TOWARDS A NET ZERO AND CLIMATE RESILIENT BENGALURU

Bengaluru CLIMATE ACTION & RESILIENCE PLAN

FULL REPORT

This report should be referred to as the 'Bengaluru Climate Action and Resilience Plan (BCAP), 2023'"
"All maps in this report are intended as visualizations to communicate city-wide data analysis for information purposes only and are not to scale.

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SCAN AND VIEW

Webpage of
Bengaluru Climate Action Cell
Please visit 'resources' page for BCAP documents

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LIST OF ABBREVIATIONS

AFOLU	Agriculture, Forestry and Other Land Use
AI	Artificial Intelligence
AI-ML	Artificial Intelligence and Machine Learning
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AOA Scheme	Afforestation on Other Areas
AQ	Air Quality
AQI	Air Quality Index
AQMC	Air Quality Monitoring Committee
AR	Assessment Report
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASP	Activated Sludge Process
BAU	Business As Usual
BBMP	Bruhat Bengaluru Mahanagara Palike
BCAP	Bengaluru Climate Action and Resilience Plan
BDA	Bangalore Development Authority
BEE	Bureau of Energy Efficiency
BESCOM	Bangalore Electricity Supply Company Limited
BIAPPA	Bangalore International Airport Area Planning Authority
BMA	Bangalore Metropolitan Area
BMC	Biodiversity Management Committee
BMLTA	Bengaluru Metropolitan Land Transport Authority
BMR	Bangalore Metropolitan Region
BMRCL	Bengaluru Metro Rail Corporation Limited
BMRDA	Bangalore Metropolitan Region Development Authority
BMTC	Bengaluru Metropolitan Transport Corporation
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
BSCOM	Bangalore Electricity Supply Company Limited
BSWML	Bengaluru Solid Waste Management Limited
BTP	Bengaluru Traffic Police
BUA	Bangalore Urban Agglomeration
BUD	Bengaluru Urban District
BWG	Bulk waste generators
BWSSB	Bangalore Water Supply & Sewerage Board
C&D	Construction and Demolition
CAAQMS	Continuous Ambient Air Quality Monitoring Station
CAA	Citizenship Amendment Act
CAC	Climate Action Cell
CAGR	Compound Annual Growth Rate
CAP	Climate Action Plan

CBG	Compressed Biogas
CCRA	Climate Change Risk Assessment
CESL	Convergence Energy Services Limited
CGWB	Central Ground Water Board
CH_4	Methane
CIRIS	Cities Inventory Reporting and Information System
CMP	Comprehensive Mobility Plan
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COD	Chemical Oxygen Demand
COVID	Coronavirus Disease
CPCB	Central Pollution Control Board
Cr	Crore
CSCAF	Climate Smart Cities Assessment Framework
CSTEP	Center for Study of Science, Technology and Policy
CWSS	Cauvery Water Supply Scheme
DCR	Development Control Regulations
DDMP	District Disaster Management Plan
DMC	Deputy Municipal Commissioners
DMP	Disaster Management Plan
DTCP	Directorate of Town and Country Planning
DULT	Directorate of Urban Land Transport
DWCC	Dry Waste Collection Centres
E&P Scenario	Existing & Planned Scenario
ECBC	Energy Conservation Building Code
EF	Emission Factor
EIE	Environmental Insights Explorer
EMPRI	Environmental Management & Policy Research Institute
ENS	Eco Niwas Samhita
ERV	Energy Recovery Ventilation
EV	Electric Vehicle
EWS	Economically Weaker Section
FAME	Faster Adoption and Manufacturing of Electric Vehicles in India
FAR	Floor Area Ratio
FSI	Floor Space Index
FVA	Flood Vulnerable Area
GAIL	Gas Authority of India Limited
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System

GoI	Government of India
GoK	Government of Karnataka
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
GPS	Global positioning system
GRIHA	Green Rating for Integrated Habitat Assessment
GRP	Groundwater recharge potential
GSDP	Gross State Domestic Product
GUA Scheme	Greening Urban Area Scheme
GWD	Ground Water Directorate
GWP	Global Warming Potential
GWP	Ground Water Potential
ha/yr	Hectares Per Year
HEPA	High Efficiency Particulate Air
HIG	Higher Income Groups
HRV	Heat Recovery Ventilation
IAQ	Indoor Air Quality
ICAP	Inclusive Climate Action Planning
ICLEI	International Council for Local Environmental Initiatives
ICT	Information and Communication Technology
IEA	International Energy Agency
IEC	Information, Education & Communication
IGBC	Indian Green Building Council
IISc	Indian Institute of Science
ILI	Influenza-Like Illness
IMD	India Meteorological Department
INR	Indian Rupees
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IPR	Intellectual Property Rights
IPT	Intermediate Public Transport
IRERM	Integrated Renewable Energy Resource Management
ISWM	Integrated Solid Waste Management
IT	Information Technology
ITS	Intelligent Transportation Systems
IUWM	Integrated Urban Water Management
JNNSM	Jawaharlal Nehru National Solar Mission
K-ECBC	Karnataka Energy Conservation Building Code
KEONICS	Karnataka State Electronics Development Corporation
KPCL	Karnataka Power Corporation Limited
KPI	Key Performance Indicator
KPTCL	Karnataka Power Transmission Corporation Limited

KREDL	Karnataka Renewable Energy Development Limited
K-RIDE	Rail Infrastructure Development Company (Karnataka) Limited
KSAPCC	Karnataka State Action Plan for Climate Change
KSDB	Karnataka Slum Development Board
KSDMA	Karnataka State Disaster Management Authority
KSNDMC	Karnataka State Natural Disaster Monitoring Centre
KSPCB	Karnataka State Pollution Control Board
KSPCDCL	Karnataka Solar Power Development Corporation Limited
KSRTC	Karnataka State Road Transport Corporation
KTCP	Karnataka Town and Country Planning
kVA	kilovolt-ampere
kW	Kilo Watt
LEED	Leadership in Energy and Environmental Design
LEZ	Low Emission Zone
LIFE	Lifestyle for Environment
LIG	Lower Income Group
LMV	Light Commercial Vehicles
LPG	Liquefied petroleum gas
LST	Land Surface Temperature
m	Metre
Max	Maximum
MERL	Monitoring, Evaluation, Reporting and Learning
mg/l	Milligram/Litre
MIG	Middle Income Group
Min	Minimum
MLD	Million Litres per Day
mm	Millimetre
MMI	Multi Modal Integration
MMT	Million Metric Ton
MoEFCC	Ministry of Environment, Forest and Climate Change
MoPNG	Ministry of Petroleum and Natural Gas
MPC	Metropolitan Planning Committee
MRF	Material Recovery Facility
MSME	Micro, Small, and Medium Enterprise
MSW	Municipal Solid Waste
MW	Mega Watt
MwH	Megawatt Hour
N2O	Nitrous Oxide
NAMP	National Air Quality Monitoring Programme
NAPCC	National Action Plan for Climate Change
NBC	National Building Code
NBS	Nature-Based Solution

NCAP	National Clean Air Programme
NCEI	National Centers for Environmental Information
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organisation
NGT	National Green Tribunal
NIUA	National Institute of Urban Affairs
NMEEE	National Mission for Enhanced Energy Efficiency
NMT	Non-Motorised Transport
NNE-SSW	North--North-East—South--South-West
NOx	Nitrogen Oxide
NRW	Non-Revenue Water
NSIC	National Small Industries Corporation
NSM	National Solar Mission
NSS	Non-Specified Source
NUHM	National Urban Health Mission
NULM	National Urban Livelihood Mission
O3	Ozone
ORR	Outer Ring Road
OSHA	Occupational Safety and Health Administration
PAT	Perform, Achieve and Trade
PBR	People's Biodiversity Register
PBS	Public Bike Sharing
PCKL	Power Company of Karnataka Limited
pH	Potential of hydrogen
PM	Prime Minister
PM	Particulate Matter
PMAY-U	Pradhan Mantri Awas Yojana-Urban
PMUY	Pradhan Mantri Ujjwala Yojana
PNG	Piped Natural Gas
PPAC	Petroleum Planning and Analysis Cell
pph	Persons Per Hectare
PT	Public Transport
PWD	Public Works Department
R&D	Research and development
RCP	Representative Concentration Pathway
RDF	Refused Derived Fuel
RE	Renewable Energy
RMP	Revised Master Plan
rpm	Revolutions Per Minute
RR Nagar	Raja Rajeshwari Nagar
RSP	Revised Structure Plan
RWH	Rainwater Harvesting

SARI	Severe Acute Respiratory Infection
SBM	Swachh Bharat Mission
SBS	Sick Building Syndrome
SCM	Smart Cities Mission
SCSP	Scheduled Caste Sub-Plan
SDG	Sustainable Development Goal
SME	Small and Medium Enterprises
SO2	Sulphur Dioxide
SOP	Standard Operating Procedure
Sq.m	Square Metres
STP	Software Technology Park
STP	Sewage Treatment Plant
SWD	Storm-water Drainage Department
SWM	Solid Waste Management
T&D	Transmission and Distribution
T&L	Thunderstorm and Lightning
TERI	The Energy and Resources Institute
TG Halli	Thippagondanahalli
TH	Total Hardness
TK Halli	Thoraikadanahalli
TOD	Transit-Oriented Development
TPA	Tonnes Per Annum
TPD	Tonnes Per Day
TPP	Thermal Power Plants
TSP	Tribal Sub-Plan
UfW	Unaccounted-for Water
UHI	Urban Heat Island
UIDF	Urban Infrastructure Development Fund
ULB	Urban Local Body
ULEZ	Ultra-Low Emission Zone
UNFCCC	United Nations Framework on Climate Change Convention
URDPFI	Urban and Regional Development Plans Formulation and Implementation
VA	Vulnerability Assessment
VKT	Vehicle Kilometres Travelled
VOC	Volatile Organic Compounds
VRE	Variable Renewable Energy
VVMP	Voluntary Vehicle Fleet Modernisation Program
WHO	World Health Organization
WRD	Water Resource Department
WRI	World Resources Institute
WtE	Waste to Energy
%	Percent

°C	Degrees Celsius
$\mu g/m^3$	micrograms per cubic metre

FOREWORD

Shri D.K. Shivakumar
Bengaluru Development Minister and
Deputy Chief Minister,
Government of Karnataka

Bengaluru, the capital of Karnataka and one of the fastest growing cities in India, holds a unique position in the country's urban landscape. The city is one of the largest attractors of talent globally, with a strong innovation and startup ecosystem. Bengaluru, historically known as the Garden City of India, has gradually become the Silicon Valley of India, being one of the largest hubs of Information Technology companies in the world.

While the city has been proactive in formulating progressive policies to manage its growth, it is not insulated from the perils of growth. The pressure of urbanisation has not only impacted the natural resources and ecological networks in the city-region, but its effect can be felt in the city's liveability conditions. At the same time, the growing concern over climate change and its impact on cities has added a sense of urgency to our efforts to enhance Brand Bengaluru as one of the most liveable and inclusive cities in the world and a preferred investment destination.

The Government of Karnataka, together with Bruhat Bengaluru Mahanagara Palike (BBMP), in an effort to tackle these challenges and reiterate its commitment to the shared international goal to limit global warming and uphold the Paris Agreement as a member of the C40 cities, is pleased to put forward the first ever Bengaluru Climate Action and Resilience Plan (BCAP). Developing an actionable roadmap to mitigate and adapt to climate change, and to build better resilience, is a priority of the government of Karnataka, and must be seen as a human development agenda. Over the next few years, the BCAP will be implemented as a multi-sectoral collaborative effort, drawing participation from various departments of the Government of Karnataka, civil society and the private sector.

Launching a roadmap for climate action for Bengaluru is a strategically significant step for the state of Karnataka. With 1 in 7 persons in the state living in Bengaluru, and given the city's forward and backward linkages in the state and national economy, the BCAP is going to positively impact not just the citizens of Bengaluru, but many more lives. I am confident that Bengaluru will emerge as a lighthouse not only for other cities in Karnataka and India, but as a global example of inclusive climate action.

FOREWORD

Smt. Vandita Sharma
Chief Secretary to Government,
Government of Karnataka

As per the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6), with every increment in global warming, regional changes in the mean climate and extremes become more widespread and pronounced. Adverse impacts from climate change will continue to intensify in future. India's updated Nationally Determined Contribution (NDC) is a milestone in this effort, and seeks to enhance the country's contributions towards strengthening the global response to the threat of climate change, as per the Paris Agreement. The Government of Karnataka is committed to being a frontrunner in helping the country embark on low-emission and resilient pathways. Cities are the engines of economic growth, and it is high time that they take up the mantle. I am happy to see that Bengaluru is already championing this effort, with the Bengaluru Climate Action and Resilience Plan (BCAP). With the launch of the BCAP, it will become one of the few cities in the world, and the third in India, to have a global standard Climate Action Plan.

Spearheaded by the Bruhat Bengaluru Mahanagara Palike (BBMP), the BCAP is Bengaluru's first data-driven, multi-stakeholder collaborative exercise to address its GHG mitigation and climate change adaptation challenges. The goals, targets and actions recommended by this plan provide clear pathways to achieve a net zero and climate-resilient Bengaluru. As it is the largest city of Karnataka, its plan is sure to provide a roadmap to other cities in the state to act against climate change.

For any plan to be successful it is imperative that all stakeholders take ownership. The successful implementation of the BCAP would require coordination and coherence amongst government departments, civil society organisations, NGOs, research organisations and, most importantly, citizens. With every actor playing their part in turning this plan into reality, I am optimistic that the city will transform its challenges into opportunities.

Vandita

FOREWORD

Shri Rakesh Singh, IAS
Additional Chief Secretary to Government,
Urban Development Department,
Government of Karnataka

Climate change is one of the biggest challenges that cities are grappling with in the 21st century, and thus it must be addressed to achieve the mission of sustainable and inclusive urban development. With the successful adoption and launch of the Bengaluru Climate Action and Resilience Plan (BCAP), Bengaluru can become a model for other cities and towns in Karnataka to become climate-progressive.

Bengaluru is the largest of Karnataka's 10 municipal corporations. Therefore, the scale and complexity of the challenges it faces are mammoth. Apart from the Bruhat Bengaluru Mahanagara Palike (BBMP), there are multiple departments and agencies responsible for providing different types of services and planning for the city. These include the Bengaluru Electricity Supply Company Limited (BESCOM), Bangalore Water Supply and Sewerage Board (BWSSB), Bengaluru Metropolitan Transport Corporation (BMTC), Bangalore Metro Rail Corporation Limited (BMRCL), Bangalore Development Authority (BDA), and the Disaster Management Department. Climate action is an agenda that cuts across sectors. The goals, targets, and actions for greenhouse gas mitigation and resilience-building set by the BCAP have been developed in consultation and consensus with all relevant agencies. It is now incumbent on us to deliver on the ambitious targets set by BCAP with the utmost sincerity.

The Urban Development Department of the Government of Karnataka is committed to supporting the BBMP and all other key stakeholder departments and agencies in implementing the BCAP with highest level of coordination and coherence. The momentous effort put in preparing the BCAP will only be realised on the ground when all the stakeholders working in and for Bengaluru align with each other. I hope this effort will set a precedent for other cities in Karnataka and the rest of the country in making cities plan and deliver on climate action commitments.

CITY LEADERS' PLEDGE FOR CLIMATE ACTION

Shri Tushar Girinath
Chief Commissioner,
Bruhat Bengaluru Mahanagara Palike

Bengaluru, the capital of Karnataka and the fifth largest city in India, is among the handful of cities across the globe to decisively declare its commitment to tackle climate change. Bengaluru joined the C40 cities network in 2017, and is committed to contribute its fair share to limit warming to 1.5 degrees, while being equally committed to prepare itself to adapt to climate change impacts. The city is also the co-lead of the Global Air Quality Network. By presenting the Bengaluru Climate Action and Resilience Plan (BCAP), we reaffirm the city's commitment to fight climate change for Bengaluru's citizens, for our country and, in the true spirit of a 21st century city, for the global community.

The BCAP is not a mere document, but a firm step towards charting a roadmap for the city - informed by data, research, the best available knowledge practices and, most importantly, lived experiences. With this plan, Bengaluru has embarked on an ambitious journey to reduce GHG emissions in line with the commitment given by the Govt of India to the United Nations Framework Convention on Climate Change. Our endeavour will be to achieve these long-term emission reduction targets by implementing BCAP actions within the framework of the relevant policies of the Govt of India. The BBMP will endeavour to actively pursue the policies and to contribute more to arrest the climate change.

An evaluation of BCAP goals and targets will be done every three years, based on insights provided by monitoring exercises described in the previous section. The goals and targets will be revised if required based on the evaluation exercise. The entire BCAP will be revisited every five years, based on updated evidence and progress on goals set.

As we adopt and start the implementation of the BCAP, it is important to internalise the plan's intent in letter and spirit, in the policies, processes and practices of planning, managing and governing the city. While the Bruhat Bengaluru Mahanagara Palike, along with all the key departments of the Government of Karnataka working in and for the city, will lead the implementation of the plan from the front, the BCAP can only be a success with participation from and partnerships, which include citizens and civil society, knowledge institutions, and the private sector. With the adoption of the BCAP, Bengaluru takes yet another leap towards securing a healthy, safe, and resilient urban future for its citizens.

I thank C40 Cities and WRI India for their stewardship in developing the BCAP for Bengaluru.

MESSAGE

Ms. Shruti Narayan,
Regional Director, South and West Asia,
C40 cities

Bengaluru, the fifth most populous urban agglomeration in India, has been a C40 city since 2017, committing to accelerated climate action as a part of C40's Leadership Standards. Integral to this, Bengaluru has now published its Climate Action Plan (BCAP) committing to playing its fair role in reducing carbon emissions, thereby setting a roadmap to becoming carbon neutral by 2050 aligned with the Paris Agreement and also contributing to India's NDCs and the target of carbon neutrality by 2070.

The Bengaluru Climate Action Plan is data-driven based on a GHG inventory of 2019-2020, that sets clear yet achievable targets, of 16% by 2030, 26% by 2040 and 56% by 2050 and further endeavours to work towards achieving net zero by 2050 in line with the extended scenario (34% by 2030, 58% by 2040, and 91% reduction by 2050). This is an important milestone for Bengaluru and an inspiration for cities in the Global South, leading the way in demonstrating how political commitment and leadership bringing diverse stakeholders in the discussions, can result in an ambitious yet implementable climate action plan.

A critical component of the BCAP is to build resilience to immediate and future climate risks and address inclusive climate actions by putting health and economic recovery by creating jobs at the forefront. The BCAP has been developed on consensus, collaboration and coherence with national, state and city policies and actions. The Urban Development Department, GoK and Bruhat Bengaluru Mahanagara Palike (BBMP), with strategic support from WRI India and C40 Cities, have led from the front on many of these discussions and helped frame the key priorities that can enable this transition. We look forward to continuing our engagement with BBMP along with the State Government and other institutions in the implementation and delivery of targets set out to create a Resilient and Liveable Bengaluru.

Shruti Narayan

MESSAGE

Ms. Jaya Dhindaw
Director, WRI India Ross Center, and
Executive Program Director, Sustainable Cities,
WRI India

Bengaluru, one of the world's largest innovation hubs, and fastest growing economies, is a favoured destination for investors and talent alike. In the phase of pandemic recovery, the city has been through a lot, given the hectic pace of growth and the continuous onslaught of extreme climate events. In this context, the Bengaluru Climate Action and Resilience Plan (BCAP) provides a decisive and inclusive stance on climate action, training its lens on fore-fronting interconnected actions that are beneficial for people, nature and climate.

The BCAP is unprecedented because the solutions it suggests, to address Bengaluru's vulnerabilities and strengthen climate resilient growth, are highly data and evidence-based. Furthermore, it also takes into account ground realities based on multiple deliberations with citizens and public agencies.

The Plan sets clear goals, targets, and actions across seven key sectors: Energy and buildings, transport, solid waste, water and wastewater, air quality, urban planning, greening and biodiversity, and disaster resilience. The recommendations offered in the Plan span institutional mechanisms and regulations, to infrastructure development, finance and capacity. The BCAP is a valuable opportunity to drive coherence across sectors and agencies towards delivering outcomes and impact on the ground. The plan interfaces with multiple disciplines and is therefore, well equipped to inform policy and complementary action by a varied range of stakeholders to shape a liveable and thriving city.

As we focus on reducing emissions, inequities and restoring nature, there are reasons for optimism, as Bengaluru is only the third city in India with a climate action plan adhering to global standards and will play a pivotal role in India's transition towards climate proofing its citizens and economy.

Climate-resilient, sustainable, well-planned urban development, reduces inequality, improves inclusion, and enables better quality of life, while respecting planetary boundaries. WRI India looks forward to supporting Bengaluru in achieving its goal of pursuing low-carbon, just, equitable and resilient growth, and safeguarding the future of Bengalureans through collective climate-positive actions.

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We sincerely thank the C40 Cities team for giving us the opportunity and guiding the city throughout the process of preparing the Bengaluru Climate Action and Resilience Plan (BCAP). We express our gratitude to WRI India for supporting the Bruhat Bengaluru Mahanagara Palike as a knowledge partner in preparing the BCAP since its inception and throughout its development and until the final approval stage. We thank all the stakeholder agencies, especially the nodal officers, who supported us with data, time, resources and suggestions. We appreciate the support received from all the officials from BBMP, including its zonal and ward offices, who participated in the development of the BCAP. We thank all the experts, practitioners, and members of academia and civil society for their valuable time in making the preparation of the BCAP a multi-stakeholder consultative exercise. We express our gratitude to all the advisors and reviewers from C40 Cities and WRI India. Specifically, we would like to thank all the individuals, authors, the support teams and organisations listed below, for their unconditional support and contributions to the BCAP.

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List of stakeholder departments/agencies consulted

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Bangalore Water Supply & Sewerage Board (BWSSB)
Bengaluru Metro Rail Corporation Limited (BMRCL)
Bengaluru City Police
Bengaluru Solid Waste Management Limited (BSWML)
Bengaluru Traffic Police department
Bengaluru Metropolitan Transport Corporation (BMTC)
Central Ground Water Board (CGWB)
Commissionerate of health and family welfare
Department of Industries and Commerce
Directorate of Urban Land Transport (DULT)
District Disaster Management Authority (under Revenue Department)
Environmental Management & Policy Research Institute (EMPRI)
GAIL (India) Limited
Ground Water Directorate (GWD)
India Meteorological Department (IMD)
Indian Institute of Science (IISc)
Karnataka Biodiversity Board
Karnataka Forest Department
Karnataka Power Corporation Limited (KPCL)
Karnataka Power Transmission Corporation Limited (KPTCL)
Karnataka Renewable Energy Development Limited (KREDL)
Karnataka Solar Power Development Corporation Limited (KSPDCL)
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Karnataka State Road Transport Corporation (KSRTC)
Karnataka State Natural Disaster Monitoring Centre (KSNDMC)
Karnataka Transport Department
MSME Development Institute (DI)
Petroleum Planning and Analysis Cell (PPAC)
Power Company of Karnataka Limited (PCKL)
Rail Infrastructure Development Company (Karnataka) Limited (KRIDE)
The Energy & Resources Institute (TERI)
Urban Development Department
Water Resource Department (WRD)

VISION: TOWARDS A NET ZERO AND CLIMATE-RESILIENT BENGALURU

'Urban systems are critical for achieving deep emissions reductions and advancing climate-resilient development, particularly when this involves integrated planning that incorporates physical, natural and social infrastructure (high confidence).'

Synthesis Report of the IPCC Sixth Assessment Report (AR6), 2023

The Bengaluru Climate Action and Resilience Plan (BCAP) foregrounds human wellbeing in the city's fight against climate change through its commitment to tackle contributors and impact of climate change with equal priority, both of which have profound consequence on shaping Bengaluru's transition to a future that is just, resilient, inclusive and equitable.

BCAP acknowledges that the window of opportunity for securing a livable future for Bengaluru is rapidly closing and the choices we make today will determine the choices we leave for future citizens of Bengaluru. BCAP sets ambitious goals for mitigating GHG emissions (in line with the commitment given by the Govt of India to the United Nations Framework Convention on Climate Change) and enhance Bengaluru's resilience by propelling adjustments in ecological, social or economic systems of the city in response to risks posed by climate change.

BCAP acknowledges the 2070 net zero goal set by India's Nationally Determined Contributions. Bengaluru, as the hub of innovation and start-ups, with access to advanced knowledge and resources, and home to a thriving civil society, intends to lead the way by setting more ambitious targets and implementing innovative solutions to help achieve India's declared climate goals, and at the same time become an incubator of climate solutions which could be replicated by other cities.

Enshrining a three-pronged priority of human wellbeing, natural protection and economic growth, the pathways for achieving climate goals for the city are based on the following three pillars of success:

Consensus: Build informed conversation among all actors as a continuous process during preparation and implementation of BCAP and beyond.

Collaboration: Catalyse radical partnerships with both state and non-state stakeholders for implementation of actions

Coherence: Ensure interdependencies of policies, plans, processes and practices are well-addressed to ensure sustainability of actions.

We believe that BCAP will provide a much-needed climate-progressive roadmap for Bengaluru.

Photo Credit : Chetan Sodaye/WRI India

1 INTRODUCTION

Bengaluru (also known as Bangalore) is the fifth most populous urban agglomeration in India, and one of the fastest-growing metropolises[1] (Census 2011). It is the capital and the primate city of the state of Karnataka, accommodating about 39% of the total urban population of the state. Situated approximately 920 metres (m) above mean sea level in the Cauvery and Ponnaiyar (also known as Dakshin Pinakini) river basin, Bengaluru is bestowed with rich biodiversity and natural resources. Thanks to an intrinsic network of lakes (locally referred to as tanks), natural drainage channels, and green spaces, Bengaluru is known as the Garden City of India. Primarily a cantonment town during the colonial period, the city has gradually transformed into a major economic centre of the country, attracting people and businesses from all over India and across the world. The city's manufacturing-based economy in the post-Independence period was overtaken by strong tertiary/service sector growth in the 1990s, led by the growth of the IT sector. Since then, Bengaluru has also come to be known as the Silicon Valley of India, producing the largest share of India's IT jobs and exports. A thriving centre of knowledge and innovation, Bengaluru has also emerged as a leading start-up hub in recent years. In 2019-20, Bengaluru Urban District (BUD) contributed 36% of Karnataka's Gross State Domestic Product (P. Department 2021).

Bengaluru's economic growth was accompanied by the growth of the population and physical expansion. The city has grown rapidly since the 1990s, with almost a three-fold expansion of the municipal corporation area in 2007. The jurisdiction of the Bruhat Bengaluru Mahanagara Palike (BBMP), the municipal corporation of the city, covers an area of about 713 sq. km., and accommodated 8.5 million people in 2011. The estimated population of BBMP was approximately 10 million in 2019. The BBMP area could be seen as a cumulation of three broad area categories: the city core (the erstwhile municipal corporation area), areas under eight smaller municipalities that were merged with the erstwhile municipal corporation to form BBMP in 2005, and 110 villages that were adjoining the city core before the formation of BBMP and are now part of BBMP in its current avatar. As of 2021, the total area under BBMP is divided into eight zones and 198 wards (BBMP now has 225 wards after a delimitation exercise was carried out in 2023).

While the expansion of the city's municipal boundary created room to accommodate its growing population and economic activities, it also propelled the need for extending adequate urban infrastructure and services to the peripheries of the city. More importantly, the rapid growth over the past two decades has led to urban sprawl, loss of green cover, and deteriorating liveability conditions, negatively impacting Bengaluru's attractiveness as an investment destination. This has underscored the need for balancing the city's growth aspirations and liveability conditions with better evidence-based urban planning and management practices. Moreover, the increasing frequency of hazards being experienced by Bengaluru, as a combined result of extreme weather events and lack of preparedness to

[1] According to the World Population Review, Bengaluru urban agglomeration (which includes Bengaluru city and adjoining outgrowths) has a population of 18 million in 2023 (Review 2023) (Nations 2018)

manage their impacts, makes it imperative for the city to reimagine its future through the lens of climate change.[2]

Cities are increasingly being put at the centre stage of climate discussions on two counts: one, they are major emitters of GHGs, accounting for almost 75% of global CO2 emissions (UNEP 2017), and two, cities face increased risk from climate change impacts due to the concentration of population and economic activities, plausibly leading to severe loss and damage (IPCC 6th Assessment Report noted observed high negative impact on cities due to climate change). Addressing these two aspects of climate change has multiple other co-benefits for cities such as better liveability, reduced economic burden on the city and citizens, improved air quality and public health, greater opportunity for green jobs and so on. Bengaluru has been addressing many of these challenges through different initiatives. The Climate Action and Resilience Plan gives Bengaluru an opportunity to intensify and coordinate its efforts to plan and manage the perils of rapid urban growth in a way that is climate-aware and aligned to the global climate agenda as well as India's Nationally Determined Contributions (NDCs)[3].

Bengaluru joined the C40 cities network in 2017. It is also the co-lead of the Global Air Quality Network and a signatory to Deadline 2020[4] set by and for the C40 cities network. Deadline 2020 was a call for all c40 cities to chalk out a roadmap by 2020 to deliver the Paris Agreement[5], i.e., to limit the global temperature rise to 1.5 degrees, with an eye to reduce GHG emissions by 2030, and neutrality by 2050. The BBMP started the preparation of the Bengaluru Climate Action and Resilience Plan (BCAP) in August 2021, in partnership with C40 cities and WRI India. The primary aim of the BCAP is three-fold: one, to find pathways with tangible targets for the mitigation[6] of GHGs, which are the main contributors to climate change; two, to identify strategies for adaptation[7] and resilience-building[8] to climate change impacts at the city level; and three, to mainstream climate action in the city's core activities and develop suitable mechanisms for tracking progress on identified actions and pathways. The goals and targets for implementing mitigation and adaptation pathways take cognisance of India's commitments on international platforms (such as the revised Nationally Determined Contributions), emerging national and sub-national policy aspirations and Karnataka's own ambitions for acting on climate change as put forward by the Karnataka State Action Plan for Climate Change 2021.

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[2] Climate change is defined as per the IPCC 5th Assessment Report. Refer to the glossary for the definition.

[3] India released its first ever NDCs in 2015, followed by an updated version released in August 2022. The updated NDCs aims to achieve net-zero emissions by 2070 (UNFCCC 2022a).

[4] Deadline 2020 is the first significant roadmap for achieving the Paris Agreement, outlining the pace, scale, and prioritisation of action needed by C40 member cities (Cities 2016).

[5] The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015. It entered into force on 4 November 2016. Its overarching goal is to hold 'the increase in the global average temperature to well below 2°C above pre-industrial levels' and pursue efforts 'to limit the temperature increase to 1.5°C above pre-industrial levels' (UN Climate change 2019).

[6] Mitigation generally refers to efforts to reduce or prevent emission of greenhouse gases. Refer to the glossary for the definition of mitigation as per IPCC 5th Assessment Report

[7] Adaptation generally refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. Refer to the glossary for the definition of adaptation as per IPCC 5th Assessment Report.

[8] Resilience generally refers to the capacity or ability to anticipate and cope with shocks, and to recover from climate change impacts. Refer to the glossary for the definition of resilience as per IPCC 5th Assessment Report.

Spanning over more than a year, the preparation of the BCAP was a multi-sectoral and multi-stakeholder initiative. The objective was to arrive at a plan of action that is backed by science and evidence, grounded in reality, and owned by agencies across sectors as well as the citizens of Bengaluru.

1.1 Approach and key steps

The overarching approach to the preparation of the BCAP was anchored to the C40 Cities Climate Action Planning framework essentially embedded in commitment, evidence, and action-based planning. This framework is primarily built around the following four components:

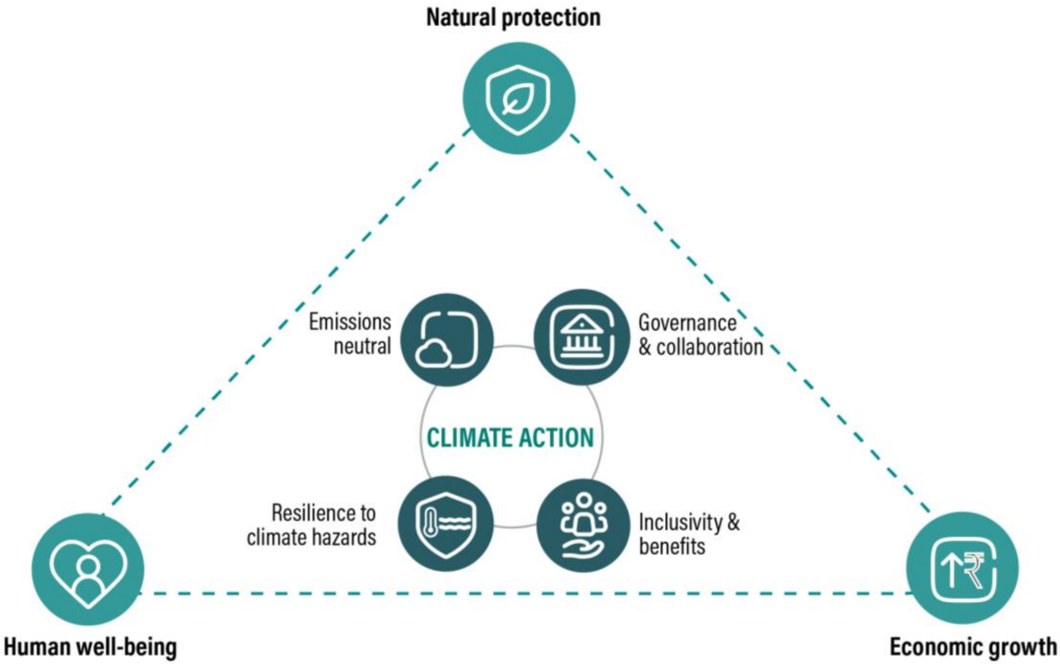
a) **Emission reduction/neutrality:** Create a GHG emissions baseline for the city, and develop a pathway to inform the strategies and targets that will be needed to accelerate the delivery of an emission-neutral city by 2050, with an ambitious interim target.
b) **Climate change risk and vulnerability reduction:** Conduct a Climate Change Risk and Vulnerability Assessment (CCRA-VA) for the city and demonstrate how the city will adapt and improve its resilience to the climate hazards that may impact the city now and in future climate change scenarios.
c) **Inclusivity and benefits:** Engage with the community to inform the plan, outline the social, environmental, and economic benefits expected from implementing the plan; and establish ways to ensure equitable distribution of these benefits to the city's population.
d) **Governance and collaboration:** Outline the city's governance, responsibilities, powers and capacity, and identify the partners who need to be engaged in order to accelerate the delivery of mitigation targets and resilience goals.

The GHG inventory and CCRA-VA form the basis of BCAP, both of which offer a data-driven scientific evidence base for the city, created with multi-stakeholder contributions.

The approach to analytics, action framing and prioritisation in the BCAP enshrine three key tenets of a thriving and sustainable city, namely, human well-being, natural protection, and economic growth. This also reflects the BCAP's alignment to the Sustainable Development Goals (SDGs), especially SDG-11, which aims to make cities and urban areas inclusive, safe and resilient, and SDG-13, which calls for urgent action to combat climate change and its impacts. These are addressed at the cross-section of other SDGs that focus on critical aspects of access to basic services and amenities and protection of ecological systems.

