG stations⁶. 	<ul style="list-style-type: none"> Water resources assessment, demand Management Strategy and Implementation Plan in place. NRW is around 30-40%. 10-20% of wastewater is recycled and reused. 	<ul style="list-style-type: none"> GMC has a Private Sector Participation model for solid waste. 100% segregated waste collection⁷. Material Recovery Facility (MRF) of 100 TPD⁷. 17% of wet waste is composted⁷. C&D waste collected at four centres⁷.
Areas of improvement	<ul style="list-style-type: none"> Increase LED streetlights (around 3% in 2019). Implement measures for promoting green buildings. Increase power generation from RE sources (<5% currently). Promote rooftop solar in residential and commercial buildings. 	<ul style="list-style-type: none"> Develop actions, allocate budget and monitor implementation for water body and green space conservation. No actions for biodiversity conservation. A biodiversity committee is a first step. Increase per capita green space from 1 m² to at least 10 m²¹. Prepare a disaster management plan and document loss and damage due to disasters. 	<ul style="list-style-type: none"> Increase number of buses (currently 0.02 buses per 1000 population) Increase coverage of NMT (5% of roads with NMT network currently) Increase share of clean-fuel shared mobility (currently 0%) 	<ul style="list-style-type: none"> Reduce NRW Revive the Swarnarekha river. Conduct flood risk assessment and prepare action plan. Conduct energy audit for pumping stations and treatment plants. 	<ul style="list-style-type: none"> Capture methane gas from landfills. Central bio methanation plant required Increase wet waste composting. Increase waste recycling. Set up plastic waste collection centres and MRF⁷. Set up 50 TPD construction and demolition waste recycling centre⁷.

Greenhouse Gas Emissions Inventory

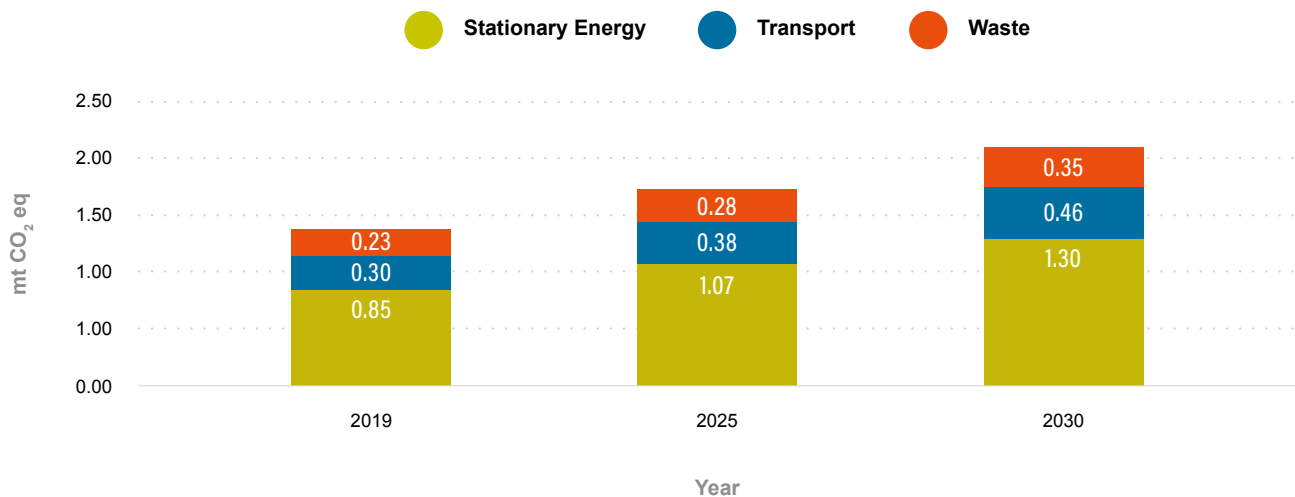
In 2019, Gwalior's GHG emissions (including emissions from electricity consumption in manufacturing industries) were 1.37 mtCO₂e (1 tCO₂e per person). The emissions inventory was compiled to the Global Protocol for Communities (GPC) BASIC standards using C40's City Inventory Reporting and Information System (CIRIS). The contribution of the four sectors to total emissions in the city: 62% from stationary energy (most of this from energy and electricity use in residential buildings); 22% from transportation; 3% from waste, and 13% from wastewater.

The business-as-usual projected emissions for Gwalior are presented in ES Figure 3. The emissions are projected to increase by 26% by 2025 and 53% by the end of the decade till 2030, compared to the baseline emissions of 2019 if no action is being taken. 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.

ES Figure 2: GHG Emissions Profile (Source: WRI India analysis using primary data)



ES Figure 3: Projected emissions for Gwalior (Source: WRI India analysis using primary data)



Vulnerability assessment

According to this analysis, Gwalior has a low composite vulnerability. For water resources, Gwalior is very highly

vulnerable; That is, there is a very high risk of decreasing water availability, increasing stresses on crop water, and increase in frequency of extreme events like floods and droughts.

ES Table 2: Future Climate Risks for Gwalior (Source: CEEW, 2020)

Projected Climate Changes	Potential Impacts and Risks ⁸
Warmer conditions, including more intense and frequent high-temperature extremes and heat wave days.	<ul style="list-style-type: none"> Warm days are likely to increase by 50 before the end of the century. If air quality also decreases, this could have further negative health effects including increases in mortality. Increase in water stress and drought-like events
Higher annual rainfall totals and change in frequencies	<ul style="list-style-type: none"> In a high emissions scenario, by 2100, total annual rainfall in the city is likely to increase 9% from 2010 levels. In 2015, the city received 211.5 mm of precipitation; in 2019, it was 821.9 mm. This indicates extreme variation in precipitation trends⁹.

Goals and Sectoral Strategies

Goals and actions were prepared to ensure Gwalior achieves a low carbon and climate-resilient growth while

also reducing inequality and increasing inclusivity in development.

ES Table 3: Summary of goals and actions for Gwalior (Source: WRI India)

Goals	Actions	Outcomes
Goal 1 Green housing for all in Gwalior	<ul style="list-style-type: none"> Promoting energy-efficient appliances in residential buildings. Promoting green and cool roofs in residential buildings. Implementing measures to promote green buildings in Gwalior. Mandating or incentivizing rooftop solar panels and solar water heaters in all new residential and commercial buildings including hotels, malls and hospitals Exploring common solar PV projects for community low-income housing 	<ul style="list-style-type: none"> GHG emission reduction. Climate-resilient urban housing. Improved housing for all.
Goal 2 Climate smart tourism in Gwalior	<ul style="list-style-type: none"> Developing a pedestrian friendly heritage network trails and an electric hop on hop off bus service in tourist areas Incorporating zero-carbon building components in heritage redevelopment projects Dry waste recovery and plastic reverse vending machines at tourist centres 	<ul style="list-style-type: none"> Reduce GHG emissions Strengthen sustainable and equitable economic activity
Goal 3 Make Gwalior a solar city	<ul style="list-style-type: none"> Implementing solar rooftop panels for all government buildings and public spaces Piloting solar-bus stops Awareness programs and tools for promoting residential rooftop solar Solarisation of sewage treatment plants and water pumping stations 	<ul style="list-style-type: none"> GHG emission reduction. Increased penetration of renewable energy. Improved access to affordable energy. Reduced urban heat island effect and induced cooling effect.

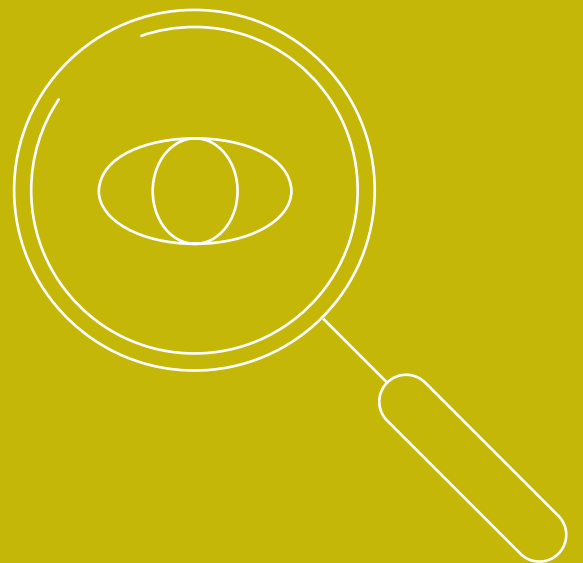
Goals	Actions	Outcomes
Goal 4 Improve air quality and make Gwalior a connected & accessible city	<ul style="list-style-type: none"> • Augmenting the existing bus fleet • Fuel efficiency and driver training for diesel-powered public and private buses • Setting up of infrastructure for service centres and charging stations for electric vehicles. • Implementing a comprehensive data strategy for enhanced public transport ridership • Strengthening NMT infrastructure in the city • Improved parking management in Gwalior • Scaling up and improving the uptake for Gwalior's public bicycle sharing system 	<ul style="list-style-type: none"> • Improvement in air quality. • Decrease in negative health effects. • Improved mobility access. • Reduced travel by private motor vehicles.
Goal 5 Green and blue resilient urban ecosystem	<ul style="list-style-type: none"> • De-concretization of the Swarnarekha and Morar rivers and integration of green infrastructure in river rejuvenation projects • Developing inclusive green spaces in Gwalior • Promoting green terraces. • Developing a heat action plan • Data, information, and awareness for biodiversity conservation. 	<ul style="list-style-type: none"> • Improved water security. • Reduced flood risk. • Improved air quality and climate resilience. • Increased access to affordable drinking water through groundwater recharge
Goal 6 Zero-waste Gwalior	<ul style="list-style-type: none"> • Decentralized composting in Gwalior • Converting waste transport fleet to electric vehicles • Public-private model for managing construction and demolition waste • Revenue-generating models for recycling C&D waste • Innovative models for recycling plastic waste. 	<ul style="list-style-type: none"> • Reduced GHG emissions particularly from waste management • Beautification of the city and improved access to clean energy sources. • Increase in recycling rates.
Goal 7 Water-resilient Gwalior	<ul style="list-style-type: none"> • Developing and implementing an NRW reduction strategy • Disaster risk-reduction through developing and implementing an integrated flood and storm water management plan incorporating nature-based solutions • Implementing energy-efficient water supply and wastewater management systems. 	<ul style="list-style-type: none"> • Reduced NRW losses. • Increased access to potable water. • Increased flood resistance • Reduced water costs and improved equitable access. • Better sewage management. • Increased energy efficiency in water supply system.

City authorities can select actions and recommendations in this plan to develop a detailed implementation plan for pilot projects that can be rolled out in the short, medium, and long term. The GHG emission profile of the city included in the plan can be used as a guiding analysis to prioritize implementation of actions in different sectors. The plan also provides guidance on mainstreaming actions with existing policies, schemes and programs to establish convergence of implementation.

Lastly, this plan must be treated as a dynamic document and must be updated regularly with the latest emissions profile of the city. It will be necessary to institute a city-level climate change cell — with representation from

concerned ULB departments, Smart City, citizen forums, academic institutions and civil society — to lead and coordinate this process. Periodic stakeholder consultations would help in strengthening the plan as per the evolving requirements of the city.

INTRODUCTION



Cities are both significant contributors to climate change and vulnerable to its consequences. And with appropriate measures, they can make significant contributions to mitigating climate change and becoming resilient to its impacts. State Action Plans for Climate Change (SAPCCs) have served as the primary policy document guiding climate actions at the sub-national level; any city-level climate actions must be in synergy with SAPCCs. Actions cities take will help India not just meet its NDCs but also support reaching its SDGs.

World Resources Institute India has partnered with the State Knowledge Management Centre on Climate Change, EPCO, Department of Environment, Government of Madhya Pradesh, to support the Department of Urban Development and Housing, GoMP, and seven smart Cities in MP to build their capacities in planning adaptation and mitigation strategies and to develop city climate action plans in line with the Climate Smart Cities Assessment Framework launched by the Ministry of Housing and Urban Affairs, Government of India.

Vision of Gwalior Climate Action Plan

The vision for Gwalior Smart City has been “to comprehensively transform Gwalior through promotion of heritage and cultural assets, to create new economic opportunities, and reinforce its strengths in education, health and trade.”⁴ . The Gwalior Climate Action Plan envisions a world class city of the future: a vibrant, equitable city that provides real quality of life, sustainability

for all its citizens, a low-carbon, climate-resilient and adaptive society. Taking cues from the risks that climate change presents to future generations living in the city, this CAP recognizes that actions must be taken on priority towards six goals across sectors of mobility, solid waste management, air quality, green cover, energy and water management.

Figure 1: Vision for Gwalior (Source: WRI India)



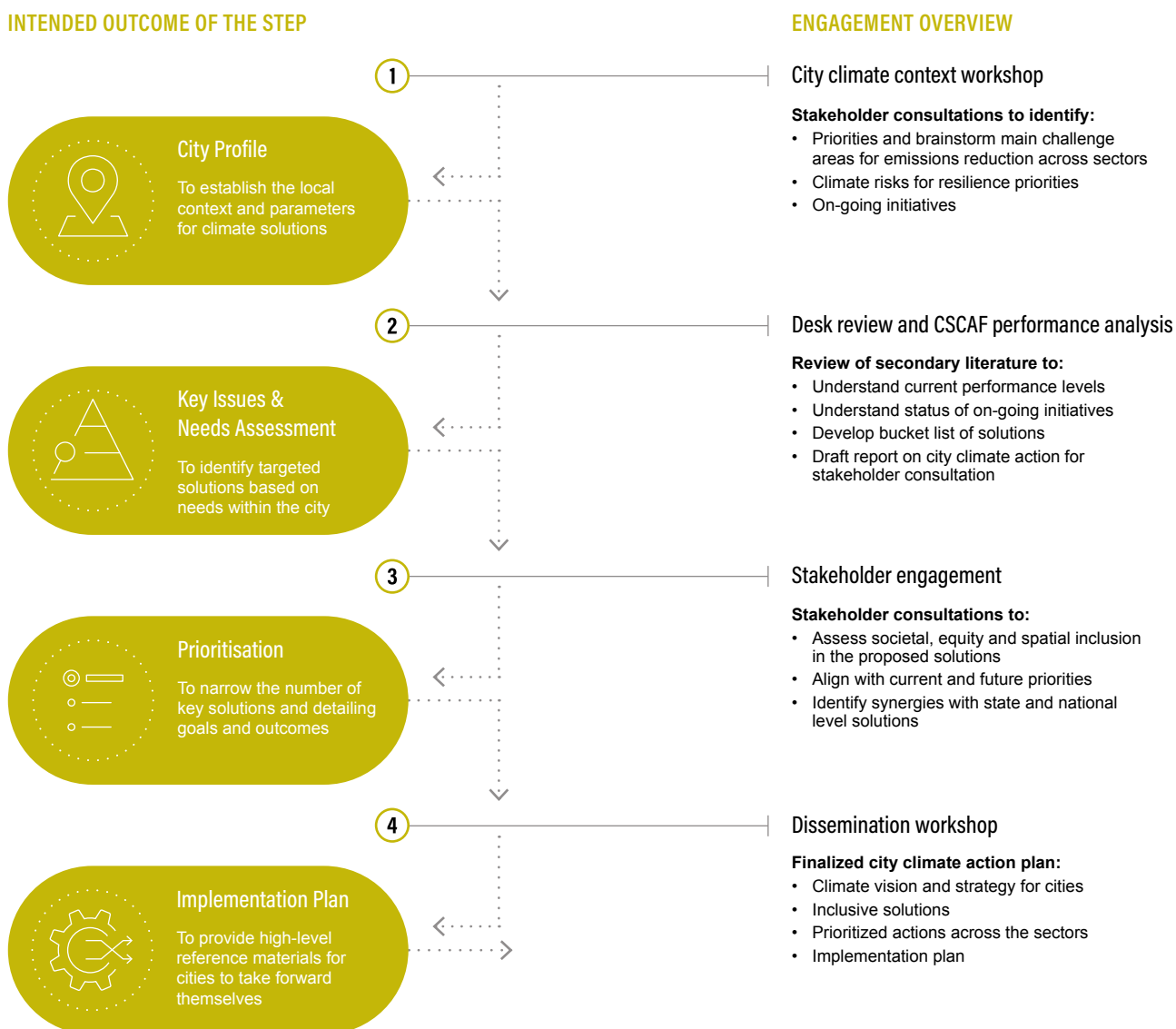
Climate Action Planning Process

WRI India adopted a 4-pronged approach to prepare the Climate Action Plan:

- First, on 20 February 2020, a planning-cum-launch workshop was organized in Bhopal with state and city officials, academicians and civil society organizations. Aside from apprising the participants about the importance and relevance of developing city-level plans, the idea was to identify prominent development challenges and key climate risks in urban areas in MP, and to understand ongoing initiatives, in order to establish a local context for climate solutions.

- This was followed by an extensive desk review of Gwalior’s smart city proposal to identify the city’s vision and key sectoral priorities. The review included submissions made by the city as a part of CSCAF 2.0, sectoral plans, government reports, and other documents. Based on these, WRI developed a detailed climate profile of the city — including temperature and rainfall projections, baseline and a projected greenhouse gas inventory. The vulnerability assessment prepared by EPCO was used to identify climate risks. This process yielded a list of sectoral goals and actions.

Figure 2: CAP development process (Source: WRI India)

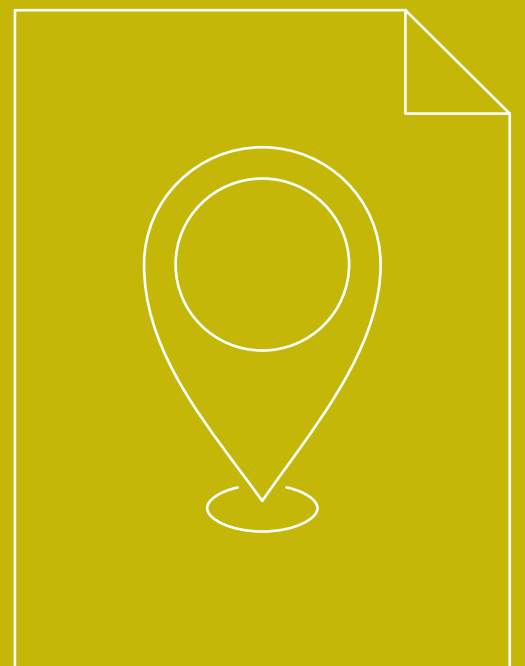


- Next, a stakeholders consultation workshop was organized in Gwalior, in September 2021, with participation from city officials, sectoral experts and civil society representatives, to present the preliminary findings and seek inputs on the goals and actions proposed.
- The final CAP provides prioritized sectoral actions, an implementation plan, and a governance mechanism for effective coordination and monitoring of implementation



Source: Gwalior Smart City Development Corporation Ltd.

CITY PROFILE



Gwalior is the tourist capital of Madhya Pradesh. The Gwalior fort is a notable attraction, and the city has a reputation of being the birthplace of many famous singers such as Tansen and Baiju Bawara¹⁰. In the here and now, the city is well connected with the rest of India by road, rail and air, and it is among the eleven counter-magnet cities to the National Capital Region.

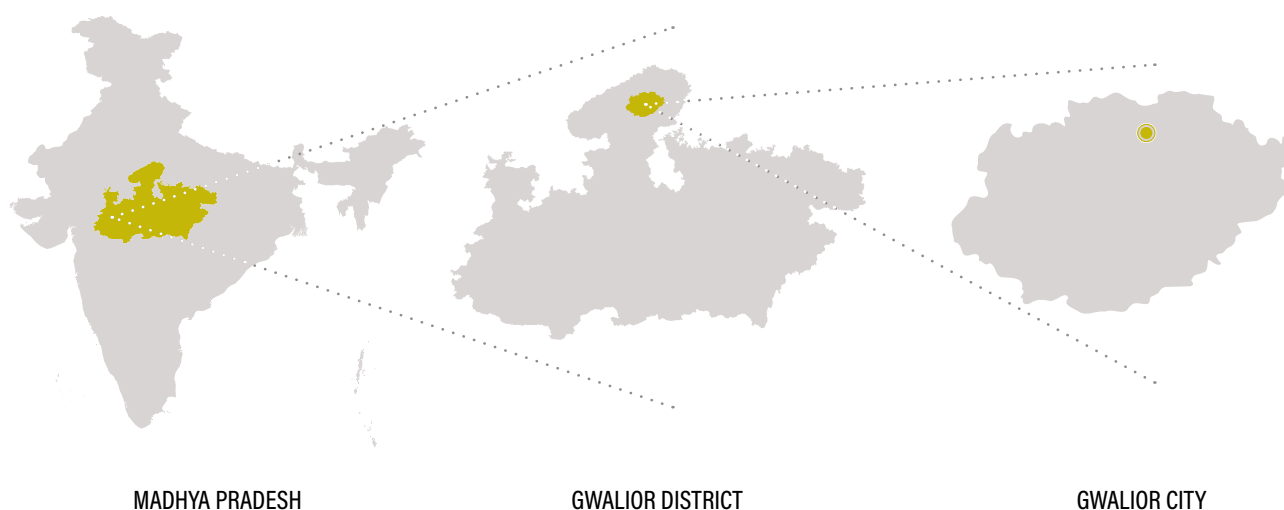
The major chunk of land (54%) is under agricultural use, followed by residential land (15%) hills and hillocks (15%), recreational land use and scrub land (almost 2.5%), and water bodies, including lakes and rivers (less than 1%)¹. Gwalior has three major nuclei: Lashkar, Hazira and Morar. Morar is the easternmost part of the city, bordered by the cantonment area, the Hazira, and Tatipur. The Hazira is the old city area and refers to the settlement around the fort. Lashkar is mostly the Maharaj Bada, an important trade centre. The 803 acres of the Area Based Development (ABD) area are mostly within Lashkar, bounded on the west and north by the Swarnarekha river, on the northeast by Jai Vilas palace, Chattris to the east, and dense urban settlements to the south. This area is important not just because it is an important trade centre, but also because it reflects the culture and heritage that

Gwalior is proud of. Considering the land value — not just economic; but also, aesthetic and cultural — the ABD area has great potential as a centre of business, trade and culture. But it also has issues like congestion, insufficient formal public transport and lack of green spaces. Therefore, while a robust public transport system connecting the ABD to all major nodes of the city is necessary, urban development must utilize the full land values without damaging the green spaces of the city.