A summary of this approach is illustrated in Figure 1 below.

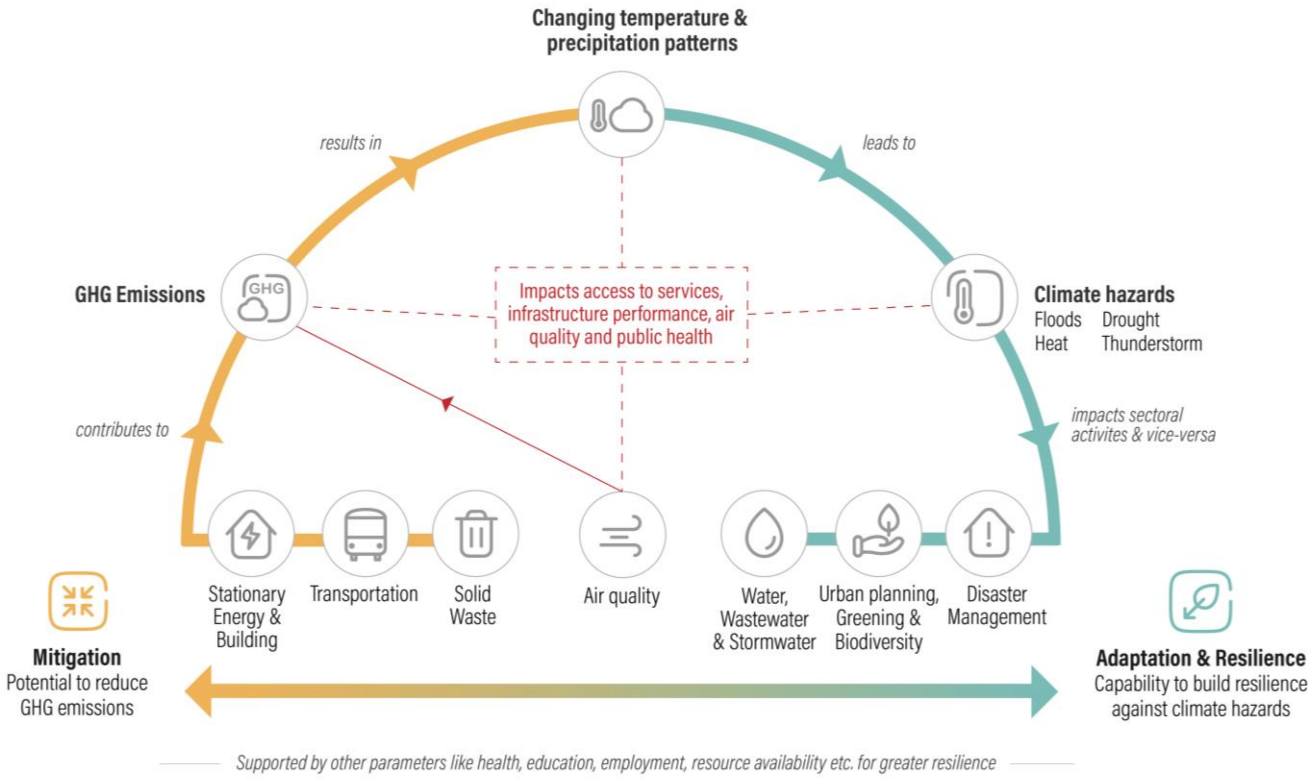
Figure 1 Approach to the preparation of the BCAP



Source: WRI India and C40 Cities

It is important to acknowledge that cities in India are subject to multiple planning interventions, and Bengaluru is no exception. The city's spatial growth, land use, and development are largely guided by the Master Plan (the Revised Master Plan for Bangalore-2015), which is a statutory planning instrument. On the other hand, planning for infrastructure and amenities creation, maintenance, and service delivery are guided by sector-specific plans, programmes or schemes conceived by agencies with the relevant mandate. Besides, there are policies and acts pertaining to each of these sectors and elements. The intended objective of the BCAP is to add a climate lens to all the existing and upcoming sectoral and institutional efforts in a manner that is best informed by available evidence and knowledge. Being cognisant of this reality, efforts have been made to align or link the climate actions proposed under the BCAP to sectors and agencies that are mandated to deliver a certain agenda. Therefore, actions proposed under BCAP have been aligned to seven key sectors responsible for delivering on either the mitigation and/ or the adaptation/ resilience-building objectives of the BCAP. These sectors are: **Energy and buildings; Transportation; Solid waste; Air quality; Water, wastewater, stormwater; Urban planning, greening and biodiversity;** and **Disaster management** (refer to Figure 2). Notably, the actions under these sectors will have both forward and backward linkages, and cascading effects on other important social sectors, such as economic development and employment, health, and education and so on.

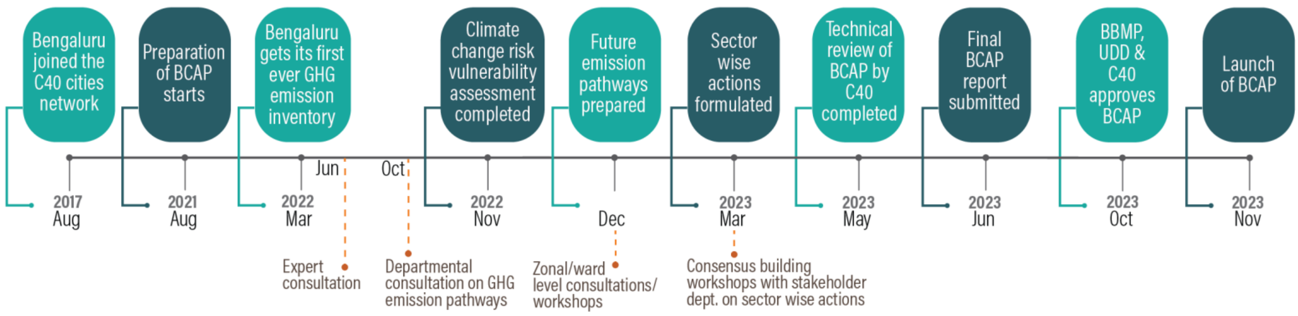
Figure 2 Sectoral alignment of BCAP for action framing



Source: As identified by BBMP with the technical support of WRI India

Key stages in the preparation of the BCAP are summarised in Figure 3.

Figure 3 Key milestones in BCAP preparation



Source: WRI India

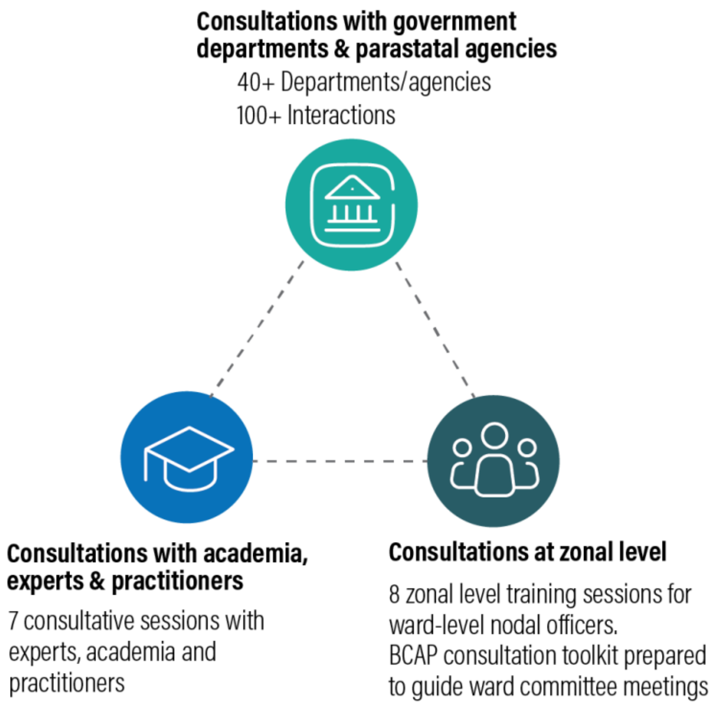
This report adheres to the IPCC's Fifth and Sixth Assessment Report (AR5 and AR6) (IPCC 2022) for all key concepts used. The detailed methodologies and tools used for each stage are discussed in the respective chapters. Broadly, the GHG inventory for the city has been developed adhering to the Global Protocol for Community-scale Greenhouse Gas Emission

Inventories (also referred to as GPC).[9] For the assessment of risk from climate-induced hazards, the study used the Climate Change Risk Assessment (CCRA) framework (C40 Cities 2018), developed by C40, and a Climate Hazard Vulnerability Assessment (CHVA)[10] Framework, developed by WRI India.

1.2 Encouraging participation in the formulation of the BCAP

The entire process of preparing the BCAP was informed by a series of consultations. A three-pronged consultation process was adopted to seek inputs from three different stakeholder groups, as illustrated in Figure 4. The section below gives detailed information about each of these stakeholder consultations.

Figure 4 Three-pronged approach for stakeholder consultations



Source: As identified by BBMP with technical support of WRI India

Consultations with government departments and parastatal agencies

These consultations were conducted with government departments and parastatal agencies throughout the BCAP preparation process. This was carried out through individual meetings as well as sector-wise inter-departmental convening to seek inputs and, suggestions as well as build consensus on sector-wise goals and targets, action tracks, priorities, and responsibilities. These were held for all the seven priority sectors identified for BCAP, where collectively more

9 GPC is a GHG Protocol standard developed by C40, World Resources Institute and ICLEI - Local Governments for Sustainability. This is available as a dashboard for C40 cities. Refer to the glossary for details.
10 Details of WRI's Vulnerability Assessment framework can be found in the CCRA report.

than 40 departments/agencies were consulted. For the list of departments consulted, see *Annexure A*.

Consultations with academia, experts, and practitioners

A series of seven consultative sessions were held with experts and representatives from academia, think-tanks and NGOs, and practitioners, covering different sectors such as energy and green buildings, transport, air quality, solid waste, water and wastewater, urban planning and disaster resilience, green cover, and biodiversity. These sessions were conducted virtually in webinar format.

The discussions across sessions were framed against the following broad guiding questions, on which inputs were sought from sector-specific experts:

- What are the strategic opportunities for Bengaluru in mitigation and adaptation that are ambitious, yet feasible to pursue in the short and long term?
- What are the challenges in enabling an inclusive climate action lens in all sectoral and developmental agendas in Bengaluru?
- What type of governance arrangements are required for the successful adoption and implementation of the Climate Action Plan with respect to a) institutions and capacities, b) plans and policies, and c) processes and platforms?

A summary of key take-aways from this round of consultation can be found here. The list of participants in the expert consultation is placed at *Annexure A*.

Consultations at zonal levels

These consultations were held at two levels to capture inputs from citizen groups:

1. Zone-level sensitisation workshops; and
2. Pilot ward committee meetings, where the BCAP agenda was introduced.

Zone-level sensitisation workshops

The zone-level workshops were conducted to sensitise BBMP officials about the BCAP, and to train them on how to capture inputs and feedback from ward committees and citizen groups. A BCAP Consultation Toolkit was prepared for this purpose, which was disseminated during these workshops. The objective of this bi-lingual toolkit was to facilitate ward-level consultations with diverse stakeholder groups. The toolkit has five sections as follows:

- Section A: Instruction for conducting consultations using the toolkit
- Section B: Posters on the BCAP
- Section C: Format for capturing feedback and suggestions
- Section D: A video explaining the BCAP and about the consultation process
- Section E: Frequently Asked Questions (FAQs)

The toolkit can be found here.

These sensitisation workshops were conducted for all eight zones of Bengaluru in December 2022. The participants in these training sessions were ward-level zonal officers, supervisors, Assistant Executive Engineers, Junior Health Inspectors, Executive Engineers, and Joint Commissioners.

Pilot ward committee meetings, where BCAP agenda was introduced

As a start, the BCAP was introduced in three ward committee meetings in different parts of the city (Banashankari Temple [South zone], HSR Layout [Bommanahalli zone], and Mathikere [West zone]). The objective was to sensitise the ward committee members on the need for and intent of the BCAP, capture ground realities of climate change impacts faced locally by different groups, identify implementation opportunities and bottlenecks in locally led climate actions, and understand citizen priorities for mitigation and adaptation actions. The responses obtained from these wards provided insights to the BCAP team, which were incorporated into the action plan.

It is to be noted that this was a beginning, and similar consultations will be conducted in all ward committees as the BCAP goes for implementation.

1.3 Addressing inclusivity and equity in the BCAP

Climate change is inextricably linked to the challenges of eradicating poverty and creating a more equal world (Cities 2018a) Hence, it is impossible to tackle climate change without tackling inequality and vice-versa. This cannot be achieved by pushing sectoral priorities solely. India is committed to the goals of the Paris Agreement, whereby it strives to reduce climate risk, alleviate poverty, build shared prosperity, and promote sustainable development. There is a need for Inclusive Climate Action Planning (ICAP) that facilitates local governments to assess climate-related risk and identify actions that are consistent with the country's climate goals. Inclusivity in climate action planning can be achieved by ensuring (Cities 2018a):

- *Inclusivity of the process:* Engagement with a wide range of communities and stakeholders.
- *Inclusivity of the policy*: Fairness and accessibility in design and delivery.
- *Inclusivity of the impact*: Wider benefits of action as equitably distributed as possible.

The BCAP team has adopted the above throughout the CAP preparation process to integrate inclusivity and equity.

The BCAP integrates co-benefits for Bengaluru's residents, such as improving urban health and well-being, increasing economic prosperity, ensuring equitable access to resources, promoting education and, skill development, and ensuring resilience to climate hazards. All actions that are a part of the BCAP (presented in detail in Chapter 5) were assessed using the action analysis database, in order to understand their inclusivity and equity implications. Vulnerable groups, such as women, the elderly, persons with disabilities, children, low-income communities, and informal communities (residents and workers) were mapped in the vulnerability assessment, and specific mitigation and adaptation actions have been suggested.

Lastly, the planning process has been highly consultative, and has integrated feedback from various stakeholders within the government and civil society groups.

For further details on promoting inclusivity in climate action, please refer to Chapter 5, Section 5.4.

1.4 Aligning BCAP with global, national, and sub-national planning goals

The BCAP is aligned to the goals set at higher levels of planning and governance, to leverage favourable policy environments, align with funding and financing mechanisms, and ensure coherent reporting mechanisms across common climate and environment protection goals. The BCAP is informed by India's updated Nationally Determined Contributions (NDCs), and the emission mitigation pathways developed under this are informed by national-level policies and long-term vision documents such as India's long-term low-carbon development (UNFCCC 2022b) by the Ministry of Environment, Forest and Climate Change (MoEFCC).

Multiple efforts and initiatives have also been taken up at the national, state and city levels, in the form of sectoral plans, policies, programmes, targets, and schemes. Table 1[11] illustrates examples of the major policies at national and sub-national levels referred for the BCAP. City-level guiding policies and plans considered are mentioned in respective sector-specific discussions in chapter 2.

Table 1: Indicative examples of policies and frameworks considered for preparation of the BCAP

National-level guiding policies, plans, and frameworks • National Action Plan on Climate Change (NAPCC), Climate Smart Cities Assessment Framework, National Mission on Sustainable Habitat • National Solar Mission, National Renewable Energy Policy • National Urban Transport Policy (NUTP), Climate Smart Cities, Faster Adoption and Manufacturing of Electric Vehicles in India – Phase II (FAME II) • Solid Waste Management Rules, 2016, Swachh Bharat Mission • National Clean Air Program (NCAP) • National Water Policy 2012, National Water Mission • National Mission for Green India, Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines • National Disaster Management Policy
Sub-national guiding policies, plans, programmes, and frameworks • Karnataka State Action Plan on Climate Change (SAPCC) • Karnataka Renewable Energy Policy, Karnataka State Building Bye-Laws • Karnataka Energy Conservation and Building Code (K-ECBC) • Karnataka State Urban Solid Waste Management (SWM) Policy – 2020 • Karnataka State Pollution Control Board (KSPCB) regulations, Graded Response Action Plan (GRAP) • Karnataka State Water Policy

[11] This is an indicative list and not an exhaustive list. Refer to specific sector-related sections for more details.

- Bangalore Development Authority (BDA) Act, Karnataka State Housing Policy
- Karnataka State Disaster Management Plan

BCAP provide an enabling climate lens to sectoral activities and the development agenda being taken up for the city, so that climate action is integrated right from the beginning in the plans, programmes and projects for the city, and not as an afterthought. This is done by setting strategic action paths aligned to these initiatives at different levels (detailed in Chapter 5), thus ensuring coherence across programmatic outcome targets.

1.5 Scope, limitations, and exclusions

BCAP Jurisdiction: The area under the BBMP boundary has been considered as the plan boundary. All action recommendations pertain to this jurisdiction. The actions, though limited to the BBMP area, were suitably informed by the existing and projected situation over the larger region within which Bengaluru is located, so as to ensure that impacts of macro-climatic variables on the city are duly accounted for (e.g., analysis pertaining to Representative Concentration Pathway scenarios were considered for the Cauvery and Ponnaiyar river basins). It is to be noted that the study considered the erstwhile 198 wards of the BBMP for analytical exercises. This is because the BBMP ward delimitation exercise was carried out only during the latter part of 2022, when the preparation of the BCAP had reached an advanced stage, and no recalibrated data on demographic and socio-economic parameters was available for the new 225 wards. Nevertheless, the overarching findings, action recommendations, and outcomes do not change, and they apply at the city and zonal levels as is.

Base year: The BCAP has adopted 2019 as the base year for the GHG inventory, as well as for all other analyses, wherever feasible. This is to ensure that the study considers an accurate account of the present situation while avoiding any externalities that might have taken place due to the COVID-19 pandemic between 2020 and 2022.

Horizon year: The final horizon year for the BCAP is 2050, while 2030 and 2040 have been adopted as interim horizon periods for projections.

Data sources: The data used for BCAP preparation were primarily sourced from respective government departments, parastatal agencies and secondary literature. No primary survey was conducted for the purpose of this study. For certain parameters, the study used the 2011 Census of India data. The unavailability of Census data beyond 2011 remained a challenge. The population of the BBMP area for the base year (2019) has been estimated based on historical trends in the absence of Census or any other primary survey data.

GHG emissions inventory and pathways analysis: The BCAP adhered to the BASIC[12] scope of the GPC protocol for reporting GHG emissions covering three sectors: energy and buildings,

[12] The BASIC scope of the GHG inventory includes emissions from three sectors: stationary energy, transport, and waste, with specific scopes for each. For more information, refer to Section 2.3 of this report.

transport, and waste. Sectors such as industrial production and agriculture were excluded from the inventory and pathways analysis.

1.6 How to read this report

The BCAP report is structured in seven chapters, including the introduction (Chapter 1: this chapter). Chapter 2 presents Bengaluru's city context and the status of sectors. Chapter 3 is primarily focused on the evidence baseline created for the city, i.e., GHG emissions inventory and climate change risks and vulnerability assessment[13]. This is followed by a description of pathways, targets and strategies to be adopted by Bengaluru contributing to a fair-share 1.5°C warming scenario in Chapter 4. After this is a description of identified goals and actions for all seven sectors in Chapter 5. Chapter 6 presents the governance and institutional structure proposed for implementation of the BCAP, followed by a framework for monitoring progress in Chapter 7.

[13] Refer to the report on Climate Change Risk and Vulnerability Assessment for Bengaluru for details.

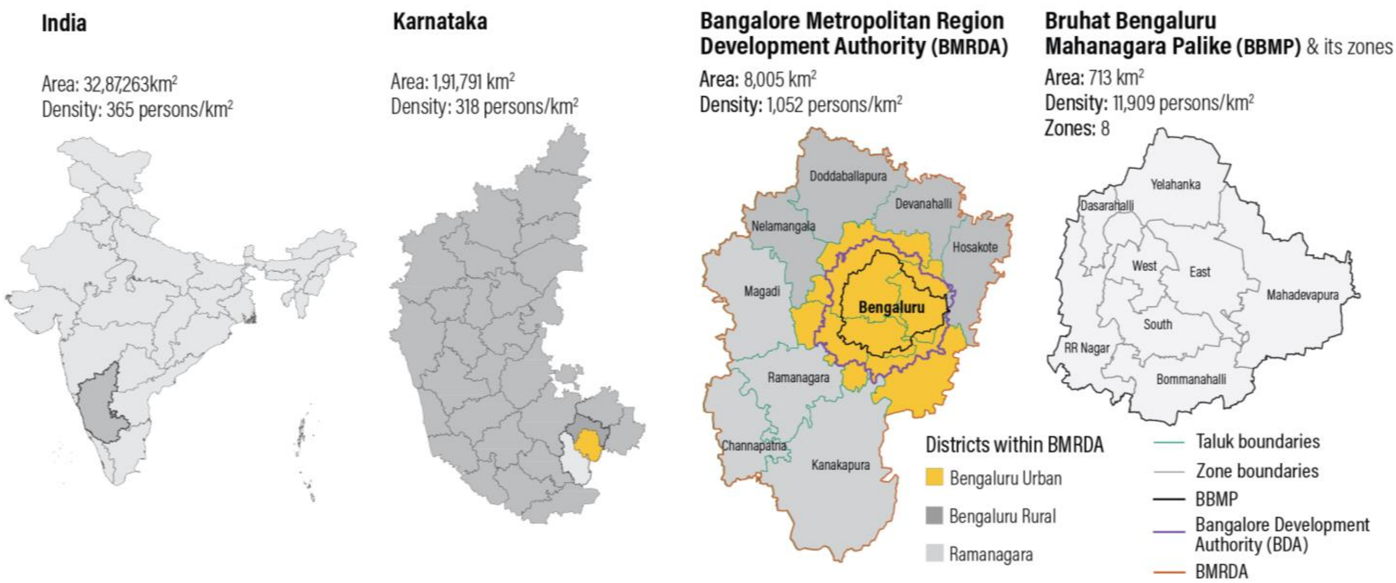
Photo Credit: Praseeda Mukundan/WRI India

2 BENGALURU CITY CONTEXT AND SECTORAL ASSESSMENTS

2.1 City context

Apart from being the administrative capital of the southern state of Karnataka, Bengaluru is also the commercial and industrial capital of the state in many ways. The city has always had a historical significance. Founded in 1537, Bengaluru (whose name was changed from the anglicised 'Bangalore' in 2014), has evolved from a small native township and trading centre in the 18th century, to South India's largest British civil and military station in the 19th century, to India's premier science and technology hub in the 20th century, now competing at the global level. Following India's Independence from British rule in 1947, the city was retained as the capital and administrative centre of the new, enlarged State of Mysore (renamed 'Karnataka' in 1973). Starting with mechanised textile production and other manufacturing activities, the wheels of industrialisation gained momentum from the 1940s to the 1960s, with the establishment of many large, nation-building, public sector undertakings in the city. Simultaneously, the defence base also expanded, and Bengaluru became the heart of the Indian aviation industry. The other significant development during this period was the emergence of several science, technology, and R&D institutions in the city. Gradually, it also grew into a prime centre for education and healthcare, while trade and commercial activity flourished. This favourable mix of science, research, and industry– combined with the conveniences of a modern, cosmopolitan city and an agreeable climate, provided the perfect setting for the next phase of growth. The 1990s and 2000s saw a major technology boom, with Bengaluru spearheading the greatest IT and biotechnology revolutions India had witnessed. The city's economy is diversified across hi-tech service sectors, defence and aviation, automobile, engineering, textiles/garments, and floriculture, each contributing a significant share in the city's economic outputs.

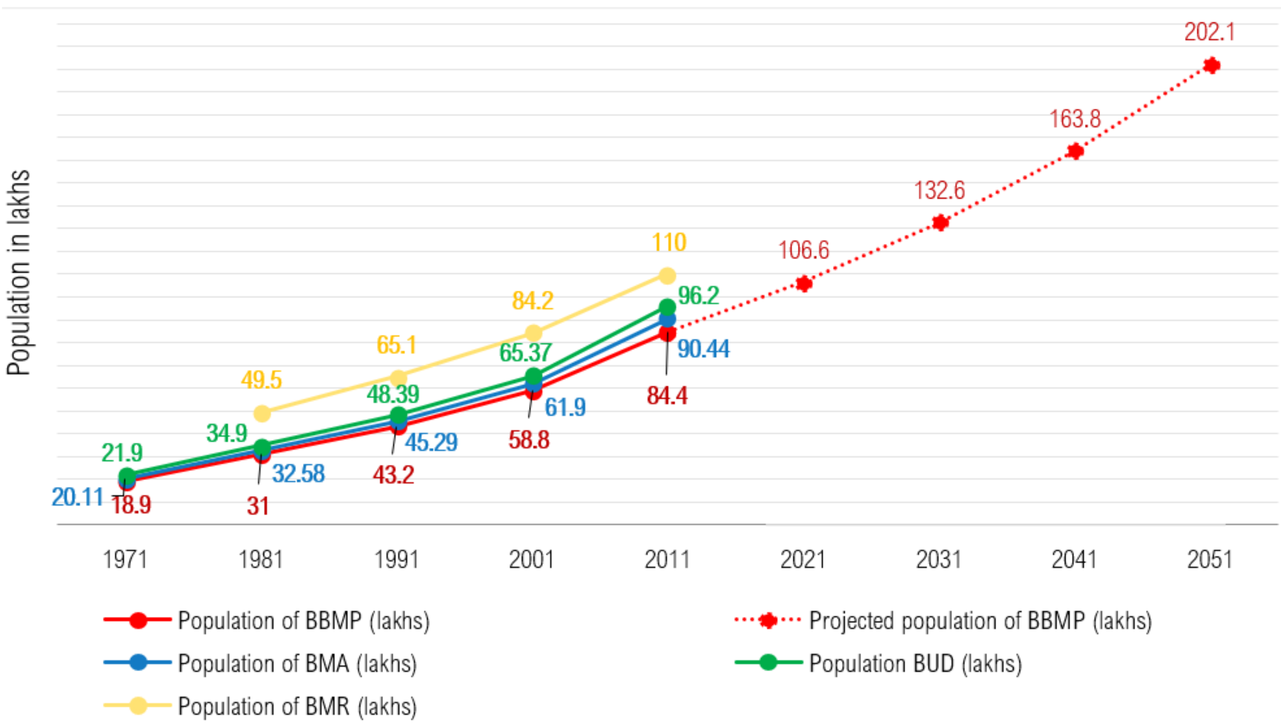
Figure 5: Geographical location and relevant administrative jurisdictions for Bengaluru and its adjoining area



Source: WRI India analysis using Census 2011; BBMP; BMRDA, Government of Karnataka

Bengaluru is located in the southeast of Karnataka (see Figure 5). The municipal corporation area spans 713 sq. km. and, as per the 2011 Census, housed a population of 84,43,675 (8.43 million). Analysis done for this study estimates a population of 101,76,238 (10.17 million) in 2019, residing in the BBMP jurisdiction. A major share of Karnataka's urban population resides in Bengaluru, and 36% of the state's urban population lives in the BBMP area (Census 2011), resulting in Bengaluru-centric urbanisation in the state. Figure 6 depicts the population growth in Bengaluru from 1991 to 2011, showing a 95% increase in population over the two decades. The projections for population growth are based on data from the Census Handbook, 2011, and a report provided by the Japan International Cooperative Agency (JICA 2017). JICA outlines three scenarios for population growth rates: high growth, medium growth, and low growth. For the BCAP, we have considered the high-growth scenario population projections from the JICA report, according to which Bengaluru's population is likely to increase to about 20.2 million by 2051, which is almost double the present number. *Annexure F* provides detailed information on the population projections by JICA and other agencies. It presents a comprehensive explanation of the rationale behind selecting JICA projections, including the factors considered and the challenges encountered when comparing projections from different agencies and jurisdictions.

Figure 6 Population growth in Bengaluru



Jurisdiction	Area (in sq. kms)
Bruhat Bengaluru Mahanagara Palike (BBMP)	713
Bengaluru Metropolitan Area (BMA)	1294
Bengaluru Urban District (BUD)	2196
Bengaluru Metropolitan Region (BMR)	8005

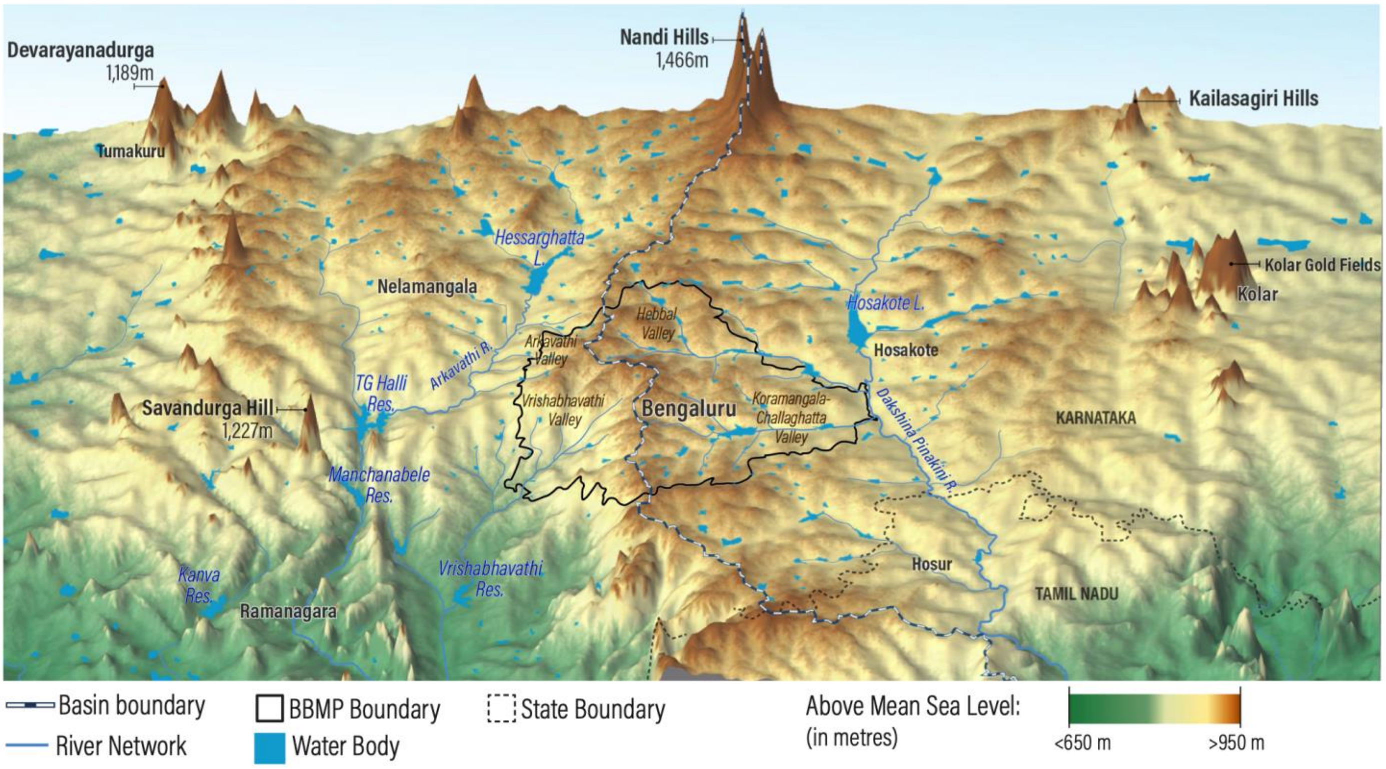
Source: WRI India analysis using Census 2011, BBMP, RSP 2031-BMRDA, JICA BWSSB Report

The built-up area in the city grew from 192 sq. km. in 1985 to 518 sq. km. in 2015, a 170 percent increase in 30 years. This posed a challenge to city authorities in terms of quality of life issues, service delivery, and governance. As a response, the eight surrounding municipal corporations and 110 surrounding villages were amalgamated with the then Bangalore City Corporation area of 226 sq km in 2007. The new and expanded municipal corporation area was renamed Bruhat Bengaluru Mahanagara Palike (BBMP) and covered a total area of approximately 713 sq. km.

2.1.1 Climatic and ecological landscape context

Bengaluru is located in the heart of the Mysore plateau, and at an elevation of 920 m above mean sea level. The city's topography can be classified as a plateau, with a central ridge running north to south with land sloping gently on either side. The roads have gentle to medium gradients. Bengaluru has several freshwater tanks, the largest of which are Bellandur lake, Varthur lake, Nagawara lake, Madivala tank, Hebbal lake, Ulsoor lake, and Sankey tank (Mundoli, Nagendra, and Premji 2018). The tanks or water bodies in the city were designed in a cascading system, from higher to lower levels, making them part of a large network of drainage channels. The idea was that if one lake overflowed, the excess water would flow to the subsequent lake. The naturally undulating terrain of the city helps this system. The flow of water is from North to South-east as well as North to South-west, along the natural gradient of the land. (BIOME 2017) The soil is predominantly red soil interspersed with rock, helping quicker drainage.

Figure 7: River valley system of Bengaluru and the adjoining region

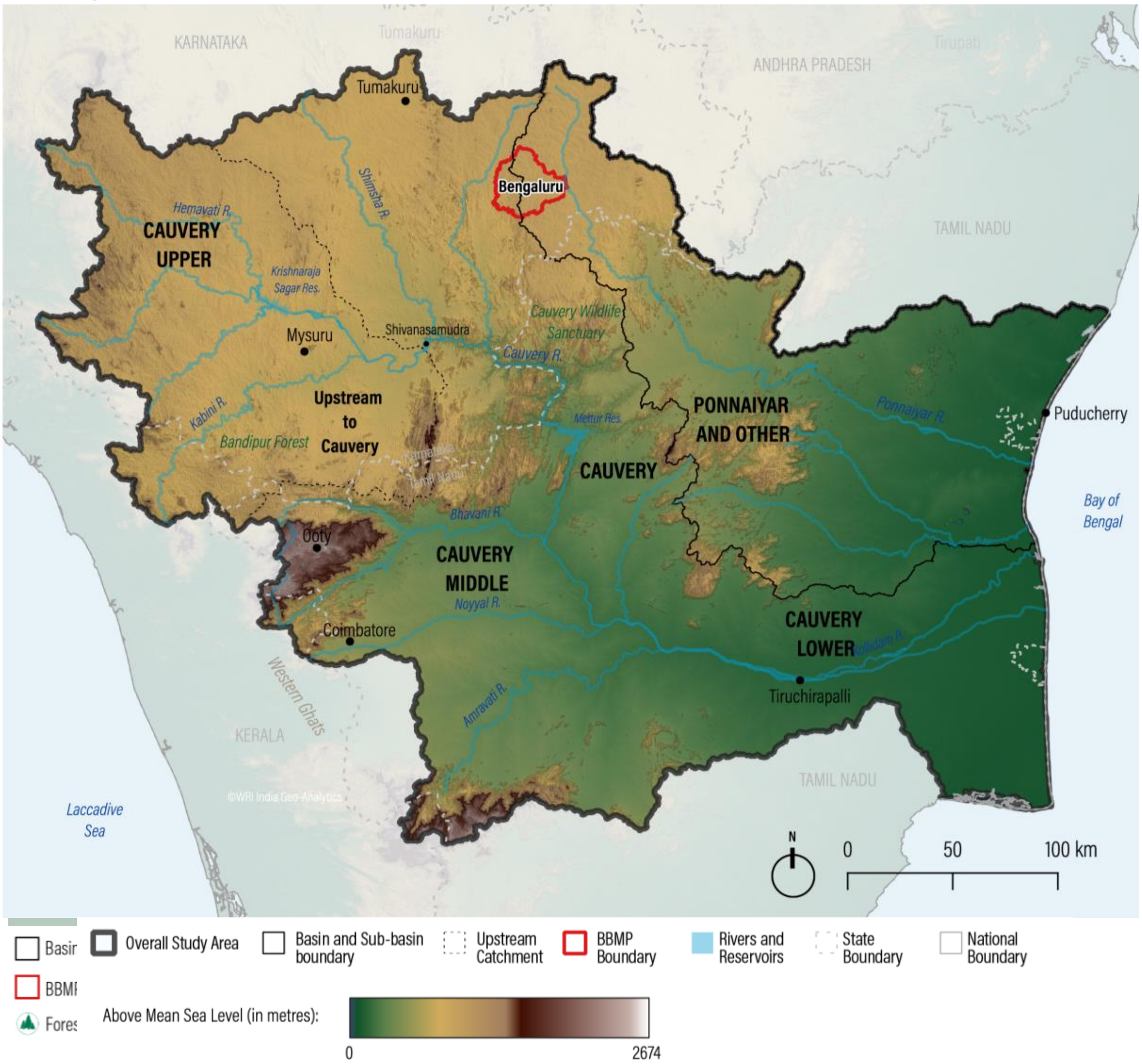


Source: Exaggerated relief visualisation; WRI India using Shuttle Radar Topography Mission (SRTM) (refer to CCRA-VA report for details)

Bengaluru is part of the Eastern Dry Agroclimatic zone of Karnataka. It has a tropical savanna climate (Köppen climate classification[14]) with distinct wet and dry seasons. Due to its elevation, the city enjoys a pleasant and equable climate throughout the year. Winter temperatures rarely drop below 12°C and summer temperatures rarely exceed 38°C. Monsoons commence sometime around mid-April. The wettest months are August, September and October, in that order. The city receives annual average rainfall of about 790mm from the North-East and South-West monsoons as per IMD (refer to Chapter 3 for more details).