Currently, there is an absolute lack of open spaces in the dense fabric of the ABD; there are no breathing spaces between areas and even down to the neighbourhood level. In addition, existing drainage is encroached upon by construction, which often results in flooding. This is further exacerbated by the concretization of the Swarnarekha riverbed, resulting in the non-percolation of the rainwater. This situation necessitates a regulated wastewater management system¹.

The recommended transformation aims to boost the city's economy by leveraging its rich cultural heritage while making it more commercially viable, culturally dynamic and environmentally friendly.

Figure 3: Map of Gwalior (Source: WRI India)



Demography

The population of Gwalior city increased from approximately 0.8 million to 1 million between 2001 and 2011. The decadal growth rate of 24% during that period is higher than the state figure of 20.3%. As Figure 4 below shows, population growth has been the highest in the

last decade, indicating inward migration due to economic opportunities in the city. In 2019, Gwalior's population within the 423.35 sq.km. municipal area was 13.6 lakh, making it a densely populated city: around 3232 people per sq. km¹⁴.

Figure 4: Population growth in Gwalior from 1981-2020 (Source: Census of India and CSCAF 2.0)

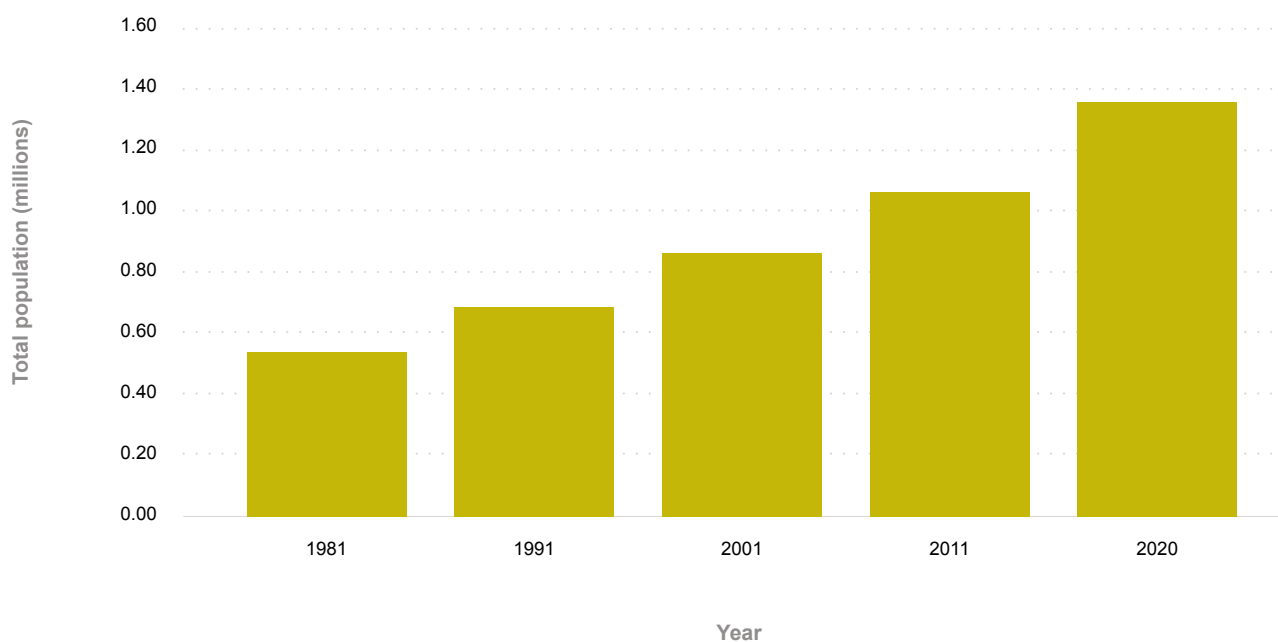


Table 1: Demographics (Source: Census of India)

Particulars	2001 ²			2011 ³		
	Total	Males	Females	Total	Males	Females
Population	8,27,026	4,42,343	3,84,683	10,69,276	5,69,003	5,00,273
Literates	5,72,736	3,34,504	2,38,232	7,99,194	4,51,741	3,47,453
SC Population	1,37,470	74,015	63,455	1,85,384	98,823	86,561
ST Population	13,539	7,156	6,383	14,366	7,735	6,631
Total Workers	231,656	1,99,867	31,789	3,31,598	2,81,042	50,556
Number of Households	1,44,728			2,02,066		

Climate Profile

Gwalior is in a semi-arid region and is thus at risk of extreme temperature variations, leading, in summer, to heat stress. Madhya Pradesh is divided into 11 agro-climatic zones. The climate risk profile of Gwalior city, as outlined in the analysis⁸ below, focusses on observed changes and future projections of temperature and rainfall. Projections are provided for two emissions scenarios, representative concentration pathways (RCPs), which span the range considered in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC):

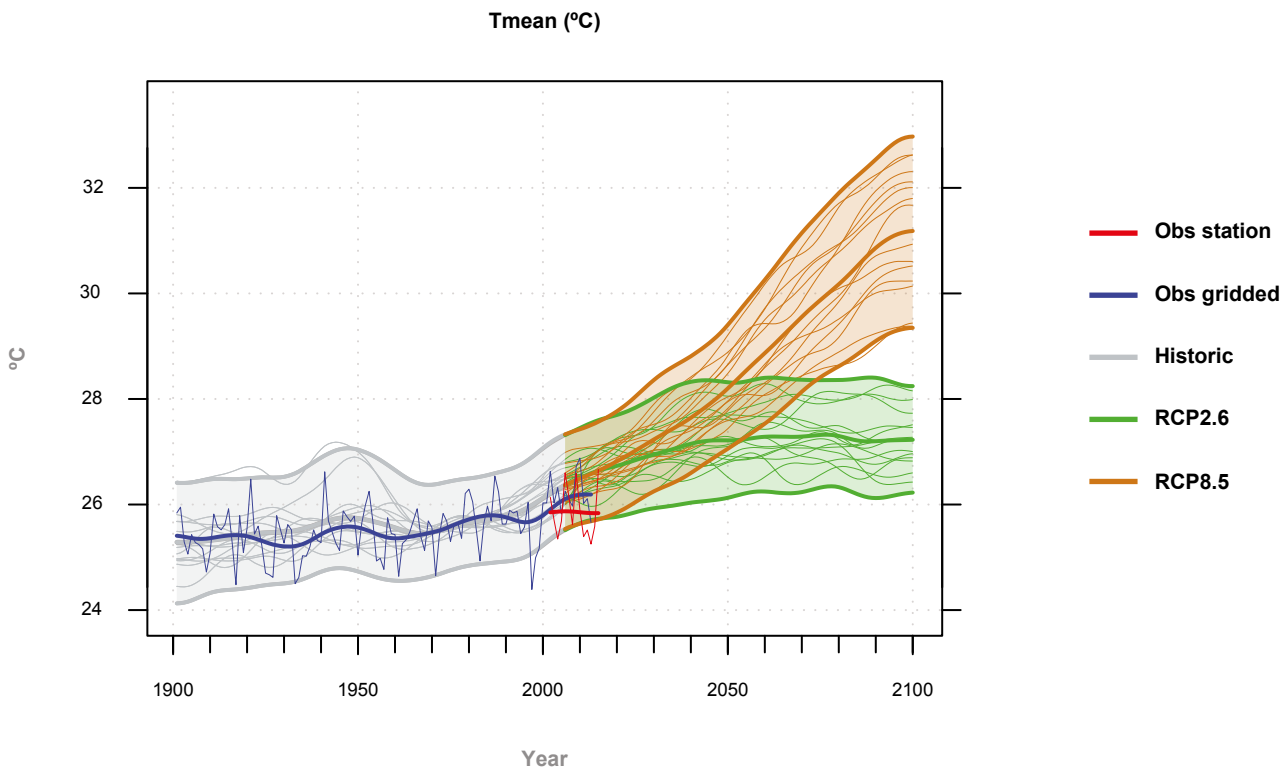
- RCP8.5: a high-end 'business-as-usual' scenario.
- RCP2.6: a low-end, mitigation scenario (consistent with the objective of the 2015 Paris Agreement to limit the global temperature increase to 2°C or lower compared to pre-industrial conditions).

Temperature projections

The observations as well as simulations show an increase in mean annual temperature (Figure 5). Under a high emissions scenario (RCP 8.5), this trend is projected to continue till the end of the century, with an average rise of 4.6°C from 1981-2010 to 2071-2100. If emissions decrease rapidly in low emission scenario (RCP 2.6), the average rise is limited to about 1.3°C.

The number of warm days (Figure 6), for example, is projected to increase by about 50 days on average from 1981-2010 to 2071-2100 under a high emissions scenario. If emissions decrease rapidly, the rise in warm days is limited to about 15 days on average. Coupled with Gwalior's poor air quality, increasing heat stress could also result in mortalities and decreasing labour productivity.

Figure 5: Increase in mean temperature for Gwalior (Source: CEEW, 2020)



Rainfall

The rainfall observations (Figure 7) are dominated by large decade-to-decade and year-to-year variability. The simulations show a general tendency towards increasing total annual rainfall, although the variability is large. Under a high emissions scenario, total annual rainfall is projected to increase by about 9% (about 80 mm) on an average from 1981-2010 to 2071-2100. If emissions decrease rapidly, this rise is limited to about 40 mm. In 2015, the city received only 211.5 mm of precipitation; in 2019 it was 821.9 mm. This indicates extreme variation in precipitation trends⁹. Days with extreme heat as well as heavy precipitation events are likely to become more frequent, putting energy, transport and water infrastructure at immense risk.

The analysis on the whole, indicates a robust pattern of change towards higher temperatures. For rainfall,

it indicates a greater uncertainty in both the direction and magnitude of rainfall change than is the case for temperature.

Key implications for climate change risk assessment in Gwalior include:

- Gwalior is subject to large year-to-year variability particularly for rainfall. Thus, even in the absence of anthropogenic climate change, the city needs to be resilient to this variability.
- Trends indicate a clear trend towards higher temperatures and more frequent temperature extremes.
- Projections show tendencies towards higher rainfall totals and more intense and frequent precipitation extremes.

Figure 6: Increase in temperature extremes for Gwalior (Source: CEEW, 2020)

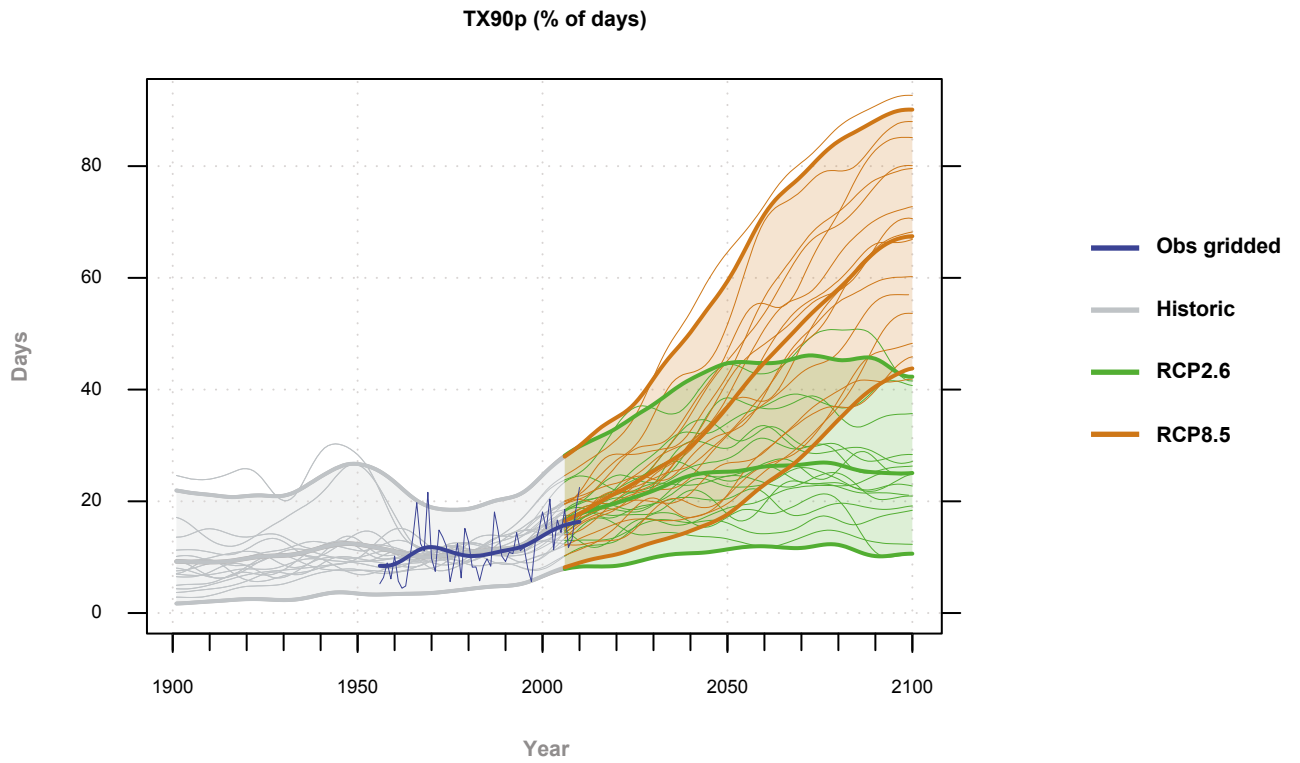


Figure 7: Increase in mean precipitation for Gwalior (Source: CEEW, 2020)

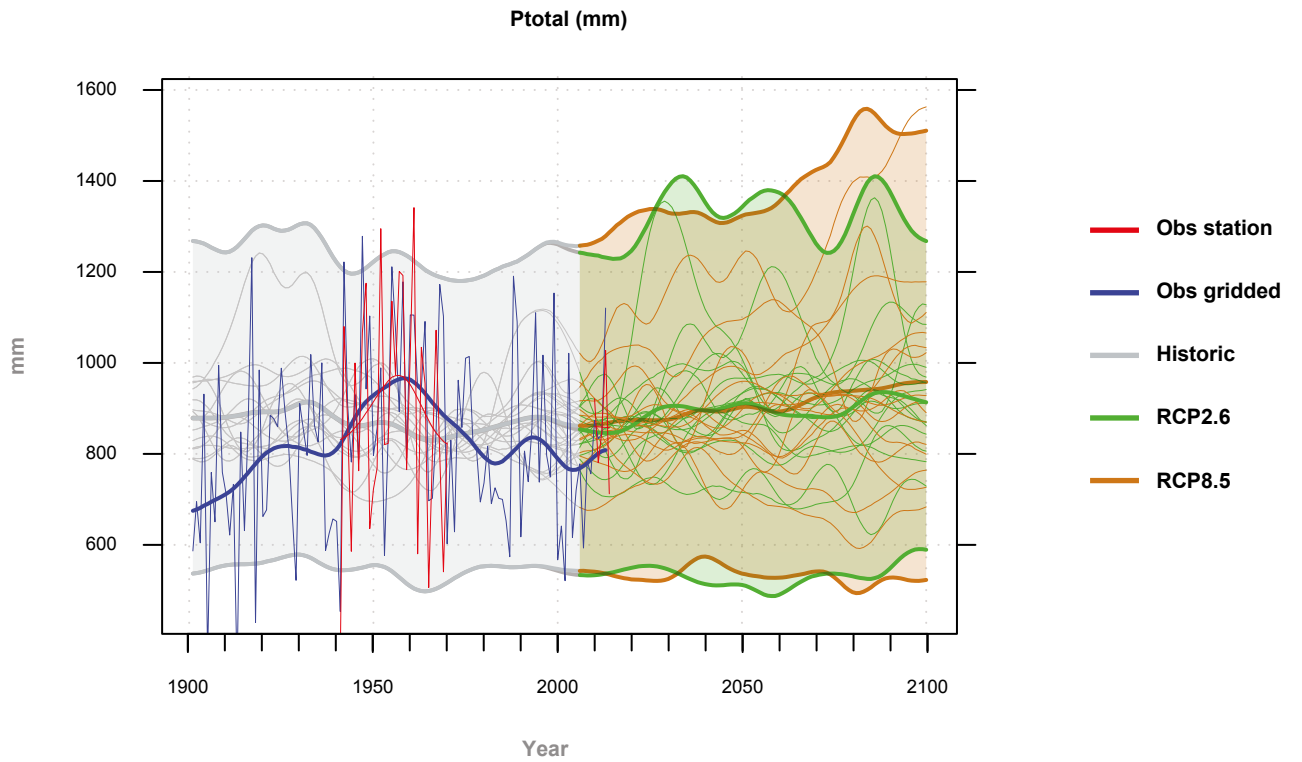


Table 2: Baseline and projected values for rainfall and temperature in Gwalior (Source: CEEW, 2020)

	Observed 1981-2010	2030s RCP8.5	2050s RCP8.5	2080s RCP8.5	2080s RCP2.6
Temperature					
Mean Temperature	25.9°C	+1.5 (1 to 1.8) °C	+2.2 (1.6 to 2.8) °C	+4.6 (3.2 to 5.6) °C	+1.3 (0.7 to 1.9) °C
Warm Days	13 days	+15 (7 to 24) days	+23 (11 to 40) days	+49 (29 to 68) days	+13 (5 to 27) days
Warm Nights	14	+20 (14 to 24) days	+30 (23 to 38) days	+60 (49 to 71) days	+15 (8 to 24) days
Rainfall					
Total Rainfall	787 mm	+2 (-14 to +12) %	+3 (-15 to +15) %	+9 (-21 to +37) %	+5 (-10 to +16) %
Heavy Rainfall Days	12 days	+1 (-3 to +9) days	+2 (-2 to +7) days	+3 (-3 to +9) days	+2 (-2 to +6) days
Consecutive Dry Days	90 days	+2 (-7 to +16) days	+2 (-10 to +21) days	+7 (-18 to +28) days	0 (-12 to +9) days

Table 3: Projected climate risks and potential impacts for Gwalior (Source: CEEW, 2020)

Projected Climate Changes	Potential Impacts and Risks ^a
Warmer conditions, including more intense and frequent hot extremes and heat wave days	<ul style="list-style-type: none"> • Warm days are likely to increase by 50 before the end of the century. Increasing heat stress could result in mortalities and decreasing labour productivity. This can also increase energy consumption for cooling. • If air quality also decreases, this could have further negative health effects including increases in mortality. • Increase in water stress and drought-like events
Higher annual rainfall totals and more frequent heavy rainfall events	<ul style="list-style-type: none"> • In a high emissions scenario, by 2100, total annual rainfall in the city is likely to increase 9% from 2010 levels. This increase can be limited to 4.5% with stringent emission measures. • In 2015, the city received 211.5 mm of precipitation; in 2019, it was 821.9 mm. This indicates extreme variation in precipitation trends⁹.

Socio-Economic Profile of Gwalior

The sex ratio of Gwalior city is 879 females to 1000 males, less than both the state average (931) and national average (940). The overall literacy rate in GMC is 74.8%, out of which 56% comprise males and 44% are females. This is near to the national average of 74%. As of 2015, there were 214 slum settlements in Gwalior with a population of 3,83,218, comprising 28%¹. These areas have narrow inner roads, inadequate electricity meter connections, insufficient street lighting, inadequate water meter connections and lack piped water¹⁴.

Gwalior's industries are mainly in the areas of Sitholi, Banmore and Malanpur. The Gwalior Rayons and Silk Manufacturing or GRASIM, the flagship company of the Aditya Birla group was established in Gwalior in 1947 and has grown to be a leading global player in Viscose Staple Fibre and a prominent producer of Chlor-Alkali, Advanced

Material, Linen Yarn and Fabrics in India¹⁵. Among the current industries are cotton, yarn, paint, ceramics, chemicals, and leather products. A major part of the city's revenue comes from these industries. The district is also dependent on agriculture, which provides livelihoods to sections of the population. The chief agricultural products are pearl millet, paddy, sorghum, black gram, green gram, pigeon pea, sesame, soybean.

The colourful Gwalior Trade Fair, started in 1905, is now MP's biggest fair. Another significant contributor, thanks to the city being well connected via road, rail and air, is tourism. The Tansen Samaroh is an important festival in Gwalior. This along with the Gwalior fort, Man Mandir palace, Gujari Mahal and Tansen's tomb attracts more than 2.2 million tourists annually¹⁶.

The city has also emerged as an education hub, home to platforms for higher education like IIITM Gwalior, Jiwaji University, Raja Man Singh Tomar Music University, Scindia School, and JC Mills School¹⁷.

| City Typology

To ensure that the CAP identified relevant actions for vulnerable groups, WRI developed a socio-economic profile of the city. The methodology is adapted from the World Resources Report “Towards a More Equal City¹⁸” and contextualized for cities in MP. The method uses these parameters to categorize cities:

- Decadal population growth
- Decadal income growth
- Ratio of income growth to population growth

Based on these parameters, cities are classified into four categories

- **Aspiring Cities** have a low GDP per capita today, and a low ratio of projected income growth to projected population growth during 2021-2030. We classify these as aspiring cities because they are soon likely to experience more rapid population growth than economic growth, resulting in a resource gap.
- **Emerging Cities** have a low income today, and a high ratio of income growth to population growth during 2021-2030, as compared to other cities. While their economic strength is low today, their projected economic growth is greater than their projected population growth, indicating increases in economic

productivity. These cities are more likely to have the capacity to overcome current resource constraints and strengthen their position globally.

- **Thriving Cities** are not only economically strong today, but their economic growth is also projected to outpace their population growth during 2021-2030. These cities are growing and thriving.
- **Stabilizing Cities** are economically strong today, but their economic growth is expected to be lower relative to their population growth during 2021-2030 compared to emerging or thriving cities. That is, these cities are starting to stabilize, and, in some cases, their economies are starting to shrink.