Bengaluru falls within the Cauvery-Ponnaiyar river basin which sets the larger natural geographic context of the city. This, along with the city's elevation, determines its topography, climate and natural resource flows, making it a critical component in understanding the city's climatic variations.

Figure 8 Geographical and hydrological context of Bengaluru within Cauvery-Ponnaiyar Basin region



Source: WRI India analysis using SRTM and Central Water Commission (CWC)

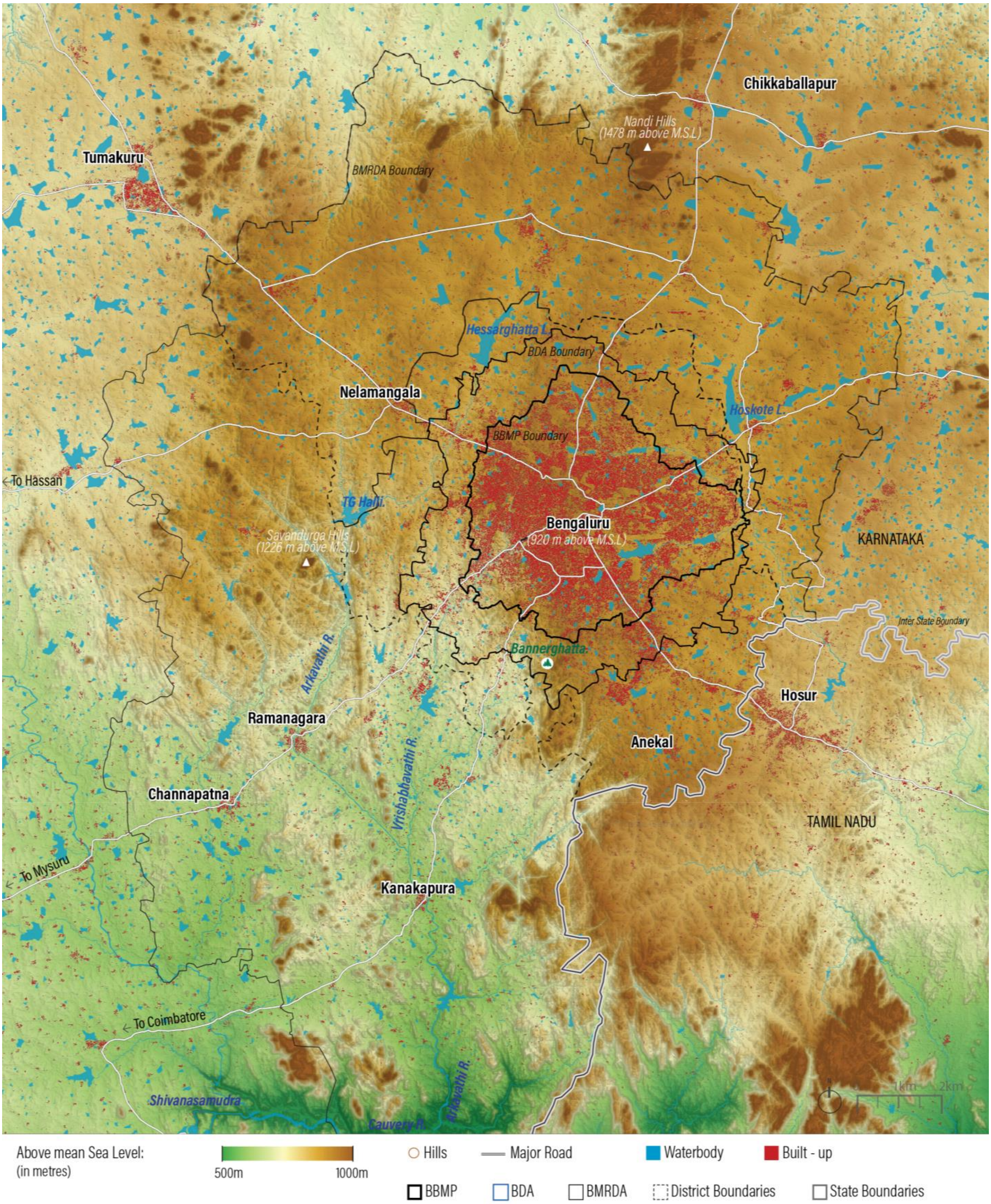
[14] This is a widely used vegetation-based empirical climate classification system developed by Wladimir Kopppen. Bengaluru comes under Aw (Type A: Warmest temperature zone and w: Winter dry season)

2.1.2 Urban landscape

Planning and management is an important part of the city's governance. Considering a larger spatial and strategic planning perspective, the Bangalore Metropolitan Region (BMR) covering an area of 8,005 sq. km. is considered as the immediate hinterland influenced by Bengaluru. Apart from Bengaluru, the BMR has smaller cities and villages, and is bordered by the Cauvery river to the south, from where Bengaluru sources water for its daily use. Bengaluru is the primate city within BMR, accommodating approximately 70% of the region's total population. The strategic planning within BMR is guided by a regional-level plan (i.e., Structure Plan of BMR), which is non-statutory in nature.

The administration of Bengaluru is governed by the BBMP, which is referred to as the Bengaluru city corporation area (or BBMP area). This is also the jurisdiction considered for the BCAP. The spatial planning jurisdiction for Bengaluru, however, covers a larger area of 1,307 sq. km. including the BBMP area, known as Bangalore Metropolitan Area (BMA). The land use master planning exercise for the city is conducted for BMA area by the Bangalore Development Authority (BDA). For the purpose of delivery of basic services, the services provided by BBMP cover the municipal area. Some of the services provided by other agencies or parastatals (such as water supply, transport etc.), cover slightly different jurisdictions, based on their individual mandates over and above the BBMP area.

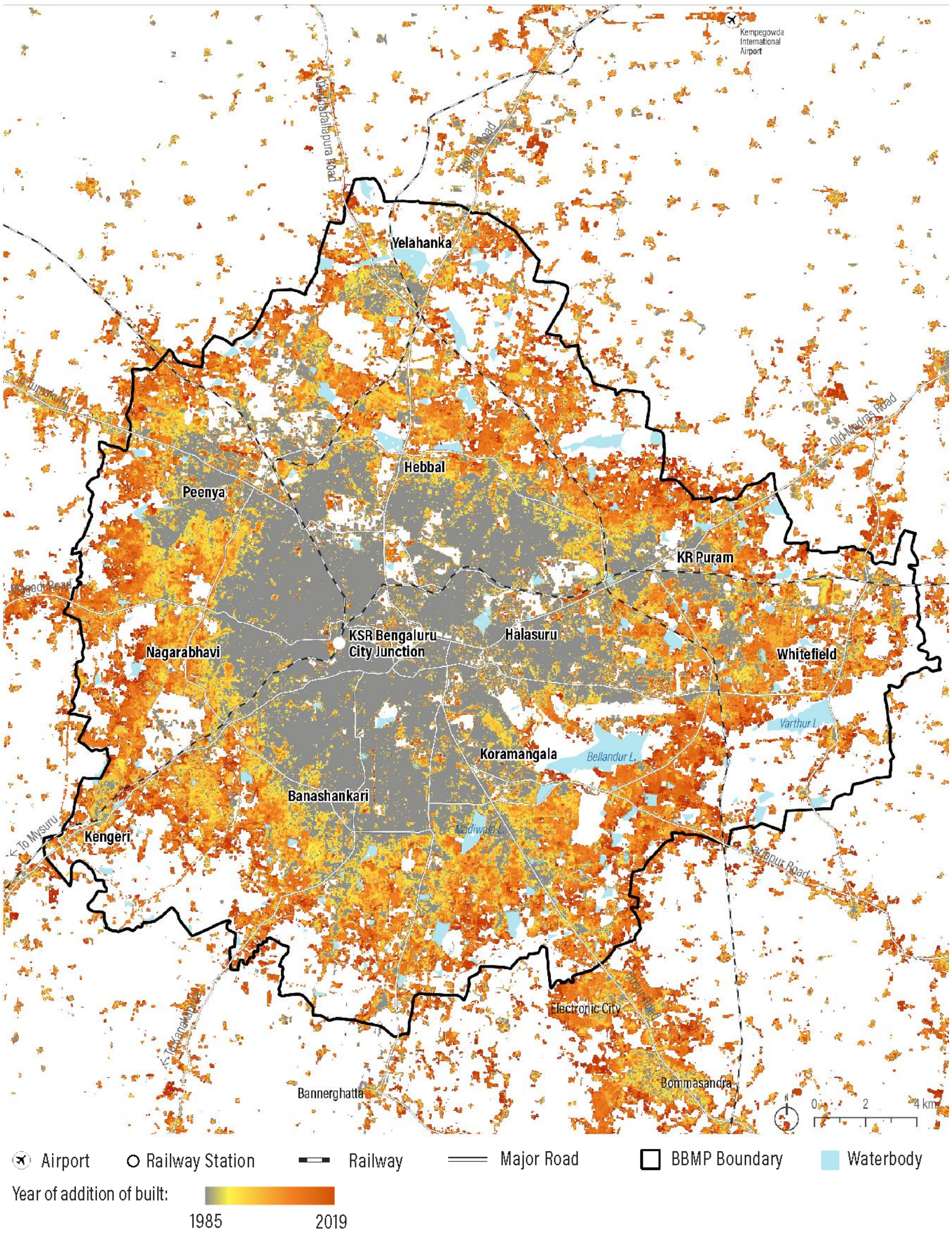
Figure 9 Physical geography and jurisdictions of BBMP, BMA and BMR



Source: WRI India analysis using SRTM, NASA; World Settlement Footprint 2019, German Aerospace Center (DLR)

The BMA area currently holds nearly 14.6 % of the state's population and 40% of the urban population of Karnataka[15]. A 42% growth in population between 2001 and 2011 points towards the fast-paced urbanisation being experienced by the city. Bengaluru has had high annual growth rates compared with other cities in the country, at 3% for the total population; 6% for employment; and 9% for incomes. Within urban Karnataka, the share of the population held by the Bangalore Urban Agglomeration (BUA) has more than doubled, increasing from 17.66% to 35.96%, during the period from 1951 to 2011. Figure 10 depicts the increase in built-up footprint in Bengaluru from 191.79 sq.km in 1985 to 539.40 sq.km. in 2019.

Figure 10 Built footprint evolution across Bengaluru (Between 1985 to 2019)



Source: WRI India analysis using World Settlement Footprint (WSF) Evolution 1985-2015, and WSF 2019; German Aerospace Center (DLR)

[15] This is based on Revised Master Plan for Bengaluru 2031 (Draft), which is no longer in action.

This increase in built-up footprint has resulted in a corresponding decrease in the green and blue cover in the city. Multiple studies have been conducted by researchers on this loss of blue-green networks. Studies indicate a loss of green cover from 68.27% (1973) to less than 15% (2013), and a loss of lakes from 3.4% (1973) to less than 1% (2012) (*Green Spaces in Bengaluru*, IISc.) These factors need to be integral components of city planning and management, while also considering the diversity of people living in the city.

2.1.3 Socio-economic context

According to the Economic Survey 2019-20[16], Bengaluru Urban District (BUD) contributes to 36% of GSDP (IBEF 2019) in which Bengaluru city is the prime economic generator. BUD also has the highest per capita income in Karnataka. The IT sector in Karnataka is primarily concentrated in Bengaluru, contributing to almost 25% of the state's GDP and making Karnataka the largest IT exporter in the country[17]. This started with the creation of the Karnataka State Electronics Development Corporation (KEONICS) in 1976 and the establishment of Electronic Park, India's first Software Technology Park (STP), in Bengaluru, propelling the development of many such clusters across the city. It gives direct employment to over 12 lakh professionals, while also creating over 31 lakh indirect job opportunities, encouraging people from across the country to come to the city. Apart from the IT sector, Bengaluru also has a significant concentration of biotechnology, aerospace and aviation, and manufacturing-related activities. Due to rising land prices, development control regulations, and pollution control norms, most of the large industries have gradually moved out of Bengaluru to adjoining areas. The city still has a significant presence of micro, small and medium enterprises (MSMEs).

With growth of economy and employment opportunities, Bengaluru has become home to a diverse range of people and cultures. As with other Indian states, Karnataka too was carved out considering the predominant language spoken by most of the population. The capital, Bengaluru, has retained Kannada as the official language, while accommodating other languages such as English, Tamil, and Telugu. over time, due to the diversity of its population.

This economic growth, along with the city's overall geography, has long attracted people to make it their home. The 2011 Census captured the socioeconomic and demographic characteristics of the city extensively, which have been summarily captured in the sections below, namely <u>*Demography*</u> and <u>*Socio-Economy*</u>. These are followed by a section on <u>*Accessibility*</u>, which looks into access to key infrastructure and services. The sections below give an overview of each of these aspects through basic statistics and a representative map. For more details on demographics, socio-economic aspects, and accessibility, refer to Chapters 5 and 6 of the CCRA-VA report.

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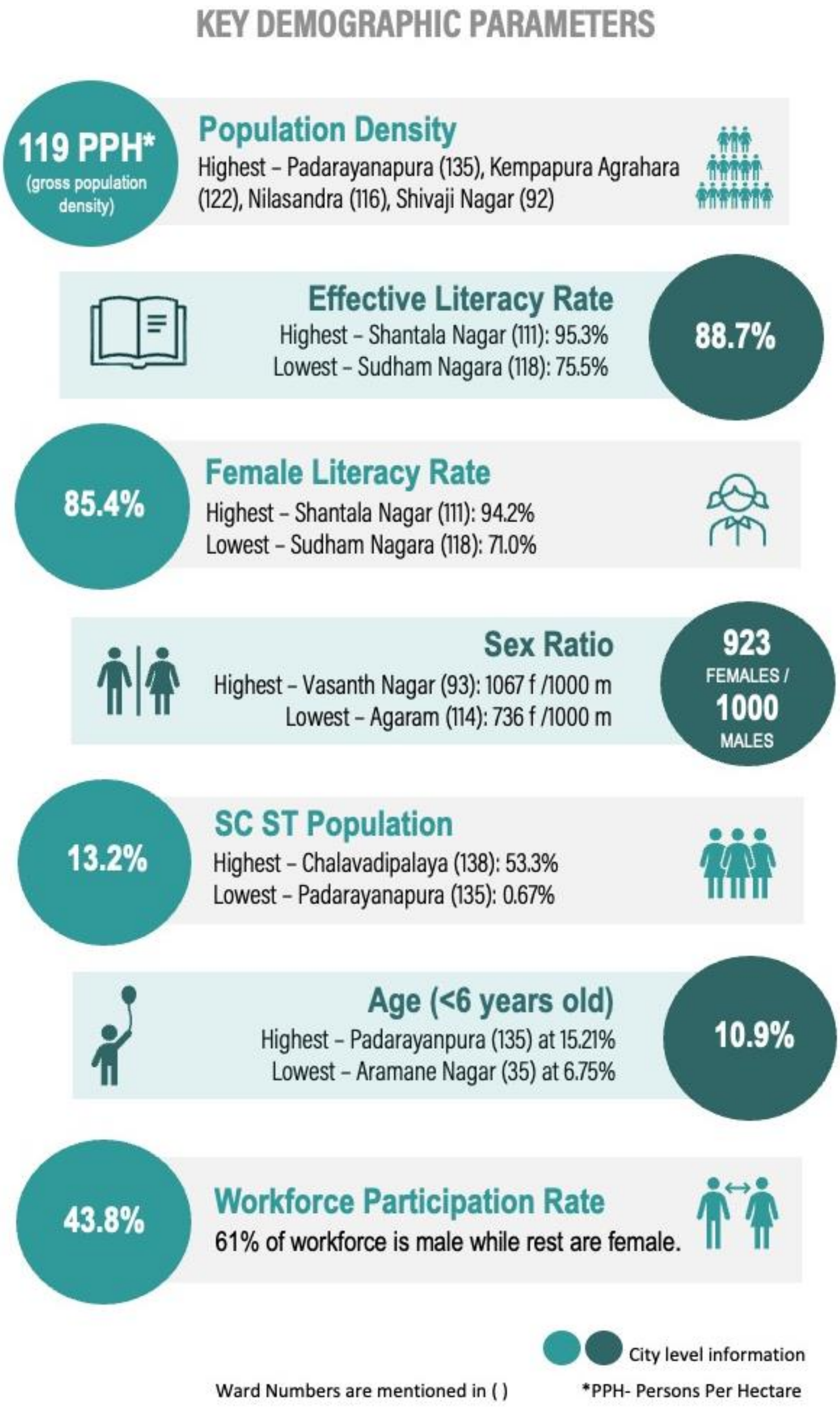
[16] The economic Survey which is the most reliable source of economic landscape of India presents results at district level and not city level. Hence Bangalore Urban District has been chosen as a proxy for understanding the economy of Bengaluru city which is located within this district and is the most prime economic hub.
[17] Karnataka's had nearly 40% of the country's information technology exports of 155 billion USD in 2019-20

Demographics parameters

Key demographic parameters of Bengaluru are given in Figure 11.

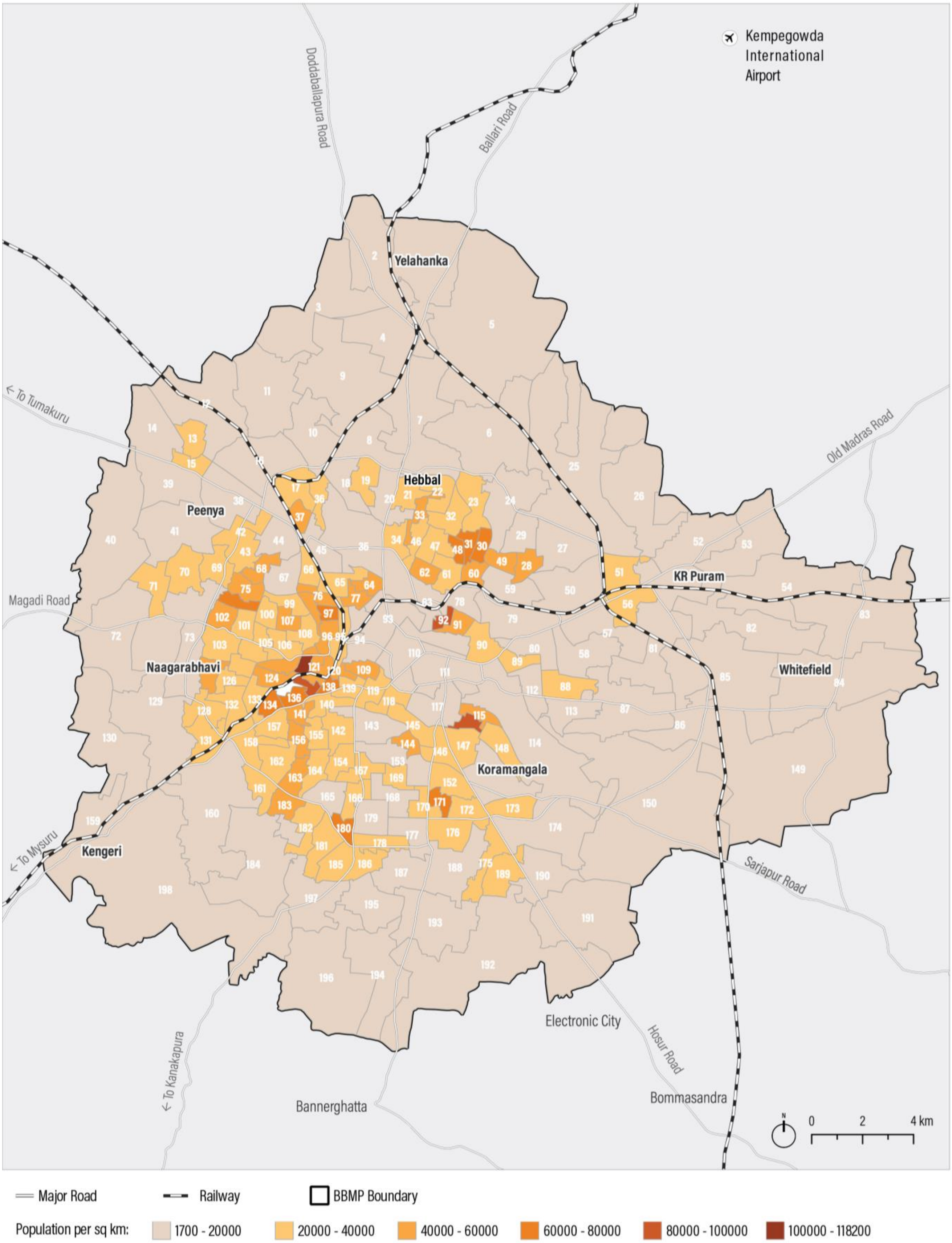
The gross population density of Bengaluru is 119 persons per hectare. Figure 12 shows the ward-wise distribution of population density. It can be seen from the map that wards within the core city are denser than peripheral wards. The core city could be attributed the erstwhile Bangalore Mahanagar Palike (BMP). To accommodate the increasing growth pressure, the city had to expand beyond the core, thus leading to unplanned urban spread. The city's built-up growth (see Figure 10) indicates its expansion towards its periphery, where urban planning measures have not been able to keep pace with the growth pressures, resulting in the creation of areas which are vulnerable to climate hazards.

Figure 11 Key demographic parameters of Bengaluru



Source: WRI India analysis using Census, 2011; wards information from BBMP

Figure 12 Distribution of population density by ward



Source: WRI India analysis using Census, 2011; wards information from BBMP

Socio-economic parameters

Key socio-economic parameters of Bengaluru are given in Figure 13.

A significant proportion of the city's population lives in informal settlements and slums. As per the Karnataka Slum Development Board (KSDB), Bengaluru city has 257 notified slums, housing more than 3 lakh people (KSDB 2011) while the other categories of slums are home to nearly 4 lakh residents[18]. Figure 14 indicates the location of notified slums in Bengaluru.

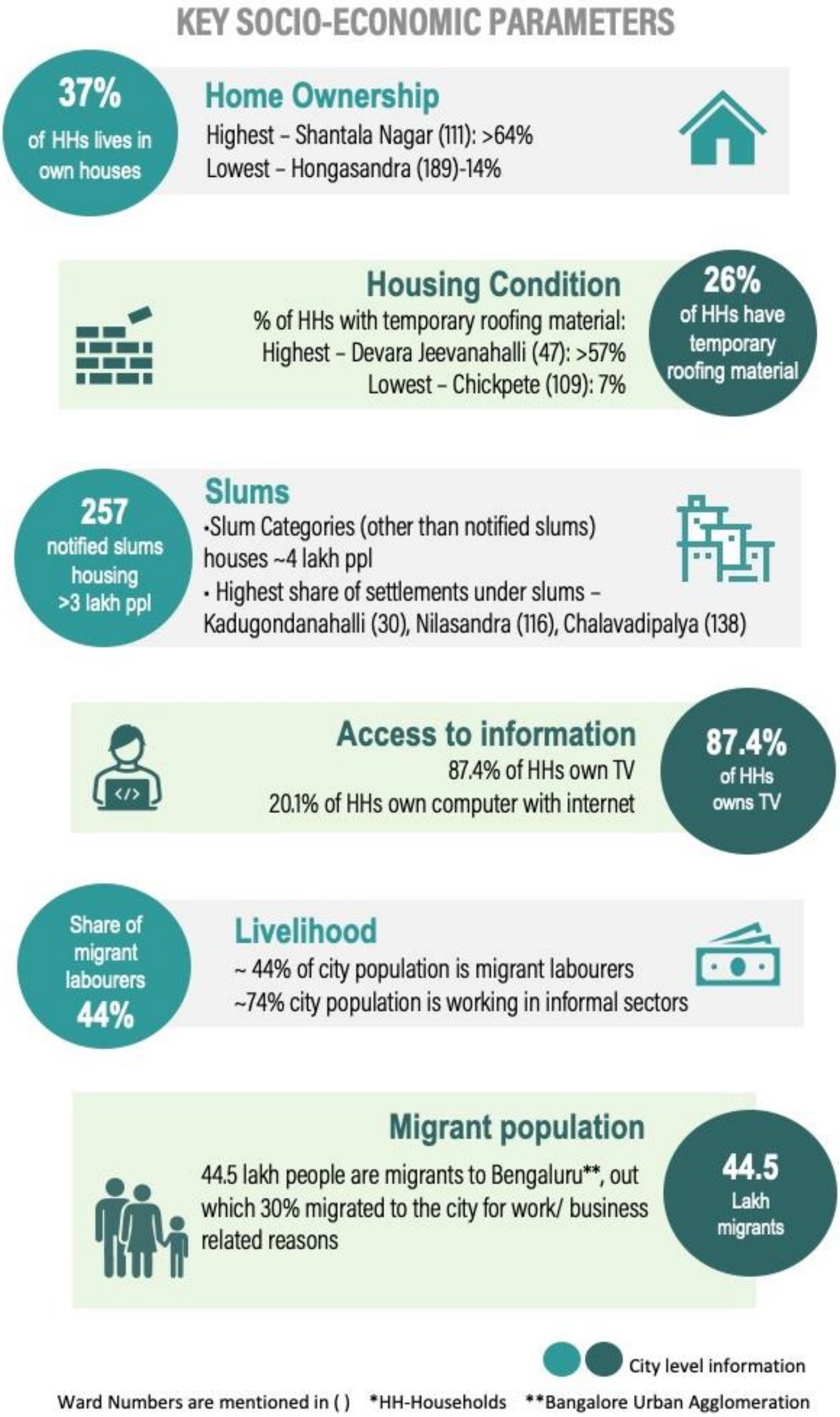
The houseless population, population living in houses with temporary roofing and wall materials, and households that do not own the residence they are living in, are all factors indicative of inadequate housing access. However, due to paucity of data on the houseless population, these often remain unaccounted though these are one of the most vulnerable groups. Observing the city's housing condition, the Census 2011 reveals that almost a quarter of households do not have permanent roofing material, making them susceptible to climatic risks.

As per Census 2011, nearly 44.5 lakh people are migrants to Bengaluru[19], out which 30% migrated to the city for work/ business related reasons. According to Karnataka's State Economic Survey 2021-22, Bengaluru emerged as one of India's top job-providing cities, leading to its reputation as a city of migrants. However, there is a lack of data on climate-induced migration in Bengaluru. Studies have shown that millions of people in India were displaced in 2021 due to climate-related disasters, highlighting the need for detailed data at the city level. These studies underscore the importance of addressing climate migrants and their impact in research and climate analysis.

[18] The 2011 Census includes three types of slums: notified, recognised and identified slums. Slums in India: A statistical compendium 2015 [*I cannot insert a comment in footnotes, hence inserting text here:* should this be in brackets? Is it a Census-related document? It's a bit awkward to just insert it as ordinary text between two sentences in a footnote. I suggest using parentheses]. As per the 2011 Census, BBMP (municipal corporation area + outgrowths) slums have total of 1,65,341 households and a population of 7,12,801. PCA Slum: Primary census abstract data for slum, India and States/UTs - Town Level - 2011, Census 2011.

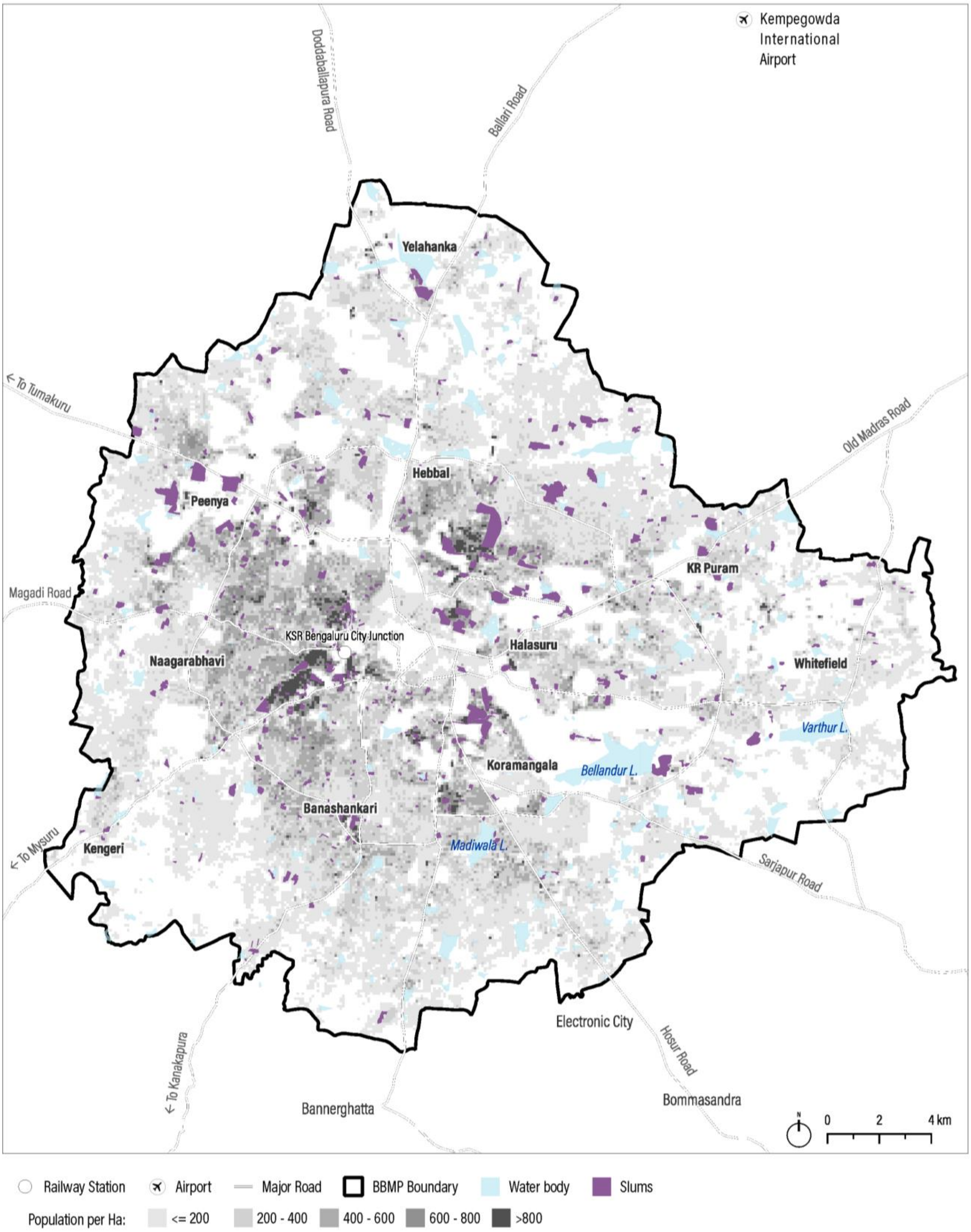
19 Numbers refer to the 'Bruhat Bangalore Urban Agglomeration' – area a slightly bigger than the current ULB limits. Total migrants consist of all durations of residence. Census 2011, D-Series (D03, UA-2900-MDDS). https://censusindia.gov.in/census.website/data/census-tables

Figure 13 Key socio-economic parameters of Bengaluru



Source: WRI India using Census 2011; Karnataka Slum Development Board, (Patel, Furlan, and Grosvald, 2021) (IIMB 2020), wards information from BBMP.

Figure 14 Location of slums along with population density distribution as per built settlement



Source: WRI India using KSRSAC buildings data; Landuse from BBMP, and estimated population density from Census 2011 (refer to CCR-VA for details)

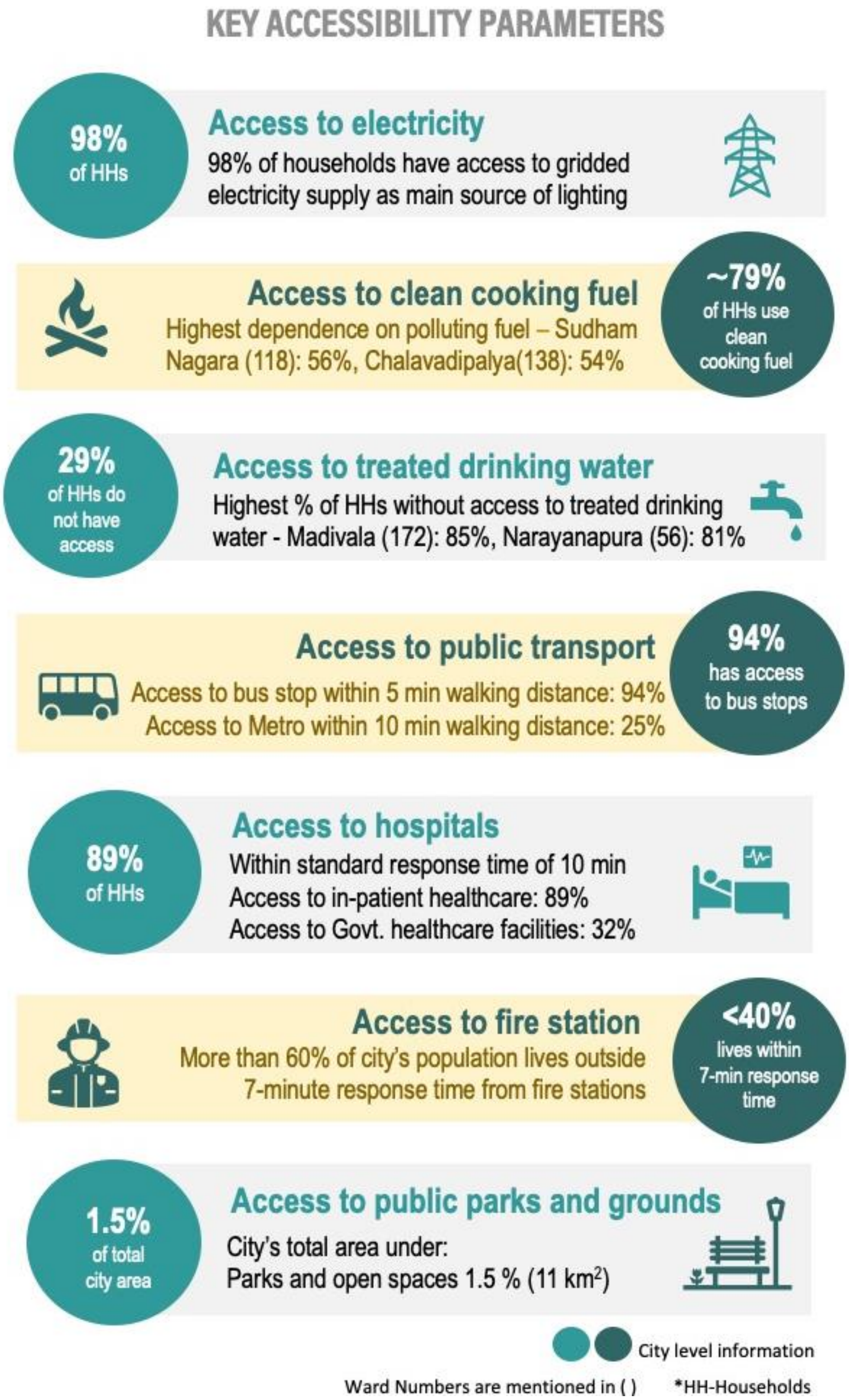
Accessibility parameters

Figure 15 illustrates key accessibility parameters of Bengaluru. Maps from Figure 16 to Figure 22 depict access of households to various services and infrastructure in the city.