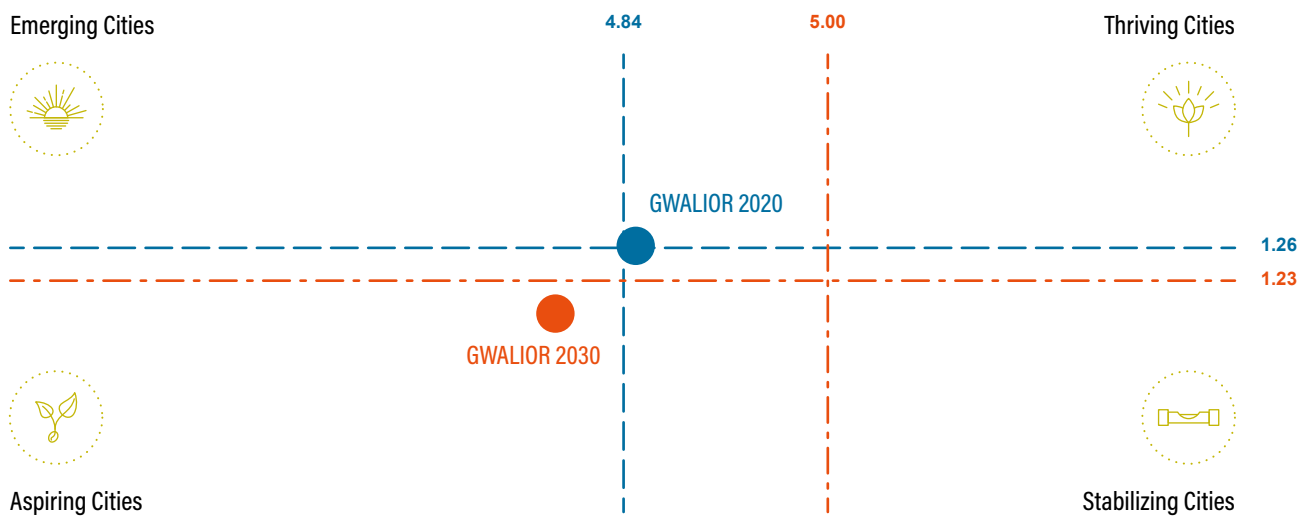
This socio-economic profiling helps identify both the challenges in providing urban services and the opportunities to avoid locking in unsustainable patterns of urban development. The figure below shows the socio-economic transition of Gwalior city from the decade 2011-2020 to 2021-2030. On the x-axis we have log of per capita GDP for the base year and on the y-axis ratio of per capita GDP growth to population growth. We have used logarithmic scale to respond to skewness towards the larger values. The point where both the axes cross is India’s value.

While Gwalior followed the national figures in the past decade closely, it is likely to move into the Aspiring Cities category by 2030; that is, it is likely to experience more rapid population growth than income growth, leading to a resource gap. Addressing this, urban expansion requires planning and management initiatives to optimally utilize available resources.

Figure 8: City Typology (Source: Adapted from World Resources Report: Towards a More Equal City)



Figure 9: Transition of Gwalior City between 2020-2030 (Source: WRI India)



Source: Gwalior Smart City Development Corporation Ltd.

BASELINE ASSESSMENT



CSCAF 2.0 Analysis

Gwalior has performed well in the first two rounds under CSCAF. While the city has done some wonderful work in the waste management sector, it has been an average

performer in other sectors. Some of current initiatives and possible areas of improvement are listed below.

Table 4: CSCAF 2.0 Scores for Gwalior (CSCAF 2.0 submission for Gwalior)

Overall Score as per CSCAF 2.0	Energy and Green Buildings	Urban Planning, Green Cover and Biodiversity	Mobility and Air Quality	Water Management	Waste Management
★★	★★	★★	★	★★	★★★★★
CSCAF 2.0 Score	227.5	117	43	200	486
Current measures being undertaken in the city	<ul style="list-style-type: none"> • Promoting restoration and adaptive reuse of heritage buildings like heritage building precinct near Urvai gate at Gwalior fort and Old collectorate Gorkhi palace³. • A goal of meeting at least 20% of total power demand from renewables⁴. • Solar panels on public buildings³. • Increasing LED streetlights on a PPP basis³. 	<ul style="list-style-type: none"> • GIS Mapping of open spaces and water bodies. • Linking Pradhan Mantri Awaz Yojana to the Ankur program, which rewards citizens for tree plantation. • 82% of the municipal area is under tree cover. • Has a disaster management cell. • A plan for a 50-hectare forest and zoological park near KSR hospital⁵. • Maintains 520 gardens and parks⁶. 	<ul style="list-style-type: none"> • Five multi-level parking locations identified⁶. • Three continuous ambient air quality monitoring stations; two continuous emissions monitoring stations⁶. • 6067 LPG vehicles and 6981 CNG vehicles registered in the city; six CNG stations⁶. 	<ul style="list-style-type: none"> • Water resources assessment, demand Management Strategy and Implementation Plan in place. • NRW is around 30-40%. • 10-20% of wastewater recycled and reused. 	<ul style="list-style-type: none"> • GMC has a Private Sector Participation model for solid waste. • 100% segregated waste collection⁷. • Material Recovery Facility (MRF) of 100 TPD⁷. • 17% of wet waste is composted⁷. • C&D waste collected at four centres⁷.

Overall Score as per CSCAF 2.0	Energy and Green Buildings	Urban Planning, Green Cover and Biodiversity	Mobility and Air Quality	Water Management	Waste Management
Areas of improvement	<ul style="list-style-type: none"> • Increase LED streetlights (around 3% in 2019). • Implement measures for promoting green buildings. • Increase power generation from RE sources (<5% currently). • Promote rooftop solar in residential and commercial buildings 	<ul style="list-style-type: none"> • Develop actions, allocate budget and monitor implementation for water body and green space conservation. • No actions for biodiversity conservation. A biodiversity committee is a first step. • Increase per capita green space from 1 m² to at least 10 m². • Prepare a disaster management plan and document loss and damage due to disasters. 	<ul style="list-style-type: none"> • Increase number of buses (currently 0.02 bus per 1000 population) • Increase coverage of NMT (5% of roads with NMT network currently) • Increase share of clean-fuel shared mobility (currently 0%) 	<ul style="list-style-type: none"> • Reduce NRW • Revive the Swarnarekha river. • Conduct flood risk assessment and prepare action plan. • Conduct energy audit for pumping stations and treatment plant. 	<ul style="list-style-type: none"> • Capture methane gas from landfills. • Central bio methanation plant required • Increase wet waste composting. • Increase waste recycling. • Set up plastic waste collection centres and MRF⁷. • Set up 50 TPD construction and demolition waste recycling centre⁷.

Greenhouse Gas Emissions Profile

A GHG Inventory includes an analysis of all sectors and sources that emit GHGs, including transport, waste and energy. A citywide inventory forms a critical piece of any CAP, establishing the activities that contribute towards emissions, which allows the development of mitigation policies and strategies.

This emissions inventory was compiled to the Global Protocol for Communities (GPC) BASIC standards using C40's City Inventory Reporting and Information System (CIRIS) tool.

Critical Emission Sources

In 2019, Gwalior's GHG emissions (including manufacturing and industrial emissions) were 1.37 mtCO₂e (1 tCO₂e per person). This includes Scope 1 emissions (from activities taking place within city boundaries), Scope 2 emissions (from electricity consumption), and Scope 3 (emissions outside city boundaries due to activities originating within city limits).

Energy and electricity use in industrial and heavy industrial buildings is the biggest contributor, followed by residential buildings. Stationary energy accounts for 62% of total emissions followed by transportation (22%), waste sector (3%) and wastewater (13%) (Figure 11).

Figure 10: Total Emissions Contribution by Sector (Source: WRI India analysis using primary city data)

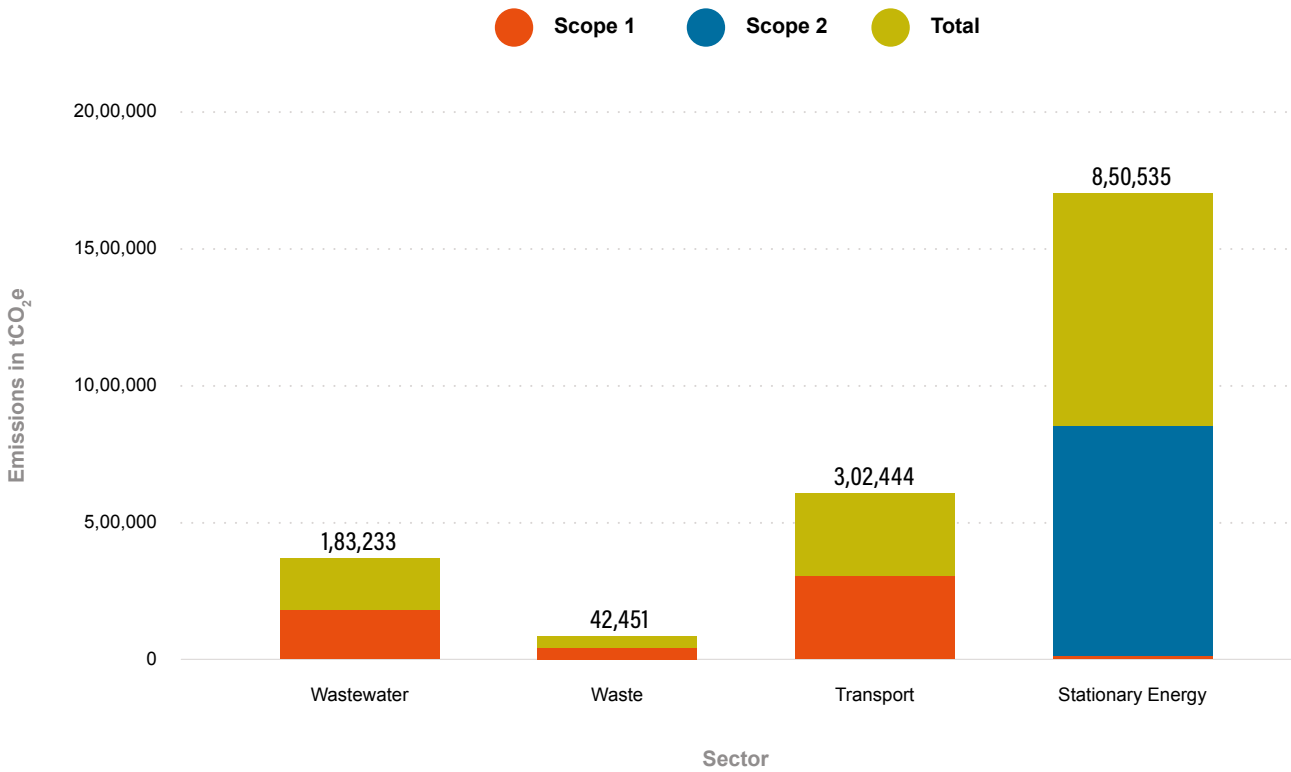
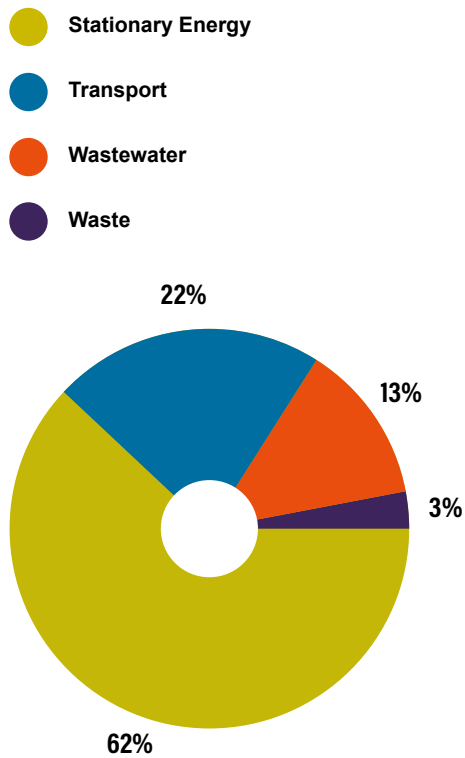
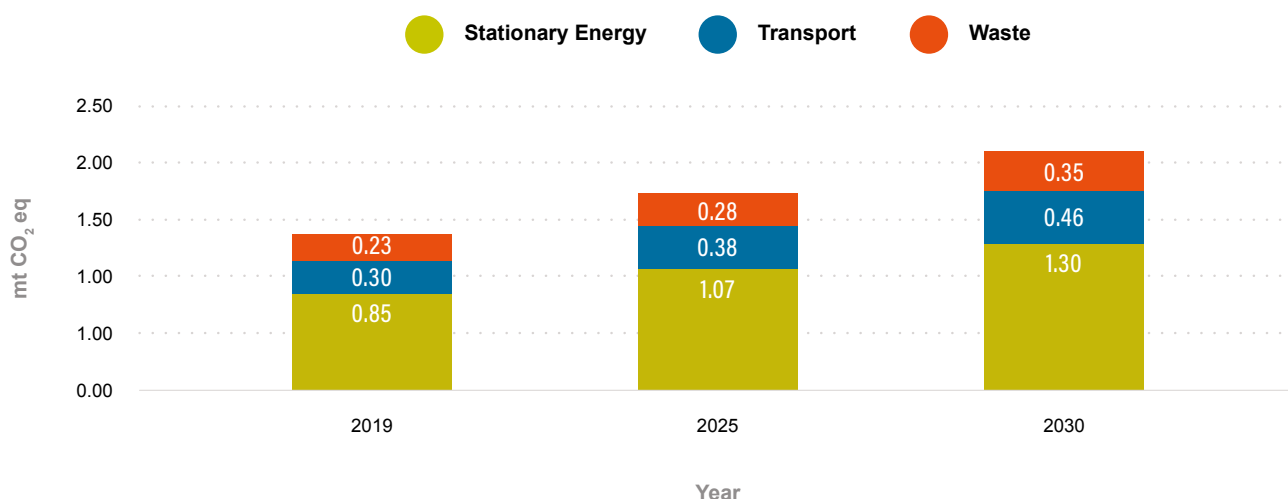


Figure 11: Percentage Distribution of Emissions by Sector (Source: WRI India analysis using primary data)



Gwalior's total emissions are projected to rise by 26% by 2025 and 56% by 2030 under a business-as-usual scenario if no action is taken (Figure 12).

Figure 12: Projected emissions for Gwalior (Source: WRI India analysis using primary data)



Stationary Energy

This includes emissions from electricity consumption and fuel consumption mainly LPG from residential buildings, commercial buildings, institutional buildings, urban agriculture and manufacturing industries with the municipality. According to data from the state Distribution Company (DISCOM), in 2019, electricity consumption from stationary sources was 10,23,399 MWh. Residential buildings had the highest share at 6,04,795 MWh (59%), followed by commercial buildings at 2,24,066 MWh (22%). Consequently, residential buildings contributed the highest to emissions (60%), followed by commercial buildings (21%) and manufacturing industries (9%) as seen in Figure 13.

Figure 13: Stationary energy emissions contribution by sub-sector for 2019 (Source: WRI India analysis using primary data)



LPG consumption in the city was 44871 Mt for domestic sector (93% of total LPG consumption), and 3176 Mt for commercial consumption (7%) as shown in Figure 14.

This sector accounts for 15,139 tCO₂e of Scope 1 emissions and 8,35,396 tCO₂e of Scope 2 emissions. The figure below presents the distribution of Scope 1 and 2 stationary energy emissions (Figure 15).

Figure 14: Liquefied petroleum gas (LPG) consumption
(Source: Primary data from fuel agencies)

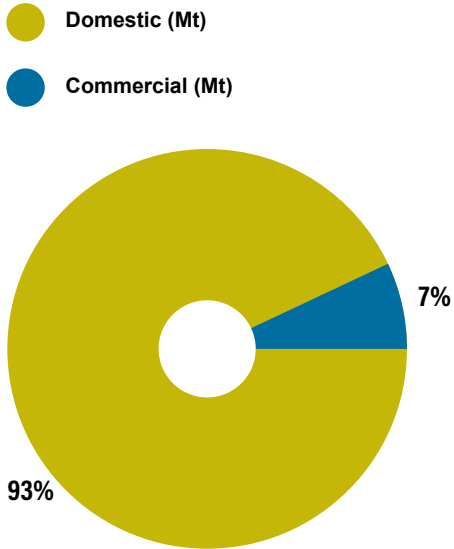
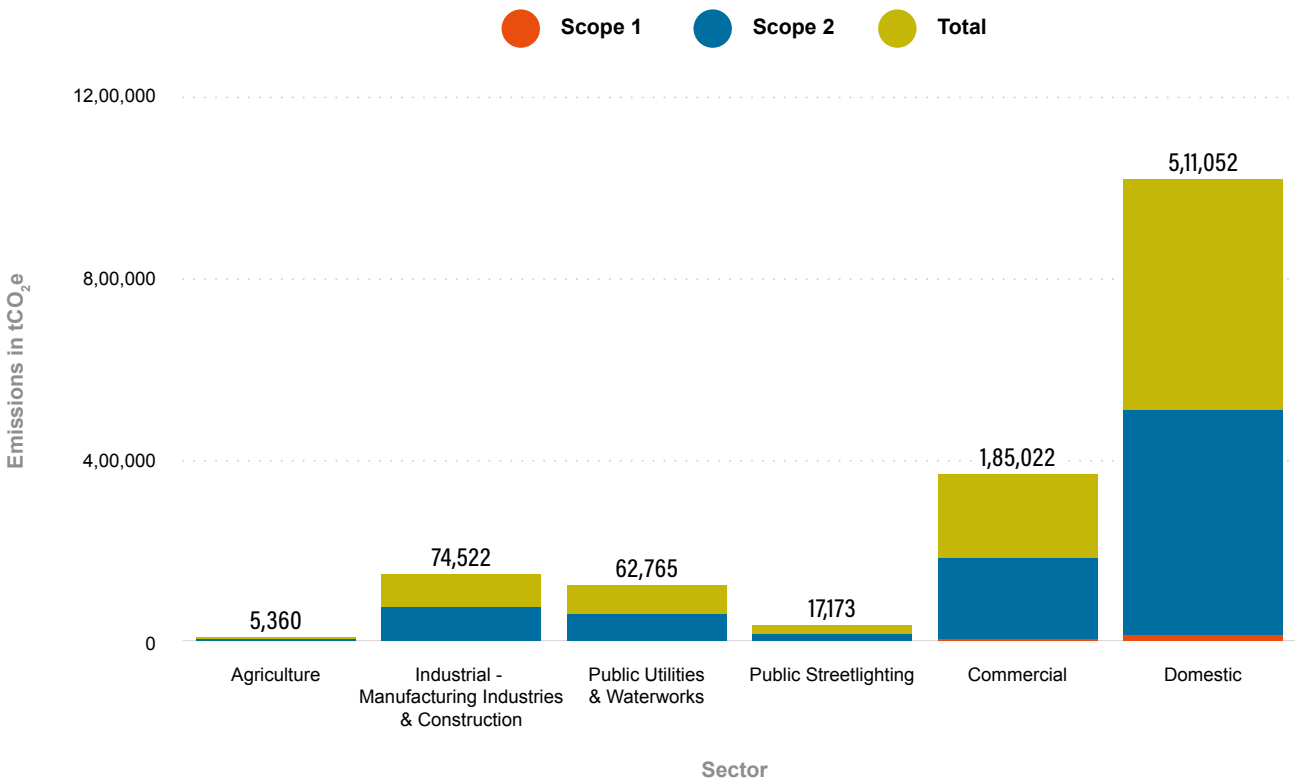


Figure 15: Stationary energy emissions by sub-sector and scope (Source: WRI India analysis using primary data)



Transportation Sector Emissions

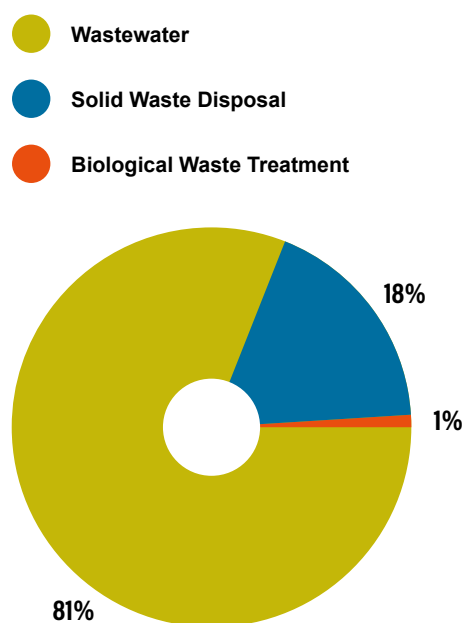
The transport sector’s consumption of petrol and diesel in on-road transport accounts for 3,02,444 tCO₂e of

emissions. Data was obtained from fuel agencies such as IOCL, BPCL and HPCL.

Waste Sector Emissions

Waste accounts for 2,25,684 tCO₂e of emissions, most of it due to management of wastewater in the city (81%) as seen in the figure 16. The rest is from solid waste in landfills (18%) and composting of biological waste (1%). (The city had not provided data on emissions due to incineration of waste, or on waste composition, so that has not been included; the inventory’s accuracy can be refined further with this information.)

Figure 16: Waste sector GHG emissions by sub-sector (Source: WRI India analysis using primary data)

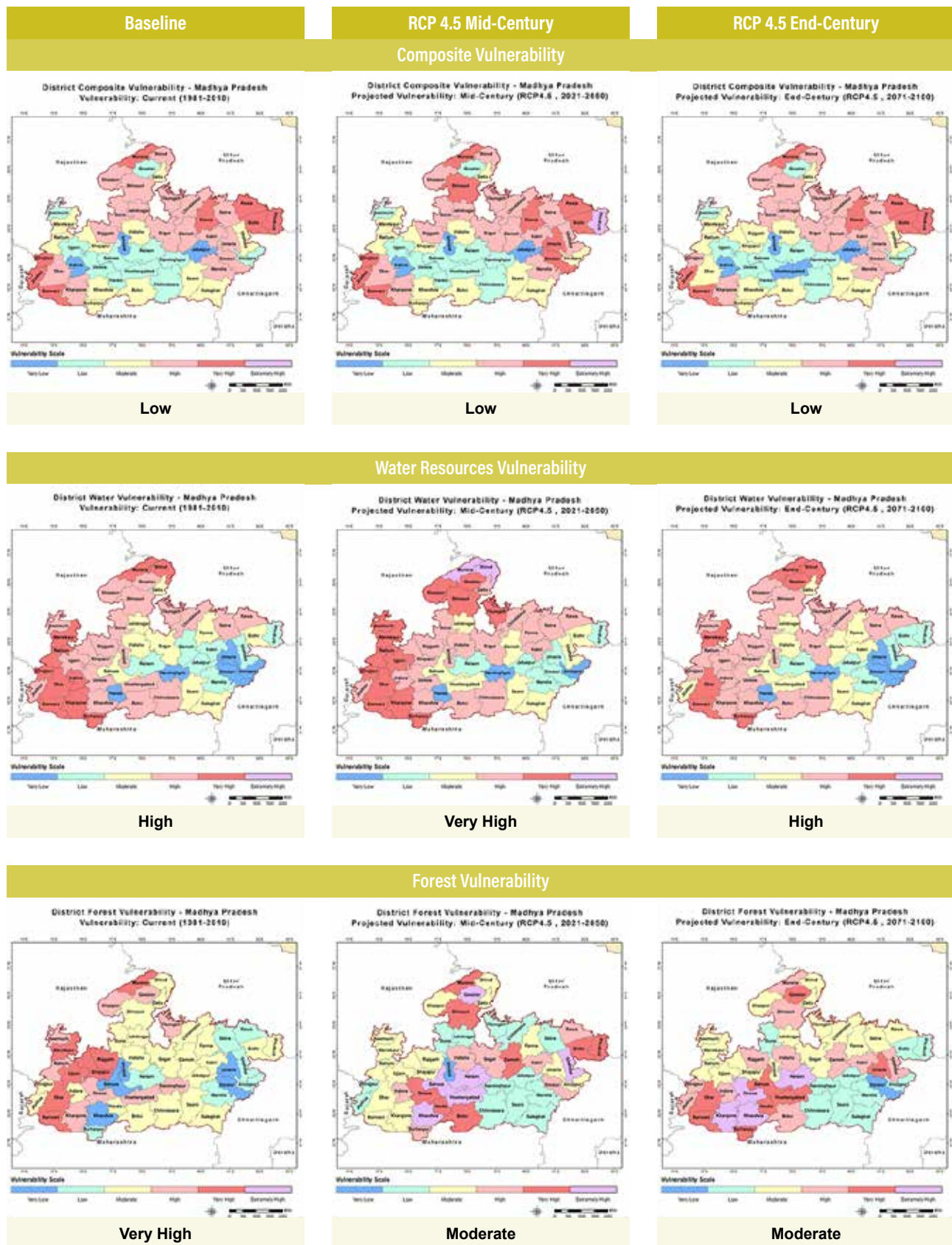


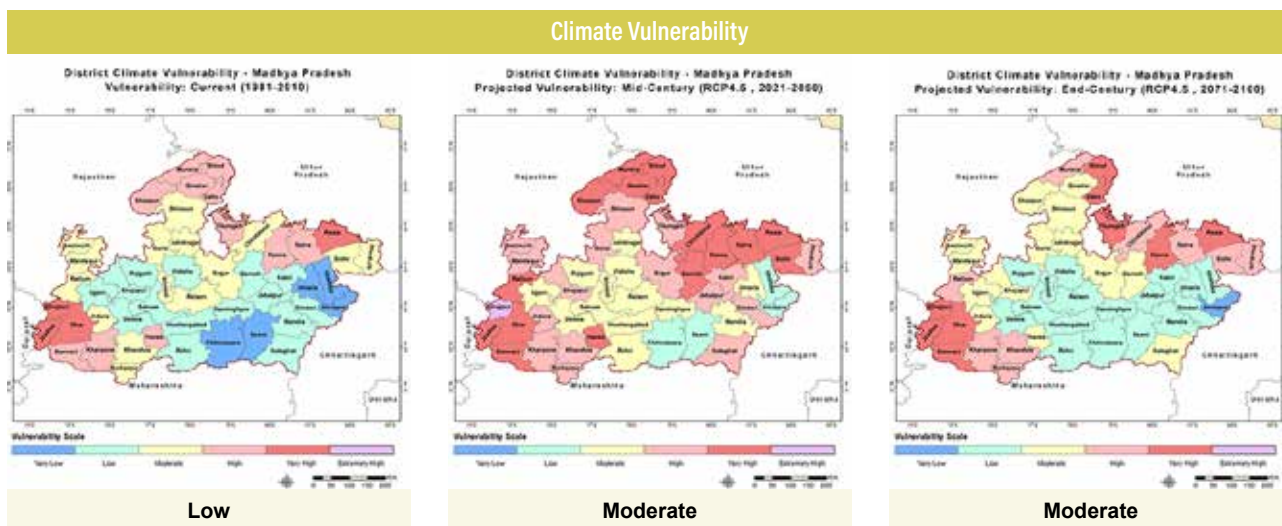
Vulnerability Assessment

EPCO has assessed the climate change impact and vulnerability assessment for water, forest, agriculture and health sectors for MP’s 52 districts. Their analysis was carried out for projected climate in the state over the periods 2021–2050 (Mid-century/MC below) and

2071–2100 (End-century/EC below) using a multi-model ensemble from the Coordinated Regional Climate Downscaling Experiment (CORDEX) for RCP4.5 and RCP8.5 scenarios.

Figure 17: Sectoral vulnerability profiles for Gwalior (Source: Madhya Pradesh Climate Change Knowledge Portal)



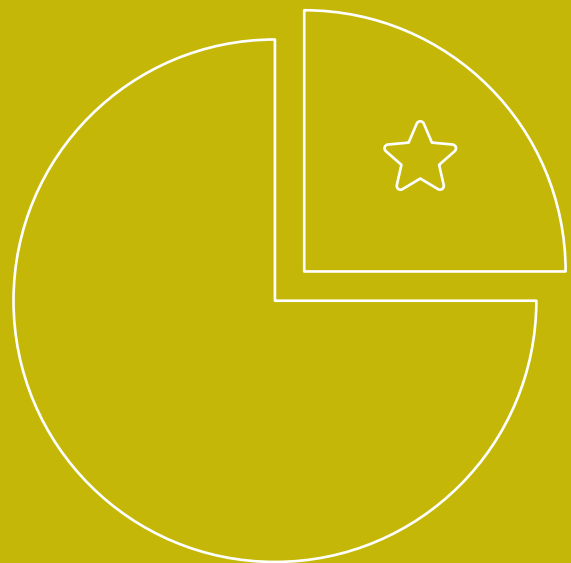


According to this analysis, Gwalior has a low composite vulnerability. For water resources, Gwalior is very highly vulnerable; there is a very high risk of decreasing water availability, increasing stresses on crop water, and increase in frequency of extreme events like floods and droughts in both the MC and EC scenarios.

For forests, there is extremely high vulnerability in the mid-century scenario, with extremely high risk of decrease in biological richness, accelerated forest cover changes based on the disturbance index, changes in canopy cover, and shift in slope and vegetation. The end century projections reduce slightly to very high risk.

With climate, the city is very highly vulnerable in the mid-century projections, with a very high risk of decrease in average annual rainfall, increase in intensity of precipitation and rise in heat index. The risk reduces slightly to moderate in the end century projections.

SECTORAL PRIORITIES



This section provides a detailed description of Gwalior’s current performance under CSCAF 2.0. Sectoral goals can

then be set to address the gaps and challenges.

Sectoral Assessment

Energy and Green Buildings

Total electricity consumption in the city in 2019 was 10,23,399 MWh. This is divided into domestic (59%), commercial (22%), industrial (9%), public water works (7%), and street lighting (2%)¹⁹. Per capita energy consumption was 748 kWh. Total electricity consumption has more than doubled (109% increase) in the period between 2010–2017, and emissions have

increased proportionately¹. LPG, CNG, petrol and diesel consumption contributed to 5,43,267 tCO₂e in 2019.

Only 3% of streetlights were energy efficient in 2019²⁰ and the city is working on increasing the same and plans to install 52,000 LED streetlights along with Energy Efficiency Services Limited (EESL), which is currently in progress²¹. The city has also started work on installing solar panels on public buildings with MP Urja Vikas Nigam³.

Table 5: Breakup of fuel consumption, FY 2019-20 (Source: Primary data from fuel companies in the city)

Type of Fuel	Consumption
Diesel	58,448 kl
Petrol	46,697 kl
CNG	5522 Mt
Domestic / Residential LPG	44871 Mt
Commercial LPG	3176 Mt

Urban Planning, Green Cover and Biodiversity

Gwalior Municipal Corporation (GMC) is having a rich green cover, with 82% of municipal area under green cover. However, this is only distributed in some wards, with a few wards having scarce vegetation²². GMC maintains 520 gardens and parks⁶. Gwalior has 1 sqm of green space per person, far less than Urban and Regional Development Plans Formulation and Implementation (URDPFI)’s prescribed 10-12 sq. m./person¹.

ments on water bodies and open spaces as per CSCAF 2.0. Gwalior is rich in biodiversity and is home to over 600 species of plants. A survey made two decades ago indicated the presences of 100 types of trees²². However, to conserve and reassess its biodiversity, Gwalior must establish a biodiversity management committee which can include representatives from Horticulture Department, Forest Department, Town Planning and Country Planning Organization, municipal corporation and Development Authority, as per the Biological Diversity Act, 2002²¹.

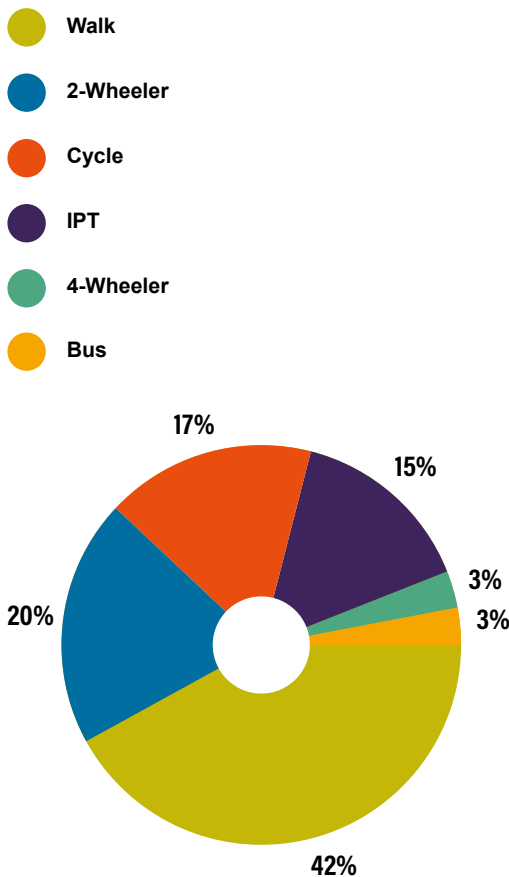
Total carbon sequestered by all the six major city parks is 0.6 tCO₂e/year; 10 identified urban water bodies sequester 21.05 tCO₂e/year; and all the trees in the city sequester 45,188 tCO₂e/year¹. GMC recently upgraded several parks including Shivaji Park, Ladies Park, and Nehru Park³. Currently, there is a plan for a 50-hectare forest land and zoological park near KSR hospital, which would include a yoga centre and walking tracks. A 150-acre park has also been proposed in Dinarpur⁵.

Clean Air and Mobility

In 2019, Gwalior had a fleet of 28 buses, managed by Gwalior City Transport Services Limited (GCTSL)²³, amounting to 0.02 buses per 1000 people, much less than the service level benchmark by MOHUA of 0.2 buses per 1000 population²⁴. The city has around 8000 privately operated tempos, autos and minibuses which cater to majority of public transport needs⁴. In 2018, 42% of Gwalior’s residents commuted on foot. The remaining modal split comprised of cycle (17%); two-wheelers (20%); intermediate public transport (15%); four-wheelers (3%); and buses (3%)²⁵.

The city has developed GIS based maps of open spaces and water bodies. However, the maps should be revised to capture data such as area, depth, volume, foliage cover, type of land, ownership of land, current status, etc. Moreover, data should be made available on encroach-

Figure 18: Transport mode share for Gwalior city 2017-18
(Smart city open data portal)



Despite the high share for walking and cycling, less than 5% of the city's road network features usable footpaths and cycle tracks, and there is encroachment over footpaths and street parking²¹. The city has installed a public bicycle sharing system consisting of more than 500 cycles across 50 stations on a PPP basis. However, as per reports, the cycles are not being used and are in bad condition²⁶.

In terms of clean fuel vehicles, the city has six CNG filling stations, 6,067 LPG vehicles, 6,981 CNG vehicles, and 1,158 e-rickshaws registered⁶. Gwalior had opened a tender for 80 midi CNG Intra City Buses on GCC model but received a low response due to Covid 19 and plans to re-tender it. 40 electric buses are also planned subject to VGF availability. Smart multilevel car parking is planned at Gandhi market³.

As per a 2016 WHO study, the air in Gwalior city was the worst in India and second-most polluted in the world². The major contributing factors were the presence of kilns and quarries. Gwalior has four Continuous Ambient Air Quality Monitoring Stations (CAAQMS) in Phool Bagh, DD Nagar, City Centre and Maharaj Bada²⁷. The city prepared an air pollution action plan in 2019⁶ and must conduct an impact assessment of the plan with evidence

of improvements through monitoring and evaluation frameworks.

| Water Management

Gwalior's estimated water requirement is 155.52 MLD while total daily supply is 130 MLD. Drinking water for Gwalior comes from Tigra dam, enough to fulfil demand. 22% of the city's water undergoes secondary treatment, but there is a need for more data on tertiary treatment. Due to inadequate distribution, a third of the population does not have access to piped water⁹.

Only 70% of households in the city that have toilets are part of the city sewerage network: an estimated 16% of wastewater reaches the STP, with the rest being delivered to the irrigation canal without treatment. This has contaminated the Morar river's water, making it unfit for human consumption⁹. The concretization of the Swarnarekha river has also resulted in the non-percolation of the rainwater¹.

Gwalior has a Water Demand Management Strategy and Implementation Plan indicating the status and conservation of city-level water bodies, and a groundwater information booklet. According to level 5 under the CSCAF 2.0, the city can revise these plans to integrate climate change factors. The NRW is currently less than 40%²¹. GSCDCL is also implementing rainwater harvesting in phases³. As per EPCO's vulnerability assessment, Gwalior city faces a high risk of urban flooding due to increased intensity and frequency of precipitation. However, the city has not prepared a flood management plan²¹.

| Waste Management

Gwalior generates around 335 Mt of waste a day, including 20-25 tonnes of vegetable waste. There is 100% door-to-door collection of segregated household waste. The city has 120 waste collection trolleys but requires another 30. GMC has five transfer stations and 1 Material Recovery Centre of 100 TPD capacity. 17% of wet waste is processed using mechanical composting, but a central bio-methanation plant is required. In terms of plastic waste, Gwalior generates 11.23 Mt per day but is not equipped with a plastic Material Recovery Facility (MRF) or collection centres⁷.

In terms of construction and demolition waste, Gwalior has four collection centres for construction and demolition waste, but no C&D recycling facility. A 50 TPD C&D recycling plant is needed. GMC has formulated bylaws for C&D waste recycling⁷.

Gwalior has only 1 electronic waste collection centre in the city and has not yet linked collection with authorized

recyclers or dismantlers. The city also needs to focus on integrating the informal waste sector within its waste management particularly for plastic waste and electronic

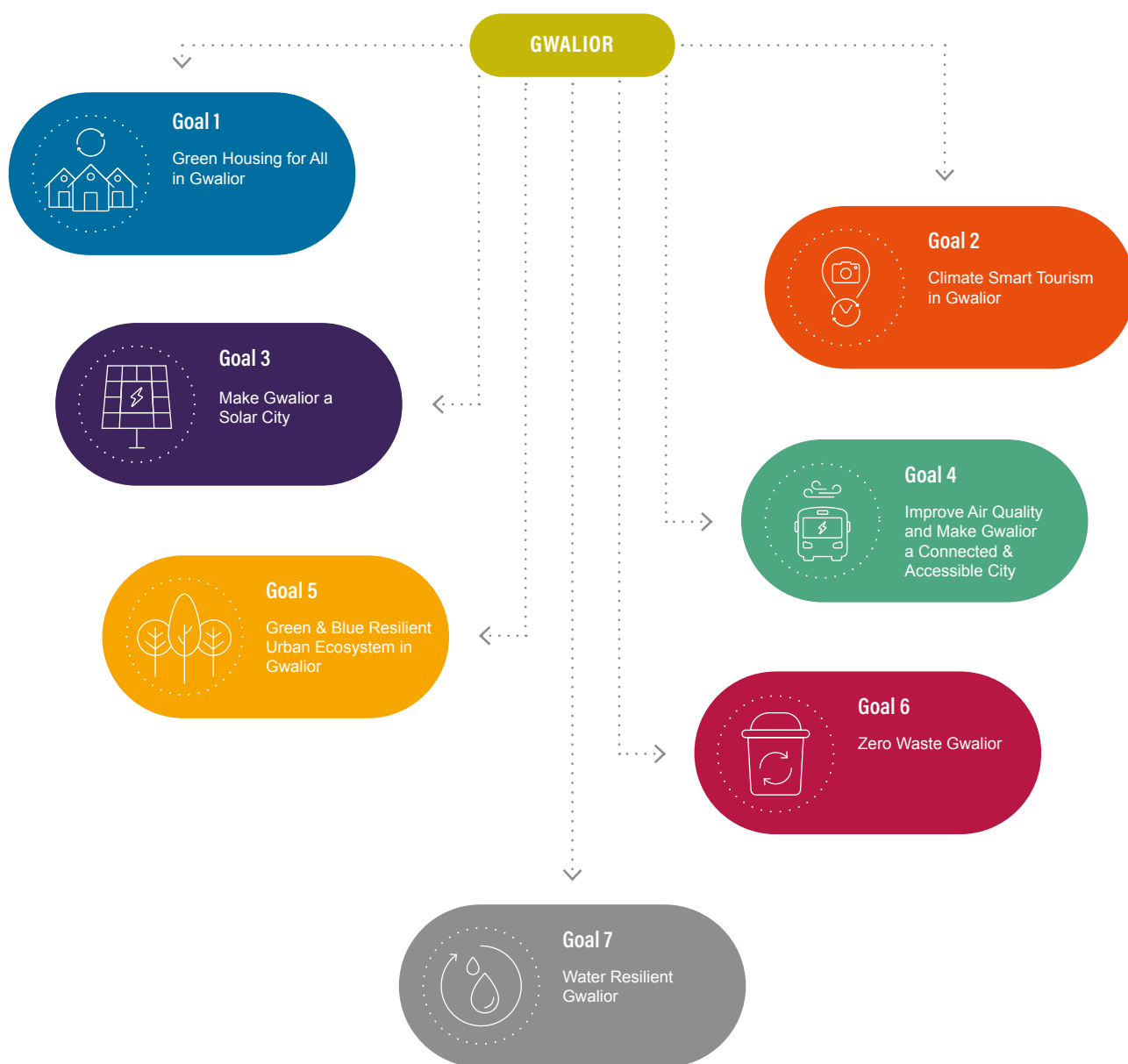
waste⁷. Gwalior has only one STP of 50 MLD in Lalitpara and is planning for 4 more of 145 MLD, 4 MLD, 65 MLD and 8 MLD²⁸.

Sectoral Goals

The sectoral goals identified for Gwalior city are aligned with the priorities of existing sectoral departments to ensure efficient implementation of the Gwalior CAP. However, there is considerable scope to establish

convergence and dove-tailing across sectors, establish collaborations across departments and reap the co-benefits of holistic solutions. The six goals identified are as follows:

Figure 19: Sectoral goals for Gwalior (Source: WRI India)



Mainstreaming Inclusivity in the Gwalior Climate Action Plan

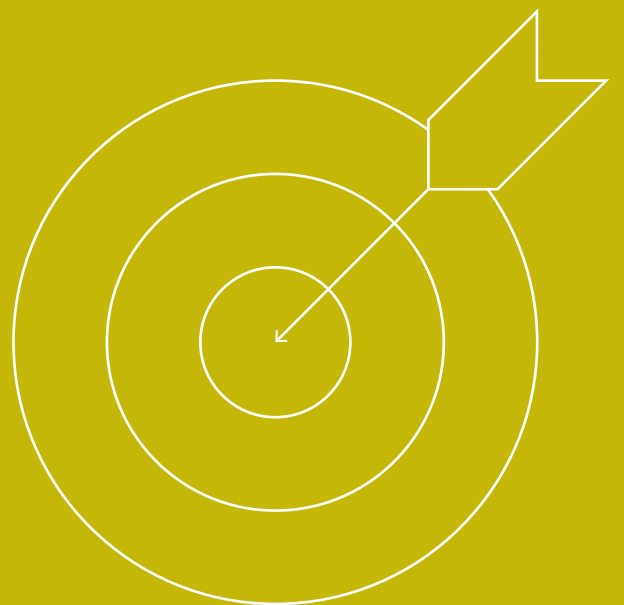
Gwalior’s CAP process stresses the importance of inclusive planning. An inclusivity analysis has been included for each sectoral action to ensure that the action has equitable benefits for all identified impact groups. The analysis has been adapted from the guidance document on “How to tackle climate change and inequality jointly: practical resources and guidance for cities” prepared by World Resources Institute Ross Centre for Sustainable Cities and C40 cities in 2019²⁹. As a first step towards mainstreaming inclusivity, cities must ensure that inclusivity is embedded in processes, policies, and

impacts (Figure 20). Inclusivity of process ensures that each policy making process involves engagement with stakeholders, especially the ones most vulnerable to climate change. Inclusivity of policies should ensure that policies are designed with people at the centre of decision making. Finally, the actions proposed should include clear indicators and monitoring frameworks to measure the inclusivity of impacts across each impact group. Impact groups can include the elderly, children, disabled, religious minorities, informal communities, temporary workers, etc.

Figure 20: Inclusive climate action planning (Source: WRI Ross Centre and C40 cities)



SECTORAL CLIMATE ACTIONS



Goal 1: Green Housing for All in Gwalior

One of the goals of the smart city is attaining a higher level of urban lifestyle by creating liveable neighbourhoods, developing affordable housing units under PMAY as well as amenities like night shelters, residential care homes and hostels for working women. Given that Gwalior has <5% of its total energy demand being met by renewables, we suggest making this a climate smart goal by incorporating green building techniques and renewable energy usage in existing and new projects.