The city has managed to provide electricity access to almost all its households. It can be seen from Figure 16, that barring a few wards in the inner-city area, the majority of peripheral wards comparatively lack access to clean cooking fuel. Figure 17 shows that peripheral wards also lack access to the water distribution network. Around 15%[20] of households in the city do not have access to either piped sewers and/ or septic tanks. The paucity of connection to the centralised network or to septic tanks is significantly higher in peripheral wards (see Figure 18). The overall percentage of households in the city with access to a latrine within the premises is about 97%. The city is fairly well connected in terms of public transport through bus stops (see Figure 19), but connectivity, frequency, and other issues contribute to higher dependence on private modes of transport. In terms of access to healthcare, 89% of the city's population has access to an in-patient facility within the standard response time of 10 minutes. However, most government hospitals, as seen in Figure 20, are located within the city core, and the population outside the core (beyond the intermediate ring road) has to travel more than 5 km on average to access a government hospital in an ambulance. The city has 17 fire stations within the BBMP limits, and two more just outside the periphery. More than 60% of city's population live outside a 7-minute response time from these fire stations (see Figure 21). Highly dense areas of the city such as Devara Jeevanahalli, Malleswaram, and Basaveshwara Nagar lack immediate access to fire services. Bengaluru excels on school accessibility, with 100% of its population within 10 minutes' walking distance of a school. In addition, 97% of the population also has access government schools within said walkable time. The city core has reasonable access to organised green open spaces (see Figure 22), with the exception of Kammanahalli (Ward 28), which has no public park or playground within a walking distance of 10 minutes. The periphery of the city has the least provisioning of organised green open spaces. For example, in Gottigere (Ward 194), and Chowdeswari (Ward 02), only around 12% and 25% of the population respectively has easy access to organised green spaces.

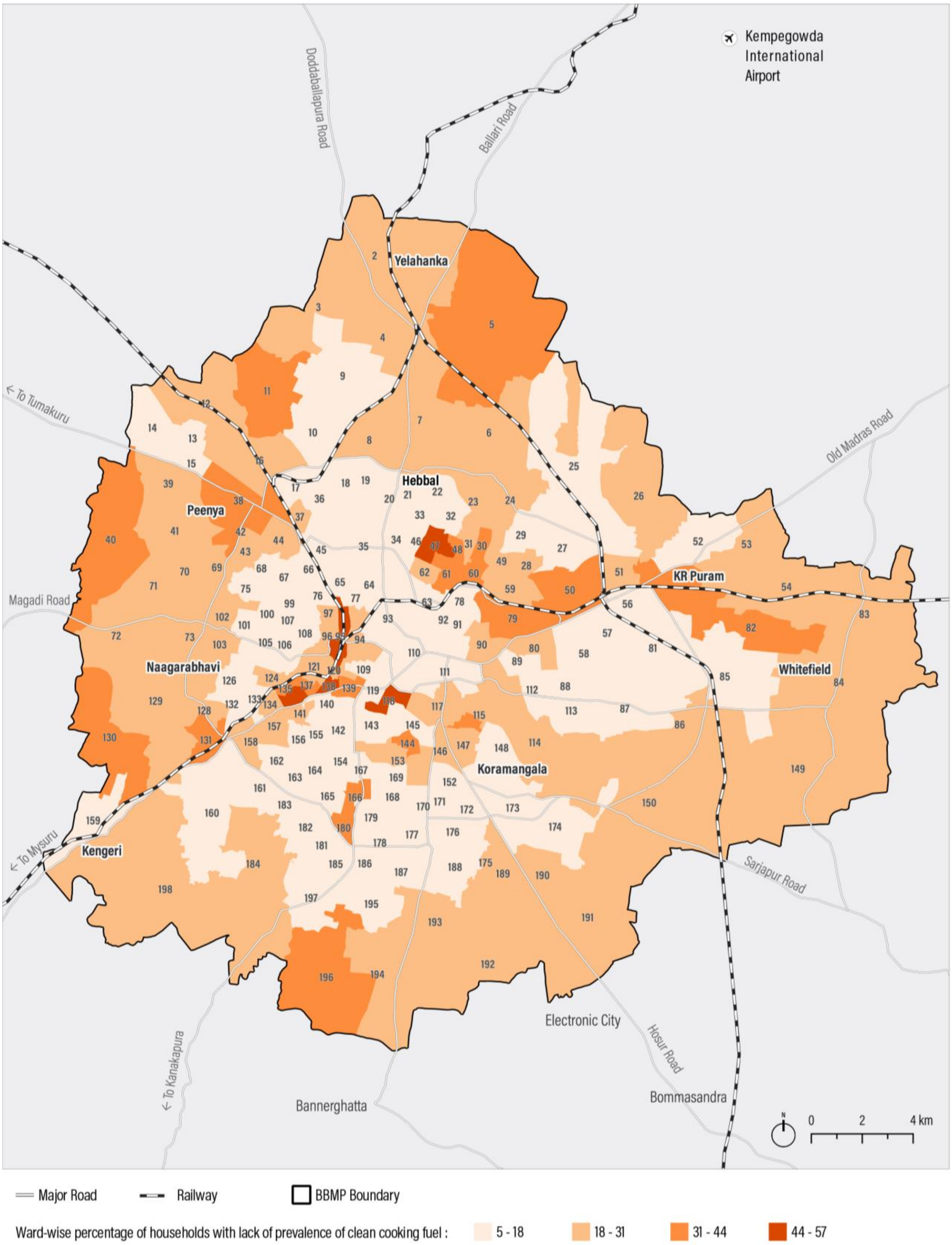
[20] This includes latrines connected to systems other than septic and piped water sewer systems: pit latrine with slab, pit latrine without slab, open pit, service latrine with night soil disposed into open drain, service latrine with night soil removed by humans, service latrine with night soil serviced by animals, and any other.

Figure 15 Key Accessibility parameters of Bengaluru



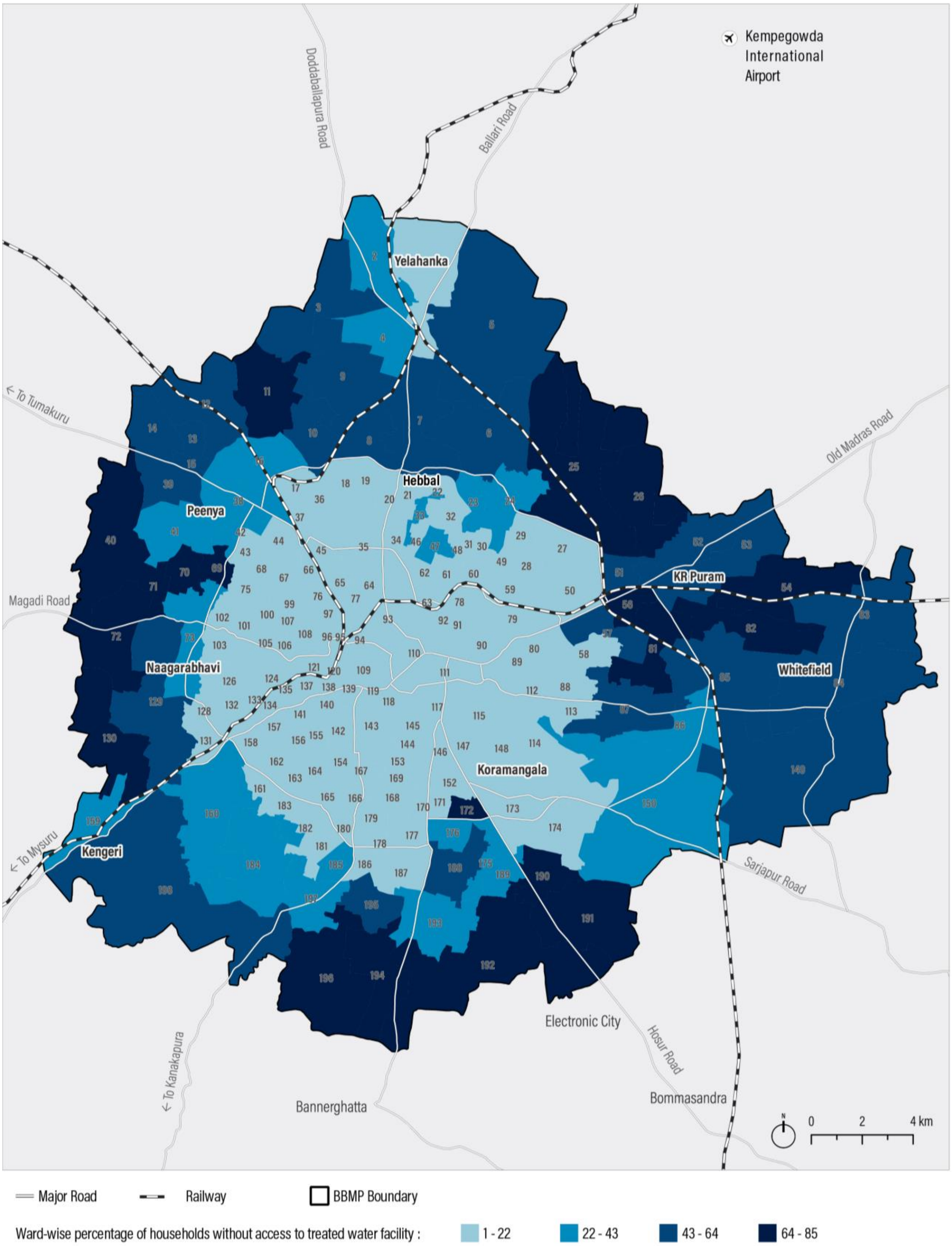
Source: WRI India using KSRSAC buildings data; Landuse from BBMP, and estimated population density from 2011 (refer to CCR-VA for details)

Figure 16 Ward-wise lack of prevalence of clean cooking fuel



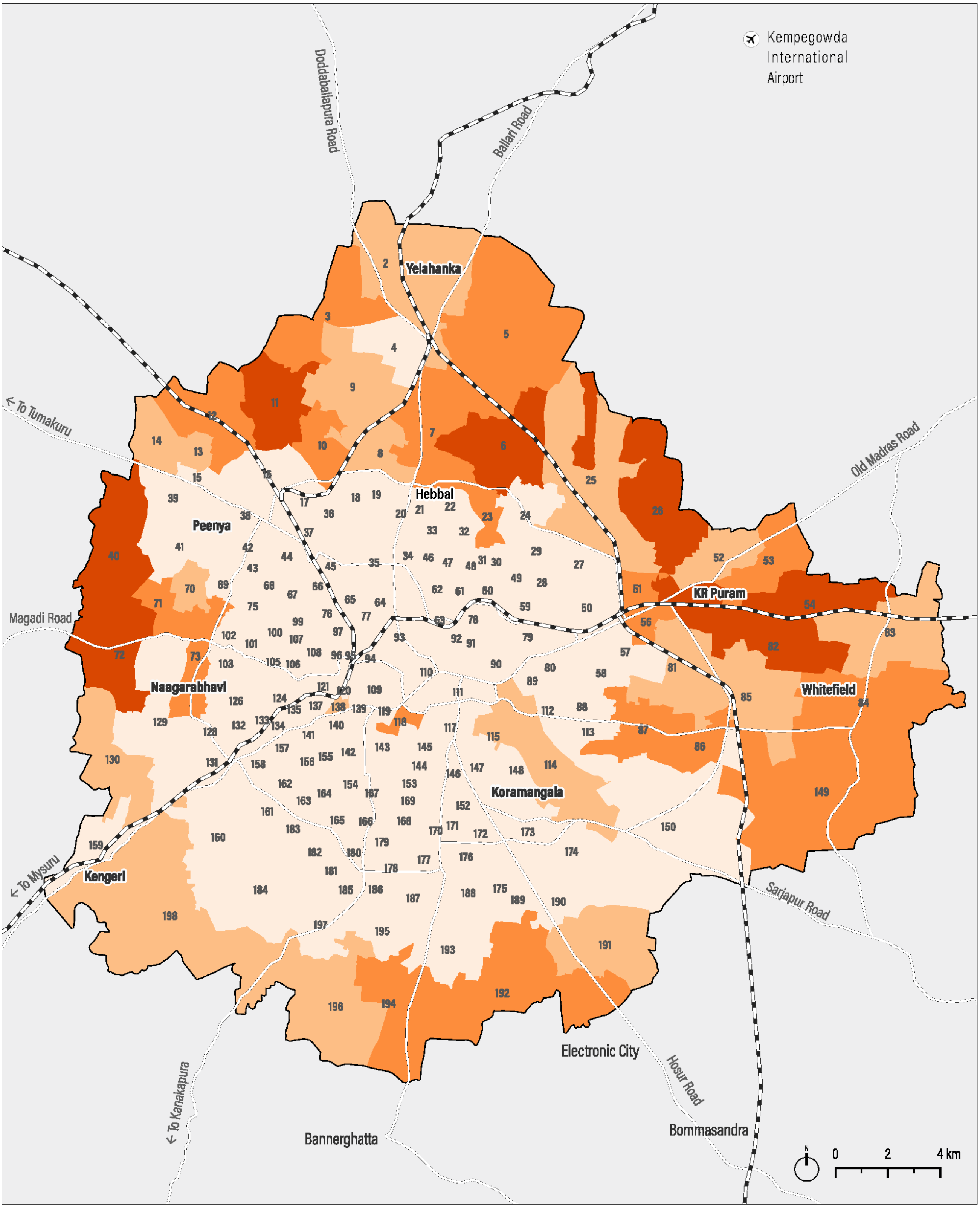
Source: WRI India analysis using Census 2011; wards information from BBMP

Figure 17 Ward-wise lack of access to treated drinking water



Source: WRI India analysis using Census 2011; wards information from BBMP

Figure 18 Ward-wise access to piped sewer and septic tanks

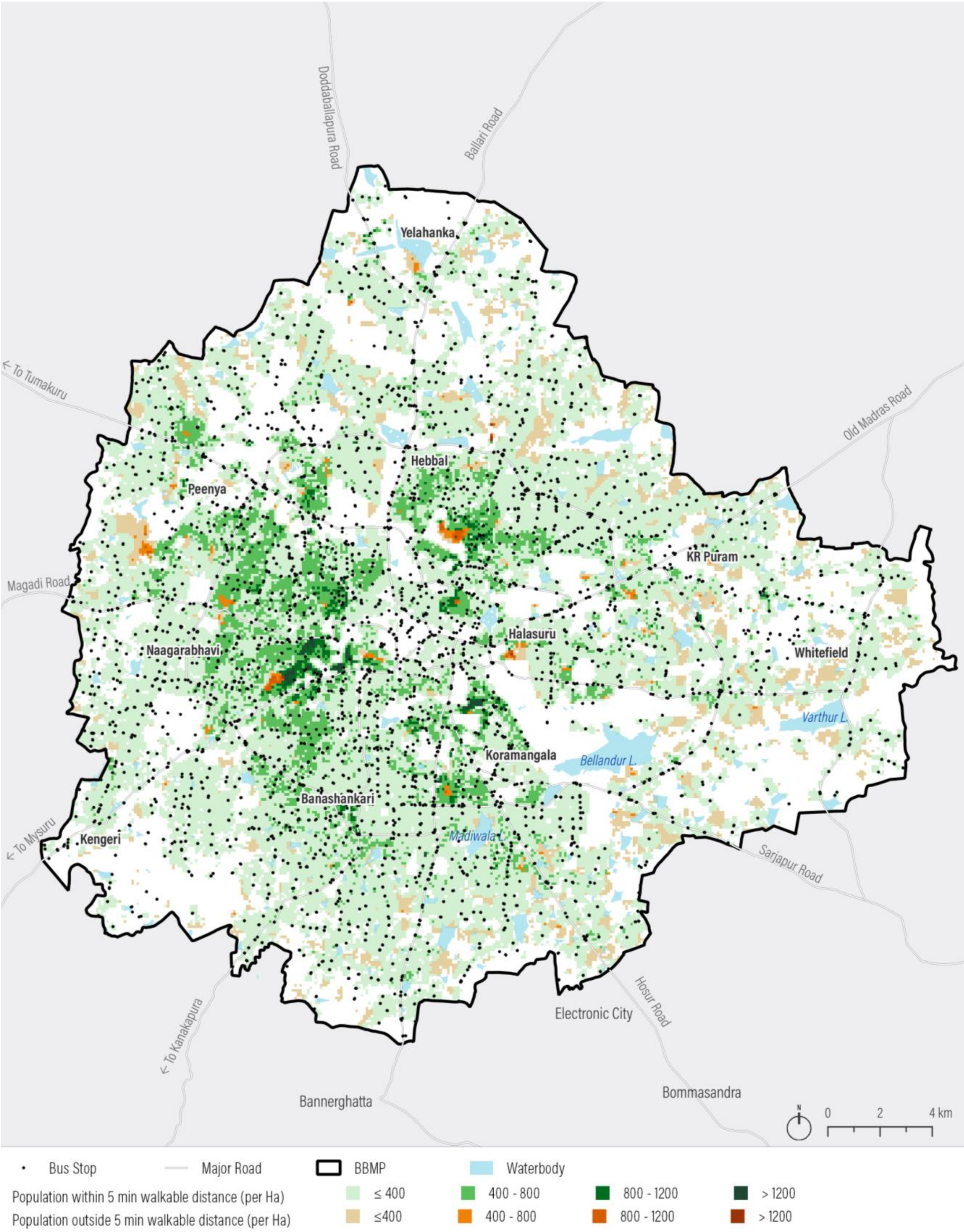


Major Road   Railway   BBMP Boundary

Ward-wise percentage of households without access to piped sewer and septic tanks: 0 - 18   18 - 36   36 - 54   54 - 73

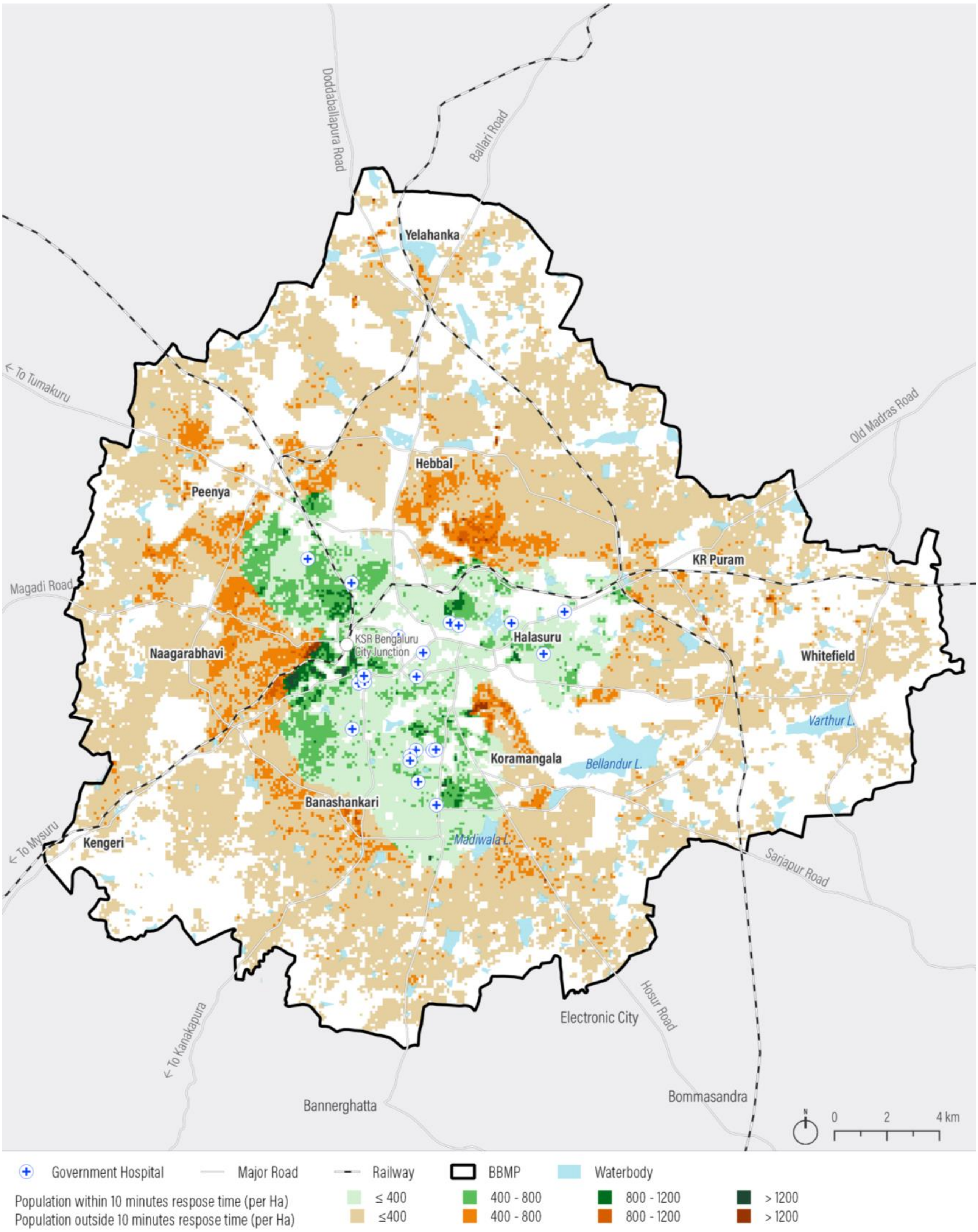
Source: WRI India analysis using Census 2011; wards information from BBMP

Figure 19 Access to public transport (bus stops) within 5-minute walkable distance



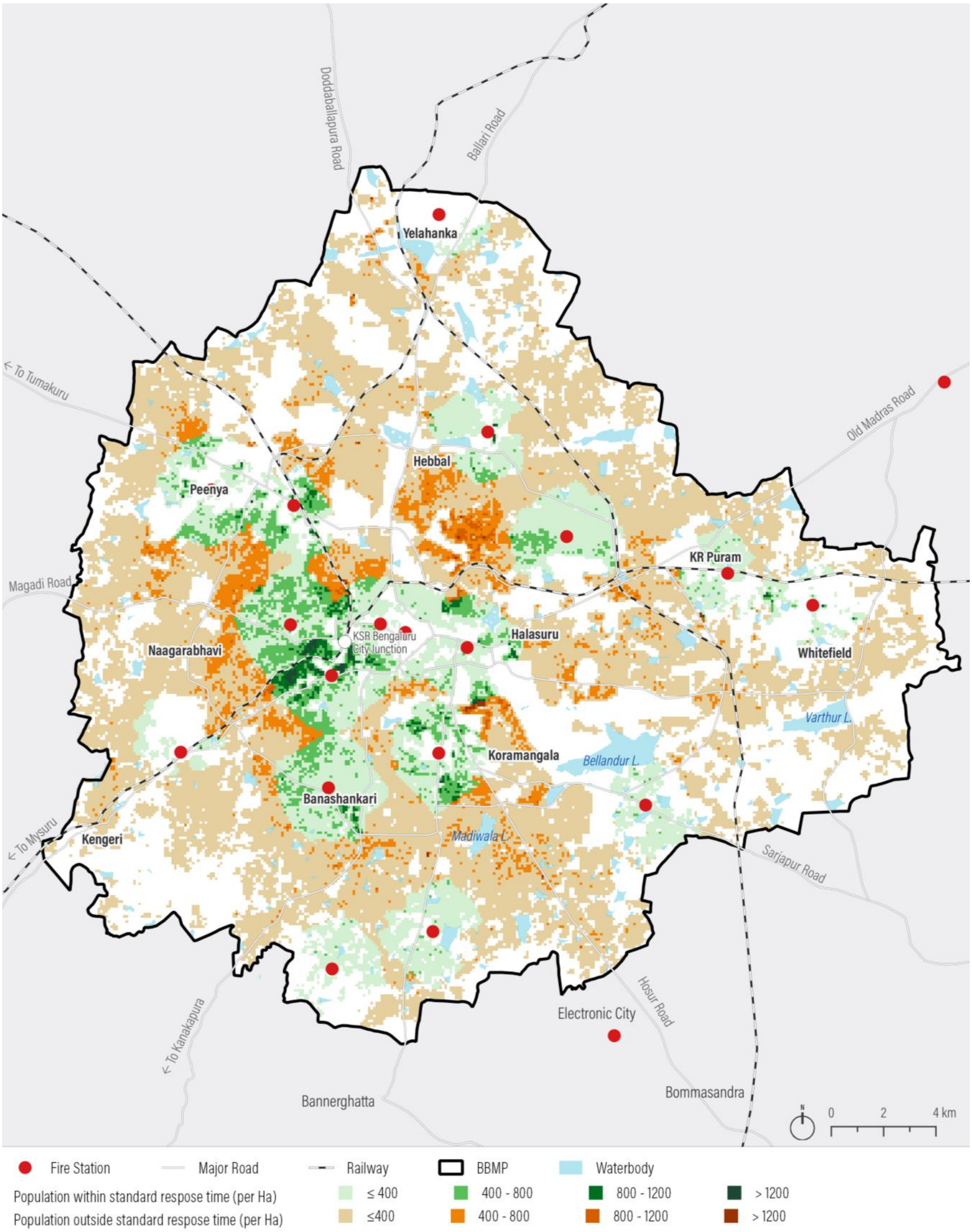
Source: WRI India analysis using bus stops and buildings data from KSRSAC; Landuse from BBMP and population density estimated using Census 2011 (refer to CCRA-VA for details)

Figure 20 Access to government hospitals within 10-minute of ambulance service area



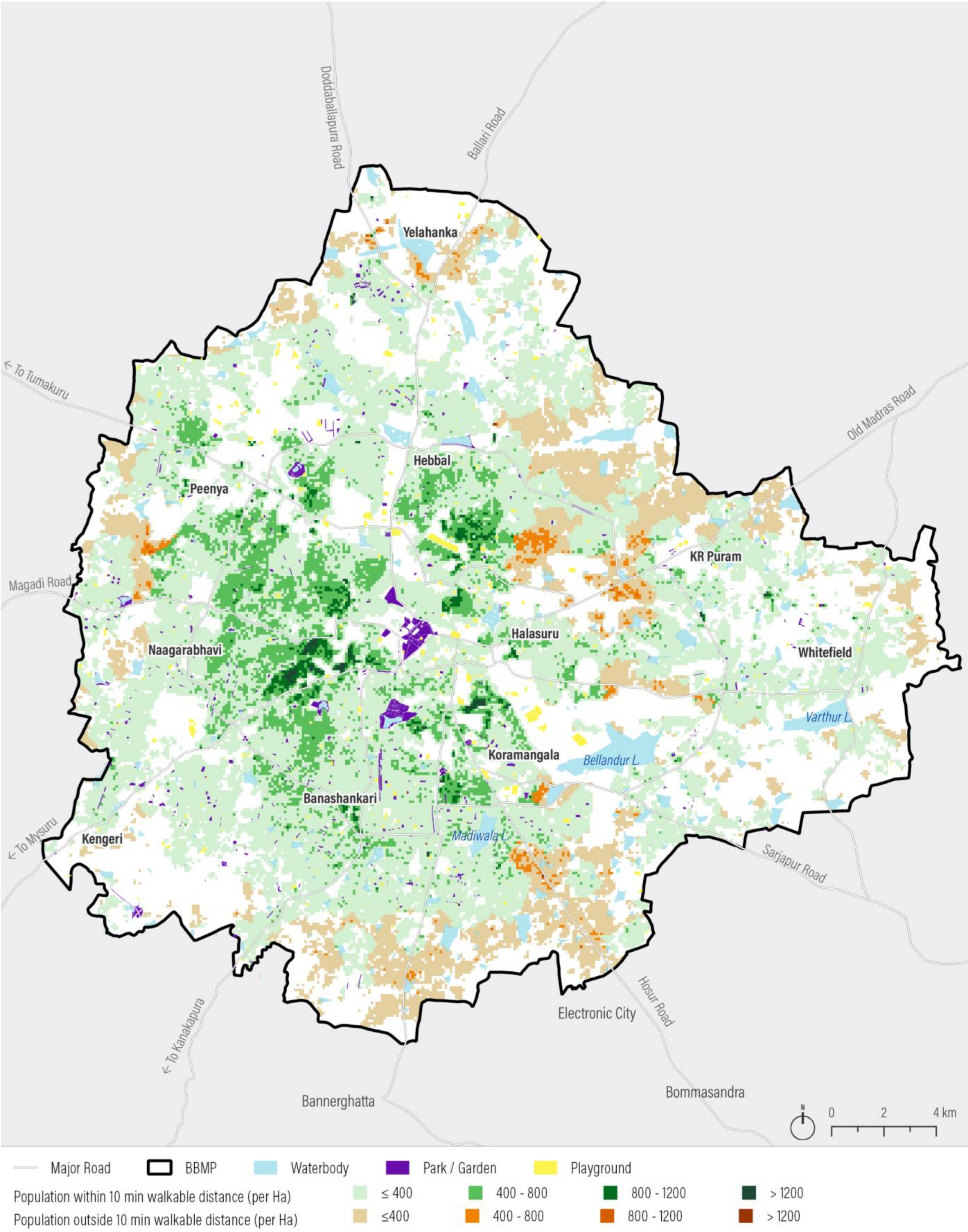
Source: WRI India analysis using hospital information from Vigeyepms 2022; buildings data from KSRSAC; Landuse from BBMP and population density estimated using Census 2011 (refer to CCRA-VA for details)

Figure 21 Access to fire stations within 7-minute standard response time for fire tenders



Source: WRI India analysis using fire stations from K-GIS 2022; buildings data from KSRSAC; Landuse from BBMP and population density estimated using Census 2011 (refer to CCRA-VA for details)

Figure 22 Access to parks and grounds within 10-minute walkable distance



Source: WRI India analysis using KSRSAC buildings data; Landuse from BBMP, and estimated population density from 2011 (refer to CCR-VA for details)

2.2 Sectoral status and emerging challenges

As mentioned in Chapter 1, seven priority sectors have been identified for developing mitigation and adaptation/resilience strategies for Bengaluru to transition towards a carbon-neutral and resilient city. These sectors are mentioned in Figure 23 (also refer to Figure 2). The following section will give an overview of the existing situation for each sector. This is explained through three main aspects: 1) status quo of the sector, 2) ongoing initiatives in the sector, and 3) key challenges to be addressed in the sector. This assessment is based on information gathered from stakeholder consultations, literature review, and the experience of working in the city. Along with quantitative assessments from Chapters 3 and 4, insights gathered from this section have significantly contributed to arriving at sector-specific actions recommended through the BCAP.

Figure 23 Priority sectors identified for targeted actions

Source: As identified by BBMP with the technical support of WRI India

2.2.1 Energy and buildings

Status quo of the sector

The energy and buildings sector is an important infrastructure component for the growth of an economy, especially for Bengaluru. Karnataka's economic growth is concentrated around the city, which has a significant influence on the demand for energy in terms of electricity and fuel for wide-ranging activities.

While LPG is widely available in Karnataka (PPAC 2020), including in Bengaluru, affordability remains a barrier to consistent use. As a result, a portion of low-income households remain reliant on fossil fuels such as firewood, which affect air quality and health.

All states and Union Territories have established green building cells. The promotion and adoption of green buildings in cities is evident. Maharashtra leads the country, with the highest number of green buildings, while Karnataka is fourth (Manasi et al. 2021). In Karnataka, Bengaluru has some of the highest-rated buildings. There are approximately 36 LEED/IGBC and GRIHA-certified buildings in BUD. In 2021, Bengaluru achieved 3 out of 5 stars in the city preparedness performance assessment under the Climate Smart Cities Assessment Framework (CSCAF) 2.0, conducted by the Ministry of Housing and Urban Affairs. It has been recommended that cities like Bengaluru focus on energy efficiency and the adoption of green buildings to address the cooling requirements of the built environment, especially considering extreme heat and GHG emissions (NIUA 2021). Presently, the Karnataka Energy Conservation Building Code (K-ECBC) 2014, is mandatory, and is applicable for commercial buildings or complexes with a connected load of 100 kW or greater, or a contract demand of 120 kVA or greater. Notably, the K-ECBC is only applicable for major renovations and new buildings in the commercial segment. The Eco Niwas Samhita (ENS) is applicable for new residential buildings only and no exiting building or renovations/ additions are included under its scope.

Industry accounts for 18-19% of the total electricity demand in Karnataka (Strafford Regional Planning Commission 2018). For the past few years, the industrial plants within the BBMP area were either being shifted to nearby industrial areas or were being closed. There are 370 large-scale industries, 413 medium-scale industries, and 91,312 MSME (enterprises comprising both manufacturing and service entities) in BUD (MSME 2016).

Ongoing initiatives in the city

The energy and buildings sector is governed by multiple statutory and regulatory frameworks. Some key ones are listed below:

- Energy Conservation Act and Amendment (Central Act, 2022)
- Electricity Act and Amendment (Central Act, 2003 and 2007)
- Karnataka Electricity Reforms Act, 1999
- Karnataka Electricity Regulatory Commission Regulation, 2000
- Karnataka Model Building Bye-laws, 2016
- Karnataka Electricity Regulatory Commission - net metering regulations 2016

Several ongoing initiatives developed by national and state agencies are being implemented by city- or state-designated nodal agencies in a manner suitable for their respective locations. Table 2 below lists some such initiatives in Bengaluru, categorised on the basis of their strategic orientation. The broader objectives of these initiatives, and their alignment with the BCAP goals, are also listed in the table.