Identified Actions

Action 1: Promote energy-efficient appliances in residential buildings

- **Challenges addressed at the city level:** Around 60% of emissions from stationary energy sector came from residential buildings in 2019. Gwalior is also not actively promoting green buildings in the city²⁰.
- **Description:** Gwalior should take steps to promote energy efficient appliances in all existing and new residential buildings. These can include:
 - An on-ground survey should be done to assess current penetration of energy efficient appliances like cookers, chillers, refrigerators, LED lighting, etc in residential and commercial buildings.
 - Incentives like tax rebates can be provided. This can be funded through money saved by DISCOMs due to lower energy consumption.
 - GMC can also reduce GST rates on energy-efficient equipment³⁰.
 - Incentives can be provided for those installing solar PV or solar water heater, energy efficient fans or ACs through reduction in other utility bills like water or waste collection.
 - Awareness training workshops can be conducted on uptake of energy-efficient appliances and energy conservation measures for resident welfare associations and large-scale distributors.
 - Energy-efficient equipment drives / sales with private distributors can be organized and GMC can encourage innovative financing through on-bill payment, upfront payment via online platform or periodic payment.
 - Provide low-cost energy-efficient appliances for residential consumers. (Andhra Pradesh Electricity Regulatory Commission provides products at discounted rates.) Reduced GST on such products³¹.
 - Collaboration with DISCOMs to implement initiatives under the MP Electricity Regulatory Commission Demand-side Management (DSM) regulations 2016.

- **Inclusivity analysis:** Where renewable energy or energy-efficient appliances are not cost-competitive, or upfront costs of installation are high, cities can provide targeted rebates for low-income groups. Cities can target energy efficient appliance installation in affordable housing schemes under the Pradhan Mantri Awas Yojana³². Low-income workers can also be provided training for operating and installing these energy efficient appliances.
- **Implementing stakeholders:** GSCDCL (lead), IGBC cell, MP Madhya Kshetra Vidyut Vitaran Company Limited (MPMKVVCL), MPUVN, RWAs, builders' associations, equipment manufacturers.
- **Timeframe:** Short term: 1–2 years.
- **Alignment with schemes:** Housing for All Plan of Action (HFAPoA): Gwalior under PMAY³³.
- **Alignment with CSCAF indicators:** Indicators 1 (energy consumption in the city), 5 (promotion of green buildings) and 6 (green building adoption) under Energy and Green Buildings.
- **Monitoring indicators:** Energy cost savings from implementation of energy-efficient technologies, # (number) of appliances sold, % of residential buildings with such appliances disaggregated by income type.

Action 2: Promote green and cool roofs in residential projects/colonies/apartments

- **Challenges addressed at the city level:** As per IMD data, the city faced strong heat waves, with temperatures rising up to 46°C in 2022³⁴.
- **Description:** To reduce the impact of heat waves, Gwalior can promote and implement green and cool roofs in residential projects and households.
 - **Cool roofs:** Promote measures for evaporative cooling, such as placing wet jute sacks on roofs, painting them with white reflective paint, using highly reflective surfaces that stay cool, coatings and treatments such as lime-based whitewash, white tarp, white China mosaic tiles, and acrylic resin coating. These provide affordable cooling for those most vulnerable to the health effects of extreme heat. This measure was an important part of the 2017 Ahmedabad Heat Action Plan³⁵ and has been piloted by the Greater Hyderabad Municipal Corporation³⁶ as part of their state building energy efficiency program. Surat and Indore have also

begun similar projects in which over 100 households were coated using low-cost techniques and green cool-proofing materials such as lime concrete, helping to reduce temperatures and the costs of electricity and water.

- **Green roofs:** City can promote green roofs with a vegetative cover in all municipal buildings to encourage uptake. In Chennai, Bengaluru, Mumbai, and Hyderabad, the concept of green buildings is slowly but steadily becoming the new norm. Some cities are also using treated wastewater to maintain these gardens which not only reduce ambient temperatures but also improve visual appeal³⁷.
 - **Inclusivity analysis:** Retrofitted programs may lead to higher rental costs or other fees for the upgrades, and low-income communities and businesses may be displaced. Informal communities may have few incentives to undertake these improvements because of lack of land tenure security, while low-income communities may not be able to finance the upfront costs of such programs. They often face higher heat stress due to roofing material. For example, slums in Mumbai were 5-6 degrees hotter than the neighbouring areas³⁸. Since Gwalior had around 28% of its population living in slums in 2013¹, these initiatives can be taken up for free or at a subsidized cost for informal housing.
 - **Implementing stakeholders:** GMC (lead)- gardens department and town planning departments, Gwalior Smart City, RWAs, builders' associations, NGOs
 - **Timeframe:** Medium Term: 2–5 years.
 - **Alignment with schemes:** Housing for All Plan of Action (HFAPoA): Gwalior under PMAY
 - **Alignment with CSCAF indicators:** Indicator 2 (proportion of green cover) under Urban Planning, green cover and biodiversity.
 - **Monitoring indicators:** Percentage of buildings with green roofs and cool roofs (disaggregated by income type), percentage increase in rooftop green cover, reduced illnesses, or reduced mortality due to heatwaves
- Action 3: Implement measures to promote green buildings in Gwalior**
- **Challenges addressed at the city level:** As per CSCAF 2.0 data, Gwalior is not taking initiatives to promote green building and scored low under that indicator.
 - **Description:**
 - ECBC 2017 codes have been mandated in commercial buildings. However, compliance is low. Gwalior should ensure strict compliance through monitoring permit requirements, calculation methods, regular inspections, monitoring energy bill reductions, etc.
 - Set up a functioning high-level green building committee or equivalent, with members including ULB's commissioner and representatives of the city's green building cell, smart city officials, Urban Development Department, town planner, Public Works Department, green building certification agencies, developers and building professional associations. This committee must provide strategic advice for the promotion and adoption of energy-efficient and green buildings in the city.
 - Gwalior must also have a functioning green building cell for knowledge dissemination, creating public awareness, empaneling green building schemes and their promotions, verification, and faster approvals for green buildings in the city. The cell should have architects, planners, engineers, certified green building professionals, auditors, and municipal engineers. The cell should work in close coordination with the committee and provide technical assistance, regular feedback, and recommendations.
 - **Inclusivity analysis:** GMC can ensure that the low-cost housing is retrofitted with components that increase energy efficiency, optimize water consumption, reduce heating effect, or manage waste effectively without increasing rental costs. Moreover, a tiered approach can be adopted where buildings in high income areas can aim for higher green building standards compared to those in low-income areas.
 - **Implementing stakeholders:** GMC (lead), Gwalior Smart City, RWAs, buildings associations, IGBC city chapter, MPMKVVCL, MPUVN
 - **Timeframe:** Short term: 1–2 years; plus, monitoring and implementation for more than five years
 - **Alignment with schemes:** ECBC 2017, India Cooling Action Plan 2018, UJALA Scheme 2015, Policy for Implementation of Solar Power-based projects in Madhya Pradesh 2012, Madhya Pradesh Policy for Decentralized Renewable Energy Systems 2016, Smart Cities Mission, MP Renewable Energy Policy 2022
 - **Alignment with CSCAF indicators:** Indicators 2 (total electrical energy derived from renewables) and 5 (promotion of green buildings under energy and green buildings).

- **Monitoring indicators:** Reduction in energy demand from residential buildings, reduction in GHG emissions from stationary energy, number of green buildings in the city, green building built up area as a percentage of all buildings.

Action 4: Mandate or incentivize rooftop solar panels and solar water heaters in all new residential and commercial buildings including hotels, malls and hospitals

- **Challenges addressed at the city level:** Less than 5% energy coming from renewables as per CSCAF 2.0.
- **Description:** The city can first conduct a survey to understand the current percentage of residential buildings, hotels, malls and hospitals in the city with solar water heaters. They can even speak to distributors to understand the increase in solar water heater sales over the past few years, reasons for uptake and challenges faced if uptake is low. GMC can mandate all new commercial and residential buildings to have solar water-heaters and rooftop solar including hotels, hospitals and malls. This should be included in new Development Plan and building bylaws. Alternatively — or complementing this — GMC can subsidize the capital costs for hotels, offer rebates on property tax or electricity bills, and provide other concessions usually limited to the residential sector, for hospitals and hotels. For example, BESCO in Bengaluru requires developers to install solar water heaters in dwellings with a floor space more than 600 ft² (56 m²); the mandatory solar thermal capacity is linked to room size and increases based on the interior space available³⁹. Karnataka state government provides rebate of ₹0.50 per unit, up to ₹50 per month, for installing SWH⁴⁰. Pune city gives a 5% tax rebate if a building has implemented one of three energy efficiency initiatives (SWH, composting, RWH), 10% for implementing two⁴¹.
- **Inclusivity analysis:** Implementation may not be cost-effective for smaller hotels and hospitals as they require relatively high upfront costs for installation and maintenance. This can be offset by incentivizing hotel owners for collective purchase of RE. Training and awareness programs need to be conducted for hotel, hospital and mall owners and staff. Staff from low-income communities can be involved and trained for installing and maintaining these solar water heaters.
- **Implementing stakeholders:** GMC (lead), GSCDCL, MPUVN, RWAs, real estate and builders' associations, MPMKVCL, hotel and hospital associations
- **Timeframe:** Medium term: 3-5 years

- **Alignment with schemes:** Policy for implementation of solar-power-based projects in Madhya Pradesh, 2012.

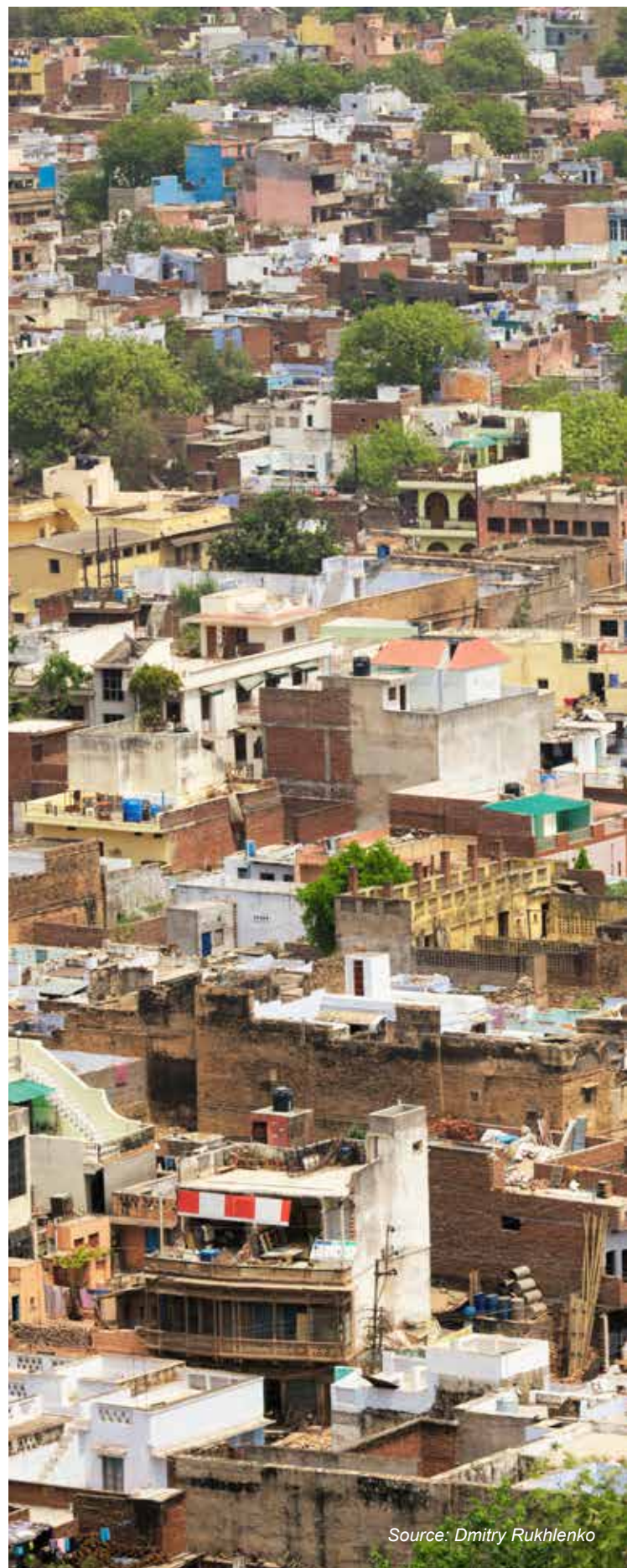
Housing for All Plan of Action (HFAPoA): Gwalior under PMAY, MP Renewable Energy Policy 2022.

- **Alignment with CSCAF indicators:** Indicator: 1 (total electrical energy derived from renewable energy sources) under Energy and Green buildings
- **Monitoring indicators:** Electricity generation from implementation of rooftop solar and reduction in energy demand from conventional sources from implementation of solar heaters, % of residential buildings with solar water heaters disaggregated by income type, % of hotels, malls and hospitals with solar water heaters, % increase in SWH sales

Action 5: Explore common solar PV projects for community low-income housing

- **Challenges addressed at the city level:** Less than 5% energy coming from renewable sources²⁰. 28% of Gwalior's population also live in slums¹.
- **Description:** Gwalior can develop models integrating grid-connected solar PV systems for shared utilities like pumps, lighting, elevators, wherein members of the housing complex receive monetary compensation through net metering (after paying for consumption from the grid). GMC should first identify a suitable social housing scheme with fossil-fuel-based energy consumption for common utilities; assess the types of appliances used; and availability of rooftop area without shadow for solar PV.
- Rajkot's Krantiveer Khudiram Bose social housing project has successfully implemented a similar project. This project consists of five buildings with 140 dwelling units. Common amenities like lifts, pumps and lights consumed 3000 kWh per month. A rooftop 31.5 kWp grid-connected PV system installed generated 3780 kWh per month, with a potential to reduce 37 tCO₂e GHG emissions per year. Excess energy is sent to the grid, and residents get approximately ₹12,000 credited to their accounts by the DISCOM each month. It was set up on a PPP basis for 10 years⁴². This action can be piloted in Indra nagar, Aadarsh Nagar, Lakshmanpura or Sanjay Nagar areas in Gwalior.
- **Inclusivity analysis:** This must be accompanied with training residents in these low-income areas to maintain solar panels. In Rajkot, ICLEI- Local Governments for Sustainability provided such training for residents.

- **Implementing stakeholders:** GMC (lead), MPMKVCL, RWAs, private technology manufacturer, GSCDCL, MPUVN
- **Timeframe:** Medium term: 3-5 years.
- **Alignment with schemes:** Implementation can be undertaken in alignment with the Housing for All Plan of Action (HFAPoA): Gwalior under PMAY, Policy for implementation of solar power-based projects in Madhya Pradesh, 2012, MP RE policy 2022
- **Alignment with CSCAF indicators:** Indicator 1: total electrical energy in city derived from renewable energy sources under energy and green buildings
- **Monitoring indicators:** % of low-income housing with solar PV, % electricity from renewable sources, # new jobs created, increase in income for low-income communities.



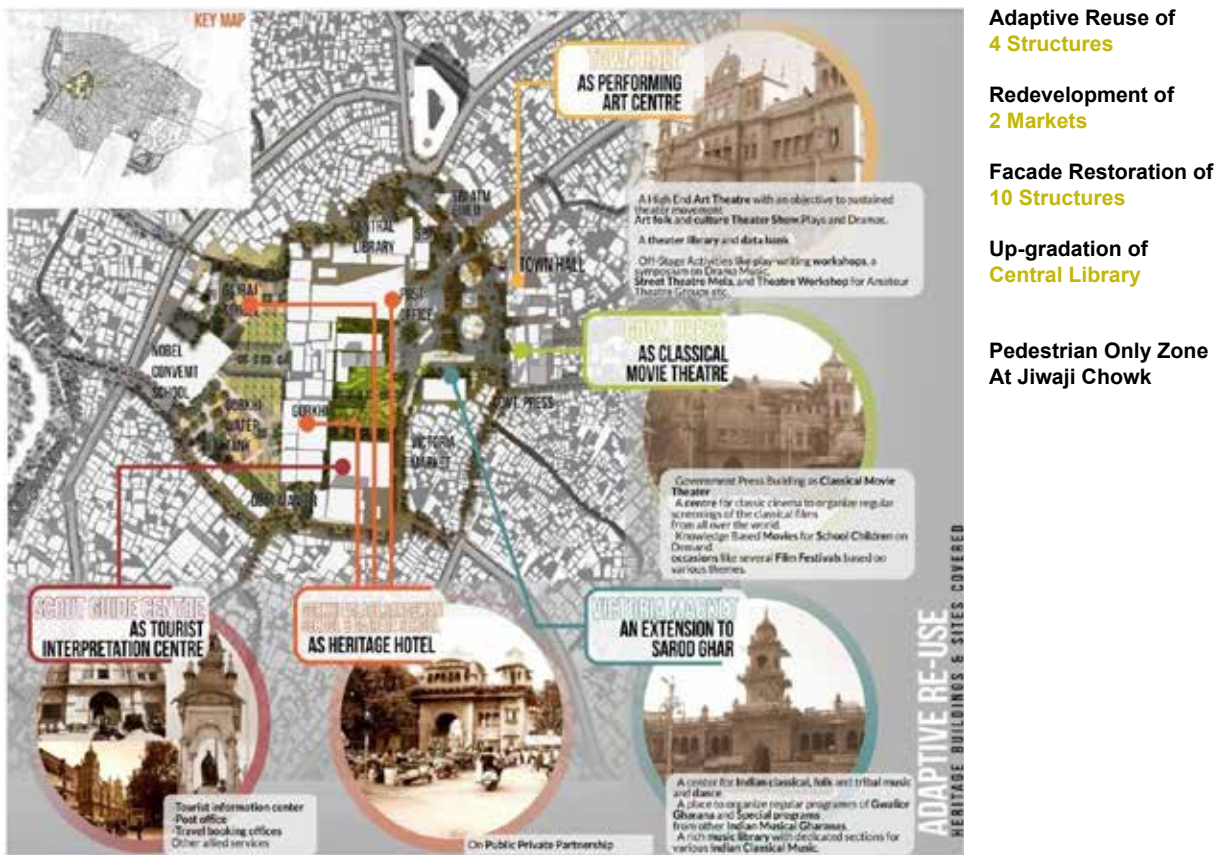
Source: Dmitry Rukhlenko

Goal 2: Climate Smart Tourism in Gwalior

One of the goals of the city is to strengthen Gwalior's identity as a cultural capital of Madhya Pradesh, increase tourist arrivals through tourism packages and improve tourist circuit linkages and infrastructure. The city is seeking to prepare a strategic plan for heritage revival and urban design, integrating it with the City Master Plan to transform its image holistically. The city is looking at

conservation and adaptive reuse of heritage buildings, proposing façade restoration in the Maharaj Bada area, planning a heritage walk with facade treatment and control guidelines, and setting up two tourist facilitation centres. Based on these priorities, the actions suggested within this goal are aimed at promoting sustainable tourism in Gwalior.

Figure 21: Outline of the plan for revitalizing the Maharaj Bada area (Source: Gwalior Smart City Proposal)



Identified Actions

Action 1: Develop a pedestrian friendly heritage network trails and an electric hop on hop off bus service in tourist areas

- Challenges addressed at the city level:** The city's PM2.5 emissions are five times WHO recommendations⁴³ and put its air quality in the moderate category. The city centre is also in the moderate zone, sometimes going towards unhealthy. This calls for reducing air pollution through options like reducing fossil fuel-based vehicles⁴⁴. The city also has no electric buses and less than 5% of its roads have footpaths.

- Description:** The city is currently implementing pedestrianization of Maharaj Bada, with multilevel underground parking, and a 15.625-Km smart road, currently in the work-order stage³. While undertaking this project, the city can ensure that roads have street furniture, sufficient lighting, segregated cycle lanes, signages, water coolers and other elements. GSCDCL is also planning to implement 40 electric buses, subject to VGF funding³. They can consider piloting these in tourist centres as electric hop-on-hop off tour buses. Part of the funding for maintenance and drivers' salaries can come from tourist collection fees. This should be accompanied with adequate charging infrastructure for the buses at bus stops, parking lots, petrol

bunks, malls, etc. Secondly, the implemented public bike sharing system should be revamped and introduced in tourist areas with proper marketing and clear cycle tracks connecting tourist spots.

- **Inclusivity analysis:** When designing street space and bikeshare programs, the city must consider the needs of people with disabilities, the elderly, children, women, informal and low-income communities, and migrants. Footpaths and cycle tracks should have ramps, street furniture and adequate lighting. GMC can provide maps and real-time information on safe bicycle routes, ensuring that information is also shared in Hindi. Bus stops can have shelters, especially for summer and, to improve women ridership, separate seating for women, women drivers, and panic buttons for women's safety, directly connected to the nearest police station can be incorporated into the electric buses.
- **Implementing stakeholders:** GSCDCL (lead), MP Tourism Board, UNESCO New Delhi, GMC, MP Transport Department, Gwalior City Transport Services Limited (GCTSL)
- **Timeframe:** Medium term: 2–3 years.
- **Alignment with schemes:** The MP state government has selected Gwalior as a pilot city for the Historic Urban Landscape program and survey by UNESCO New Delhi and the Tourism Department of MP. This program will serve as a tool for heritage-based urban development⁴⁵. This action can be linked to this project. It is also linked to the National Clean Air Action Program.
- **Alignment with CSCAF indicators:** Indicators: 1 (clean technologies and shared vehicles) and 3 (percentage of coverage of NMT network in the city) under the Mobility & Air quality sector.
- **Monitoring indicators:** Proportion of NMT infrastructure out of the total road network length, percentage of electric buses in the fleet, # of electric hop-on-hop-off buses introduced, % mode share of public transport and NMT disaggregated by gender and income groups

Action 2: Incorporate zero-carbon building components in heritage redevelopment projects

- **Challenges addressed at the city level:** Gwalior is currently not taking measures to promote green buildings. Moreover, <5% of its total energy consumption comes from renewables as per the CSCAF 2.0.

- **Description:** Gwalior is currently redeveloping the Huzrat Kotwali Market mandi. It is also planning to tender for the redevelopment of Maharaj Bada town hall and the adaptive reuse of old collectorate Gorkhi palace complex and a heritage building near Urvai gate at fort Gwalior³. These projects can include low carbon or zero carbon building components. Gwalior's Smart City proposal included the Habitat and Trade Centre, with an art gallery, library and resource centre, training and learning centre, auditorium and conference venues, event lawns, affordable housing, business spaces, food and beverage facilities, guest accommodation, and more. This can also be piloted as a zero-carbon building. A (net) zero carbon building (ZCB) can be defined as an energy efficient building that supplies most (but not all) of its annual energy use through on-or near-site renewable energy sources. Key components of such buildings can include:
 - Energy efficiency: Ensuring energy efficiency through compliance with local codes and standards through energy efficient equipment use.
 - Renewable energy: Achieving further reductions in building emissions through renewable energy sources through on-site RE generation, off-site RE generation or purchase.
 - Carbon offsets: Carbon offsets can be used to balance out residual emissions. The emissions reduction benefits must be claimed through a credible mechanism such as carbon credits or a local carbon credit fund.

Best practice examples which can be adapted include the Delhi's Indira Paryavaran Bhawan. It is compliant with local codes and standards, has natural lighting in the daytime, shading, landscaping, uses 70% lesser energy than a conventional building and is India's highest green rated building⁴⁶. Most of the Infosys campuses in the country are LEED platinum buildings and have PV panels, RE electricity and off-site RE plants⁴⁷.

- **Inclusivity analysis:** The net-zero transition in such large-scale government projects could open value pools around green building materials and promote business for small start-ups manufacturing green/alterative building materials and those in their supply chain. This would also encourage more youth entrepreneurs to explore avenues for green/low-carbon alterative material manufacturing in the city.
- **Implementing stakeholders:** GMC (lead), GSCDCL, MP Tourism Board, MPUVN, MPMKVVCL, IGBC city chapter
- **Timeframe:** Medium term: 2–3 years

- **Alignment with schemes:** Energy Conservation Building Code, MP Renewable Energy Policy 2022, Policy for Implementation of Solar Power-based projects in Madhya Pradesh 2012, Madhya Pradesh Policy for Decentralized Renewable Energy Systems 2016.
- **Alignment with CSCAF indicators:** Indicator 2: Total electricity derived from renewable sources and Indicator 6: Green building adoption under the Energy & Green buildings sector
- **Monitoring indicators:** Energy savings from municipal buildings, # of low carbon or zero carbon buildings in the city, proportion of energy consumed from renewable sources, improved indoor air quality, % reduction in GHG emissions from energy and buildings

Action 3: Dry waste recovery and plastic reverse vending machines at tourist centres

- **Challenges addressed at the city level:** Gwalior has no plastic collection centres as of 2021⁷.
- **Description:** Upcoming tourist information centres³ can be used to promote ecotourism and encourage waste management practices. PET bottle reverse vending machines can also be set up near the Gwalior fort and other areas. Easy to use digital reverse vending machines have already been introduced in many cities. In Delhi⁴⁸, users get coupons for hotels, restaurants or other shops. Hyderabad⁴⁹, Mumbai⁵⁰,

and Delhi have introduced these machines in railway stations and bus stops. In Mumbai machines were provided by Wockhardt Foundation. Jute and cotton bags can also be distributed with a message to not use plastic. Garbage bins must be placed near food and tea stalls to prevent littering and improve segregation.

- **Inclusivity analysis:** For waste collectors in the informal sector, recovery and recycling booths put their livelihoods at risk; they are also exposed to risk when space and equipment for collecting, transporting, sorting and storing recyclable materials are not available. Integrating them as paid service providers to run waste recovery/recycling booths, for example, would enable their inclusion and help retain their jobs.
- **Implementing stakeholders:** GMC waste department (lead), MP Tourism Board, UNESCO New Delhi, GSCDCL, vendors, informal waste pickers
- **Timeframe:** Short term: 1 year.
- **Alignment with schemes:** Swachh Bharat Mission – Urban 2.0
- **Alignment with CSCAF indicators:** Indicator 6 (waste minimization initiatives undertaken by the city) under the waste management sector.
- **Monitoring indicators:** Amount of plastic waste recovered and recycled; number of PET reverse vending machines installed, # of bottles collected and recycled per year



Source: Gwalior Smart City Development Corporation Ltd.

Goal 3: Make Gwalior a Solar City

As per CSCAF 2.0, less than 5% of Gwalior's energy comes from renewables. The city is heavily dependent on fossil fuels, not just for private consumption, but also for essential public services and transport systems. Gwalior is also part of the Solar City Initiative and hopes to meet at least 10% of total power demand — in residential, municipal and commercial — through solar. Given a good annual average solar irradiation index of 5.49 kWh/m²/day, Gwalior has immense potential to tap into this resource⁴.

Identified Actions

Action 1: Implement solar rooftop panels for all government buildings and public spaces

- **Challenges addressed at the city level:** Gwalior currently has very little energy demand (<5%) coming from renewables annually. They city also needs to take steps to promote green and energy efficient buildings²⁰. As per stakeholder consultations, there is a lack of feasibility studies for installation of rooftop solar panels in municipal buildings.
- **Description:** GMC should first study the scope for rooftop solar installations in public spaces (crematoria, playgrounds, vacant land, stadiums, schools, bus stops, and other open spaces, including gardens), and all municipal buildings (including universities, schools, hospitals, the railway station). In 2016, Central Public Works Department (CPWD) signed a Memorandum of Understanding with Solar Energy Corporation of India (SECI) for generation of solar power and installation of grid-connected rooftop PV panels in all buildings maintained by CPWD⁵¹. This must be implemented in Gwalior and further expanded to GMC owned buildings. Since GSCDCL is planning to re-tender the smart school's project, it can include solar rooftop, solar water heaters and other components in schools³.

Innovative funding mechanisms can be considered like:

- **Revenue sharing:** Delhi Municipal Corporation had opened a tender for PVs in all municipal buildings, where revenue is shared between agency and DMC over a minimum of 25 years⁵².
- **Green/Masala bonds:** Bonds issued outside India but in INR. Investors bear risk rather than the borrower. Indore plans to issue green masala bonds for funding a floating solar project⁵³.

- **Inclusivity analysis:** Installing solar PV for lighting and cooling in schools can help create an enhanced learning environment in schools which lack regular electricity supply. For example, 26 Anganwadis and primary government schools in Telangana were equipped with solar systems ranging from 0.3 kW to 2kW capacities connected to a battery system and inverter. This had led to a much more comfortable learning environment for the children. Children also learnt about the importance of solar power. It also helped create more jobs in these districts for installing and maintaining these solar panels and batteries⁵⁴. Similar impact can also be seen in Gwalior with such initiatives.
- **Implementing stakeholders:** GMC (lead), MPUVN, CPWD, MPMKVCL, SECI, Gwalior Smart City, RWAs, financial institutions, school and Anganwadis teachers and children
- **Timeframe:** Long term: More than 5 years.
- **Alignment with schemes:** MP Policy for Decentralized Renewable Energy Systems 2016, MP RE policy 2022
- **Alignment with CSCAF indicators:** Indicators: 2 (total electricity from renewables), 6 (green building adoption, and 5 (promotion of green buildings) under energy and green buildings.
- **Monitoring indicators:** Percentage of government buildings with solar PV, reduced energy costs for municipal buildings, higher proportion of energy from renewable sources

Action 2: Pilot solar bus stops

- **Challenges addressed at the city level:** Less than 5% energy from renewables as per CSCAF 2.0, 62% emissions from stationary energy sector in 2019
- **Description:** Decentralized solar rooftop can be looked into for the 200 bus stops Gwalior is constructing presently³. Tiruchirappalli⁵⁵, Madurai⁵⁶, Delhi⁵⁷ and Lucknow⁵⁸ have piloted solar bus stops at average costs of ₹5-7 lakh. Varanasi got its first solar bus stop in 2022 with a floor made of recyclable materials, mobile charging facility, LED lights and CCTV surveillance⁵⁹. Gwalior can explore learnings from such examples.

- **Inclusivity analysis:** These bus stops should ensure that commuters have shelter, drinking water, toilets and other amenities. Bus stops should also allow wheelchair access. GMC must ensure that these bus stops are equitably distributed across low-and high-income wards.
- **Implementing stakeholders:** Gwalior Municipal Corporation (lead), Gwalior City Transport Services Limited, Gwalior Smart City, private players, RWAs, MPMKVVCL
- **Timeframe:** Short term: 1–2 years
- **Alignment with schemes:** MP Policy for Decentralized Renewable Energy Systems 2016, MP RE policy 2022
- **Alignment with CSCAF indicators:** Indicator: 2 (percentage of energy from renewables) under Energy and Green buildings
- **Monitoring indicators:** Higher percentage of energy from renewables, percentage of bus stops with solar power

Action 3: Awareness programs and tools for promoting residential rooftop solar

- **Challenges addressed at the city level:** 62% of GHG emissions came from stationary energy sector in 2019 out of which 60% came from energy consumption in residential buildings.
- **Description:** GMC needs to increase awareness and access to solar energy amongst consumers. They can collaborate with NGOs or research students working in the energy space to develop a Do-It-Yourself solar tool with step-by-step PV installation guidance to consumers including available financing subsidies, rooftop area needed, application process, timelines and policies. An NGO in Bengaluru developed such a tool which has been used by nearly 15000 citizens⁶⁰. The tool should be effectively marketed across various platforms, in schools, marketplaces, buses, etc. This tool can also provide a 24x7 helpline number for consumers to call regarding any doubts or maintenance trouble shooting.
- **Inclusivity analysis:** The tool should be communicated in local languages along with English to ensure mass outreach to low-income groups. The tool can also be used by companies to install free solar rooftops in low-income housing through Corporate Social Responsibility projects. Workshops can be held with resident welfare associations to answer any questions regarding the process.

- **Implementing stakeholders:** GMC (lead), Gwalior Smart City, MPUVN, RWAs, MPMKVVCL, NGOs, universities like Indian Institute of Information Technology and Management Gwalior
- **Timeframe:** Medium term: 3–5 years.
- **Alignment with schemes:** Policy for Implementation of Solar Power based projects in Madhya Pradesh Madhya Pradesh Policy for Decentralized Renewable Energy Systems, 2016, Madhya Pradesh Urban Services Improvement Project (ADB), MP RE policy 2022
- **Alignment with CSCAF indicators:** Indicator: 2 (total electrical energy derived from renewables) under Energy and Green Buildings.
- **Monitoring indicators:** Number of houses with PVs disaggregated by income level, DIY tool that is easily accessible, number of tool users.

Action 4: Solarisation of Sewage Treatment Plants and water pumping stations

- **Challenges addressed at the city level:** Less than 5% energy from renewables. Gwalior has also not conducted an energy audit of its wastewater and water supply systems²⁰.
- **Description:** Gwalior has only one STP of 50 MLD in Lalitpara and is planning for 4 more of 145 MLD, 4 MLD, 65 MLD and 8 MLD²⁹. Gwalior should first conduct an energy audit of its existing sewage treatment plants and understand the scope and feasibility for piloting solar power in the plant. While focusing on wastewater management in the revival of Swarnarekha river plan for the ABD area, the city can pilot solar powered sewage treatment plants. The city can also pilot solar power in its proposed plants. A similar pilot is coming up in Tamil Nadu⁶¹. Gujarat's government issued a statement⁶² that its Urban Development Department will use solar energy instead of the conventional electricity from DISCOMS to power STPs in eight municipalities and WTPs in 15 towns. Delhi⁶³ inaugurated a solar powered sewage treatment plant in 2015. In 2019, Indore announced its plan to issue rupee-denominated masala bonds of approximately ₹450 crore to install a floating solar project in Jalood and Yeshwanth Nagar to power water pumping stations⁶⁴. Maharashtra Energy Development Agency was also seeking to implement a 3.658 MW grid-connected rooftop and ground-mounted PV system at existing water lifting plants in the state⁶⁵. Gwalior can take pointers from these examples and try to pilot the same.

- **Inclusivity analysis:** Equitable access to treated water for all communities must also be ensured. New solar STPs can be installed in low-income areas which lack access to drinking water or water for domestic use. Training should also be provided for workers in these STPs on effective operation and maintenance of solar PV systems. The energy cost reduction due to solar power can be used to invest in energy efficiency initiatives in low-income areas.
- **Implementing stakeholders:** GMC (lead), Gwalior Smart City, DISCOM, funding agencies, STP and WTP operators, MPMKVCL, MPUVN
- **Timeframe:** Short term: 1-2 years (for pilot).
- **Alignment with schemes:** Policy for Implementation of Solar Power based projects in Madhya Pradesh 2012, Madhya Pradesh Policy for Decentralized Renewable Energy Systems, 2016, Madhya Pradesh Urban Services Improvement Project (ABD), MP RE policy 2022, AMRUT.
- **Alignment with CSCAF indicators:** Indicators: 6 (energy-efficient wastewater management systems) under Water Management, and 2 (total electrical energy derived from renewables) under Energy and Green Buildings.
- **Monitoring indicators:** % of solar-powered STPs out of total STPs, reduced energy bills for water treatment.



Source: Gwalior Smart City Development Corporation Limited

Goal 4: Improve Air Quality and Make Gwalior a Connected & Accessible City

One of the main objectives of Gwalior Smart City is to make it connected and accessible by creating fast, safe, affordable and lucrative urban mass transit and also promoting walking and cycling by pursuing TOD. The goal is to develop an integrated low-carbon transport network which includes a mass transit system and NMT. In its mobility module, Gwalior's Smart City is working on improving vehicular intersections, improving pedestrian junctions, supporting IPT services by introducing e-rickshaws, and pedestrianizing the Bada area and adjoining market streets. Actions under this goal will help Gwalior become a sustainable mobility-driven city and help address the issue of poor air quality, limited public transport and lack of accessible footpaths.

Identified Actions

Action 1: Augment the existing bus fleet

- **Challenges addressed at the city level:** Gwalior has only 28 buses amounting to 0.02 buses per 1000 population, which is at the lowest level of MOHUA's service level benchmark²⁴. Moreover, as per 2017-18 data, only 3% of total trips were made by bus²⁵.
- **Description:** Gwalior has only 0.02 buses per 1000 people. The city is planning to increase its fleet by procuring 80 CNG buses and 40 electric buses³. It should ensure that the fleet is augmented in a planned manner. The first step in planning for new city buses is to identify the route structure, which can be done by plotting the major activity centres, determining travel patterns and calculating ridership demand. In the absence of a structured public transport operation, this can also be done by surveying the travel demand met by IPT services like rickshaws and autos. Through this, the main corridors and major bus stops can be identified. Next, to identify the operational plan, which is usually either destination-oriented (direct connections between multiple destinations) or direction-oriented (combination of interconnected routes)⁶⁶.

The city must also conduct period route and service rationalization exercises at least once in 5-10 years. Regular bus routes can be supplemented with feeder buses or midi buses, which help increase access in parts of the city that are outside the purview of the public transport route and to enable better last-mile connectivity.

New buses should be complemented with adequate infrastructure. Bus stops must be closed shelters located without issues of road safety at main junctions with sufficiently wide footpaths, and in proximity to overhead bridges and pedestrian crossings. As per calculations and Indian Roads Congress 1983 standards, bus bays need to be at least 79m in length and 5m in width to provide sufficient bus docking and tapering length⁶⁶. Branding can be done through colour-coding or numbering and can be route wise. For example, the fronts of buses are painted pink in Chennai to denote free fares for women. Bengaluru has 4 different categories of buses based on fares and route with different colours⁶⁶.

- **Inclusivity analysis:**
 - Passenger safety and convenience must be incorporated at all stages. Buses can be fitted with ramps for disability access²⁹.
 - Road design plays an important role in ensuring safe use of bus services, with elements such as traffic calming measures, speed control and signages.
 - Bus terminals can also include toilets, water and other facilities.
 - Fare rationalization and multimodal fare integration is important to make public transport accessible to low-income and minority groups.
 - Poorly designed infrastructure for pedestrians and cyclists may exclude people with disabilities and create safety concerns.
 - Communication material can be provided in English and native languages to enable better access.
 - Women's safety must be incorporated in new buses, perhaps through the training of women drivers, separate seats for women, limiting overcrowding in buses, or having women-only buses on some routes.
- **Implementing stakeholders:** GCTSL (lead), Gwalior Smart City, GMC, financial agencies, private operators, RWAs, traffic police, RTOs
- **Timeframe:** Medium term: 3-5 years. Maintenance and route rationalization: long term: more than 5 years.
- **Alignment with schemes:** AMRUT
- **Alignment with CSCAF indicators:** Indicators: 1 (clean technologies shared vehicles), 2 (availability of public transport), 3 (Percentage of coverage of non-motorized transport network in the city) under Mobility and Air Quality.

- **Monitoring Indicators:** % modal share of public transport (disaggregated by gender and income), % of roads with walking paths, % buses with female drivers, panic buttons and separate seating, % buses with ramps

Action 2: Fuel efficiency and driver training for diesel-powered public and private buses

- **Challenges addressed at the city level:** 22% GHG emissions came from transport in 2019 due to petrol and diesel consumption.
- **Description:** Fuel efficiency training and management programs can be conducted initially for public buses and then scaled up to include all buses such as college and school bus operators. This program consists of:
 - Driver training to help drivers understand the vehicle technology and external factors affecting efficient operation.
 - Management systems which involve data collection and monitoring of driver performance through bus malfunction reports, refresher trainings and driver consistency in the same route.
 - Vehicle maintenance using Key Performance Indicators (KPIs) such as fuel efficiency, missed mileage, fleet utilization and cost per bus per day. Incentives can also be provided to drivers based on annual improvements in fuel efficiency.

Training conducted in Bhopal for Prasanna Purple Mobility Solutions buses resulted in a 32% increase in fuel efficiency⁶⁶.

- **Inclusivity analysis:** This action will help increase awareness and instil a sense of responsibility amongst drivers, who may usually belong to low-income communities. Financial incentives for those who achieve high performance ratings will also help overcome financial access barriers and increase participation.
- **Implementing stakeholders:** GCTSL (lead), Gwalior Smart City, GMC, private companies, GoMP Urban Development department, GoMP Transport department, drivers, third party organizations for conducting the training, fuel companies
- **Timeframe:** Short term: 1–2 years in the beginning but should be constantly monitored for longer terms over 5 years.
- **Alignment with schemes:** NA
- **Alignment with CSCAF indicators:** Indicators: 1 (clean technologies shared vehicles) under Mobility and Air Quality, and 3 (fossil fuel consumption in the city) under Energy and Green Buildings.

- **Monitoring Indicators:** Number of workshops conducted along with participation numbers, % increase in fuel efficiency of the fleet before and after the training, % increase in mode share for buses, reduced fuel sales for the bus fleet due to reduced consumption, % reduction in emissions from transport

Action 3: Set up infrastructure for service centres and charging stations for electric vehicles

- **Challenges addressed at the city level:** 22% of emissions came from transport in 2019, calling for a shift towards low-carbon options and electrification. The city currently has less than 1% electric vehicles as per RTO data. Consultations also highlighted that there is no fast-charging infrastructure in the city.
- **Description:** GMC is already introducing e-rickshaws³. To boost and support uptake of EVs, GMC and GSCDCL must allocate land for service centres and charging stations. The city can mandate converting parking lots to be EV-ready by 2040, and install charging facilities in apartments, offices, shopping malls, government buildings, universities, etc. GMC can also introduce charging in public parking lots, petrol pumps, streetlights, bus stations, etc. In March 2021, the Delhi Government mandated all commercial and institutional buildings with parking for more than 100 vehicles to allocate 5% of their spaces for EV charging. The city can take further guidance from the handbook developed by WRI India and NITI Aayog⁶⁷.

GMC can tie up with private players such as Ola to increase the fleet of electric cars, two-wheelers, buses and rickshaws. This must be accompanied with strengthened charging and battery swapping infrastructure⁶⁸. Nagpur launched Maharashtra's first multimodal e-mobility project with Ola⁶⁹, which launched a fleet of 200 EVs, primarily buses, taxis and e-rickshaws, and four charging stations with 53 charging points. The company catered to over 350,000 customers, covering more than 7.5 million clean kilometres. In Mumbai, EV charging stations are set up at strategic locations, including popular malls, business hubs, highways and neighbourhoods; the chargers can monitor battery charging status and units consumed while charging⁷⁰. Gwalior can also introduce charging stations in key tourist hotspots.

- **Inclusivity analysis:** Ensuring equitable distribution of charging infrastructure across income areas. Low-income workers can also be trained for installing and maintaining these charging stations. GMC can ensure partial financial support for the malls, universities and offices to install chargers. This must also be accompanied with awareness creation programs.

- **Implementing stakeholders:** GMC and Gwalior Smart City (lead), GCTSL, GoMP Transport department, research organizations, private operators, RWAs
- **Timeframe:** Medium to long term: 3–6 years.
- **Alignment with schemes:** FAME Phase II, Madhya Pradesh EV Policy, 2019, AMRUT
- **Alignment with CSCAF indicators:** Indicators: 1 (Clean Technologies Shared Vehicles) 4 (level of air pollution) within Mobility and Air Quality, and 3 (fossil fuel consumption) under Energy and Green Buildings.
- **Monitoring Indicators:** Increase in purchase of EVs, % increase in EV registrations (RTO data), number of charging stations in a 3x3km grid or per million population, percentage of streetlights with charging infrastructure, number of charging points per unit area, % of malls and parking lots with charging infrastructure

Action 4: Implement a comprehensive data strategy for enhanced public transport ridership

- **Challenges addressed at the city level:** The city has only 28 public buses²³. Consultations with stakeholders highlighted that owing to Gwalior’s small size and inadequate infrastructure, people do not prefer public transport options.
- **Description:** Gwalior smart city already implemented Intelligent Transport Systems with traffic surveillance and analytics³. To further increase the public transport accessibility and comfort, Gwalior can develop an open-data strategy for effective communication of mobility-related data sets such as schedules, fares, routes, real-time location and capacity of transit services, linked to their Integrated Command and Control Centre. This can be planned after the city increases its bus fleet. This will help improve the reliability, affordability, access, and uptake of public transport.

For example, the city of Mysuru has successfully installed public information systems in all bus stops, providing real time information on bus arrival on LED boards. CMC was the lead systems integrator tasked with end-to-end systems integration and implementation. The project was funded by GEF (Global Environment Facility)-SUTP (Sustainable Urban Transport Project)⁷². GMC can also implement such passenger information systems in all bus stops. GMC can also collaborate with private players like Chalo, who has developed apps for Mumbai⁷³ and Chennai⁷⁴ to provide real time bus tracking.

- **Inclusivity analysis:** Information should be communicated in regional languages as well. Apart from digital boards, signages in bus stops can also have Braille, to ensure there is access to information to all.
- **Implementing stakeholders:** GCTSL (lead), Gwalior Smart City, GMC, GoMP Transport department, GoMP Urban Development and Housing department
- **Timeframe:** Medium term: 3–5 years.
- **Alignment with schemes:** AMRUT, Data Smart Cities Strategy under the smart cities mission, NUTP
- **Alignment with CSCAF indicators:** Indicator: 2 (availability of public transport) under Mobility and Air Quality
- **Monitoring Indicators:** % of bus stops with public information systems, increase in public transport ridership and modal share for public transport disaggregated by gender and income, increase in commuter satisfaction.