Table 2 Ongoing initiatives in the energy and buildings sector in Bengaluru

Strategic Orientation: **Grid electricity decarbonisation**	
Initiatives: • Karnataka Renewable Energy Policy, 2022-2027 • National Solar Mission (NSM), 2010 • Rooftop Solar Programme Ph-II, 2019	*Objectives:* These initiatives aim to strengthen Karnataka's position as a preferred destination renewable energy (RE) sector and create an ecosystem for sustainable and green energy development, thereby reducing GHG emissions. They ensure that efforts are made to lessen the detrimental effect of electricity generation on the environment. The initiatives also aim to foster the just transition to cleaner fuels for electricity generation.
Strategic Orientation: **Green buildings and low-carbon buildings**	
Initiatives: • K-ECBC, 2014 • Eco-Niwas Samhita (ENS) – Part 1, 2018	*Objectives:* These initiatives aim to lay down the minimum requirements for the energy-efficient design and construction of buildings and their systems without

• Eco-Niwas Samhita (ENS) – Part 2, 2021 • National Building Codes, 2016 • Karnataka Model Building Bye-Laws, 2016	compromising on the comfort, health, and productivity of the occupants. The implementation of these initiatives is expected not only to result in significant energy savings, but also to reduce GHG emissions and promote sustainable development.
Strategic Orientation: **Energy efficiency**	
Initiatives: • Karnataka Energy Conservation and Energy Efficiency Policy 2022 – 2027 • Phase-II Hosa Belaku, 2017 • Pavan Scheme, 2017 • National Mission for Enhanced Energy Efficiency (NMEEE), 2011	*Objectives:* These initiatives aim to promote energy-efficient appliances and energy conservation to increase the resilience and reliability of the electricity grid, and to provide environmental, community, and health benefits. The key objective is to increase buildings that use less energy to heat, cool, run appliances, and electronics, as well as manufacturing facilities that use less energy to produce goods without compromising the performance and end-result.
Strategic Orientation: **Transition to clean fuels**	
Initiatives: • Pradhan Mantri Ujjwala Yojana 2.0, 2016 • Go Electric campaign - eCooking Devices, 2021 • Perform Achieve and Trade Scheme (PAT), 2012 • Gruha Jyothi Scheme, 2023	*Objectives:* These initiatives aim to promote usage of cleaner fuels in residential, commercial, and industrial buildings.

Areas of improvement for addressing barriers to a climate-progressive energy sector

1. *System operation flexibility*

Operation flexibility is a kind of preparedness for unexpected or unforeseen electricity production or consumption variations, and it determines how easily grid infrastructure can be modified and can withstand such variations. According to the International Energy Agency (IEA) phase assessment framework, Karnataka is currently in phase 3 of renewable integration, and is ahead of other Indian states in electricity generation from variable renewable energy (solar and wind). Hence, Karnataka is experiencing system integration challenges that other Indian states are yet to experience. As the integration of renewable energy sources increases, we can expect to see challenges that have not been experienced by any Indian state (IEA 2021). Hence, increasing resilient infrastructure and strengthening the grid distribution network is a matter for careful consideration and planning, along with tariff reforms.

2. *Present contracting protocols making clean energy prices higher to the end-consumers*

Despite increased procurement of renewable power by BESCOM in recent years, BESCOM continues to pay the fixed charges of long-term agreements with thermal power plants, leading to an overall increase in power-purchase cost per unit and therefore an increase in tariffs.

3. *Incentives and enforcement of energy-efficient buildings in the city*

The World Green Building Council estimates that green buildings could generate higher returns by saving 0.5% to 12 % in additional costs and have the potential to decrease operational costs by up to 37%. The sales of green buildings are much faster, with sales premiums of up to 31%. Such buildings also have up to 23% higher occupancy rates and rental income up to 8% higher than conventional buildings. At the same time, there are not many financial inducements to make passive energy conservation measures economically viable. Adoption and enforcement of the implementation of ECBC and ENS codes in Bengaluru remains a challenge. The amended Energy Conservation Act, 2022, has extended the codes to new residential and office buildings.

4. *Penetration and adoption of electric cooking*

Understanding user preferences and the local cooking context can play a key role for policy makers in developing cooking solutions that will see greater adoption for accelerating e-Cooking transition. The ability of low-income households to pay for the increase in electricity costs due to cooking compared to electricity is to be considered in this regard. The promotion of the health benefits associated with electric cooking needs to be accelerated.

2.2.2 Transportation

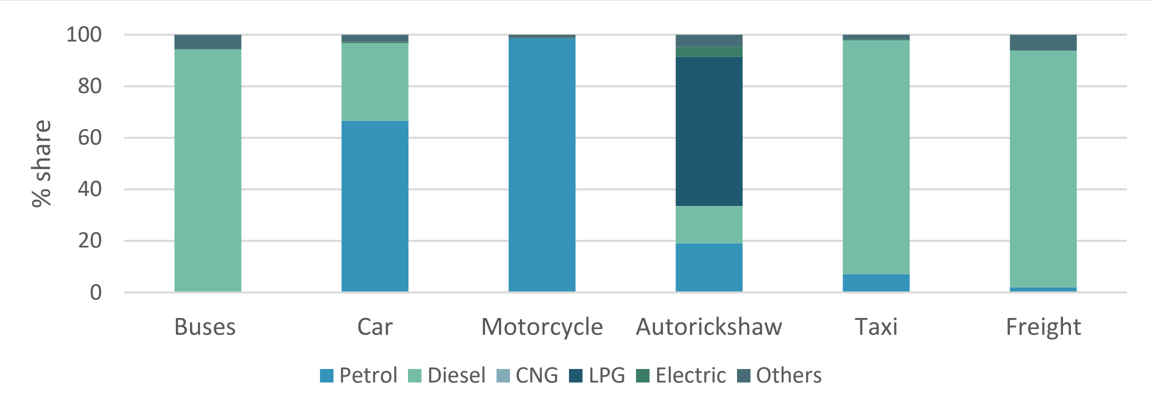
Status quo of the sector

At present, Bengaluru's public transport system primarily includes two modes: bus services offered by BMTC[21], and metro rail services offered by BMRCL. A suburban rail system is being planned by KRIDE, which is currently under construction. The distribution of trips according to mode of travel reveals that 32% of trips in the city are made using public transport (bus and metro), while the share of private modes, i.e., motorcycles and cars, is 27% and 7%, respectively (CMP-Bengaluru 2020)[22]. Autorickshaws and taxis offering intermediate public transport (IPT) services in the city have a combined mode share of 7%, and 26% of trips are on foot, which is lower than in other metro cities such as Mumbai (46%) (CMP-Mumbai 2016) and Delhi (35%) (Delhi 2019). The estimated annual Vehicle Kilometres Travelled (VKT) by all modes is 30,000 million km.[23] At present, all motorised modes in Bengaluru are predominantly fossil fuel based, as seen in

Figure 24.

[21] And KSRTC for few routes.
[22] Data based on RITES Study, 2016.
[23] WRI India Analysis done for calculating Transport sector's GHG emissions inventory 2019.

Figure 24 Fuel share of different transport modes in Bengaluru for 2019



Source: WRI India analysis based on vehicle registration data till 2019 for RTOs within the BBMP boundary, Vahan Dashboard - Ministry of Road Transport & Highways (MoRTH)

Ongoing initiatives in the city

The transport sector in the city is governed by multiple statutory and regulatory frameworks. The key ones are listed below:

- The Motor Vehicles Act, 1988 (Central Act 59 of 1988)
- Central Motor Vehicles Rules, 1989
- The Karnataka Motor Vehicles Rules, 1989
- The Karnataka Motor Vehicles Taxation Act, 1957 (Karnataka Act 35 of 1957)
- The Road Transport Corporations Act, 1950

Bengaluru is currently implementing (or planning for) various policies, plans, and schemes within this sector. Some key initiatives are listed below, categorised on the basis of their strategic orientation. The broader objectives of these initiatives along, with their alignment with the BCAP goals of mitigation, adaptation and resilience-building, are listed in the table below.

Table 3 Ongoing initiatives in the transportation sector in Bengaluru

Strategic Orientation: **Land Use Transport Integration and Overarching Transport Plans/Policies**	
Initiatives: • Comprehensive Mobility Plan (CMP) for Bengaluru, 2020[24] • Bengaluru Transit-oriented Development (TOD) Policy, 2022 • Approved BMLTA Bill, 2022	*Objectives:* These initiatives aim to achieve land use transport integration, which will help reduce vehicular trips and minimise travel distances, thereby reducing emissions. Other initiatives focus on improving the existing transport ecosystem and processes in the

[24] Strategies/Themes under CMP include: 1) Integrated Land Use and Mobility Plan, 2) PT Improvement Plan, 3) Road Network Development Plan, 4) NMT Plan, 5) Multi-Modal Mobility Plan, 6) Private Transport Management Plan, 7) Freight Movement Plan, 8) Travel Demand Management Plan, 9) Regulatory Measures, 10) Governance Measures, and 11) Fiscal Measures.

• City Logistics Plan	city, which indirectly helps reduce vehicular emissions through strategies such as having an overarching transport authority and coordinated freight movement. Therefore, these initiatives mainly address the BCAP goal of mitigation.
Strategic Orientation: **Public Transport Improvement Strategies**	
Initiatives: • Extension of metro rail network • Suburban rail lines under construction • Metro feeder services by BMTC • E-Bike Taxi Scheme • Bengaluru Parking Policy 2.0 • CMP strategies • Shakti Scheme, 2023	*Objectives:* These initiatives aim to improve public transport network connectivity, ridership, accessibility, first- and last-mile connectivity, i.e., overall improvement of the city's public transport system, thereby helping reduce the use of private motorised modes. Hence, they mainly address the BCAP goal of mitigation.
Strategic Orientation: **Non-Motorised Transport (NMT) Strategies**	
Initiatives: • Extension of Public Bike Sharing (PBS) • CMP Strategies • Draft Active Mobility Bill– Karnataka, 2021 • Street or NMT infrastructure improvement projects under the Smart Cities Mission	*Objectives:* These initiatives aim to improve the ecosystem for non-motorised transport in the city and facilitate its uptake. They address the mitigation goal of the BCAP by reducing the use of motorised modes of transport.
Strategic Orientation: **Clean Fuel and Fuel Efficiency Strategies**	
Initiatives: • Electric Vehicle and Energy Storage Policy 2017 (GoK) • Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME 2) • E-Bike Taxi Scheme • BMTC leases e-buses under 'Grand Challenge' by CESL • Introduction of BS6 vehicles • Initiatives on sustainable urban freight by DULT • Voluntary Vehicle Fleet Modernisation Programme (V-VMP)/ Vehicle Scrappage Policy, 2021 • Feasibility study on use of EVs for solid waste collection – conducted by DULT in collaboration with BBMP and Kinetic Green Energy and Power Solutions Ltd	*Objectives:* These initiatives aim to promote the use of cleaner fuels in vehicles, and to improve vehicle technology to reduce emissions and increase their fuel efficiency. They directly address the mitigation goal of BCAP.

Areas of improvement for addressing barriers to a climate-progressive transport sector

1. *Integration of land use and transport*

Rapid urbanisation, along with rising income levels and motorisation rates, have led to the horizontal expansion of the city. At present, 25% of the city's population resides within 10 minutes' walking distance of metro stations.[25] The average trip length in the city has increased from 6.47 km[26] in 2011 to 8.93 km (CMP-Bengaluru 2020) in 2016, which can be attributed to the physical expansion of the city. A city growth strategy based on the integration of land use and transport, as well as compact development principles, can help reduce the number of trips and trip distances, and encourage a shift to sustainable low-carbon modes of transport, thereby reducing emissions and other negative externalities. The recently approved Bengaluru TOD Policy is a welcome step in this direction. The BMLTA bill is expected to be play a significant role.

2. *Public transport services*

There is need for improvement in seamless multi-modal integration, and first- and last-mile connectivity (especially in the outer suburbs/peripheries). About 94% of the city's population has access to bus stops within five minutes' walking distance[27]. However limited fleet size of buses results in service-connectivity and frequency issues. Availability and affordability of IPT services for first- and last-mile connectivity is also a barrier to the greater uptake of public transport modes.

3. *NMT and road infrastructure*

Bengaluru's road network spans 14,000 km. However, it lacks adequate structure, a clear functional hierarchy, and connectivity, particularly in the outer new growth areas (CMP-Bengaluru 2020). This has contributed to growing traffic congestion and low travel speeds (10-15 kmph) on all major roads in the city. The quality of pedestrian and cycling infrastructure is decisive in increasing the share of NMT modes. As per CMP 2020, at present, footpaths are available only along 47% of the road length (CMP-Bengaluru 2020). The introduction of the Public Bike Sharing (PBS) system in the city has fuelled the usage of bicycles. This, along with the mode share of walking (26%), illustrates the potential for a shift to NMT modes if adequate infrastructure is provided.

4. *High dependence on private modes*

In 2019, the total number of vehicles registered in the BBMP area was almost 84 lakh,[28] putting Bengaluru only behind Delhi's 1.5 crore vehicles (Kulkarni 2019). The number of vehicles in the city is growing at an alarming rate, with a 6,099% increase observed between 1976 and 2016 (E. Bureau 2017). The consequences of this include severe traffic congestion

[25] WRI Analysis done for phases 1 and 2 of Bengaluru Metro. Refer CCRA-VA report for the map.
[26] Bangalore Mobility Indicator -BBMP+BIAPPA*, 2011 by DULT. Data of 2010-11.
[27] WRI Analysis. Refer to CCRA-VA report for the map.
[28] The precise number is 83,85,360. WRI Analysis using data from Parivahan Portal of Transport Department. Data taken till March 2019.

and increase in travel time, accidents, parking demand (resulting in unregulated parking), fuel consumption, and air pollution, ultimately impacting public health and productivity.

5. *High fossil fuel dependency*

In 2019 (baseline year for this study), Bengaluru had less than 1% of electric vehicles (EVs) in its total fleet (see Figure 24). Decarbonising road transport would require an urgent shift towards cleaner fuels such as electricity and hydrogen, as well as improved fuel efficiency. This must be supported with a conducive ecosystem of policies, finance, and infrastructure. Refer to *Annexure D* for a detailed barrier analysis on shifting towards cleaner fuels.

6. *Sustainable freight management*

Freight vehicle registrations in the city increased significantly at a CAGR of 4.8% between 2009 and 2019 (Somya Jain 2021). The majority of freight vehicles (55%) in Bengaluru are light commercial vehicles (LCV), and there is a surge in their numbers. A major reason for this is the increase in e-commerce related activities (Somya Jain 2021). Figure 43 shows that freight contributes 42% of GHG emissions. Hence, it is crucial to look holistically at this sector from the perspective of shifting these modes away from fossil fuels and optimising their movement.

7. *Resilient transport system*

The transport sector is particularly vulnerable to climate change impacts, and is frequently affected by flooding on roads and degradation of pavements, disrupting the smooth flow of traffic (Vajjarapu, Verma, and Allirani 2020). The extreme flood events that Bengaluru has witnessed frequently in recent years affect the transport system in multiple ways – by increasing travel time and vehicle kilometres travelled (VKT) and decreasing travel speeds – leading to congestion. This, in turn, affects life, property, productive hours, and the city's economy, especially the informal and gig economy. Flood events also affect NMT infrastructure, further restricting people from using these modes. Therefore, a resilient transport infrastructure is needed for making the city climate resilient.

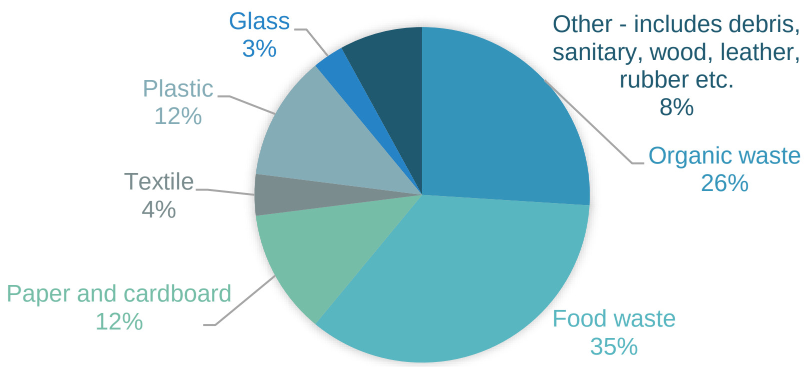
2.2.3 Solid waste management

Status quo of the sector

Bengaluru's waste generation is increasing continuously, due to the growing population, economic development, and lifestyle changes. Of the various types of waste, solid waste is the primary contributor to GHG emissions from waste in the city. In 2019, Bengaluru's daily solid waste generation was 5,400 tonnes,[29] translating to 0.56 kg per capita per day, of which 61% was wet and 39% was dry waste, as seen in Figure 25.

[29] 2019 data shared by BBMP with WRI India for the BCAP preparation.

Figure 25: Solid waste composition in Bengaluru

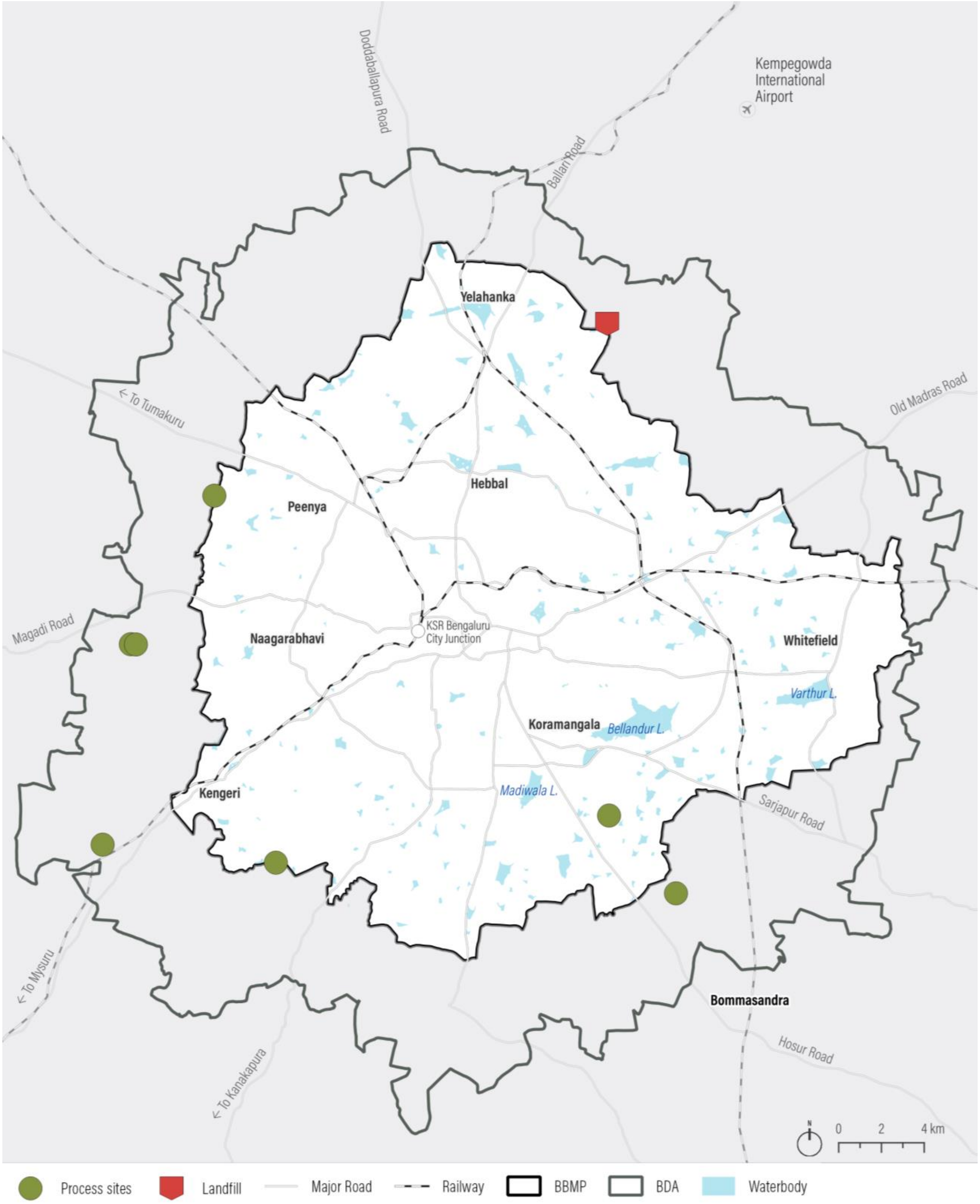


Source: Solid Waste Management: Current Scenario and Challenges in Bengaluru | Intech Open

Bulk waste generators contribute 25% of the city's waste. BBMP, the agency responsible for managing solid waste, established Bengaluru Solid Waste Management Limited (BSWML) as a government-owned company in 2021, to execute solid waste management projects on its behalf (Subhashini 2023). At the time of this study, about 30% of waste is handled directly by BBMP, and the remaining 70% by empanelled service providers. As per directions by the High Court of Karnataka, BBMP has notified bulk generators to segregate waste into different categories and to either manage their waste *in situ* or utilise the services of BBMP empanelled service providers (BBMP 2015). Of more than 20,000 *pourakarmikas*, 3,917 are assigned to street sweeping, while 18,562 take care of door-to-door collection and transportation of waste (Naveen and Puvvadi 2020). Currently, there is only one active landfill in the city, in Mitaganahalli, where mixed waste is dumped. Further, there are only five functional wet waste processing units, with a capacity of around 1,100 TPD, and 119 dry waste collection centres across the city.[30] Figure 26 presents a map of the city's landfill and processing units. Considering reports of open burning of waste contributing to the air pollution in the city, BBMP has introduced several measures to reduce the open burning of waste.

[30] 2019 data shared by BBMP to WRI India for the BCAP preparation

Figure 26: Location of currently functional landfill and processing units in Bengaluru



Source: WRI India analysis 2021; BBMP 2019

Ongoing initiatives in the city

The city's solid waste management sector is governed by multiple statutory and regulatory frameworks. A few key ones are listed below:

- Solid Waste Management Rules, 2016
- Construction and Demolition Waste Management Rules, 2016
- Plastic Waste Management Amendment Rules, 2021
- Swachh Bharat Mission, Ministry of Housing and Urban Affairs, GoI (2014 onwards)
- BBMP SWM Bye-laws, 2020

Bengaluru is currently implementing (or planning for) various policies, plans, and schemes within this sector. Some key initiatives are listed below, categorised on the basis of their strategic orientation. The broader objectives of these initiatives along with their alignment with the BCAP goals of mitigation, adaptation and resilience building are listed in the table below.

Table 4 Ongoing solid waste management initiatives in Bengaluru

<table>
<tr><td colspan="2">Strategic Orientation: Improving waste collection, transportation and monitoring</td></tr>
<tr><td><u>Initiatives:</u>
• Single use plastic ban
• Streamlining bulk waste generators
• A pilot ward level micro plan as per the SWM manual, 2017.
• Tenders floated for new waste collection vehicles
• Purchase of 25 sweeping machines
• ICT-based technology solutions - GPS tracking of tipper vehicles
• Introduction of a control room and mobile app to manage collection and transportation
• Ezetap app for imposing penalties on polluters and monitoring garbage-vulnerable points</td><td><u>Objectives:</u>
These initiatives aim to achieve efficient segregation of waste at source, which will help reduce the excessive mixed waste entering the landfill and improve collection efficiency, thereby reducing emissions. They directly address the mitigation goal of the BCAP by contributing to promote inclusive development and building resilience.</td></tr>
<tr><td colspan="2">Strategic Orientation: Increasing waste processing and recycling capacity</td></tr>
<tr><td><u>Initiatives:</u>
• Upgrading old/existing processing units
• Building 50-TPD bio-methanation plants
• Decentralised processing of waste by stream
• Adding more DWCC and aggregators.</td><td><u>Objectives:</u>
These initiatives aim to achieve increased centralised and decentralised waste processing in the city, contributing to reduced landfill usage, mitigation of GHG emissions, job creations and economic benefits, and resilience building.
They directly address the adaptation/resilience and mitigation goals of the BCAP.</td></tr>
<tr><td colspan="2">Strategic Orientation: Implementing legacy waste management and recovery strategies</td></tr>
<tr><td><u>Initiatives:</u>
• Implementing biomining at the Mandur landfill (closed) with about 135 acres of land, to deal with legacy waste
• Proposed six waste-to-energy (WtE) plants with a total capacity of 2,600 tonnes</td><td><u>Objectives:</u>
These initiatives aim to achieve improved decomposition of organic waste and land reclamation, also adding to groundwater and environment protection. The other initiative of WtE would increase energy generation and resource recovery. These initiatives contribute to improving public health, reducing environmental contamination, and enhancing</td></tr>
</table>

	community well-being. They directly address both the adaptation/resilience and mitigation goals of the BCAP.

Areas of improvement for addressing barriers to a climate-progressive solid waste sector

1. *Segregation at source*

In 2019, the city had about 70% segregation of dry and wet waste at the source of the household. BBMP's SWM Bye-laws, 2020, categorised waste into six categories: wet (biodegradable), dry (non-biodegradable), domestic hazardous, e-waste, construction and demolition (C&D), and garden waste. Illegal dumping of C&D waste is a major challenge, and the strict implementation of C&D Management Rules, 2016, is needed for the effective collection of debris.

2. *Waste transportation infrastructure*

The waste is collected in pushcarts and autos/tempos and transported to the primary collection centres. A portion of the segregated waste from source ends up getting mixed, due to the lack of compartmental provisions in transport. Adequate transportation infrastructure for solid waste, with clear compartments and continuous tracking and monitoring, would also improve processing performance.

3. *Processing and recycling units*

Out of the total solid waste collected, about 36% of the city's total wet waste is composted, and 20% of dry waste is recycled. There are five functioning centralised composting, and five bio-methanisation units, across the city. Currently, there are only a few community-level composting plants. BBMP is working to develop a Decentralised Processing Unit (Bengaluru 2019). At the time of this study, 16 wards have identified a location for a local composting plant. Enforcement of the 'polluter pays' principle is a significant challenge (Reddy 2018). There is one operational C&D waste processing plant in Bengaluru, in Chikkajala, on the outskirts of the city, where 20% of the city's C&D waste is recycled (B.M. Bureau 2022).

4. *Waste recovery*

While six waste-to-energy (WtE) plants have long been proposed,[31] they are yet to be implemented. Setting up the WtE plants requires higher capital investment and is a more complex process compared to the other options for waste disposal. Lack of markets for end/recycled products, high management costs, lack of incentives to invest in such circular economy enterprises, rising fuel costs for transporting waste, insufficient funding etc., are leading to inefficient waste recovery. Unattended legacy waste and recycling and reuse of C&D waste remain challenges due to a lack of awareness of the benefits. Business models for

[31] 2019 data shared by BBMP to WRI India for Bengaluru Climate Action Plan Preparation

climate-friendly waste recovery and circular economy need to be scaled up to bridge the gaps and reduce waste.

5. *Disposal of waste and landfill management*

About 44% of mixed waste goes to the Mitaganahalli landfill, the only active landfill dumpsite in the city (Reporter 2020). The high composition of wet waste in the landfills releases methane and the seepage of leachate, leading to emissions, air pollution, and soil and groundwater contamination. Moreover, due to the lack of land available to accommodate multiple landfills, the transport of waste from all over the city to the Mitaganahalli landfill contributes to excessive costs and related externalities (Dr Roopa 2016). There is a need for scientific management of landfills and bioremediation of legacy waste to reduce GHG emissions from the waste sector.

6. *Public awareness of climate change impacts of open burning/dumping of waste*

After the ban on open dumping/burning of waste, the core city could see significant reduction in this activity. However, due to lack of awareness amongst low-income communities about the harmful effects of the open burning of waste and the benefits of alternative waste management practices, many residents continue to burn waste in open fires. While the ban on open burning of waste is an important step towards reducing air pollution in Bengaluru, more needs to be done to address the challenges and ensure that the ban is effectively enforced.

7. *Open burning of waste*

Open burning of waste is a significant contributor to both particulate matter and GHG emissions. The combustion of waste in open fires releases particulate matter, carbon monoxide, nitrogen oxides, and volatile organic compounds, which can cause respiratory problems and aggravate existing conditions. The smoke and pollutants emitted during open burning can travel long distances and contribute to the formation of ground-level ozone and smog, reducing visibility and harming vegetation. In addition, open burning can release highly toxic chemicals such as dioxins and furans, which can have serious long-term health effects. It is a significant contributor to air pollution and poses considerable impacts on air quality, it is important to implement regulations and control measures to reduce or eliminate the practice and mitigate its impacts on public health and the environment.

2.2.4 Air quality

Status quo of the sector

In India, there are 131 non-attainment cities identified for the National Clean Air Programme (NCAP), including Bengaluru. This programme aims to reduce PM 2.5 and PM10 levels by 20-30% across these 131 cities by 2024, taking levels in 2017 as the base year. Other pollutants, such as NO_x, SO_2, CO, and O_3 are mostly within the prescribed national standards (MoEFCC 2019). However, looking at the air pollution emission trends, the Government of India has updated its target reduction levels to 35-50% PM2.5 and PM10 by 2025-26, and has launched a new mission, Clean Air for All, to focus on the enhanced reduction targets.

The new mission plays a vital role as it has the potential to effectively elevate programmes to mission mode, as demonstrated previously by the National Solar Mission and others. The Karnataka State Pollution Control Board (KSPCB) developed a 44-point joint action plan for Bengaluru, which has been approved by the Air Quality Monitoring Committee (AQMC). However, the first draft action plan was not approved by the Central Pollution Control Board (CPCB), and KSPCB has prepared a revised action plan based on the feedback from the CPCB.

A comparative analysis of pollutant concentrations between the pre-lockdown (01–23 March 2020) and lockdown (24 March–12 May 2020) periods shows a huge reduction in the ambient concentration of air pollutants – 49% (NO_x), 10% (SO_2), and 37.7% ($PM_{2.5}$) resulting in improved air quality over Bengaluru during the COVID-19 lockdown period (Gouda et al. 2020). However, when the pandemic restrictions were eased, air pollution shot up to pre-pandemic levels. The city received a fresh grant of Rs 108.75 crore from the 15th Finance Commission for the financial year 2022-23 for improving air quality. This is in addition to Rs 147.35 crore for 2021-22 and Rs 279 crore for 2020-21 released by the Centre (PRANA 2019).

Ongoing Initiatives in the city

The air quality in the city is governed by multiple statutory and regulatory frameworks. Some key ones are listed below:

- Air (Prevention and Control of Pollution) Act, 1981
- Environment Protection Act, 1986
- Motor Vehicles Act, 1988
- National Ambient Air Quality Standards, 2009
- National Green Tribunal Act, 2010

There are several ongoing initiatives, developed by the national and regional agencies and implemented by city- or state-designated nodal agencies in a manner suited to their respective locations. Below are some key ongoing initiatives categorised on the basis of their strategic orientation. The broader objectives of these initiatives, and their alignment with BCAP goals, are listed in the table below.

Table 5 Ongoing initiatives in the air quality sector in Bengaluru

Strategic Orientation: **Develop best prevention and mitigation strategies to reduce air pollution**	
Initiatives: • State Clean Air Action Plan • Smart City Mission (SCM) • AMRUT	*Objectives:* These initiatives aim to improve air quality and public health by identifying cost-effective measures to reduce emissions from sectors such as transport, industries, landfills, construction and demolition waste, and residential burning.
Strategic Orientation: **Ensuring community health resilience**	
Initiatives: • Swachh Bharat Mission • Swachh Vayu Sarvekshan • Pradhan Mantri Ujjwala Yojana (PMUY)	*Objectives:* These initiatives aim to create awareness and inform citizens about health impacts related to exposure. They also help improve facility resilience and resource management, while promoting equitable access to health services.

Strategic Orientation: **Transition to low-emitting fuel and VOC free products and building materials**	
Initiatives: • FAME Scheme • Pradhan Mantri Ujjwala Yojana • Electric Vehicle and Energy Storage Policy, 2017 • ECBC • Eco-Niwas Samhita – Part 1 • Go Electric campaign - eCooking devices • National Building Codes (NBC), 2016	*Objectives:* These initiatives promote the clean fuel transition in all types of vehicles, with the aim of reducing significant exhaust emissions that deplete the air quality. They also encourage citizens to adopt sustainable materials for the construction of buildings and to improve indoor air quality and occupancy comfort.

Areas of improvement for addressing barriers to betterment of air quality

1. *Air quality monitoring system*

The main criterion for air quality network density is population. For instance, the CPCB follows the Bureau of Indian Standards (IS 5182-14 2000) to specify the criteria for deploying monitoring stations as one station for every 10 to 20 sq. km. For a city with a complex topography or a large number of pollution sources, one station per 5-10 sq. km is suggested (ISD 2019). Considering the standard requirement, Bengaluru city requires at least 36 air quality monitoring stations. At present, there are 10 CAAQMS and 13 manual stations Thus, the city is short of 13 CAAQMS, and needs to transition all 13 manual monitoring stations to CAAQMS.

2. *Emissions inventory and source apportionment studies*

For a fast-growing city like Bengaluru, emissions inventory and source apportionment studies need to be carried out at regular intervals to capture emission trends. It is essential to study emission trends every five years to develop effective localised actions and mitigation measures in keeping with the city's dynamics (CSTEP 2022). The studies should also focus on the need for hyperlocal or neighbourhood-level monitoring of air quality. Use of air quality dispersion models can help assess the impact on air quality from new economic developments.

3. *Indoor air quality management*

Currently, India does not have indoor air quality (IAQ) standards/guidelines like the ones for ambient air quality standards which could be referred by cities such as Bengaluru. However, some components involved in determining indoor air quality are considered in the National Building Codes, 2016 (NBC). There are standards and guidelines developed by the World Health Organization (WHO); Occupational Safety and Health Administration (OSHA); and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). The COVID-19 pandemic has highlighted the need for better ventilation and control measures for airborne diseases that pose significant health risks, such as respiratory problems, asthma, throat infection, difficulty in breathing, fatigue, headache, eye irritation, and skin diseases (Bedi and Bhattacharya 2021). The degrading indoor air quality and its link with airborne diseases underscore the urgent need for India to come up with guidelines on IAQ to assess the exposure levels, effective mitigation measures, and promote a healthy lifestyle.

4. *Complete feedback loop and effective cross-stakeholder engagement*

National Clean Air Programme highlights the importance of collaboration, saying that tackling air pollution requires a combined effort from every stakeholder. Even though most air pollution is caused by local sources, it is not limited to a specific city and can cross boundaries. There needs to be a set of guidelines for various regions in the state to coordinate, and a regional airshed management cell should be set up to establish authorities across state jurisdictions. There is also a need for some sort of engagement loop developed among key stakeholders that includes performance evaluation of implemented policies or executed, rather than just stopping at the proposal and implementation stage. The performance evaluation step helps identify underperforming actions and policies, facilitating decision making to remove or alter them effectively. Multiple stakeholder engagement reduces the possibility of asymmetrical distribution of knowledge and recommendations and of the duplication of efforts and resources already invested in a particular action or policy.

5. *Capacity-building of urban local bodies (ULBs) and knowledge support to implement and monitor air quality projects under the NCAP*

CPCB has directed the KSPCB and city authorities to implement the City Action Plan. With further directions from CPCB, the city has also prepared a detailed micro-action plan that lays out physical and financial targets. There is a lack of dedicated capacity to look after the overall coordination and facilitation of the implementation of the city's air action plan and more importantly to managing the day-to-day activities of the NCAP, including monitoring, evaluation, and reporting. Also, there is a need for need-based capacity-building programmes with experts having domain knowledge of various aspects of mitigation relevant to the ULBs.