Action 5: Strengthen NMT infrastructure in the city

- **Challenges addressed at the city level:** Gwalior has a high mode share for NMT (60%)²⁵. However, only 5% of total road length consists of adequate walking or cycling infrastructure²⁰. Stakeholders also highlighted that cycle tracks suffer from encroachment and littering and despite a demand for cycling, there is very poor uptake.
- **Description:**
 - **5.1 Implementing a NMT cell:** Gwalior has finished the installation of a public bicycle-sharing system as per smart city data. To further enhance uptake and increase availability of footpaths and cycle tracks, the city can institute a multistakeholder cell for NMT planning. According to MoHUA’s guidance document⁷⁴ for NMT strategies in cities, the first step is the establishment of an NMT Cell to enable policy-level and planning-level interventions, with representatives from various city agencies, local government departments, academic institutions, NGOs and the private sector. This will ensure that NMT principles are the backbone for all cross-sectoral policy making. Examples in the Indian context include Chandigarh⁷⁵, one of the best practices shared as part of CSCAF best practices book.

- **5.2: NMT policy:** The city can introduce a policy that would strengthen and sustain its efforts to improve NMT planning and implementation. Examples of cities with innovative policies include Chennai's Non-motorized Transport Policy (2014) aiming to increase the modal share of walking and cycling in addition to creating pleasant footpaths, complete streets with street furniture and infrastructure for children, cycle tracks and greenways, Pune's Policy for Pedestrian Facilities and Safety (2016) aimed at improving public transport and safety as well as pedestrian infrastructure, and Coimbatore's Street Design and Management Policy (2017)⁷⁶. The policy can set short, medium and long term NMT targets for the city. MOHUA's benchmarks of at least 25% coverage for footpaths in level 3 can be taken as a guidance²⁴.
 - **5.3 NMT focussed street design guidelines:** In order to mainstream NMT principles within urban planning, the city can implement NMT focused, inclusive design guidelines to create streets that support non-motorized. Cities like Pune⁷⁷ and Mumbai⁷⁸ have already such guidelines in place. These guidelines act as binding documents that mandate street designs and urban renovation to include people-friendly aspects and support non-motorized mobility. All new road development should follow these guidelines.
 - **Inclusivity analysis:**
 - This central, multi stakeholder coordination should enable inclusive development and planning for increased walking and cycling networks in the city. It should ensure NMT access to the disabled and other vulnerable groups. (e.g.: wheelchair access from road to pavement, supports like railings for the elderly, separate cycle tracks with clear signage, separate lane for the disabled in pavements and removal of encroachments).
 - A dedicated area for street vendors can also be planned in the pedestrianization pilots to ensure they do not lose their livelihoods. Alternatively, they can be relocated after sufficient discussions and consultations.
 - Many cities in India have painted separations which are often encroached upon by cars. The cycle tracks must be physically segregated from roads and there should be clear signages to ensure safety of children cyclists⁷⁹.
 - It is important to use a variety of engagement channels to communicate with different audiences who have different needs. Stakeholder engagement must also be regularly tracked, monitored, and improved⁸⁰. It should also be done in local languages to increase uptake and a sense of ownership.
 - **Implementing stakeholders:** Gwalior Municipal Corporation and GSCDCL (lead), GoMP Urban Development and Housing Department, Town Planning department, resident welfare associations, NGOs
 - **Timeframe:** Short term:
 - 1–2 years for NMT cell
 - Medium term: 3–5 years for NMT policy and street design guidelines
 - **Alignment with schemes:** AMRUT
 - **Alignment with CSCAF indicators:** Indicator: 3 percentage of coverage of non-motorized transport network (pedestrian and bicycle) in the city, under Mobility and Air Quality.
 - **Monitoring Indicators:** Creation and active functioning of an urban-level NMT cell, increase in length of inclusive and safe cycle and walking paths as a percentage of total road length, reduced emissions from the transport sector, increase in the modal share of NMT modes (disaggregated by gender and income groups)
- Action 5: Improve parking management in Gwalior**
- **Challenges addressed at the city level:** High mode shares for 2 wheelers (20%) and 4 wheelers (3%)²⁵. Gwalior's Maharaj Bada area faces regular congestion mainly due to narrow roads, encroachment by vendors, haphazard parking and no proper channelization of traffic. The area is 77% short in terms of meeting parking demand, with 13776 Passenger Car Units (PCUs) in peak hour⁸¹.
 - **Description:** Gwalior is working on a smart parking initiative on a PPP mode. It is also planning underground parking at Maharaj Bada and Gandhi market³. Additional actions GMC can take to ensure more efficient parking management are:
 - An app to find the nearest parking lot with real time information on occupancy, digital payment options, which allows users to note the time and place of parking and calculate parking charges can be developed. Myparking app in Delhi⁸² provides total parking capacity, used spaces and space available in each site. Partners include Paytm and ICICI.
 - Higher parking charges in central business areas, tourist spots or high-density corridors with a maximum parking fee, at least four times the minimum fee as per MoHUA's Level of Service 1²⁴.
 - Parking fee can be increased based on demand and vehicle size.
 - Dedicated parking spots or parking fee waivers can be given for electric, CNG or hybrid vehicles including freight.

- Parking lots can include cycle parking stands.
- A percentage of parking lots should have electric fast chargers.
- **Inclusivity analysis:**
 - Parking should be reserved for the elderly and persons with disability. Revenue from paid parking can be used to improve public transport and NMT services and infrastructure, especially in low-income areas.
 - Low-income workers can be involved in managing these parking lots and provided with a source of revenue. Local businesses should also be involved in consultations to reduce resistance.
 - Parking fee generated in their area can be dedicated solely towards improving the attractiveness and accessibility of the streets in their area and help them improve their customer footfall, similar to what was planned in Aurangabad's parking policy⁸³.
- **Implementing stakeholders:** Gwalior Municipal Corporation (lead), GSCDCL, RTOs, traffic police, RWAs, shop vendors
- **Timeframe:** Medium term: 3–5 years, continued over the long term.
- **Alignment with schemes:** AMRUT, Data Smart Cities Strategy under the smart cities mission, NUTP.
- **Alignment with CSCAF indicators:** NA
- **Monitoring Indicators:** Reduced rate of road fatalities, reduced congestion, # of parking lots developed, development of a parking app, % usage of parking lots, % of parking lots with chargers.

Action 7: Scale up and improve the uptake for Gwalior's public bicycle sharing system

- **Challenges addressed at the city level:** The city has installed a public bicycle sharing system consisting of more than 500 cycles across 50 stations on a PPP basis. However, as per reports, the cycles are not being used and are in bad condition²⁶. Moreover, only 5% of the road network has accessible walking or cycling paths as per CSCAF 2.0.
- **Description:** Gwalior should re-examine its public bicycle sharing system and take steps to improve it. GMC should first conduct a public perception survey to understand the need for a PBS, the demand, the areas where people frequently cycle and the current issues with the existing system. Then the entire network of bicycle rental shops that could be used as stations and repair hubs need to be mapped, and the existing

cycle rental establishments can be integrated with the new public bike sharing system⁸⁴. Gwalior should then focus on rebranding and effective marketing of cycle lanes and linking these to green areas, lakes, and other recreational spots. A rental system can be established, ensuring equitable access to cycle lanes across all wards.

- **Inclusivity analysis:**
 - Gwalior needs to ensure that the cycle tracks are inclusive and accessible to low-income groups and are physically segregated from the main road to ensure safety.
 - The bikes should be tracked with GPS to prevent theft.
 - They should be affordable for all income groups. GMC should also ensure accessible modes for usage including digital and non-digital methods to cater to those without cellphone access.
 - The PBS marketing should also be done in local language.
 - Stands should be placed in low-income areas as well.
 - The informal cycle sharing system can be integrated to ensure creation of new jobs for operating and monitoring the existing system.
- **Implementing stakeholders:** Gwalior Smart City and GCTSL (lead), GMC, GoMP Transport department, GoMP Urban Development and Housing Department, Town Planning department, RTOs, traffic police
- **Timeframe:** Medium term: 3–5 years, continued over the long term.
- **Alignment with schemes:** AMRUT, Smart cities mission (cycles4 change)
- **Alignment with CSCAF indicators:** Indicator: 3 percentage of coverage of non-motorized transport network (pedestrian and bicycle) in the city, under Mobility and Air Quality.
- **Monitoring Indicators:** % mode share for cycling (disaggregated by gender and income), % road length with cycle tracks, # new jobs created.

Goal 5: Resilient Green & Blue Urban Eco-system in Gwalior

Gwalior Smart City is looking to improve the level of urban lifestyle for its people by creating liveable neighbourhoods, increasing per capita developed open space to meet national standards, and restoring natural ecosystems like rivers and ponds. Concretization of the banks of the Swarnarekha has negatively impacted the natural drains and catchment areas in the city. The city is working on strengthening bridges over the Swarnarekha. Although Gwalior has rich green cover (82% of total municipal area), it is not equitably distributed amongst wards²². This goal seeks to augment planned green cover in Gwalior in an inclusive manner.

Identified Actions

Action 1: De-concretization of the Swarnarekha and Morar rivers and integration of green infrastructure in river rejuvenation projects

- **Challenges addressed at the city level:** The natural drains into the Swarnarekha river have been replaced with built up structures that affect the flora and fauna. Solid waste dumping and wastewater from small scale industries also contribute to pollution⁷.
- **Description:** Taking necessary action to de-concretize the Swarnarekha, regulate catchment areas, and application of green infrastructure will help recharge groundwater and revive lower order drains to carry the precipitation to the rivers. Types of green infrastructure include permeable pavements, vegetated swales or broad shallow vegetated canals, restored wetlands, infiltration trenches, rain gardens, rain barrels, downspout disconnection and green roofs⁸⁵. These techniques can be integrated into the ongoing construction of the Comprehensive Sewerage System in the Lashkar area and the planned redevelopment of Bijataal³.
- **Inclusivity analysis:** Public participation and involvement are crucial at every stage of the process. The city can also develop “lake watch committees,” like in Bengaluru, to oversee sustainable lakefront development and pollution management⁸⁶.

Effective green infrastructure for public property should be at-scale, well-designed, and informed by climate risk. If a city does not regularly collect census data on informal, migrant, and low-income communities, these measures may fail to capture the magnitude of risk for these communities.

GI on public property, such as more street trees, green roofs, and bioswales, may also raise nearby real estate prices that outprice low-income residents and unintentionally usher in “green gentrification”. This should be prevented by ensuring some allocated affordable housing even around lake development projects.

- **Implementing stakeholders:** GMC, Gwalior Smart City (lead), councillors, local experts, citizens, SKMCCC, NGOs
- **Timeframe:** Short term: 1–2 years
- **Alignment with schemes:** AMRUT- linked to projects under water supply and rejuvenation of ground water thrust area, funding under the Jal Jeevan Mission announced during the 2021 Budget, particularly for rejuvenation of water bodies and augment fresh water supply through the creation of sponge cities and green spaces⁸⁷.
- **Alignment with CSCAF indicators:** Indicator 1 (rejuvenation and conservation of water bodies and open areas) under Urban Planning, Green Cover and Biodiversity.
- **Monitoring indicators:** Rise in groundwater levels, length of permeable pavements, number of green roofs, pollution levels of the lake, % reduction in occurrence of urban water logging during heavy rains, % roads flooded.

Action 2: Develop inclusive green spaces in Gwalior

- **Challenges addressed at the city level:** Although Gwalior has 82% green cover, per capita green space is only 1m² per person, indicating inequitable distribution of green pockets¹. There is a need to plan for new urban green spaces in an inclusive manner.
- **Description:**
 - **Green and blue map:** The city should first develop an equity index and map distribution of green spaces and income of different areas to understand the percentage of accessible green and open spaces in low-income areas. Involvement of citizens, RWAs, SHGs, urban forestry experts and NGOs, is crucial from brainstorming and planning to implementation and monitoring phases.

- **Public engagement:** Consultations highlighted the limited public participation in planning for green cover. Cities should engage with all relevant stakeholders, including hard-to-reach and vulnerable groups like homeless people, older migrants, Indigenous groups and the youth. The city can run 'mapathons' with citizens to map potential new urban green spaces, apps to help citizens map trees and identify the best type of trees based on locations. For example, stakeholder consultations identified the area near the cancer hospital to be suitable for new green cover projects. Kochi had conducted a 3-day mapathon under the cities4forest initiative⁸⁸.
 - **Action plan for restoration:** The plan can include an overarching goal⁸⁹, an inventory of the city's trees and sub-species, identification of zones to be protected for example through riparian buffers, creating green zones connecting parks, etc. The plan should highlight the importance of urban green cover and its benefits for transportation, health, equity, etc. It should also include a clear monitoring plan.
 - **Mainstreaming:** The next development plan should include a mandate for at least a certain percentage green cover in all new developments.
 - **Digital methods to spread awareness:** Bengaluru has an open-source platform providing guidance and tools for mapping trees in the city⁹⁰. Gwalior can consider developing similar initiatives and can also introduce apps to help citizens map trees and identify the best type of trees to plant, based on the location. Examples include Kerala⁹¹, where an app was launched to help citizens identify the types of trees to plant based on their location and Goa⁹², which helps citizens geotag trees and monitor their health. Household surveys can also be used as a method to build a resilience roadmap for urban forestry initiatives, like in Kochi⁹³. Technical organizations can also be involved in helping GMC prepare GIS based maps of urban green cover on a yearly basis to understand decrease or increase with time. Gwalior can examine the case of Nagpur, which has prepared a methodology to map urban green spaces using GIS⁹⁴.
 - **Inclusivity analysis:** A social and vulnerability analysis can be conducted to identify all relevant stakeholders for these initiatives, particularly vulnerable sections. The new green spaces created should include components to ensure access to disabled like ramps, walking paths with permeable pavements, cycle tracks, play areas for kids, adequate lighting and drinking water.
 - **Implementing stakeholders:** GMC (gardens department) and Gwalior Smart City (lead), councillors, local experts, citizens, GoMP Directorate of town and country planning, NGOs involved in urban greening
 - **Timeframe:** Medium term: 3–5 years
 - **Alignment with schemes:** AMRUT – linked to projects under improvement in urban green cover, Nagar Van scheme, green highways mission
 - **Alignment with CSCAF indicators:** Indicator: 2 (proportion of green cover) under Urban Planning, Green Cover and Biodiversity.
 - **Monitoring indicators:** Number of communities represented in engagement initiatives, number of urban forests created, # of mapathons run, creation of app and number of users, increase in % of urban green cover and biodiversity.
- Action 3: Promote green terraces**
- **Challenges addressed at the city level:** With only 1m² per capita green space the city needs to increase accessibility of green spaces to at least 10-12 m² per capita¹. With the city frequently experiencing temperatures above 41 degrees⁹⁶, this will help reduce urban heat-island effects.
 - **Description:** Urban green terraces are an efficient way to integrate greening into existing urban infrastructure while also helping residents reduce food costs by cultivating their own produce. The government can take steps to increase awareness and interest in green terraces through subsidized kits, rebates on property tax or other utilities or financial assistance for homeowners. Government of Tamilnadu provides a 50% subsidy on materials for green terraces under the "do it yourself" kit program. Each buyer can buy a maximum of 5 kits⁹⁷. Bihar has a similar program, along with training workshops for farmers and residents⁹⁸. Gwalior can work with the Government of MP to start providing such kits. GMC can ensure setting up terrace gardens in all government office buildings and schools to set an example.
 - **Inclusivity analysis:** Terrace gardens can be set up in schools and Anganwadis to increase awareness and engagement amongst children. In low-income communities which lack necessary infrastructure, common community gardens can be set up in village community centres, Anganwadis, village clinics, etc. Food grown here can be distributed to all households who take ownership and pitch in for maintenance. Free kits can be distributed to low-income areas. Training can be given to residents on best farming practices and how to maintain the gardens.

- **Implementing stakeholders:** GMC (lead), Gwalior Smart City, GoMP Urban Development and Housing department, RWAs, farming enthusiasts, NGOs, schools, Anganwadis, Department of Horticulture and Food processing, Govt of MP
- **Timeframe:** Short term: 1–2 years
- **Alignment with schemes:** AMRUT – linked to projects under improvement in green cover, nagar van scheme
- **Alignment with CSCAF indicators:** Indicator: 2 (proportion of green cover) under Urban Planning, Green Cover & Biodiversity.
- **Monitoring indicators:** Increase in the area of green cover in the city, % of houses with green terrace disaggregated by income level, # of kits distributed or # of rebates provided disaggregated by communities

Action 4: Develop a heat action plan

- **Challenges addressed at the city level:** In June 2018, Gwalior’s temperature reached 44°C degrees recording the fourth-highest temperature in the country. The city frequently experiences heat waves, more so in the last few years⁹⁹.
- **Description:** Owing to frequent heat waves, stakeholders highlighted the crucial need to develop a local heat action plan with a strong focus on urban greening measures to maintain ambient temperatures. The plan can include the following components amongst others¹⁰⁰:
 - Training and communication on heat illnesses for medical staff.
 - Monitoring and early warning of heat alerts.
 - Water conservation measures like low flow taps, rainwater harvesting
 - Develop a cool roofs program for municipal and private buildings (including membrane cool roof, tiled, coated roofs, green roofs).
 - Temporary cooling shelters
 - Analyse and compare land-surface temperatures for different areas in the city to identify heat hotspots and their causes, such as lack of vegetation, roofing material, dense buildings, etc

The city can also look at the recent National Action Plan for heat-related illness introduced in 2021¹⁰¹

- **Inclusivity analysis:** City needs to identify heat prone areas and vulnerable communities including urban minimum wage workers, children and women. They can ensure cool roofing, drinking water vending machines, shaded footpaths and shaded workplaces

in low-income areas to reduce extreme heat risk for outdoor workers, slum dwellers and migrants.

- **Implementing stakeholders:** GMC (lead), Gwalior Smart City, GoMP department of Urban Development and Housing, gardens department (GMC), health department (GMC) and the state disaster management authority.
- **Timeframe:** Short term: 1–2 years to prepare plan; long-term implementation and monitoring
- **Alignment with schemes:** AMRUT – linked to projects under improvement in green cover, Nagar Van scheme, Ministry of Health and Public Welfare, Government of India (National Action Plan for heat-related illness)
- **Alignment with CSCAF indicators:** Indicator: 5 (disaster resilience) under Urban Planning, Green Cover & Biodiversity.
- **Monitoring indicators:** Heat action plan for the city, number of heat hotspots in the city, reduced incidences of heat-related fatalities or illnesses

Action 5: Data, information, and awareness for biodiversity conservation

- **Challenges addressed at the city level:** As per CSCAF 2.0, Gwalior has not implemented measures to conserve biodiversity.
- **Description:** Stakeholders highlighted the limited awareness on biodiversity conservation and native species. The city can implement the following:
 - Setting up a biodiversity committee which can include representatives from Horticulture Department, Forest Department, Town Planning and Country Planning Organization, municipal corporation and Development Authority, as per the Biological Diversity Act, 2002.
 - Coordinating a people’s biodiversity register at a ward-level census, engaging citizens in the process. Madhya Pradesh State Biodiversity Board has provided a manual for the same¹⁰².
 - Preparation of a biodiversity index through the tree census data and making the index publicly available. The City Biodiversity Index includes 23 indicators that measure native biodiversity, ecosystem services provided by biodiversity, and governance and management of biodiversity. Indore and Bhopal have prepared their city biodiversity indexes¹⁰³ which can be referred to.
 - Mobile application-based Toolkit for Biodiversity Conservation and Management. For example, the School of Planning and Architecture Delhi¹⁰⁴

prepared a mobile application to map out green areas, types of flora and fauna, allow citizens to post pictures of local biodiversity and species name and post grievances about biodiversity loss. The app will help local authorities develop local biodiversity strategies and action plans (LBSAPs)¹⁰⁵.

- QR codes on trees for information on tree species, age, ecosystem services and benefits, like in Delhi¹⁰⁶.
- **Inclusivity analysis:** Neighbourhoods with higher incomes, education levels, and home ownership may have higher proportions of tree cover. An index can be created to help incorporate equity in the distribution of biodiversity conservation initiatives to ensure increased biodiversity in low-income areas as well. Information should also be provided in native languages. The knowledge of forest-dependent low-income groups or tribal communities should be utilized for such initiatives.

- **Implementing stakeholders:** Gwalior Smart City and Gwalior Municipal Corporation (lead), Gwalior Development Authority, citizens, NGOs, technology providers, local communities
- **Timeframe:** Medium term: 3–5 years.
- **Alignment with schemes:** Nagar Van Scheme, The Biological Diversity Act, 2002
- **Alignment with CSCAF indicators:** Indicators: 2 (proportion of green cover) and 3 (urban biodiversity) within Urban Planning, Green Cover and Biodiversity.
- **Monitoring indicators:** Number of workshops held, # of communities engaged with, city biodiversity index, number of trees with QR codes or tagging, people's biodiversity register, % increase in species count.



Source: Gwalior Smart City Development Corporation Ltd.

Goal 6: Zero-Waste Gwalior

Waste management is a high priority, not just to reduce emissions but also to avoid negative health impacts, outbreaks of disease due to unhygienic conditions, contamination of water bodies, and degradation of land. The city has already taken some steps to improve waste management. This includes improving collection and transport infrastructure, introducing a PSP model for waste collection, and adopting integrated waste management. The city is also installing structures made from recycled waste in public areas to increase awareness³. There is a need to increase wet waste composting (currently 17%), set up plastic collection centres, and set up a construction waste recycling centre⁷. The actions within this goal would help improve solid waste and wastewater management.

Identified Actions

Action 1: Decentralized composting in Gwalior

- **Challenges addressed at the city level:** Only 17% of wet waste is processed using composting and the city requires a central bio-methanation plant for waste management⁷.
- **Description:** Gwalior can consider decentralized composting and bio-methanation to manage its wet waste. City can use land attached to MRFs, open land, parks, and land near the railway station to install zero waste management composting units. A biogas plant can also be set up near a vegetable market in Gwalior or at institutes like Anant Institute of Management Studies (AIMS) Gwalior. Zero waste management units can also be explored in each zone, generating compost and selling it to farmers, local vendors, residents, gardens, parks, and the horticultural department. For example, Mysuru has a 5 TPD decentralized waste management centre in each zone, each handling segregated biodegradable waste from five wards. The units are managed by NGOs, SHGs, or Stree Shakti Sangha's; the corporation provides vehicles and support of ₹95,000 per month. The centres generate revenue of about ₹30,000 per month¹⁰⁷. The biogas can even be used to power streetlights or run buses like in Indore¹⁰⁸.
- **Inclusivity analysis:** Jobs for low-income groups and women can be created in these centres. In low garbage collection areas, programs like exchanging compost for city-issued goods and services such as bus tickets, schoolbooks, or other needs can also be explored.
- **Implementing stakeholders:** GMC (lead), ward committees, GSCDCL, citizen forums, RWAs, market shop owners, GCTSL

- **Timeframe:** Medium term: 3–5 years
- **Alignment with schemes:** SBM - Urban 2.0
- **Alignment with CSCAF indicators:** Indicators: 3 (extent of wet waste processed) and 6 (waste minimization initiatives undertaken by the city) under Waste Management
- **Monitoring indicators:** Number of composting units set up, percentage of wards with composting units, % of wet waste composted, kg biogas generated

Action 2: Convert waste transport fleet to electric vehicles

- **Challenges addressed at the city level:** 22% GHG emissions came from transport in 2019. Currently Gwalior has no waste transportation vehicles running on clean fuels.
- **Description:** As per the District Environmental Plan, GMC needs 30 trolleys and 25 mini trucks. These trucks can be electric vehicles. GMC should explore flexibility of the current contract to shift a proportion of the fleet to electric vehicles or, in new tenders, mandate a percentage of electric vehicles. Higher tipping fees, dedicated parking spaces, dedicated loading and unloading areas in vegetable mandis, etc can incentivize conversion. This will lead to benefits including reduced emissions from waste transportation, improved air quality and reduced noise pollution particularly in dense urban areas. This has already been adopted by states like AP¹⁰⁹ and Tamil Nadu¹¹⁰. Tamil Nadu has over 1700 battery-operated waste pickup vehicles running on a PPP model, each with three bins for segregated waste. They have a range of 50km and can run for six hours on a single charge¹¹¹. Gwalior can consider these examples and try to implement them.
- **Inclusivity analysis:** Drivers of these waste pickup trucks who might be from low-income groups will need to be given training for the operation and maintenance of EVs.
- **Implementing stakeholders:** Gwalior Municipal Corporation (lead), GCTSL, Gwalior Smart City, MPPCB, GoMP Transport department, NGOs, private companies
- **Timeframe:** Medium term: 3–5 years.

- **Alignment with schemes:** FAME Phase II, SBM-Urban 2.0
- **Alignment with CSCAF indicators:** Indicator 1 (clean technologies shared vehicles), 4 (level of air pollution) within Mobility and Air Quality and 3 (fossil fuel consumption in the city) under Energy and Green Buildings.
- **Monitoring indicators:** Reduced emissions from the transport sector, percentage of EVs in the city, reduced emissions from freight, % of electric vehicles in the municipal SWM fleet

Action 3: Public-private model for managing construction and demolition waste

- **Challenges addressed at the city level:** No recycling centre for C&D waste as per District Environmental Plan 2021. C&D is also not being used currently in paving blocks, road development, etc and is being dumped in low lying areas⁷.
- **Description:**
 - Assessment of C&D waste generation ward wise, number of generators, current method of processing (% of waste reused in low lying areas): City needs to first collect data on these aspects to identify area and capacity for new recycling facility or facilities based on demand and land availability. Database of bulk waste generators should also be created. Then, a dedicated recycling facility based on capacity needed has to be set up in Gwalior. This can be done by GMC or through public private funding.
 - Public private partnership for managing recycling facility: In Gurugram, considered as a best practice, the municipal corporation appointed two agencies for secondary collection and processing. The agency also manages the collection centres, maintains a database and customer interface. They also have the authority to fine generators for not providing challan on waste generated¹⁰⁷. Separate vehicles were also deployed to transport C&D waste with geotagging and colour coding. This model can further be looked into and adapted to GMC.
 - Appointing dedicated GMC staff in each ward to monitor C&D waste management: In cities like Gurugram and Delhi, one junior engineer is deputed at each ward to monitor waste collection and recycling. They ensure collection of waste and provision of challan. Regular night patrolling is also done to prevent illegal dumping. In Delhi, the junior engineer manages each waste collection centre. GMC can also consider the same.

- **Inclusivity analysis:** Jobs can be provided for informal workers from low-income groups to manage the recycling facility, run the waste collection vehicles and monitor the waste. Awareness also needs to be created amongst bulk generators.
- **Implementing stakeholders:** GMC (lead), Gwalior Smart city, bulk waste generators, construction companies.
- **Timeframe:** Medium term: 3–5 years.
- **Alignment with schemes:** SBM- Urban 2.0, Construction and Demolition Waste Management Rules 2016
- **Alignment with CSCAF indicators:** Indicator: 3 (construction and demolition waste management) under Waste Management.
- **Monitoring indicators:** Reduced emissions due to construction waste, reduced air pollution, % of C&D waste recycled

Action 4: Revenue generating models for recycling C&D waste

- **Challenges addressed at the city level:** No recycling centre for C&D waste as per District Environmental Plan 2021 and C&D is also not being used currently in paving blocks or road development. It is only dumped in low-lying areas.
- **Description:** Gwalior can explore models to generate revenue from C&D waste. C&D waste can be converted into materials for use in construction, like ready-mix concrete, cement bricks, hollow bricks, pavement blocks, kerbstones, concrete bricks, manufactured sand, etc. In Delhi, over 16 lakh recycled concrete blocks from such a plant are being used in the new Supreme Court annex building, saving 45 acres of urban land and reducing burden on landfill¹⁰⁷. Such C&D waste can be used in new roads and development of new areas. The city can also explore the feasibility of using C&D waste in restoration of heritage buildings.
- **Inclusivity analysis:** Jobs can be provided for informal workers from low-income groups to manage the recycling facility, monitor the waste collection and recycling, develop new roads, etc. Training needs to be provided to those in the construction space on proper mixing of C&D waste for construction.
- **Implementing stakeholders:** GMC (lead), Gwalior Smart city, bulk waste generators, construction companies.

- **Timeframe:** Medium term: 3–5 years.
- **Alignment with schemes:** SBM- Urban 2.0
- **Alignment with CSCAF indicators:** Indicator: 3 (construction and demolition waste management) under Waste Management.
- **Monitoring indicators:** Reduced emissions due to construction waste, reduced air pollution, number of new jobs created, % of C&D waste recycled, % of roads and new construction with C&D waste

Action 5: Innovative models for recycling plastic waste

- **Challenges addressed at the city level:** No plastic collection centres in the city as per District Environmental Plan 2021
- **Description:** Gwalior can consider re-using plastic to make roads and eco-bricks. Shredded plastic waste mixed to make a coating for large aggregates provides roads with tremendous strength at no extra cost¹¹². The Govt of India has also issued guidelines for the same¹¹³ in 2019. Jamshedpur has constructed more than 20 km of roads with this method, Chennai has used nearly 1,600 tonnes of plastic waste to construct 1,035.23 km of roads since 2011 and Pune has used it for the 150 km Bhagwat lane at Navi Peth¹¹⁴.

Gwalior can also pilot the use of eco bricks, made from plastic, paper and inert waste for new constructions and mandate their use in the long term. In Jamshedpur, as part of school activities, children fill bottles with plastic waste; these are used as bricks for walls¹⁰⁷. GMC can conduct such activities in schools and colleges.

- **Inclusivity analysis:** These models should ensure participation from a wide range of stakeholders like children, road development authorities, private agencies, citizens, etc. Including all of them in the waste management process will instil a sense of responsibility, which would help in long term implementation.
- **Implementing stakeholders:** GMC (lead), Gwalior Smart city, schools, NGOs, Madhya Pradesh Road Development Corporation Limited
- **Timeframe:** Medium term: 3–5 years.
- **Alignment with schemes:** SBM-Urban 2.0
- **Alignment with CSCAF indicators:** Indicator: 2 (extent of dry waste recovered and recycled) under waste management
- **Monitoring indicators:** Reduced emissions due to waste sector, percentage of plastic recycled, % of roads with plastic waste mixed, # of activities conducted in schools



Source: Gwalior Smart City Development Corporation Ltd.

Goal 7: Water-Resilient Gwalior

Gwalior is part of the Sindh basin and part of the Gird Agro-Climatic Zone. The Swarnarekha and Morar rivers, major tributaries of the Greater Yamuna river basin, traverse the district. The second major reservoir in the district, Tigra, on the Sank river, is the main source of water in the urban region. Gwalior's estimated water requirement is 155.52 MLD; total daily supply is 130 MLD, leaving 1/3rd of the city without access to piped water⁹. Greater variability in precipitation and increasing extreme hydrological events have made a compelling case for improving the water management system in Gwalior.

Identified Actions

Action 1: Develop and implement a Non-Revenue Water Reduction Strategy

- **Challenges addressed at the city level:** Around 30-40% NRW as per CSCAF 2.0 which can further be reduced.
- **Description:** A city-wide SCADA-enabled water sensing, flow-sensing and leak-detection software project is under convergence³. GMC can also develop a non-revenue management strategy to increase the access to piped water supply by identifying and reducing losses in the network. A NRW reduction strategy can include:
 - Water Balance to measure different components to improve estimation / measurement techniques, meter calibration policy, meter checks and identifying improvements to recording procedure.
 - Network Audit to quantify leakage and apparent losses through leakage studies (reservoirs, transmission mains, distribution network) and operational / customer investigations.
 - Review of Network Operating Practices along with investigating historical reasons, poor practices, quality management procedures, poor materials/ infrastructure, local / political influences, cultural/ social/financial factors for losses.
 - Upgrading and Strategy Development - updating records systems, introducing zoning and leakage monitoring, initiating leak detection / repair policy and designing short / medium / long term action plans.
 - Policy Change, Training and Operation and Maintenance for training - improving awareness, increasing motivation, transferring skills, introducing best practice / technology; for operation and maintenance and strengthening community involvement for water conservation and demand management.

- **Inclusivity analysis:** Low-income and informal communities tend to use the least amount of water per capita but face the highest levels of water stress, from intermittent service to relying on expensive private vendors. The city can identify overlaps and gaps in jurisdiction between water and sanitation authorities, and coordinate short-, medium- and long-term plans to address service gaps, decrease NRW, and increase reuse. Addressing the issue of NRW ensures equitable access to piped water supply for low income and vulnerable households.
- **Implementing stakeholders:** GMC (lead), Gwalior Smart City, GoMP PHE department, RWAs, and citizen forums.
- **Timeframe:** Medium term: 3–5 years.
- **Alignment with schemes:** AMRUT; Smart cities mission; Smart meter national program; MP Urban Services Improvement Project.
- **Alignment with CSCAF indicators:** Indicator: 2 (extent of non-revenue water) in Water Management.
- **Monitoring Indicators:** Reduced NRW loss, % households with piped water access

Action 2: Disaster risk reduction through developing and implementing an integrated flood and storm water management plan incorporating nature-based solutions

- **Challenges addressed at the city level:** Gwalior city faces a high risk of urban flooding due to increased intensity and frequency of precipitation. However, the city has not prepared a flood management plan as per the CSCAF 2.0.
- **Description:** Flooding & water logging could become an issue for Gwalior, with high vulnerability, the city could experience increase in frequency of extreme events like floods and droughts.

The city should conduct a flood risk assessment and develop a rapid risk assessment report and action plan based on previous flood records and their causes, such as whether due to dam or embankment breaches or any other man-made reasons, such as encroachment of flood channels, water bodies, major drains etc. The plan should work in accordance with the departmental disaster management action plan.

As the next step, an integrated flood and storm water management plan is essential to reduce the risk of urban flooding, incorporating storm water considerations into new developments, improving water reuse and water security, reducing infiltration of untreated sewage into water bodies, improving the ground water table, and improving coordination and planning for flood risk management. The city can also incorporate sustainable urban drainage systems¹¹⁵, often regarded as a sequence of management practices, control structures and strategies designed to drain surface water efficiently and sustainably, while minimising pollution and managing the impact on water quality of local water bodies. Examples include permeable paving on driveways and footpaths, garden beds designed for infiltration (rain gardens), lawns and vegetation, swales and soak wells¹¹⁶. Gwalior can include these components in new lake and green space development projects as well as incentivize these in new residential projects through property tax rebates, increased floor area ratio, faster permits, etc.

- **Inclusivity analysis:** Low-income communities, informal residents and workers, and migrants are highly impacted due to climate change induced urban flooding. They not only typically lack basic infrastructures that mitigate flooding or heat (e.g., trees for shade, proper stormwater drainage channels), but they also lack political representation. Nature-based solutions like green infrastructure projects for residential properties, which typically have high one-time installation costs and inflexible payment schemes, may be prohibitively expensive for these communities. The city needs to regularly collect census data on informal, migrant, and low-income communities to capture the magnitude of risk for them and ensure integration of green infrastructure for flood mitigation into affordable housing schemes and low-income areas.
- **Implementing stakeholders:** GMC- town planning and development department, gardens department, water supply department (lead), Gwalior Smart City, GoMP Water Resources and PHE departments, NGOs, experts
- **Timeframe:** 3–5 years.
- **Alignment with schemes:** AMRUT, Jal Jeevan Mission
- **Alignment with CSCAF indicators:** Indicator: 4 (flood water stagnation risk management) within Water Management. In accordance with level 5 of climate action plan indicator, water-sensitive urban design¹¹⁷ considerations can also be incorporated into the city's master plan.

- **Monitoring Indicators:** Reduced flooding frequencies, reduced water stagnation, improved vegetation and ground water table, reduced infiltration of untreated sewage into water bodies

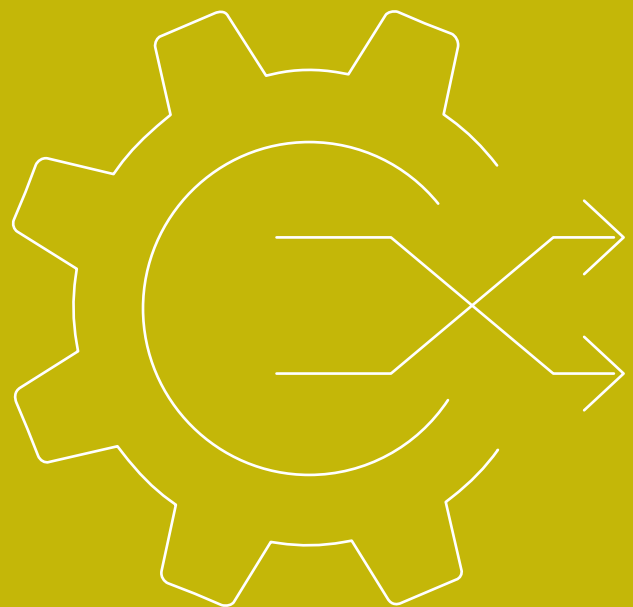
Action 3: Implement energy-efficient water supply and wastewater management systems

- **Challenges addressed at the city level:** Gwalior has not conducted energy audit of water supply and treatment systems as per CSCAF 2.0.
- **Description:** As per CSCAF indicators, the city must first conduct an energy audit for its water supply and wastewater pumping stations and treatment plants. The steps are:
 - Collect and analyse historical energy usage.
 - Study pumping systems and their operational characteristics.
 - Identify potential modification that will reduce energy usage and cost.
 - Perform an engineering and economic analysis of potential modifications.
 - Prepare a rank-ordered list of appropriate modifications.

GMC can also implement action 4 under goal 3: Solarisation of sewage and water treatment plants to reduce energy consumption in sewage treatment plants.

- **Inclusivity analysis:** GMC can train workers from low-income communities on how to conduct and monitor energy audits, install and maintain solar panels and energy efficient meters.
- **Implementing stakeholders:** GMC (Lead), Gwalior Smart City, RWAs, communities, GoMP Water Resources department, MPUVN, MPMKVCL
- **Timeframe:** Short term: 1–2 years.
- **Alignment with schemes:** SBM- Urban 2.0, MP RE policy 2022
- **Alignment with CSCAF indicators:** Indicator: 6 (energy-efficient wastewater management system) within Water Management. Indicator 2: Total electricity from renewables under Energy and green buildings
- **Monitoring Indicators:** Energy audit conducted, reduced energy costs for sewage treatment and water supply

IMPLEMENTATION AND GOVERNANCE OF GWALIOR CLIMATE ACTION PLAN



Creation of Gwalior Climate Change Cell

The GMC is responsible for infrastructure development and citizen services, and Gwalior Smart City is responsible for implementing projects as per the smart city proposal. However, there is no dedicated cell or staff to address climate change concerns in planning. Effective implementation requires the creation of a dedicated cadre or working cell to mainstream climate actions within the scope of existing departmental priorities, project plans and future proposals

| Priority 1

Creating Gwalior climate change cell

- **Description:** To align with the State Action Plan on Climate Change and implement the Gwalior City Climate Action Plan, there needs to be a dedicated climate cell with representatives or nodal officers from concerning line departments. Many cities including Coimbatore, Mumbai, Aurangabad etc. have developed such a cell which is tasked with the implementation and monitoring of the plans. The climate cell needs to coordinate with State Knowledge Management Centre on Climate Change, EPCO, Department of Environment, Govt. of MP, which is the state nodal agency for climate change to implement and report the progress of the actions proposed in the plan. Roles of the climate cell includes:
 - To facilitate coordination between EPCO and the city on climate change related issues and projects
 - To support and advise on key amendments to statutory policy regulations and liaise with parastatal agencies for data collection and information
 - To build internal capacity for climate knowledge and science
 - To engage and coordinate across departments within the city corporation to mainstream climate resilience thinking in existing and proposed projects
 - To facilitate implementation of the actions proposed in the plan
 - To report implementation and monitoring status of the plan to the state nodal agency
 - To work with sectoral experts and scientists to periodically update the plan including city GHG inventory for monitoring the GHG emissions and respective causes and challenges
- **Tentative staffing and stakeholders:**
 - Municipal Commissioner, Gwalior Municipal Corporation (Chairman)
 - Officer nominated by Forest Department (Member)
 - Officer nominated by MP Pollution Control Board Regional Office (Member)
 - Chief City Planner (Member)
 - Environment Engineer (Member)
 - Officer from Transport Section (Member)
 - Officer from Water Supply Section (Member)
 - Officer from Swachh Bharat Mission Cell (Member)
 - Officer from Energy/Electricity Section (Member)
 - Officer from Buildings Section (Member)
 - Officer from Gardens Section (Member)
 - Climate Scientist nominated by Chairman (Member)
 - Representatives from citizen forums (Member)
 - Chief Executive Officer, Gwalior Smart City, or nominated official (Member Secretary)
- **Implementation time:** Short term (1-2 years).

Creating a Gwalior City-level Climate Budget in Municipal Finance

Identifying and creating funding streams for climate action has the potential to catalyse climate-responsive development. It is estimated¹¹⁸ that in India, every \$1 spent on flood-protection infrastructure results in \$248 in avoided damages until 2050 and reduces the likelihood of areas being flooded from 4% to 2%. This will also deliver co-benefits of aligning urbanization in line with the sustainable development goals.

It is important to utilize the budgets provided by the state to tag these to climate responsive development and channelize green economy in the city. The Madhya Pradesh budget 2021-22¹¹⁹ allocated ₹112 crore for the launch of the Mukhya Mantri Swa-Rozgar Yojana to provide low-interest loans to encourage self-employment among youth. This can be leveraged by the city in the actions proposed in this plan, particularly, in the stationary energy and waste sectors, to drive more employment opportunities by a green transition. The ₹2,581 crore allocated to the Atal Grah Jyoti Yojana has also been aligned with few of the actions proposed. The ₹5,762 crore allocated towards the Jal Jeevan Mission could be effective for pilot implementation of actions proposed in the water sector.

It is prudent that Gwalior creates a climate budget to implement the climate action plan. The allocation of a municipal-level climate budget will create accountability to implement climate actions and ensure better coordinated outcomes. To achieve this, it is necessary to have this city-level climate action plan approved by the Mayor-in-Council.

Priority 2

Formulating a City Climate Budget (CCB)

- Description:** A few states in India have already taken steps to incorporate climate budgeting into their public finance management systems. Gujarat Climate Change Department (CCD) adopted a budget called 'Climate Change Budget Scheme'¹²³ which earmarks funds for specific climate change programs. Odisha has a climate budget framework¹²⁴ institutionalized for its cities. Chhattisgarh, Assam, and Maharashtra are tracking the climate change relevance of their developmental projects through budget coding¹²⁵. Thus, the state of MP and its cities also need to step up in action, considering its estimated climate risks, vulnerability score and the climate performance of its Smart cities. The climate budget should tag project activities for specific purposes in its budget documents by catalyzing a climate finance framework. The city should prepare a climate budget in alignment with the plan. The status of climate actions and achievements should be tracked quarterly and reported annually.
- Implementation time:** Short term (1-2 years).

Table 6: State vulnerability score and financial expenditures

State	State Vulnerability Score ¹²⁰	Overall Average CSCAF Scores of MP's SMART Cities ¹²¹	SDG Progress ¹²² (Benchmark Score 66)	Status of Climate Finance/ Climate Budget	Scope of Urbanization and Climate Vulnerability
Madhya Pradesh	Medium Vulnerability	★ ★ ★	Performer-62	No climate budget framework institutionalized	7 smart cities

* Priority 1 and Priority 2 should be developed in coordination with State Knowledge Management Centre on Climate Change, EPCO, Department of Environment, Government of MP after the launch of the Climate Action Plan.

The city authorities can select actions and recommendations provided in this plan to develop a detailed implementation plan for pilot projects that can be rolled out in the short-, medium- and long term. The GHG emission profile of the city included in the plan may be used as a guiding analysis to prioritize implementation of actions in different sectors. The plan also provides guidance on mainstreaming actions with existing policies, schemes, and programs to establish convergence of implementation.

Lastly, this plan must be treated as a dynamic document and must be updated regularly with the latest emissions profile of the city. Instituting a climate change cell at the city-level with representation of concerning ULB departments, Smart city, citizen forums, academic institutions and civil society becomes necessary to lead and coordinate this process. Organizing periodic stakeholder consultations would help in strengthening the plan as per the evolving requirements of the city.

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