2.2.5 Water, wastewater, and storm water management

Status quo of the sector

Topographically, Bengaluru is located at the top of a ridge, which is the water divide between the watershed of the Cauvery and the Ponnaiyar rivers (Palanichamy 2022). The major surface water intake point for the city is in the Shivanasamudra section of the Cauvery river, 100 km from Bengaluru. This is the only piped water supply source. Currently, the BBMP jurisdiction comprises one core city, eight ULBs, and 110 villages. BWSSB is the agency responsible for water supply and sewerage infrastructure and services within the BBMP jurisdiction. BWSSB provides a piped supply of about 1,450 million litres per day (MLD) of Cauvery water to the city, under the Cauvery Water Supply Scheme (CWSS) Stages I-III, and Stage IV Phases I and II, to the core city and eight ULBs (BWSSB website). Currently, about 40% of the city's population depends on groundwater (CGWB 2015). Studies show that there are over 80,000 private borewells in the city, and groundwater is illegally extracted through private tanker businesses (Raju et al. 2018). Over-exploitation, coupled with insufficient recharge, leads to water contamination and a drop in the water table. The city generates about 1,440 MLD of sewage and has an installed wastewater treatment capacity of 1372.5 MLD within the core city and eight ULBs.[32]

Bengaluru has primary drains that connect one lake to another, and secondary/tertiary drains that channelise rainwater runoff to primary drains. The CAG report records that the city has a total drain length of 842 km (First post 2022). BBMP is responsible for the maintenance of storm water drains and flood management in the city. Of about 210 lakes in Bengaluru, 167 lakes fall under BBMP jurisdiction and the rest are with other departments such as forest dept, BWSSB, and BDA (BBMP website).

Ongoing initiatives in the city

Water and related sectors in the city are governed by multiple statutory and regulatory frameworks. A few key ones are listed below:

- Water (Prevention and Control) Act, 1974
- National Water Mission
- Karnataka State Water Policy, 2019
- The Karnataka Groundwater (Regulation and Control of Development and Management) Act
- BWSSB Act, 1964
- Bengaluru Water Supply and Sewerage (Rainwater Harvesting) (Amendment) Regulation, 2019

Bengaluru is currently implementing (or planning for) various policies, plans and schemes within this sector. Some key initiatives are listed below, categorised on the basis of their strategic orientation. The broader objectives of these initiatives, along with their alignment with the BCAP goals of mitigation, adaptation, and resilience-building, are listed in the table below.

Table 6 Ongoing initiatives in water, wastewater, and stormwater sector in Bengaluru

Strategic Orientation: **Access to water supply and services**	
Initiatives: • Cauvery Water Supply Scheme Stage-V (775 MLD) • Refurbish and Rejuvenate TG Halli Reservoir City Logistics Plan	*Objectives:* These initiatives aim to augment the city's water supply by allotting water to the peripheral areas that do not have piped water supply. The initiatives contribute to enhancing public health, boosting economic productivity, promoting environmental sustainability, building community resilience, and enhancing social equity. They directly address the adaptation/resilience goal of the BCAP.
Strategic Orientation: **Improving wastewater management**	
Initiatives: • Mandatory dual piping system for new constructions	*Objectives:* These initiatives aim to achieve better wastewater management through increased treatment of wastewater

[32] 2019 data shared by BWSSB with WRI India for the BCAP preparation.

• Subline and trunk sewer mines construction • 128 MLD capacity of new 23 STPs under construction • Phase-wise rehabilitation and upgrades of old or under-capacity sections of wastewater networks and STPs	and segregation of potable and non-potable water, to maximise the use of available water resources and conserve water by reducing the strain on fresh water supplies. They contribute to improved public health, environmental protection, resource recovery, climate change mitigation, and community well-being. They directly address the adaptation/resilience and mitigation goals of the BCAP.
Strategic Orientation: **Water conservation strategies**	
Initiatives: • Property level rainwater harvesting • Reuse of treated water • Implementation of district metered areas for water loss reduction	*Objectives:* These initiatives aim to increase water storage and availability, to reduce water scarcity during drought. Initiatives to reuse treated water would decrease the dependency on fresh water for non-potable purposes. District metering would help improve the monitoring of the water distribution to reduce leaks in water supply. These initiatives contribute to reduced water bills, increased water availability, environmental protection, energy savings, climate change mitigation, and improved community well-being. They directly address the adaptation/resilience goal of the BCAP.
Strategic Orientation: **Stormwater management**	
Initiatives: • Regular desilting of drains • Expanding stormwater network installation of 26 water-level sensors by KSNDMC	*Objectives:* These initiatives aim to mitigate flood risk by ensuring free stormwater runoff into the drains. Water-level sensors help provide real-time information on water levels, which allows the authorities to take necessary action on time. These initiatives contribute to flood prevention, improved water quality, increased groundwater recharge, climate change adaptation, green infrastructure, and improved community well-being. They directly address the adaptation/resilience goal of the BCAP.

Areas of improvement for addressing barriers to a climate-progressive water-wastewater-stormwater sector

1. *Managing distribution and loss of water*

The city is heavily dependent on piped Cauvery water supply, and the source is 100 km away from the city. This contributes to the transmission and distribution loss of water, due to which, along with the peripheral areas (which still lack a piped water supply network), some parts of the core city still depend on groundwater to meet demand. Moreover, the high percentage of unaccounted-for water (UfW) due to water theft and illegal connections affects the water supply efficiency in the city (K.S.K. and Raj 2020).

2. *Ageing infrastructure*

Some of BWSSB's assets, such as ground level reservoirs, the distribution system, and other structures, are more than 50 years old and in need of rehabilitation. Going forward, BWSSB will need to focus on upgrading its ageing infrastructure, while creating new infrastructure in peripheral areas (BWSSB 2017). Identifying and locating distribution system leaks can be difficult. However, targeting problem areas for repair or replacement is critical for effective resource management and water conservation.

3. *Water pricing vs true cost of water*

BWSSB spends substantial portion of its budget on pumping water to Bengaluru. With rising costs, managing the water services of Bengaluru is becoming very expensive. As per BWSSB's vision document, the monthly power costs for pumping 1,400 MLD of water to Bengaluru are around Rs 450 million. To meet the increased demand for services and the consequent infrastructural expansion requirements, BWSSB depends on government funding, which incurs a significant debt burden. With the present tariff structure, BWSSB can only recover its operating costs.

4. *Over-exploitation of groundwater*

As per the Central Ground Water Board (CGWB), 40% of Bengaluru's population depends on groundwater (CGWB 2015). Depleting groundwater tables leads to a reduction in and drying up of groundwater wells. According to a study from the Indian Institute of Science (IISc), 78% of Bengaluru became concretised in just four decades (T. Ramachandra 2017). Studies show that only 3-8% of water reaches the groundwater (BIOME 2021). Though the city has mandated rainwater harvesting (RWH), enforcement is weak, and not all RWH structures recharge aquifers. As mentioned in the CCRA-VAVA section in Chapter 2 of this report, the meteorological drought probability is nearly 50% in the upstream areas of the Cauvery showing 20% of drought leading to water stress in the wells.

5. *Diversification of the city's water portfolio*

As the city depends heavily on Cauvery water, extreme weather conditions put pressure on water security. For instance, the floods in September 2022 inundated the TK Halli water treatment plant and two pumping station units in Mandya district (Times Now, 2022). Due to damage to pumping units at the TK Halli water treatment plant, the water supply to 50 areas across the city was disrupted (Times Now 2022). Bengaluru urgently needs a diverse water portfolio to sustain its economic and societal growth. Water conservation measures such as rainwater harvesting need stringent implementation across the city.

6. *Groundwater quality*

The Department of Mines and Geology 2011, estimates that 31% of groundwater wells water is unfit for drinking due to alkaline content, with the pH value ranging from 7.8 to 8.5. Total hardness varies from 100 to 600 mg/l in shallow and deep groundwater, leading to contamination and decreased water tables. Approximately 54% of untreated sewage in the city flows into stormwater drains.

6. *Surface run-off management*

The fast pace of built growth in the city over the last two decades has resulted in concretisation of open areas leading to less scope for seepage of rainwater to the sub-soil layers. This has led to both more surface runoff often leading to water logging and floods in different pockets of the city, and depleting groundwater tables. Moreover, built growth over stormwater drains, flood plains and natural drainage channels carrying water have reduced efficiency of the city's stormwater drainage infrastructure.

7. *Awareness on wastewater reuse and resource recovery potential to promote circular economy*

The wastewater treatment facility in the city treats 60% of the city's sewage (Ramya 2022). About 60% of treated water is reused for purposes such as minor irrigation, filling up of lakes/tanks in Kolar district and Chikkabalapur district, at the KPCL power generation plant in Yelahanka, gardening in Lal Bagh, etc. The remaining 40% is discharged into drains.[33] A market and complete value chain for wastewater reuse (such as in construction sites) is not established at present.

2.2.6 Urban planning, greening, and biodiversity

Status quo of the sector

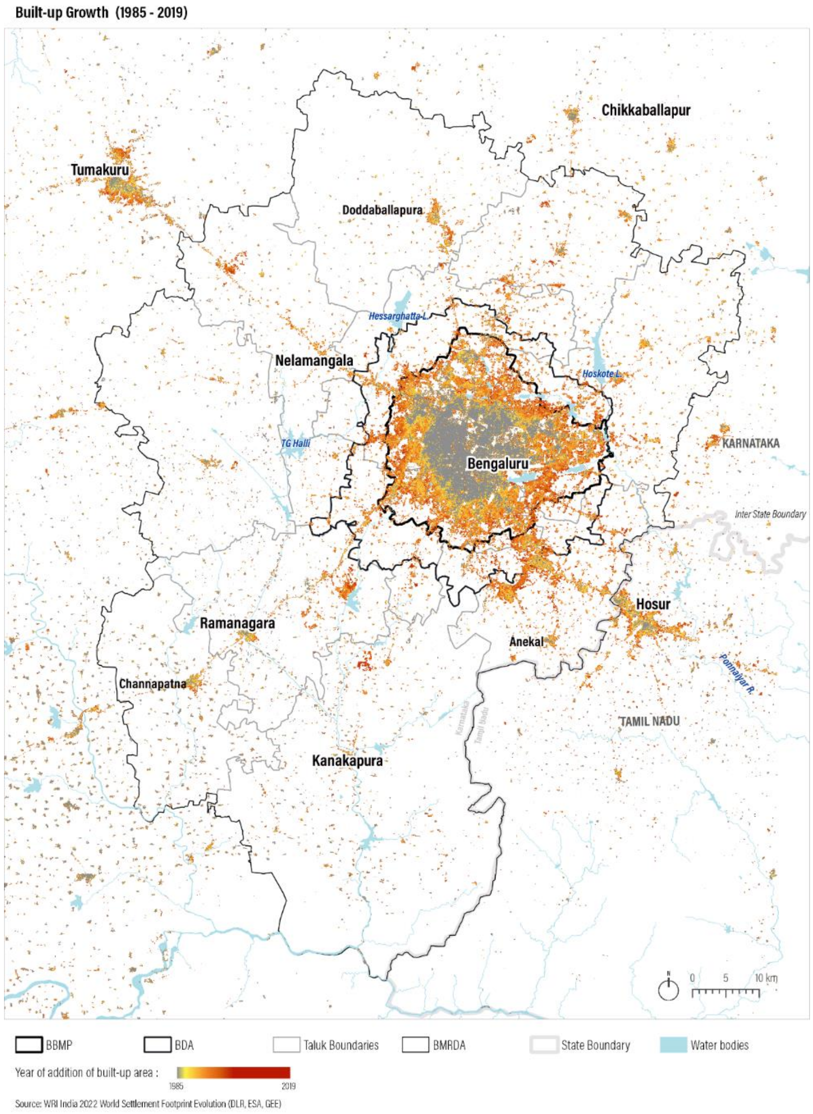
Bengaluru has seen unprecedented growth in the last few decades. Between 2001 and 2011, population densities in the BBMP and BMA limits increased by about 46%, from 82 persons per hectare (pph) to 119 pph, and from 47 pph to 70 pph, respectively (Opencity 2020). This is, however, much lower than URDPFI guidelines, which suggest a gross population density of more than 200 pph for megalopolises (i.e., cities with a population of over 10 million). Bengaluru has, in fact, seen de-densification of its inner-city areas,[34] while most of the growth – in both population and urbanised area – has occurred in its outer suburbs and peripheries beyond the Outer Ring Road (ORR), spilling beyond municipal and metropolitan limits (see Figure 27).[35]

Rapid urbanisation accompanied by land use/land cover changes and haphazard sprawl in the city region have not only led to significant inefficiencies in urban management and gaps in service delivery, but also impacted natural infrastructure and ecosystems adversely. This has cascading effects and exacerbates climate change risks for the city. These include increasing air pollution and surface temperatures, urban heat islands, and adverse impacts on biodiversity, health and productivity; lower recharge potential, increasing water scarcity and cost of access to water resources; and frequent flooding, causing loss of life and property. Furthermore, the livelihoods of local communities dependent on these ecosystems are affected, and urban inequities are reinforced or exacerbated, as poor and vulnerable

[33] 2019 data shared by BWSSB with WRI India for BCAP preparation.
[34] In the 2001–11 decade, population growth rates in most BBMP wards inside the ORR were in the negative, with the share of population falling from 69% to 55% in the period. Simultaneously, a positive and prominent growth rate of 118% was seen in outer wards beyond the ORR and peripheral areas (Opencity 2020).
[35] This has been spurred by development along arterial roads and large-scale projects in far-flung locations, such as the International Airport and Special Economic Zones. Growing levels of motorisation, greater availability, and affordability of land on the outskirts, combined with lax regulation, have led to the fluid outward spread of the city in all directions. Moreover, development in the central and inner-city areas (having the highest infrastructure and service levels) is constrained by relatively low buildable limits.

communities that bear the brunt of these negative outcomes lack the resources to cope with stresses and climate shocks (Goswami et al. 2022).

Figure 27 Built-up growth of Bengaluru



<u>Growth of total built-up area in the city-region between 1985 and 2015:</u>

Municipal limits (BBMP): 192 sq. km. to 518 sq. km. (170% increase)

Metropolitan limits (BDA): 200 sq. km. to 619 sq. km. (210% increase)

Metropolitan region (BMRDA): 273 sq. km. to 924 sq. km. (238% increase)

Source: WRI India analysis using World Settlement Footprint (WSF) Evolution 1985-2015, German Aerospace Center (DLR)

Ongoing initiatives in the city

The urban planning as well as greening and biodiversity sectors are governed by multiple statutory and regulatory frameworks. A few key ones are listed below:

- The Karnataka Town and Country Planning (KTCP) Act, 1961

- Revised Master Plan, 2015 (RMP 2015) for the Bengaluru Metropolitan Area, prepared under the provisions of the KTCP Act, 1961
- Revised Structure Plan, 2031 (RSP 2031) for Bengaluru Metropolitan Region, prepared under provisions of the BMRDA Act, 1985
- BBMP Act, 2020
- Karnataka Preservation of Trees Act, 1976 and Rules, 1977
- Karnataka Biological Diversity Rules, 2005, under The Biological Diversity Act, 2002

Bengaluru is currently implementing (or planning for) various policies, plans, and schemes within this sector. Some key initiatives are listed below, categorised on the basis of their strategic orientation. The broader objectives of these initiatives, along with their alignment with the BCAP goals of mitigation, adaptation and resilience building, are listed in the table below.

Table 7 Ongoing initiatives in the urban planning and greening and biodiversity sectors in Bengaluru

Strategic Orientation: **Urban planning and development**	
Initiatives: • Bengaluru TOD Policy, 2022 – approved • BMLTA bill, 2022 – approved • Revised Master Plan (RMP) for Bengaluru is under preparation (by BDA) • Bengaluru Smart City Mission projects – ongoing (by BBMP) • Integrated and Sustainable Urban Development along Mass Rapid Transit Corridors in Bengaluru – ongoing pilot project for TOD-MMI planning along Metro Blue Line (by DULT and BMRCL) • K-100 – ongoing pilot project to demonstrate Rajakaluve rejuvenation (by BBMP)	*Objectives:* These initiatives aim to restrict haphazard sprawling of the city and to optimise its land use/land cover changes caused due to unplanned urbanisation. They also aim to achieve land use transport integration, which will help reduce vehicular trips and minimise travel distances, thereby reducing emissions. They address both adaptation/resilience and mitigation goals of the BCAP.
Strategic Orientation: **Greening and biodiversity**	
Initiatives: • Draft Building Construction Environment Management Regulations, 2022 • Tree Census – ongoing (by BBMP) • Plantation Programmes and Tree Canopy Management (by BBMP) • Greening Urban Area (GUA) Scheme (by Forest Department) • Afforestation of Other Areas (AOA) Scheme • Road-Side Plantation (RSP) Scheme • Nagar Van Scheme • Environment Department to map trees to identify carbon-neutral areas	*Objectives:* These initiatives focus on increasing and improving the city's existing natural green cover and biodiversity. They will help improve the city's liveability and resilience to climate hazards and reduce GHG emissions. Thus, they support the BCAP goals of adaptation/resilience and mitigation.

• Biodiversity Management Committee (BMC) constituted	

Areas of improvement for addressing barriers to a climate-progressive urban planning, greening and biodiversity management

Urban land use patterns, infrastructure networks, and built forms can strongly influence a city's contribution to climate change as well as its climate-related risks. Urban planning thus plays a critical role in mitigation and adaptation, to build resilience to risks and reduce vulnerabilities. The city's green cover is not only its carbon sink, but it also supports several critical aspects of liveability, such as improving the microclimate and air quality, acting as a sponge for excess stormwater run-off, increasing groundwater recharge, and supporting biodiversity. Biodiversity, in turn, is intrinsically connected to the health of ecosystems and human well-being. Thus, strategic actions in this sector are fundamental to addressing climate change and preparing for a resilient future.

1. *Land use-transport integration and for a compact growth form*

The prevailing RMP 2015's growth strategy is premised on the 'compact city' concept. It aims to minimise urban sprawl by (i) encouraging the development of vacant lands in strategic locations, (ii) facilitating mixed uses and densification in designated areas, (iii) promoting renewal/redevelopment of older neighbourhoods in and around the core, and in derelict industrial sites, based on potential. The intent needs to be adequately supported by holistic strategies and robust enabling frameworks.

The plan offers additional development rights[36] by means of additional Floor Area Ratio (FAR). The present TOD policy offers a significant opportunity if supported by adequate statutory/regulatory frameworks to enable regeneration for a meaningful, city-wide land use transport integration and compact growth.

2. *Resource and urban management*

Given the rapid outward spread of the city, the municipal boundary was extended in 2007. This has resulted in increase of use of private vehicles, fossil fuel usage, and groundwater extraction. While the demand for water, energy, and transport is growing rapidly along with the population, inequitable access and continued dependence on unsustainable sources or means pose a challenge in terms of the adequate supply of safe, reliable and affordable services for the city's residents. There is a higher concentration of public open spaces, education and healthcare facilities within the ORR than beyond it (Opencity 2015).

A 2017 study found that the city has 19 sq. km of public open space under BBMP parks and playgrounds, accounting for around 3 to 4% of the municipal area[37]. This translates to per

[36] The RMP 2015 permits a FAR between 1.5 and 3.25 for the entire conurbation area, based on land use, access road width, and plot size, with higher provisions for larger plots along wider roads.
[37] A study conducted by Janaagraha (*Janaagraha Open Spaces Survey*) during 2017. https://www.janaagraha.org/files/publications/PARKS-PLAYGROUNDS-SCORE-OF-BENGALURU-2017.pdf

capita open space of 2.2 sq. m, lower than the URDPFI guidelines for the maintenance of basic ecosystem services, and thus needs attention.

3. *Affordable housing in safe and accessible locations*

As per Census 2011 figures, 21% of households were in 'liveable' or 'dilapidated' housing (i.e., categories other than 'good'), and 29% of households occupied houses without concrete roofing, making them susceptible to climate hazards such as high temperatures, storms, and heavy rainfall. At the time, an estimated 1.4 lakh households, or 8.4% of the city's population, (Census 2011) also lived in slums.

Urban poor settlements often tend to be located in high-density, congested areas, often in low-lying, flood-prone zones, making them most vulnerable to natural and man-made disasters.

4. *Consideration of urbanisation impacts on natural infrastructure which could increase climate risks and vulnerabilities*

A visible outcome of the present form of urbanisation (including planned, unplanned, and unmanaged urban development) in Bengaluru is the loss of natural infrastructure resources. According to one study, between 1992 and 2016, the built-up area within BBMP limits increased from 27% to 77%, while there was a decline in the area under vegetation from 46% to 7.5%, water bodies from 2.6% to 1%, and others (open lands, agriculture) from 24% to 14.6% (T.V. Ramachandra et al. 2015). Several other studies conducted for different jurisdictions or spatial extents in the city-region and time periods, reveal the same trend ('District Bengaluru Urban, Government of Karnataka | Silicon Valley of India | India' BUD; Hanjagi 2019; Hiremath et al. 2013; Journal 2016; Singh TERI). The analysis for the 1997–2017 period shows a significant loss of surface water bodies in the city region and the overlap between built-up area and vegetation loss in Bengaluru (see *Annexure E*). Changes in green cover, from forests or plantations/woodlots to agricultural land or manicured urban greens with exotic species, also have consequences for the quality and quantity of ecosystem services provided by them (Goswami et al. 2022).

The increase in paved/concretised impervious surfaces combined with a decline in blue, green, and other permeable open spaces, and tree cover, has had cascading ecological and climatic impacts, such as- an increase in average surface temperatures and urban heat island effects, affecting the local climate (Shridharan 2021).[38] Reduced infiltration and increased stormwater run-off, combined with the encroachment and loss of water bodies (M. Rao 2020; Shridharan 2021) and connecting drainage channels, has not only contributed to increased incidence of flooding (even during normal rainfall), but also reduced surface and groundwater availability due to lower holding and recharge capacities. The growth of the built-up area over high-value recharge zones has had significant impacts on the potential recharge volume, which, combined with high abstraction rates, has stressed groundwater resources in Bengaluru *(see Annexure D).*

[38] Street trees have been found to reduce air temperature by as much as 5.6°C and road surface temperatures by around 27.5°C (T. V. Ramachandra et al. 2015).

5. *Number of trees per capita and distribution of green cover*

Over the years, Bengaluru has lost significant number of trees to development, infrastructure projects and damage from extreme weather events –a problem compounded by excessive concretisation and unscientific pruning. Due to paucity of land within the city limits, compensatory afforestation or planting schemes tend to be located far from the original site, often in new growth or peri-urban areas, or even other parts of the state (Correspondent 2021; N. 2019), and effective maintenance and monitoring of survival rates remains an issue. A 2017 inventory of trees within BBMP limits found that there are about 1.48 million trees, translating to one tree for every seven persons, while respiratory carbon offset alone requires eight trees per person. There is wide variation in ward-wise tree counts and density, which ranges from less than one tree per 500 persons to 1.25 trees per person ('Green Spaces in Bengaluru' IISc). The absence or loss of tree cover in urban areas adversely not only impacts ecosystems and public health but also exacerbates climate risks and vulnerabilities. The BBMP's Forest Cell has begun a tree census, a massive exercise that will require adequate resources to complete effectively and expeditiously.

6. *Loss of natural habitats and biodiversity*

Bengaluru's parks/gardens, natural habitats (including grasslands, hillocks, sacred groves, forests, water bodies), and trees support hundreds of species of flora and fauna. The fragmentation, deterioration and loss of blue-green networks/spaces and tree cover in the city region, alongside an increase in surface temperatures, are impacting biodiversity. They threaten to wipe out endangered species such as the slender loris (Rao 2020), and are also associated with the loss of food, fodder, and livelihoods for certain lower-income and marginalised communities. As per the Biological Diversity Act, 2002, the BBMP had set up the Biodiversity Management Committee (BMC), which had prepared Bengaluru's first People's Biodiversity Register (PBR) way back in 2009. The BBMP reconstituted a new BMC in January 2020, tasked with the restoration of local biodiversity.

7. *Integration of climate lens in urban policy, planning and regulatory frameworks*

The key legislation governing urban planning in the state – the Karnataka Town and Country Planning Act 1961 – does not mandate assessment of land suitability and carrying capacity, environmental and social impacts, and vulnerability to climate/disaster risks. Nor is it explicit on the need to protect and integrate natural infrastructure and risk mitigation management measures into master plans and town planning schemes. Moreover, these spatial plans (focused on road networks, land use zoning and development regulations), are not required to integrate common city (sectoral/cross-sectoral) goals, targets and strategies, or the preparation of GHG inventories to create baselines and track emissions. As a result, current plans/schemes, development regulations, urban design, and infrastructure guidelines and standards do not adequately incorporate climate resilience parameters. Project review and approval processes such as environmental clearances also need to be more rigorous. Furthermore, the city lacks an integrated spatial database that is periodically updated and publicly accessible to track ongoing activities and improve transparency, accountability, and participation.

8. *Governance mechanisms for urban planning, management and climate action*

These challenges are made more complex by the multiple policies and institutions at the national, state, regional and local levels, which are involved in managing land, development, natural resources, and infrastructure. With their own jurisdictions and functional autonomy (i.e., governing laws, mandates, plans/schemes and budgets), these agencies currently operate in silos, with narrow expertise and little coordination. This has led to fragmented decision-making and actions that are also often conflicting, as their institutional mandates are at odds with one another). Furthermore, staff capacities are limited and inadequate for the tasks at hand.

2.2.7 Disaster management

Status quo of the sector

Climate change has been causing disasters across the globe, and this has increased so significantly in 2022 that it is being referred to as the Year of Disasters (Reliefweb 2023; Staff 2022). The disasters have been extensive, from the eruption of a volcano in Hawaii to floods in Pakistan and India. Bengaluru city has also been subject to its share and more in 2022. The end of August 2022 saw excessive rains in the city which is reflected in the datasets published by KSNDMC. Bengaluru Urban District, which normally receives 123 mm of rainfall in August, got 332 mm in August 2022, an increase of 170%. Table 8 gives taluk-wise normal and actual rainfall for the month of August 2022 (KSNDMC 2022) in the BUD region. As can be observed from the table, there is more than a +170% departure from normal for the month. Such sudden extreme events, along with inadequate planning, enhance the loss and damage to people, infrastructure and the economy.

Table 8 Taluk-wise rainfall in August 2022 for BUD region

Taluk	Rainfall in Aug 2022		Percentage departure from normal
	Normal in mm	Actual in mm	
Bengaluru North	145.1	280.0	93
Bengaluru South	135.3	389.8	188
Bengaluru East	117.6	294.5	150
Yelahanka	95.2	291.4	206
Anekal	124.4	363.1	192
Bengaluru Urban	123.0	332.0	170

Source: KSNDMC, 2022

For Bengaluru city, as part of the larger Climate Change Risk and Vulnerability Assessment (CCRA-VA), five key plausible climate and environmental hazards have been identified: urban flooding, urban heat, drought, thunderstorms and lightning, and air pollution. A detailed approach for the identification of these hazards is discussed in the Chapter 2, along with the impacts.[39] For example, a total of 19% of the BBMP area can be tentatively impacted (within a 250 m radius of flood vulnerable areas) by the floods, based on KSNDMC data, and with a further increase in intensity and magnitude, further impacts are possible. The scope of this sector in the BCAP is limited to climatic and environmental hazards as detailed in the CCRA-VA report. Considering this, there is a need to have adequate planning on actions to be taken to reduce the risks of these disasters with better disaster management and risk reduction systems. This could be via combination with more comprehensive databases on past occurrences of disasters, enabling better predictive analysis and thereby enhancing preparedness for such untoward occurrences.

Ongoing initiatives in the city

There are multiple statutory and regulatory frameworks for disaster risk reduction at both national and state levels. A few are listed below:

- The Disaster Management Act, 2005
- The Disaster Management (National Disaster Response Force) Rules, 2008
- The Karnataka State Disaster Management Policy, 2020
- National Disaster Management Plan, 2019
- Karnataka State Disaster Management Plan, 2020–21
- Indian Standard Protection of Buildings and Allied Structures against Lightning Code of Practice, 1991
- Indian Standards on Earthquake Engineering, 1993

The state of Karnataka has proactively formulated individual plans for climate disasters of concern for Bengaluru city. These are summarised in Table 9 below. Furthermore, the state has individual district-level disaster management plans (DMPs) for all districts with the exception of BUD. In addition, the current state DMP has initiated the preparation of DMPs at the panchayat level, which has been completed in approximately 2,000 panchayats[40]. At the city level, the BBMP's stormwater drains department is actively working with KSNDMC on urban flood models to predict probable areas where flooding could occur in the city and to take pre-emptive action.

Table 9 Ongoing initiatives for disaster risk reduction in Bengaluru

Strategic Orientation: **Data recording and monitoring systems**	
Initiatives: • Rainfall Atlas for Karnataka, 2019 • District-wise daily, weekly, monthly, seasonal and annual reports on rainfall, temperature and relative humidity for Karnataka • Annual reports on earthquakes in Karnataka	*Objectives:* These initiatives aim to get an understanding of the climatic parameters, i.e., rainfall, temperature and relative humidity in Karnataka, to help improve preparedness for these climatic variations. The information on earthquakes aims to give insights into locations vulnerable to seismic activity for better preparedness across the state.

[39] Refer to Chapter 2 of this document or the CCRA-VA report.
[40] Personal communication with KSDMA official in November 2022.

Strategic Orientation: **Disaster management and risk reduction planning systems**	
Initiatives: • Climate Change Scenario in Karnataka: A Detailed Parametric Assessment, 2020 • Karnataka State Disaster Management Plan – Volume 1 and 2 • Urban Flood Forecast System • Karnataka State Action Plan for Flood Risk Management, 2021 • Heat Wave Action Plan, 2022 • Lightning Action Plan, 2022	*Objectives:* These state-level assessment and action plans aim for better preparedness in the event of hazards, and an action plan during the occurrence of the hazard, thereby reducing loss and damage, and building faster recovery mechanisms.
Strategic Orientation: **Post-disaster recovery**	
Initiatives: • Manual on Administration of State Disaster Response Fund and National Disaster Response Fund	*Objectives:* These initiatives mainly aim to ensure prompt post-disaster rescue and relief measures, so that the state can recover faster and with minimal casualties.

Areas of improvement for addressing barriers to a climate-progressive disaster management system

1. *District- or city-level legal policy framework for disaster management*

Cities, especially a megapolis like Bengaluru, need to have a definite plan of action to ensure preparedness during disasters. With a risk reduction plan in place, rescue and relief operations can be performed smoothly. When all the relevant authorities are aware of the process they need to follow, there are fewer discrepancies and delays. Currently, BUD does not have a DMP. The district does have a Disaster Management Cell to oversee activities related to climate and other disasters, including chemical disasters (Citizen Matters 2015). However, the lack of a legal policy framework is still a matter of concern. BUD has five taluks, of which four constitute Bengaluru city. The extent of urbanisation and population explosion that the city has seen in the 21st century puts a greater number of people at risk. Moreover, the city houses many multinational companies and is the IT hub of the country. The loss of infrastructure potentially also translates to economic loss to the country, and having a district disaster management plan (DDMP) in place could significantly reduce the loss and damage.

2. *Risk reduction as an integral part of the urban planning process*

Currently, urban planning processes primarily take into account population growth and the need for housing based on population growth. However, given Bengaluru's high population density, the planning has to be more extensive and elaborate, incorporating better access to services and resources based on URDPFI guidelines. More importantly, in urban agglomerations, risk reduction strategies must be included in the urban planning process.

3. *Capturing of micro-level/ local inputs*

While overall city-level action plans are an essential tool for appropriate action to be taken both from a mitigation or adaptation perspective, the localised concerns also need to be addressed. Bengaluru has constituted ward committees with, representation from the local community, along with representatives from various line departments that provide services such as electricity and water to the ward. Having such a system already in place could potentially help in understanding these localised inputs on ward-level concerns, and adequate planning to address these concerns can be initiated. Ward-level inputs on localised problems could give better insights into local problems and build a resilient disaster risk reduction system.

4. *Accessible decentralised infrastructure support during disasters*

Time plays a crucial role in reducing loss and damage when a disaster occurs. Having adequate decentralised infrastructure could result in faster response to rescue and relief operations during disasters. During the pandemic, this was addressed to a certain extent, but was limited to the pandemic itself. This needs to be expanded across all disasters that the city could potentially face. There is also limited access to other support systems, such as financial and human resources, whose availability could enable better and more prompt action at the local level. Without a DDMP or city-level disaster risk reduction plan, there is limited information on the steps to be followed in such situations. Adequate capacity building, along with the formulation of a DDMP, could be a first step towards addressing these inadequacies.

5. *Coordination between different local departments*

During disasters, essential services are often disrupted. It has been observed that during disasters, there is a power cut or loss of access to potable water. Sometimes sewerage lines are also damaged, which could potentially double the consequences in instances like flooding. The floods in August 2022, for example, resulted in multiple power interruptions, especially in the flooded areas. Prompt action and pre-emptive measures by appropriate and well-coordinated services can substantially reduce the risk.

6. *Access to services and resources*

The CCRA-VA assessment details the extent of accessibility across different zones of Bengaluru city. One aspect of concern is the inequitable access to various services across the city. Areas lacking in access to basic and critical services and also prone to flooding[41], experience a cascading effect of disasters.

7. *Governance and infrastructure system to assess post-disaster loss and damage*

To ensure faster post-disaster recovery, Bengaluru needs a protocol for assessing loss and damage within a stipulated time, based on the Manual on Administration of State and National Disaster Response Fund. The city currently relies on the state-level KSDMA for this. The lack

[41] Refer to the CCRA-VA document for details on the study.

of a proactive governance and infrastructure system to assess loss and damage in the city needs to be addressed.

2.3 Existing governance and institutional structure

2.3.1 Guiding governance framework

With the 74^{th} Constitutional Amendment Act, urban local bodies (ULBs) in India were empowered to act as institutions of local self-government. The Act also empowered state governments to devolve more power, functions, and funds to ULBs. The ULB governing Bengaluru is BBMP, as per the *Bruhat Bengaluru Mahanagara Palike Act, 2020* (BBMP Act, 2020). This Act replaced the Karnataka Municipal Corporation Act, 1976, for the city, as the 1976 Act was inadequate to address the administrative and structural requirements of Bengaluru[42].

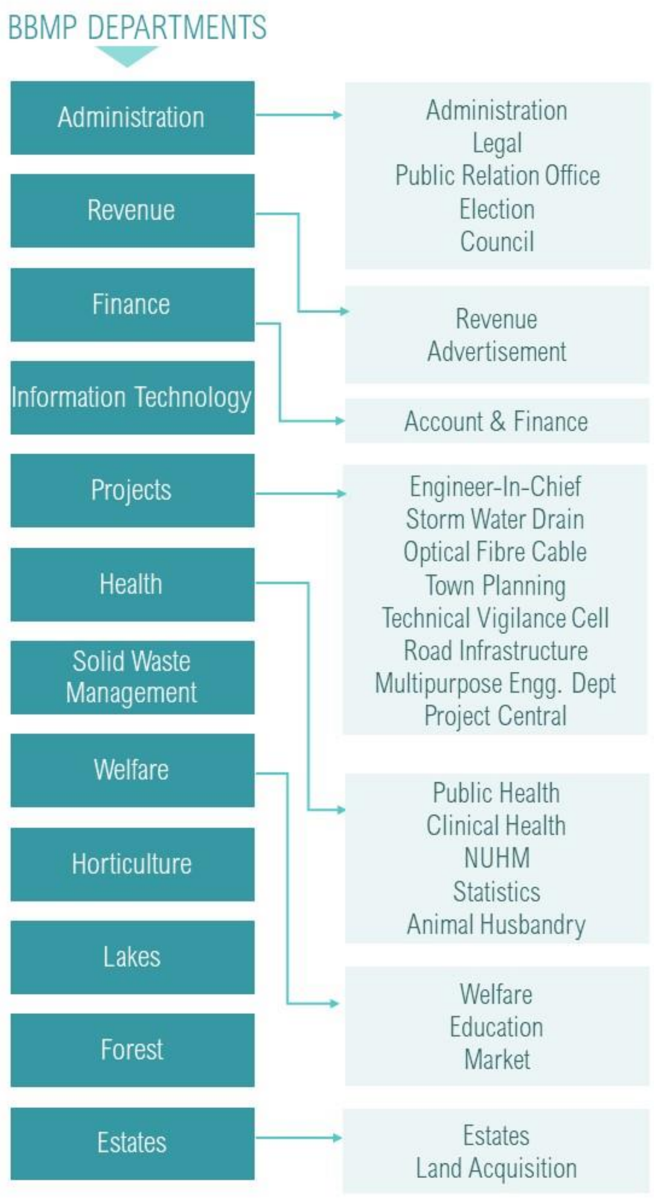
Article 243ZE in the 74^{th} CAA mentions the establishment of a Metropolitan Planning Committee (MPC) to manage and plan for larger urban agglomerations. According to this and the BBMP Act, 2020, the Metropolitan Planning Committee has been set up to prepare a draft development plan for the Bengaluru Metropolitan Area. Two-thirds of the members of the MPC are elected representatives, in keeping with the principles of decentralisation and subsidiarity. At present, landuse and city development planning exercise is carried out by the Bangalore Development Authority (BDA) for the Bangalore Metropolitan Area (BMA).

2.3.2 City-level functions and responsible agencies

BBMP has multiple departments housed within itself to carry out its prescribed responsibilities. Figure 28 illustrates the departments and subdepartments. Each department is headed by Additional/Special Commissioners or their equivalents.

[42] The BBMP Act, 2020

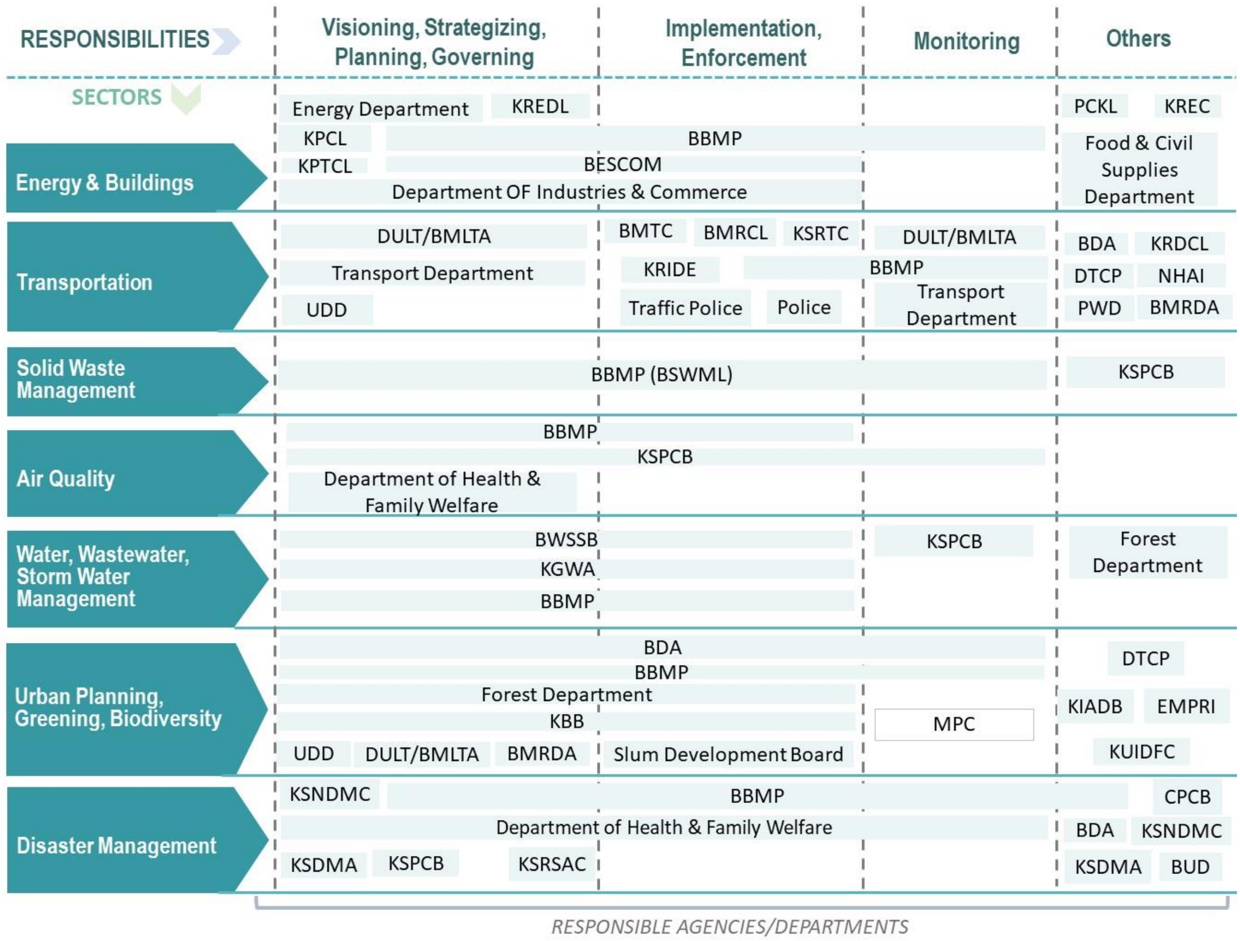
Figure 28: Departments of the BBMP and their functions



Source: Compiled by authors based on information available on BBMP Websites.

The BBMP Act, 2020 gives the ULB the power and responsibility to prepare and implement schemes for the 18 functions provided for in the 74th CAA. In Bengaluru, various parastatal agencies and departments have been carrying out many of the city functions relating to service delivery. Figure 29 lists relevant sector-wise departments/agencies and their key responsibilities. *Annexure I* lists the roles and responsibilities of various agencies and departments with respect to each of the seven sectors discussed in the BCAP. The presence of multiple agencies and associated coordination requirements make this a central idea to be addressed through an appropriate governance mechanism for effective implementation of BCAP.

Figure 29 Institutional mapping of the sectors considered in the BCAP



Source: WRI India Analysis

Photo Credit : Rajeev Malagi/WRI India

3 BASELINE ASSESSMENT FOR BENGALURU: CCRA-VA AND GHG INVENTORY

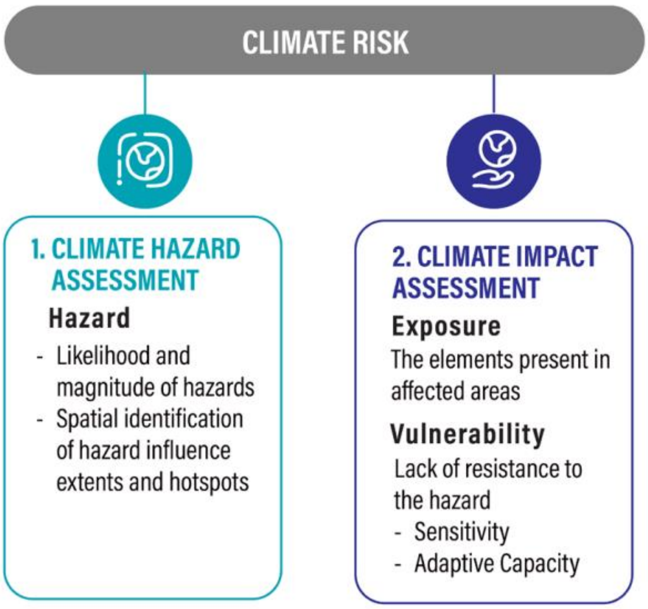
3.1 Climate Change Risk and Vulnerability Assessment (CCRA-VA)

3.1.1 Objective and components of CCRA-VA

The Climate Change Risk and Vulnerability Assessment (CCRA-VA)[43] for Bengaluru was carried out as part of the BCAP in an attempt to understand the key areas that the city needs to focus on, in order to enhance its adaptive capacity and build resilience against climate change risks, as seen through the combined lens of humans, nature and the economy. The following sections summarise the key findings of the CCRA-VA. The overall approach adopted for this assessment is a combination of two frameworks, namely the Climate Change Risk Assessment (CCRA) (Cities 2018b) framework developed by C40, and the Climate Hazard Vulnerability Assessment (CHVA) framework developed by the WRI India.

Risk assessment, the final output of the CCRA-VA report, refers to the "scientific estimation of risks from a qualitative and/or quantitative perspective, keeping into account the previously mentioned factors impacting risk" (Fifth Assessment Report — IPCC 2014). A schematic of the framework applied to assess risk is depicted in Figure 30.

Figure 30 Parameters used for Vulnerability and Risk Assessment



Source: WRI India, adapted from C40's CCRA Framework and WRI India's CHVA Framework

43 A detailed report - Climate Change Risk and Vulnerability Assessment has been prepared under BCAP and can be accessed along with this report

The following sections summarise these components of climate change risk assessed for Bengaluru:

- Past and future trends of key climatic parameters for Bengaluru leading to identification of climate hazards
- Analysis of each hazard to understand their likelihood and magnitude
- Exposure of Bengaluru to the identified hazards at a sub-city level
- Vulnerabilities of the city and its residents determining
- the extent of impact that Bengaluru is likely to face from those hazards.

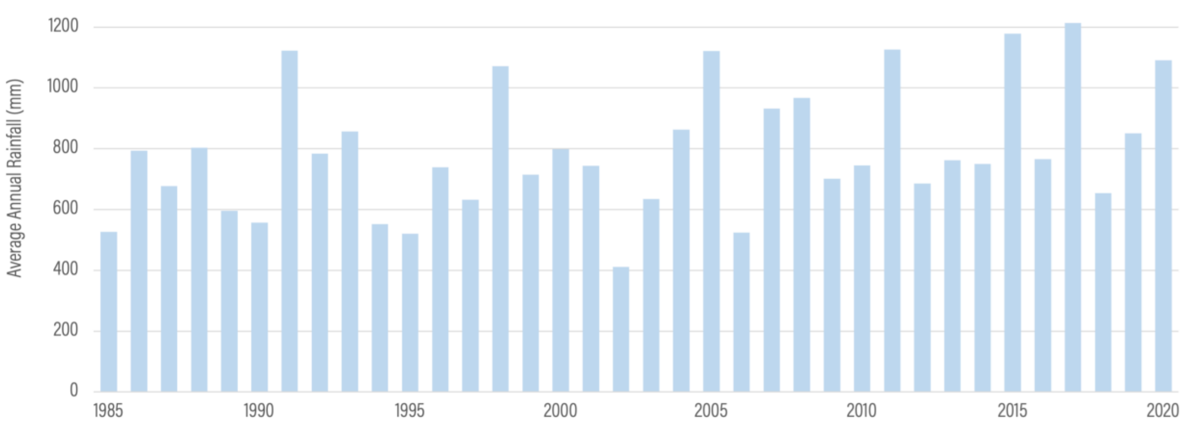
3.1.2 Climate trends in Bengaluru and adjoining regions: Recent past and future scenarios

For Bengaluru, temperature and precipitation are the two major climatic parameters that assume greater relevance, and hence the CCRA-VA focuses on them. The section is sub-divided into recent past trends and future scenarios. Details of the methodology used, data sources, description of assessments, and key findings are discussed in Chapter 3 of the CCRA-VA report. The following sections present a summary of the same.

Recent past trends for rainfall and temperature in Bengaluru

The long-term inter-annual variations in rainfall were observed for the period 1985-2020, using the Indian Meteorological Department's (IMD) daily gridded rainfall data. It was observed that the mean annual rainfall in Bengaluru is approximately 790 mm since 1985 as seen in Figure 31.

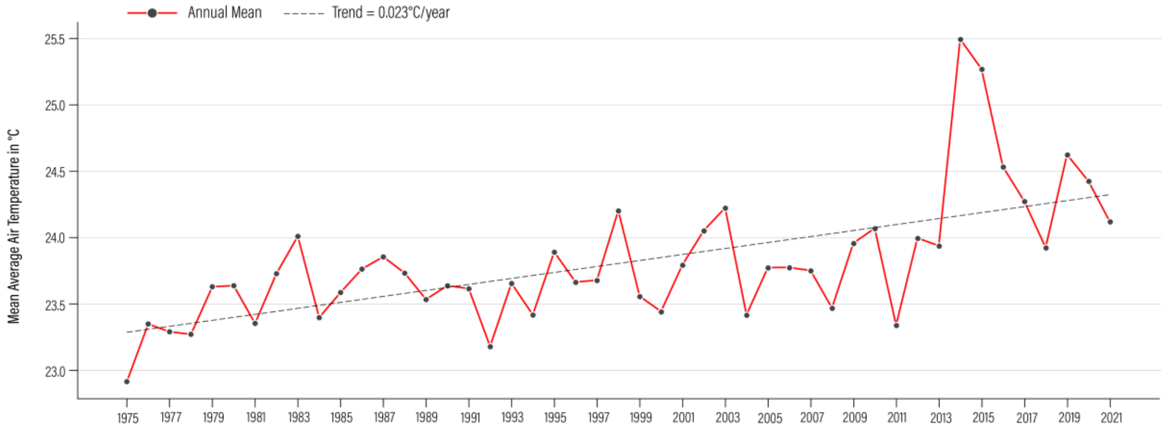
Figure 31 Inter-annual average accumulative rainfall between 1985 and 2020



Source: WRI India analysis based on IMD gridded rainfall data; accessed July 2022

Air temperature trends were analysed from 1975 to 2021, using the National Center for Environmental Information (NCEI) data to assess the annual variations. The mean air temperature in Bengaluru has been rising at 0.23°C per decade (0.023°C per year) since 1975, as seen in Figure 32.

Figure 32 Inter-annual mean air temperature between 1975 and 2021



Source: WRI India analysis based on meteorological data from NCEI; accessed July 2022

Climate projections using RCP Scenarios

The understanding of future scenarios was based on projections made by a number of Representative Concentration Pathway (RCP) models available for Bengaluru and the adjoining region for the short term (2070) and long term (2100). These projections have considered a larger area of Bengaluru and its adjoining area, covering the Cauvery Ponnaiyar basin region (as shown in Figure 8).

Assessment: The assessment focuses on the future projected changes for RCP 4.5 and 6 scenarios[44], for the short term (2021 to 2050) and long term (2071-2100) respectively. The historical baseline is observed from 1987 to 2016 aligned with the analysis followed in Karnataka State Action Plan for Climate Change (KSAPCC)[45] 2021 - Version 2. These time periods set the basis for comparing the extent of change in the climatic parameters and are also spatially represented for the projected changes in precipitation using select models. Additionally, the continuous projected time-series is utilised to study the overall 80-year-long patterns and fluctuations in the climatic parameters.

Contributing parameters: Minimum and maximum temperature as well as precipitation have been analysed. The positive deviation from the baseline is expressed as + ↑ depicting increase and the negative deviation is expressed by - ↓ depicting decrease from the baseline.

Key findings[46]:

[44] RCP scenarios have been extensively used in climate research. The two mid-range scenarios, RCP 4.5 and 6, project the CO_2 equivalent concentrations by end of the century to reach stabilisation without overshoot.
[45] KSAPCC, or the Karnataka State Action Plan for Climate Change, is the primary policy document for the state of Karnataka as mandated under the National Action Plan for Climate Change where each state needs to have a strategic action plan.
46 Analysis uses NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) for RCP 4.5, CMIP5 daily data for RCP 6, ECMWF ERA5 daily data for historical baseline. Refer to CCRA-VA document for details.

Minimum air temperature: For the horizon year of the CAP and the short-term period, based on RCP 4.5 analysis, by 2050, it is projected to increase from the baseline up to + ↑ **12%** for the BBMP area, with the highest positive change being projected for BBMP limits. For RCP 6, the BBMP is projected to have heightened variation from the baseline, ranging up to + ↑ **46%** in the long term.

Maximum air temperature: As per RCP 4.5, for the entire 80-year period, the highest projected increase in the temperature is around + ↑ **12%** across the entire study area. As per RCP 6, the percentage of projected positive change for the BBMP appears to be the most dramatic amongst all, rising by nearly + ↑ **37%** through the long term.

Rainfall: The overall study area is projected to have both rainfall deficit and intensification under different models for the study period (RCP 4.5: - ↓ **54%** to + ↑ **142**%, RCP 6: **-** ↓ **89%** to + ↑ **236%**), so the region will need to be prepared for the likely impact of both. Most of the models result in a periodic increasing/ decreasing pattern of rainfall indicating lack of consensus. Results from rainfall projections, variations and direction of change, along with average rainfall changes, lack accuracy and consistency amongst models for both RCP 4.5 and RCP 6 as rainfall is highly seasonal and subject to local conditions. However, all models largely point indicate an increase in the extent of variation leading to greater possibilities of both wetter and drier periods.

3.1.3 Assessment of Climate Hazards for Bengaluru

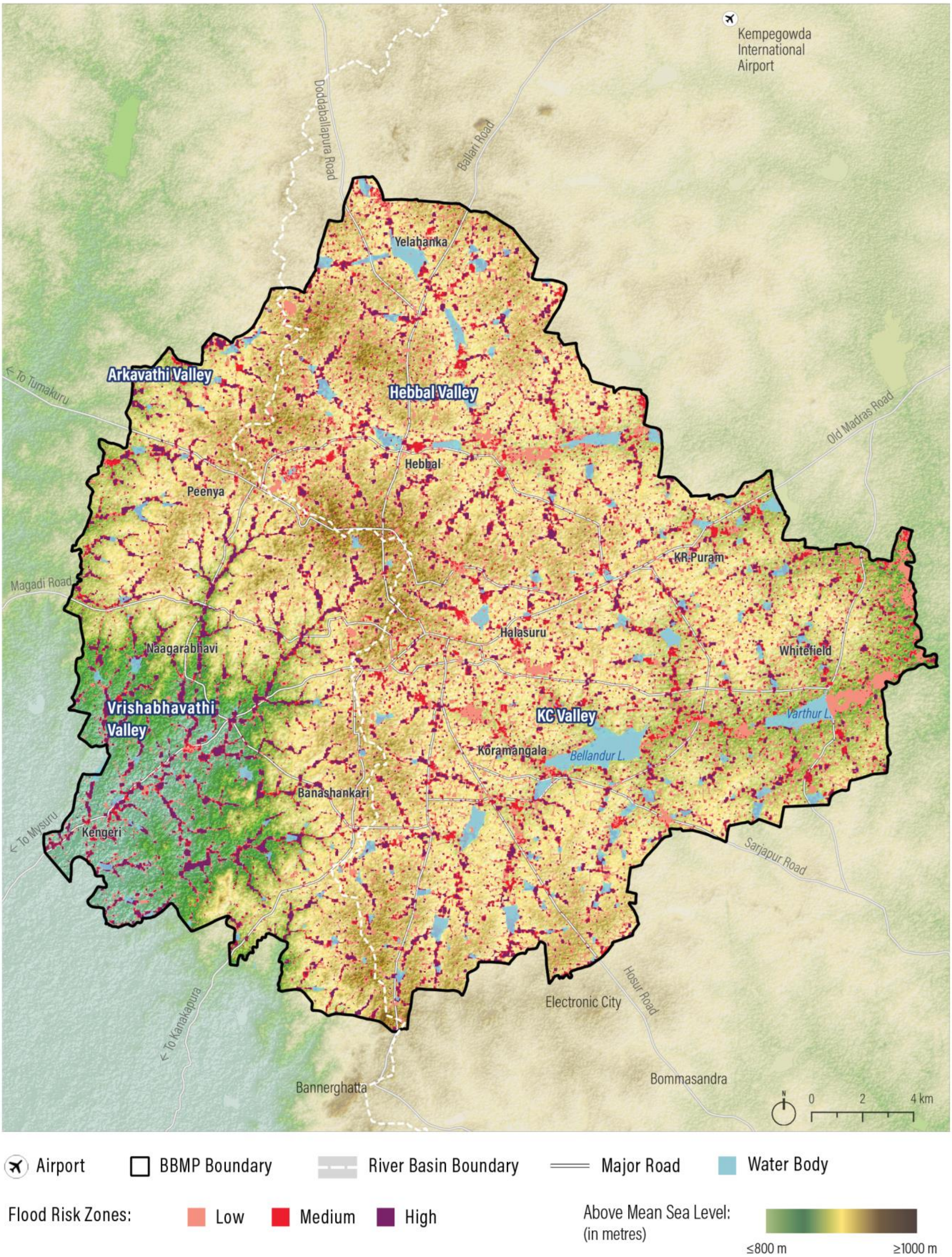
For Bengaluru, five key climate and environmental hazards have been identified. These are: a) Urban flooding, b) urban heat, c) Thunderstorms and lightning, d) Drought, and e) Air pollution. These are described in detail in Chapter 4 of the CCRA-VA report. Below is a summary of the same.

Urban flooding

The assessment of urban flooding is based on analysing two parameters: rainfall pattern, including extreme rainfall events (intensity, duration, and frequency analysis) and identification of areas at risk of flooding.

Based on IMD classification of 24-hour accumulated rainfall, Bangalore Urban District (BUD) experienced 282 Heavy and 14 Very Heavy rain events per year on average between 2016 and 2021. These rainfall events contributed to nearly 11%, of the total annual average rainfall received in the area for the study period. Most heavy rainfall events are observed in the western part of the region, within the Cauvery Basin. Moreover, it is observed that more than 90% of the rainfall events experienced in the city range from very light to moderate, while the frequency of heavy rainfall events (sum of rather heavy, heavy and very heavy events) is around 6%. Based on data from all 184 stations in the BUD between 2016 and 2021, very heavy to heavy events were mostly observed for a day, with rare occurrences of two days, while nearly 40% of moderate rain events lasted three or more days. Spatial distribution of days of consecutive (lasting two days or more) of rather heavy or moderate rainfall shows a high concentration in the Vrishabhavathi Valley within BBMP limits. Based on the observed rainfall patterns, and the data on flood-vulnerable hotspot areas provided by KSNDMC, it was analysed that a total area of nearly 180 sq. km. in the city is at risk of floods which hosts nearly 21% of the city's population. Based on the composites of various inundation extents, flood risk in the city is categorised into High, Medium, and Low risk zones containing about 6%, 4% and 11% of the population, respectively (Figure 33).

Figure 33 Flood risk zones in Bengaluru city



Source: WRI India analysis using topography from SRTM, rainfall from IMD (refer to CCRA-VA report for details)

Urban heat

The assessment of urban heat risk has been carried out by analysing air temperature anomalies and trends, heat wave incidents, heat index using NCEI datasets from the 1975 to 2021, and hotspot identification using Land Surface Temperature (LST) data.

Bengaluru's mean air temperature has been rising at 0.23°C per decade (0.023°C per year) since 1975. The increase is more profound in the last decade, at nearly half-a-degree per decade. A heat wave is an extended period of hot weather relative to the usual conditions in the area at that time of the year. IMD classifies this potentially fatal air temperature condition as a heat wave or severe heat wave based on the magnitude of departure above the long-term normal beyond a certain threshold[47]. Extreme heat wave incidents are increasing in the city, resulting in increased spending by the city's residents on air conditioners and electricity[48]. The number of heat waves has been peaking in the recent year, for example, it was the highest in 2014 and 2015. In addition, every two years since 1975, the city has been facing an additional 1.5 'caution'[49] days of high heat index. Heat index is a critical factor in human thermal comfort, heat index, confirms that the body's natural cooling mechanism – evaporation of perspiration – is effectively diminished when relative humidity in air increases resulting in dire heat disorders. In 2014 and 2015, Bengaluru residents spent nearly half of the year under the 'caution' marker, along with occasional 'extreme caution' days.

The urban heat island (UHI) phenomenon can be spatially understood through land surface temperature (LST) variations. LST is the radiative skin temperature of the land derived from solar radiation. There is a widening gap between urban and rural areas in terms of the rise of night-time LST, over the last two decades, wherein average LST has increased by more than 1.5°C. As shown in Figure 34, areas with well-planned residential layouts such as Jayanagar, Koramangala, and Indiranagar have relatively lower LST (generally between 32-33°C), while areas such as Peenya, Hebbal, and Nagarabhavi towards the periphery, and Chikkapete (a dense old core city area) have higher LST of about 35-36°C.

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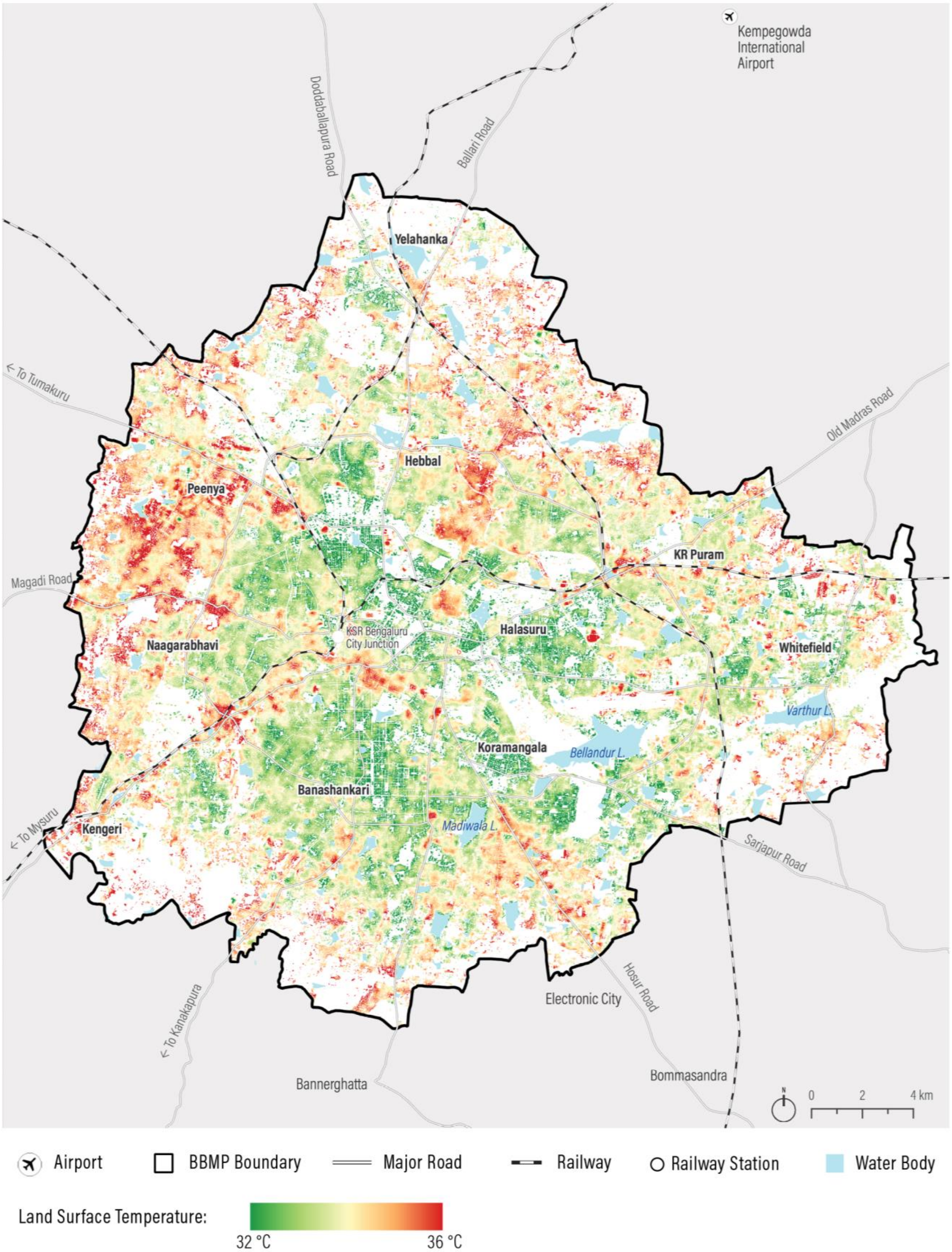
[47] A heat wave is declared if the departure of the maximum temperature of a station from the long-term average is 4.5°C to 6.4°C. A severe heat wave is declared when the departure is more than 6.4°C. Heat Wave, IMD, accessed August 2022. (IMD Heatwaves)

[48] Every two years, city residents have been enduring 1.5 more days of extreme heat waves since 1975.

[49] As per the US National Weather Service,, caution and extreme caution are advised when the heat index is greater than 26°C and 32°C respectively. For more details on its impacts, refer to CCRA-VA report.

Figure 34 Average land surface temperature over built areas of the city (summer months 2017-2021)



Source: WRI India analysis using Landsat-8, USGS/ NASA (refer to CCRA-VA report for details)

Drought

At the city level, drought is usually disregarded. However, there is an inter-connectedness between drought at a larger regional level and the availability of water resources that enhance water security in the city. This is more pertinent for a city like Bengaluru, which is highly dependent on the Cauvery river basin for its water supply. With reduced access to conventional piped water supply, there is an increasing dependency on groundwater (GW). The city and its adjoining area, for the same reasons, have been categorised as an 'overexploited zone' with respect to groundwater availability by the Central Ground Water Board. Such dependency on GW sources leads to significant damage to aquifer-system often leading to compaction, by the impact of the superimposed load leading to consolidation of ground matter. Meteorological drought probability and drought risk has been assessed to understand the drought scenario in Bengaluru.

Meteorological Drought probability: Meteorological drought is classified based on rainfall deficiency in an area with respect to long term average, that is ≥ 26% deficiency. Based on the IMD dataset for the period from 1985 to 2020, nearly 50% of the area upstream to Cauvery (confluence region for the river) has a drought probability of more than >20% (that is 20% chance of drought).

Drought risk: Drought risk is an adduced composite of hazard, exposure, and vulnerability based on WRI's Aqueduct 3.0. 84% of the Cauvery-Ponnaiyar Basin area is in the 'very high risk' category for drought. Additionally, the region also falls in the 'extremely high risk' category of overall water risk (India 2021) which posits a challenge for the region's food, water and economic sustainability.

Groundwater Recharge Potential (GRP): Examination of GRP provides a spatially granular measure to identify areas that have lost the potential to hold stormwater and help it infiltrate naturally. In the year 2000, 63% of the city's area is estimated had already been developed/ concretised, that is, it holds no natural potential to recharge groundwater. Between 2000 to 2020, a further of 31% of the city's area is assessed to have decline in GRP.

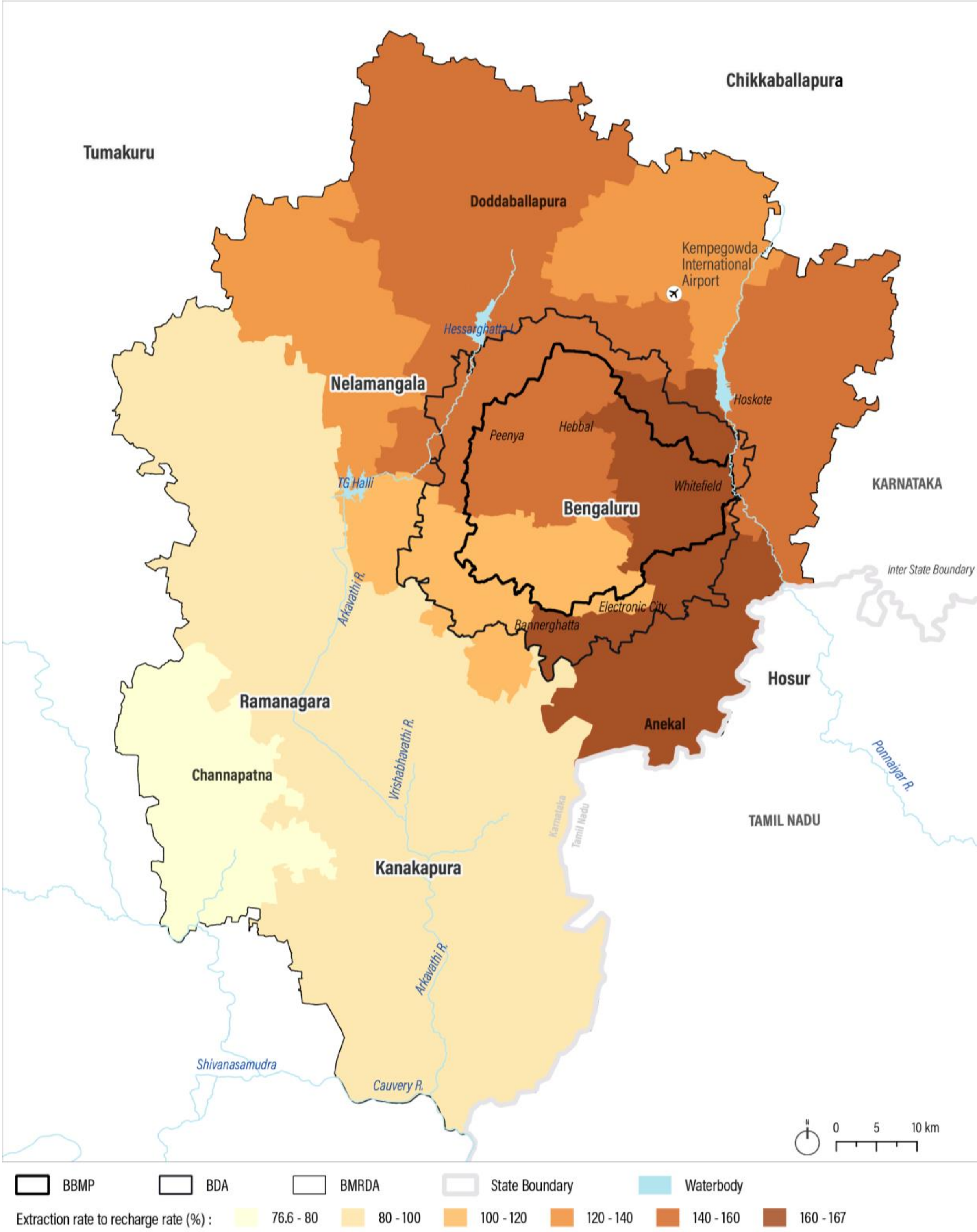
Change in GW levels over time: An assessment of changes in GW levels and quality has been done. The majority of the observation wells within BBMP limits, seasonally, show a decline in the groundwater level between 1993-2021. Especially towards the periphery, as seen in the case of Singasandra and Varthur stations, groundwater levels reported decline of nearly one metre. Outside BBMP limits, towards the rural areas of Nelamangala, Channapatna, Anekal, along the Arkavathi river, and around Devanahally, nearly 70% of the observation wells show a decline in groundwater levels during the pre-monsoon season.

GW quality: For most of the observation wells, Nitrates and pH values were observed to be within the permissible limits for the areas within the BBMP limits – except for the ones in Gottigere, Begur and Peenya. Total hardness (TH), was observed to be higher than the BIS prescribed limits for the observation wells within BBMP – in the areas Rajajinagara, Malleshwaram, Gollahalli, Kodigehalli, Vasanthapura, and Gottigere.

Stage of Groundwater Development[50]*:* The current stage of groundwater development in more than half of BMRDA, including the BBMP limits, for 2020, is defined as 'over exploited' (See Figure 35). This means that the region annually drafts groundwater at a rate higher than the resources available for human-consumption.

[50] As per the methodology recommended by the Ground Water Resource Estimation Committee 2015 (CGWB 2015), 'Stage of Ground Water Development' is computed considering the net annual Groundwater availability and gross annual draft and the water level trend of the area, thus getting the average stage of development. Taluk Wise Categorisation, Dynamic Groundwater Resources of Karnataka. Groundwater Directorate, Minor Irrigation and Groundwater Development Department. Government of Karnataka & Central Ground Water Board. 2022.

Figure 35: Taluk level Stage of Groundwater Development (Groundwater extraction rate to recharge rate) for Bengaluru Metropolitan Region



Source: WRI India analysis using taluk-level groundwater statistics for Karnataka for 2020, from Central Ground Water Board (CGWB)

Thunderstorm and lightning

There is paucity of data on incidences of thunderstorms for Bengaluru and the adjoining region. Therefore, thunderstorms incident data for Karnataka state have been referred for the study. In the 49 years (1969-2017) of thunderstorms analysed, it is observed that on average, in a year, the city gets 44 days of thunderstorms, with an average durability of 86 hours and 15 minutes annually. The highest number of thunderstorm days (62) was observed in three years, i.e., 1977, 1991 and 2017, whereas the lowest (22) was observed in 1990 (KSDMA[51], Agnihotri, Venugopal, and Hatwar 2013).

KSDMA, in its Lightning Action Plan 2022, notes that the incidents of lightning across India have been increasing, and that Karnataka state is no different. According to lightning distribution data on India, studied by IMD for the period between April 2020 and March 2021, parts of southwestern Karnataka are vulnerable to cloud to ground (C-G) thunderstorm and lightning (T&L) strikes. This has greater potential to harm people and property than other forms of lightning. Moreover, in 2021-22, Karnataka saw a 68.74% rise in lightning strikes, as per the Annual Lightning Report of 2021-22 (IMD 2021).

Air pollution

Anthropogenic air pollution is one of the biggest public health hazards worldwide, accounting for about 7 million premature deaths per year. Air pollution has a direct relation to several human and environmental health threats, which are compounded by the rising temperature. Bengaluru is one of 48 cities that are signatories to the "Clean Air Accelerator", and is taking action to tackle the main sources of air pollution. Through this accelerator, the city plans to prioritise cleaning the air by developing a diverse range of high-impact actions – from expanding air pollution monitoring networks to implementing low-emission zones, electrifying bus fleets, and shifting away from polluting fuels for heating.

Air pollution analysis is broadly classified into outdoor and indoor air pollution assessment. While outdoor air pollution is monitored through national missions and the use of sensors, indoor pollution can only be estimated based on household data of fuel and housing type. Indoor air pollution analysis is conducted based on the Census of India, 2011, National Sample Survey, 2013-14 and Human Index Survey, 2012 data. Both components of pollution analysis are critical in determining exposure rates and associated human health impacts (Leung 2015).

Outdoor pollution: The key findings of the different pollutants studied for outdoor pollution are summarised in Table 10. While most Particulate Matter and Nitrogen Dioxide concentrations remained significantly higher for a considerable number of stations throughout the study period, other gaseous pollutants were predominantly below CPCB thresholds. The table 10 therefore provides summary of Pm10, PM2.5, and NO2 concentrations in the city.

[51] Karnataka State Thunderstorm & Lightning Action Plan 2022; KSDMA

Table 10 Key observations of air pollutants for Bengaluru city

Parameter	Key observations
PM10	Based on monitoring station data, between 2016 and 2021, overall annual averages for PM10 in the city vary between 60 and 123 µg/m^3. Hotspot identification: Out of a total of 10 Continuous Ambient Air Quality Monitoring Stations (CAAQM) stations and 8 National Air Quality Monitoring Programme (NAMP) manual stations studied, those in/around Majestic, Silk Board, Jayanagar 5th Block, and Hebbal show higher PM10 concentrations throughout the study period. PM10 concentrations are observed to be highest from October to May each year.
PM2.5	Based on monitoring station data from 2016 to 2021, the city's overall annual averages for PM2.5 do not show much variation (apart from the Covid year), and remain bordering the CPCB permissible limits (between 30-40 µg/m^3 per year on average). Hotspot identification: Bapuji Nagar, Jayanagar 5th Block, and Peenya are stations that crossed the daily CPCB permissible limit for more than one-third of 2021, at 58%, 36% and 34%, respectively. Like PM10, PM2.5 concentrations are also the highest from October to May each year.
NO_2	The annual average for NO_2 for most stations in the city from 2016 to 2021 remains below the CPCB permissible limit, at an average of 26.3 µg/m^3, that is, nearly 0.6 times the CPCB permissible limits. *Hotspot identification:* Bapuji Nagar, Hebbal, and Silk Board stations recorded a higher number of days of exceedance compared to the rest of the stations.

Gaseous pollutants like sulphur dioxide, carbon monoxide and ozone were also studied, and are discussed in the CCRA-VA document. Data for these pollutants is considerably noisy, with a lot of gaps, due to which assessment results may vary. The analysis for these pollutants focused on the number of days of exceedance of CPCB permissible limits in 2021. Sulphur dioxide was significantly below the CPCB permissible limits from 2016 to 2021, with negligible days of exceedance in 2021. Carbon monoxide has been crossing CPCB permissible limits for the stations at BTM Layout, City Railway Station (Majestic) and Bapuji Nagar, for more than 78%, 57% and 24% respectively in 2021. Ozone remained higher than the eight-hourly CPCB permissible limits for some areas in the city, including Hombegowda and Bapuji Nagar, in 2021, especially between 10am and 4pm (the hotter part of the day), as the temperatures during the day favour ozone formation.

Indoor pollution: Of all the types of cooking fuel, firewood, utilised by just 4% of households in the city, contributes the most to the concentration of PM2.5. Households at risk of exposure to indoor pollution due to the most polluting cooking fuel (firewood and chips), are predominantly located in the ¬wards of Nayandahalli, Jakkuru and Kuvempu Nagar, as per Census 2011. Further, under the current policy landscape and projected population and economic growth, ambient PM2.5 levels in Bengaluru is projected to increase to 45.9 µg/m^3 by 2050, exceeding national air quality standards and resulting in air that contains 9 times the concentration of air pollution that the WHO deems safe. Table 11 gives an overall scenario of various hazards, along with likelihood of occurrence in the city and sectors relevant to the hazard.

Table 11 Likelihood of identified hazards and significant associated sectors

Hazard	Likelihood of occurrence	Sectors of significance
Urban flooding	High	Primary sectors: stormwater management, urban planning, greening and biodiversity Other sectors: water and wastewater, solid waste management, transport, energy
Urban heat	Medium	Primary sectors: urban planning, greening and biodiversity Other sectors: transport, energy, solid waste management, water and wastewater
Drought	Medium	Primary sectors: water and wastewater, urban planning, greening and biodiversity Other sectors: stormwater management, transport, energy
Thunderstorm and lightning	Medium	Primary sectors: stormwater management, urban planning, greening and biodiversity Other sectors: water and wastewater, transport, solid waste management, energy
Air pollution	Medium	Primary sectors: transport, urban planning, greening and biodiversity, solid waste management Other Sectors: energy

The table below identifies the impact of climate hazards on each of the sectors.

Table 12 Impacts of climate hazards on various sectors

Hazards impacting the sector	Impact of the hazard on sector's infrastructure	Impact of the hazard on sector's services
Sector: Energy		
Urban flooding, thunderstorms and lightning	• Submergence of substations due to flooding. • Uprooting of poles supporting transmission and distribution lines. • Extreme storm events damage generation and grid infrastructure.	• Loss of electricity leads to loss of life due to disruption of medical supply chains. • Loss of electricity disrupts traffic management systems

	• Revenue and financial losses due to damage incurred.	• Loss of electricity will disrupt IT services. • Loss of electricity affects emergency response. • Disruption of energy supply impacts the local economy.
Increase in land surface temperature and heat island effect	• Increase in air temperature will reduce power plants' generation efficiency and output. • Heatwaves impact transmission line efficiency, and overheating leads to the expansion of transmission lines and can cause them to slack. • Revenue and financial losses due to damage incurred.	
Drought	• Drought impacts hydropower generation and reduces water availability for cooling purposes to thermal and nuclear power plants. • Revenue and financial losses due to damage incurred.	
Sector: Building		
Urban flooding, thunderstorm, and lightning	• Flooding damages property, as prolonged contact with water can compromise walls and material strength . • Revenue and financial losses due to damage incurred.	• Financial losses to owners
Increase in land surface temperature and heat island effect	• Heatwaves impact building and infrastructure performance by diminishing indoor thermal comfort. • Revenue and financial losses due to damage incurred.	• Increase in temperature increases the demand for electricity and affects the stability and frequency of the grid load. • Higher urban temperatures place unequal economic stress on residents and households through higher utility demand.
Sector: Transport		
Urban flooding, thunderstorms and lightning	• Damage to transport infrastructure (bus stops, buses, roads, waiting sheds) • Damage to electrical equipment • Inundation of and damage to underground transit system (subways, underpasses) • Financial losses to infrastructure owners	• Impassable road networks, causing traffic disruptions, traffic congestion and accidents • Increase in travel time • Increase in travel distance (due to change in routes) • Decrease in average travel speed • Power outages disrupting services (metro) • Financial losses to service operators

Increase in land surface temperature and heat island effect	• Heat-related deterioration of vehicle parts (e.g., engine, tyres) • Overheating of signalling and communication systems • Increase in energy use for cooling • Increased financial burden to Transport operators and infrastructure owners	• Vehicle schedules affected due to overheating of engines, signalling and communication systems, etc. • Health and safety risk to passengers, operators, staff • Shift in demand to other modes (PT and NMT to private) • Financial losses to service operators
Drought	• Potential for service disruption if soil shrinkage causes damage to roads/tracks	• Damage to transport infrastructure (vehicle parts)
Sector: Solid waste management		
Urban flooding, thunderstorms	• Damage to infrastructure (roads, waste collection centres, etc.) • Clogging of drains • Water infiltration leads to overflow in landfills • Damage to sanitary landfill facilities due to saltwater infiltration • Financial losses to infrastructure providers • Degraded landfills causing contamination	• Health and productivity of workers • Blockage of waste collection routes • Extreme odour and exposure to flies, leading to the risk of infectious diseases/mortality/morbidity among workers and vulnerable groups exposed to waste landfills/dump sites. • Financial losses to service operators.
Increase in land surface temperature and heat island effect	• Altered waste decomposition rate in the landfill. • Increased waste collection schedules. • Reduces waste collection workers' productivity. • Financial losses to service operators.	• Increased risk of fire in landfills . • Heat-related deterioration of collection vehicles and dry waste recycling facilities. • The increased financial burden on operators and infrastructure owners.
Sector: Water and wastewater		
Urban flooding, thunderstorms and lightning	• Damage to water infrastructure. • Floods in September 2022 inundated the TK Halli water treatment plant and two pumping station units in Mandya district. (Times Now 2022)	• Disruption of water services due to damage to the infrastructure. • Due to damage to pumping units at the TK Halli water treatment plant, 50 areas across the city were affected, as water supply was halted for a couple of days. (Times Now 2022)

Drought	• Depleting water table, leading to a reduction in the water level, or to the drying up, of wells.	• Shortage of water supply from borewells, and a need to rely on private water suppliers who charge exorbitant rates.
Sector: Stormwater management		
Urban flooding, thunderstorms and lightning	• Damage to SWD infrastructure • Reduced carrying capacity of SWDs due to encroachments, sewage inflow, and solid waste dumping.	• Financial loss due to the reconstruction of SWD networks.

Ineffective planning and implementation of efficient strategies in sectors such as urban planning, greening, biodiversity, and disaster management can act as a contributor to almost all the above-mentioned hazards, along with being impacted by them. Deteriorating air quality is also an impact that is caused due to activities across sectors.

This section detailed the Climate Hazard assessment for key hazards identified for Bengaluru along with their plausible implications. The following section presents hazard impact assessment for Bengaluru as a function of two components: exposure and vulnerability.

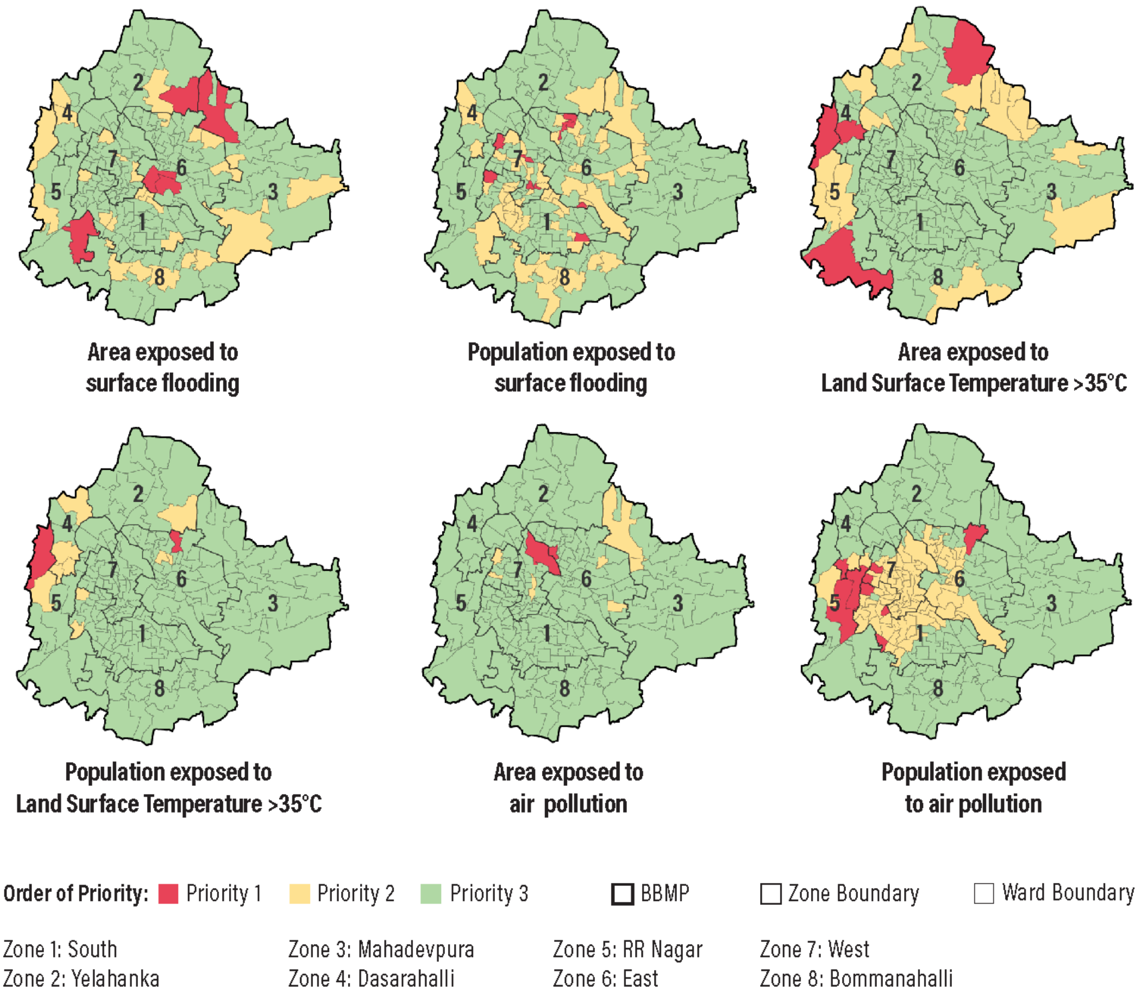
3.1.4 Climate Hazard Impact Assessment for Bengaluru

Exposure to climate hazards

This is the first component of understanding hazard impact. The area and population exposed was assessed for three of those hazards, i.e., flooding, urban heat, and air pollution. Hazard exposure is presented here in terms of a ward's order of priority, which indicates the wards that have a greater area, or a higher number of people or assets are subject to frequent climate hazards. Therefore, these have higher exposure than others. The order of priority ranges from 1 to 3, where 1 signifies that a greater number of elements exposed, compared to 3.

Peripheral zones such as Yelahanka in the North, Mahadevapura in the East and RR Nagar in the Southwest, come under the first order priority (exigency of action needed) for both flooding and urban heat. Most wards in Bommanhalli zone in the Southern peripheral region of Bengaluru come under medium to high priority for two of the three hazards, i.e., flooding and urban heat. Wards such as Shakthiganapati Nagar and Subhash Nagar in the West zone, Atiguppe in the South zone, and Devarajeevanahalli in the East zone come under high priority for air pollution. Certain wards in RR Nagar like Kottigepalya and Jnanabharathi, come under medium to high priority across all these three hazards. Figure 36 gives spatial representation of priority-based hazard exposure across Bengaluru.

Figure 36 Summarising order of priority based on hazard exposure - Surface flooding, urban heat and air pollution



Source: WRI India analysis using Census 2011, Built footprint from WSF 2019 and amenities from BBMP 2022; details in CCRA-VA report

Bengaluru's Vulnerability to climate hazards

Vulnerability is the second component for understanding hazard impact. It has an inverse relationship with adaptive capacity and is directly proportional to sensitivity. The vulnerability of a city and its population is influenced by a range of fundamental and underlying factors that operate at various scales, encompassing individuals, communities, and the entire city. Analysis of key parameters across these different layers gives a more comprehensive understanding of vulnerabilities at a granular spatial scale (either the ward or the zone level). The vulnerability analysis conducted consists of various demographic and socio-economic parameters as part of sensitivity – refer to Figure 12 for findings; and infrastructure and accessibility-related parameters as part of adaptive capacity – refer to Figure 13 and Figure 15 for results.

3.1.5 Summarising Bengaluru's Climate Hazard Risk and Vulnerability Assessment

Climate hazard risk assessment is theorised as function of both climate hazard and its impact as explained in Figure 30. Risk assessment is illustrated at the ward and zone level annotated by the exigency of action needed (order of priority). It brings a comparative interpretation of different areas within the city that contain and operate on these parameters and can be theorised as 'risk'. CCRA-VA does not conclude risk informed by vulnerability with a quantitative score, as 'vulnerability' is a relative measure.

CCRA-VA presents the findings in a manner that can help policymakers, implementers, and citizen platforms decide on their respective local priorities to build resilience against climate change. The entire exercise of deduction of risk provides an exhaustive baseline analysis of Bengaluru's current socio-economic, demographic, infrastructure and service access, and sectoral situation, in a visually comprehensible and a succinct comparable format.

The final output of risk assessment is presented by classifying wards under different 'Orders of Priority' in three broad categories:

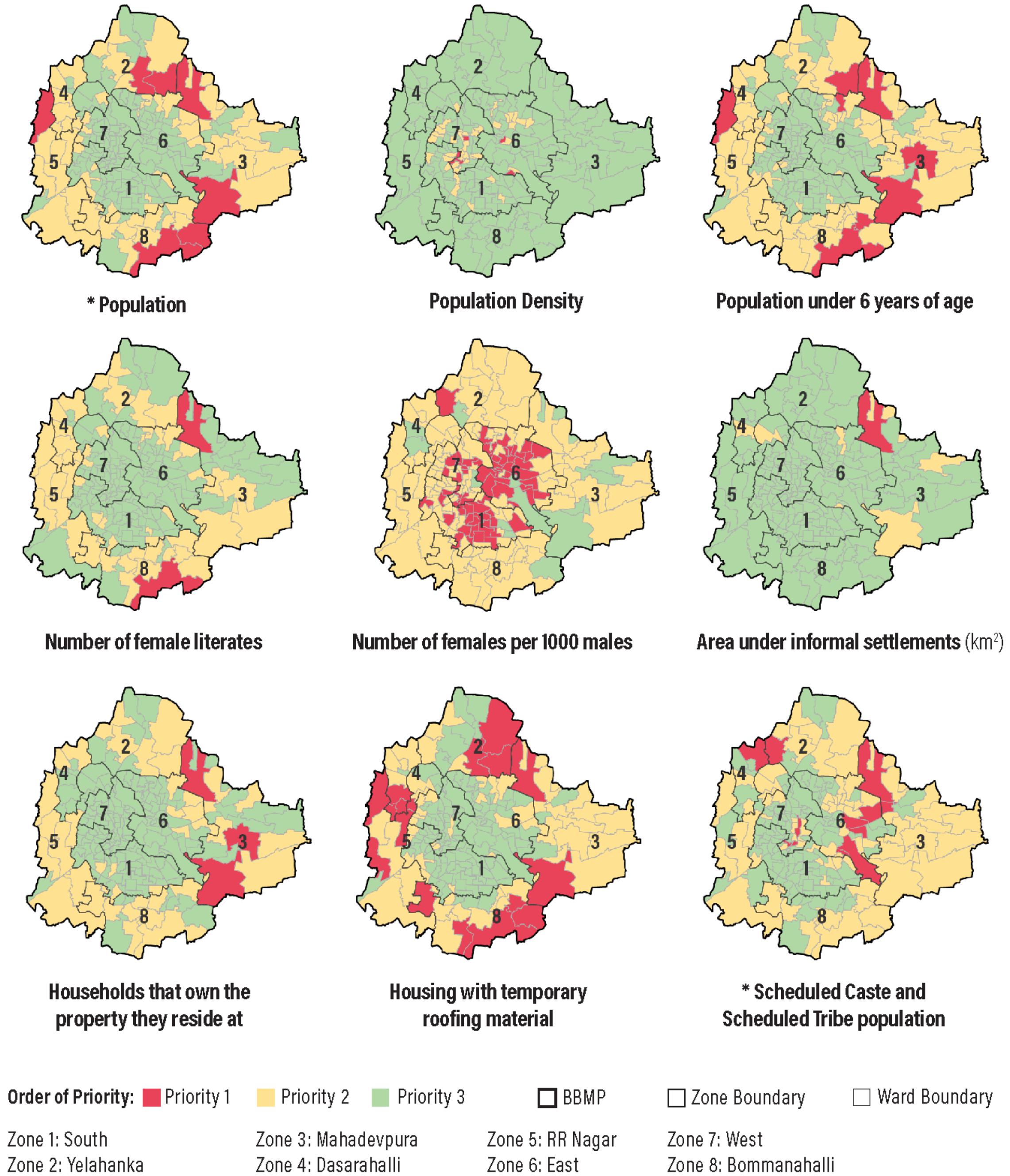
1. **Order of priority indicating exposure to hazards based on extent of impacted area and population** (presented in the previous section of hazard exposure, refer Figure-36)- This is where the city should intervene immediately to develop utmost disaster preparedness and response mechanisms, and plan carefully to put required infrastructure/ measures in place to minimize the occurrence of hazards in the coming years.

2. **Order of priority indicating sensitivity to hazards based on underlying demographic and socio-economic conditions** (Figure-37)- This order broadly identifies the wards or localities which could be deeply impacted in case of a hazard, owing to certain deep-rooted characteristics which cannot be changed in the short-term. The city needs to be cognizant of these localities to be at higher risk than others while planning for resilience building and adaptation projects. Measures that enhance access to information and education of citizens of prospective climate hazards and disaster management services would be useful proactive actions for these localities.

3. **Order of priority indicating (lack of) adaptive capacity based on access to services and amenities** (Figure -38)- This order broadly identifies the locations which are performing below certain prescribed benchmark and/ or are performing lower than the average city-wide performance against a set of accessibility parameters. These locations can be considered to have lower adaptive capacity than others in case of a hazard and hence at higher risk.

Chapter 8 of the CCRA-VA report provides details of the methodology used for deducing risk informed by order of priority and results.

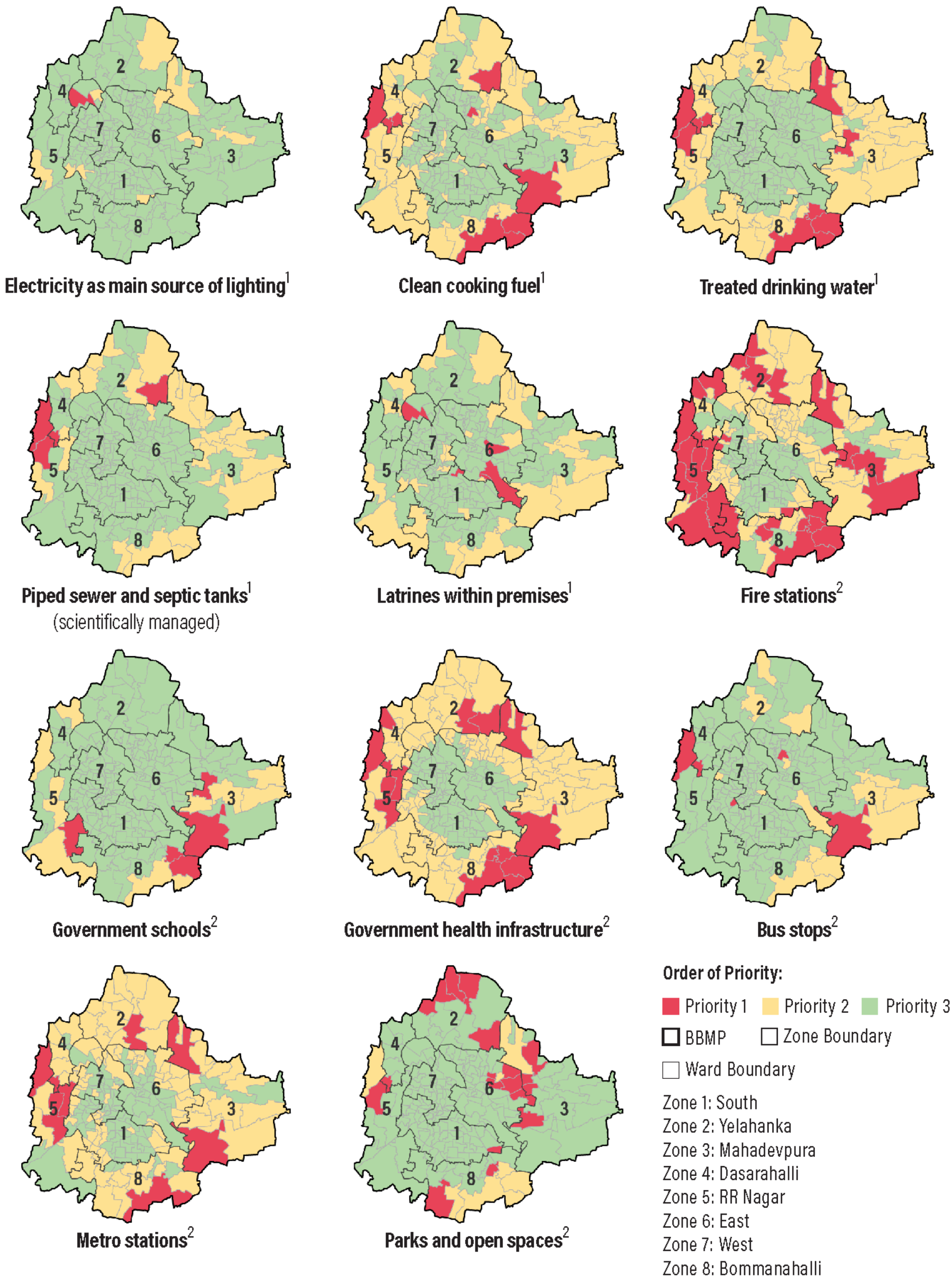
Figure 37 Summarising order of priority based on sensitivity parameters



* Number of persons

Source: WRI India analysis using Census 2011, Built footprint from WSF 2019 and amenities from BBMP 2022; details in CCRA-VA report

Figure 38 Summarising order of priority based on (lack of) adaptive capacity



[1] *Ward-wise % share of households not having access to the listed infrastructure or amenity.*

[2] *Ward-wise % share of population not having access to the listed infrastructure or amenity within the standard walkable distance or vehicular speeds.*

Source: WRI India analysis using Census 2011, Built footprint from WSF 2019 and amenities from BBMP 2022; details in CCRA-VA report

One must acknowledge that for a city such as Bengaluru, considering its geographic location, moderate climate and heterogenous population from different socio-economic backgrounds, ethnicities, languages, and cultural groups, it is difficult to attribute vulnerability to a single specific group. Factors such as migration, economic fluctuations, and urban development contribute to the dynamic nature of vulnerability. Moreover, limited data availability and hidden vulnerabilities, and the interplay of multiple factors, add complexity to attributing vulnerability.

The findings from the vulnerability and risk assessment discussed in the previous sections highlight the susceptibility of specific locations in Bengaluru which experience greater intensity of climate hazards. Most of these locations are in the peripheral parts of the city, i.e., areas which were added to the corporation limits when the present jurisdiction of BBMP was created. Notably, they are also the areas with less access to basic and critical services, and home to the urban poor, especially unskilled migrant workers who work in informal sectors or construction activities, and who often lack access to government-provided social benefits (Goldman 2010). Unskilled migrants from rural areas (Viswanathan and Kumar 2015) reside in unsafe conditions in peripheral areas, along railway lines, tank beds, quarry pits, stormwater drains, and solid waste dumpsites. They have access only to inadequate housing such as slums and informal settlements, and face heightened vulnerabilities as they lack essential amenities such as clean water, sanitation, and proper infrastructure (Chu and Micheal 2019). For instance, as shown in Figure 38, households in temporary dwellings in peripheral areas offer inadequate protection against inundation or leakage, leaving the urban poor highly vulnerable. Additionally, the lack of a proper sewer system in these areas, combined with flood risks, as shown in Figures 18 and 34, creates unhygienic conditions such as stagnant water from contaminated sewers and flooding. This further increases the vulnerability of the residents in these locations. The findings indicate that the peripheral areas, characterised by high migrant populations, urban poor communities, and socio-economically disadvantaged individuals, are particularly vulnerable, owing to their inherent vulnerabilities. The situation is exacerbated by the lack of access to basic services, placing residents at higher risk.

Apart from economic and migration status, certain inherent demographic and socio-economic characteristics such as age, gender, ability, ethnicity, and other marginalised communities (such as Scheduled Castes and Tribes, LGBTQ+ individuals) contribute significantly to vulnerability and adaptive capacity. When these attributes overlap in an individual or community, the result of such intersectionality can magnify the degree of vulnerability faced by an individual or community. Limited civic engagement and inadequate representation in decision-making processes further exacerbate vulnerability.

Lastly, Bengaluru is also a hub for the gig economy, a global economic trend. The gig economy provides income-generating opportunities outside of traditional employment relationships. However, it is still a largely unregulated sector in terms of labour rights, making workers vulnerable to extreme situations. There is a lack of reliable data on the informal workforce, as well as gig workers, in Indian cities. Access to such data would enable inclusive planning and programmes, promoting resilience and adaptability in the face of disasters.

3.2 GHG inventory: Sources and sinks

3.2.1 Scope and approach for GHG emissions inventory

The Paris Agreement's (UN 2015) central aim is to strengthen the global response to the threat of climate change by keeping the global temperature rise during this century to less than 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5°C. Additionally, the agreement aims to increase the ability of countries to deal with the impacts of climate change by lowering GHG emissions and developing climate-resilient pathways. Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2050 if it continues to increase at the current rate. A citywide GHG emissions inventory is a crucial component of a climate action plan that can provide a strategy to manage GHG risks and identify emission reduction opportunities/scenarios. It enables evidence-based mitigation action and targets, that can facilitate the monitoring of progress towards climate goals.

A city needs a GHG emissions inventory for the following reasons:

- Climate change mitigation: Helps cities develop strategies to reduce emissions and combat climate change.
- Policy development: Provides data for informed decision-making and setting emission reduction targets.
- Baseline measurement: Establishes a starting point for tracking progress and evaluating efforts.
- Planning and resource allocation: Identifies efficient and effective emission reduction opportunities.
- Stakeholder engagement: Facilitates collaboration and awareness among businesses, organisations, and residents.
- Reporting and accountability: Meets reporting requirements, demonstrates commitment, and tracks performance.
- Funding opportunities: Enhances eligibility for funding support for sustainability initiatives.

Bengaluru's GHG emissions inventory covers three major GHGs – carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The global warming potential (GWP), as discussed by IPCC in its fifth assessment report ('Fifth Assessment Report — IPCC' 2014) in 2014, has been referred to, in order to arrive at warming potential estimates. Details on GHG Accounting and Reporting Standards for Cities are in *Annexure-B.1*.

GHG inventory reporting protocol

To develop evidence-based strategies informed by climatic impacts due to the excessive release of GHGs into the atmosphere, it is essential to have a GHG emissions inventory. This inventory is an estimate of emissions from the sources and sinks within a defined spatial and temporal dimension. World Resources Institute (WRI), C40 Cities Climate Leadership Group (Cities C40), and ICLEI – Local Governments for Sustainability (ICLEI) have partnered to create a standard protocol for cities, which is formally known as the Global Protocol for Community-scale Greenhouse Gas Emission Inventories (GPC) (GHG-GPC 2014). The GPC provides a standardised method and procedures to assist local governments in quantifying and reporting GHG emissions associated with the activities of the community they govern. These standards are accepted and used in cities all over the world. Regularly updated GHG emissions inventories enable cities to understand their climate impact, implement effective policies, measure progress, engage stakeholders, and secure resources for climate action. Therefore, the C40 network recommends the same standards to develop GHG emission inventories for member cities. Hence, Bengaluru's GHG emissions inventory is quantified using standardised methods such as GPC and by the methodologies from the IPCC guidelines (IPCC 2006).

In line with the GPC emissions reporting standard, it is a requirement for membership of the C40 cities network to have a 1.5°C-aligned climate action plan and a GHG emission inventory that meets at least the GPC BASIC level from 2019 (in the last three years leading up to the present.) (Cities C40). The Bengaluru GHG emissions inventory covers the sectors and sub-sectors required for the GPC BASIC level .

BASIC-level sectors covered in the Bengaluru GHG emissions inventory.

STATIONARY ENERGY *Scope 1&2*	TRANSPORTATION *Scope 1&2*	WASTE (SOLID & LIQUID) *Scope 1&3*
Residential	On-road transportation	Municipal solid waste disposal to landfill
Commercial and Institutional		Biological treatment of MSW
Industrial	Railways	Incineration and open burning
Non-specified sources		Wastewater treatment and open discharge

GHG inventory reporting tool

The City Inventory Reporting and Information System (CIRIS) is a GHG reporting tool that was developed by the C40 cities network and has been used to report emissions. CIRIS contains instructions for users within the tool, and instructions on set-up can be found in the CIRIS user guide (Cities 2018a). The tool primarily involves basic data entry of measured, derived, or estimated activity data in the inventory tabs and uses this to calculate the associated emissions.

Bengaluru GHG emissions inventory information

Inventory boundary: Bruhat Bengaluru Mahanagara Palike (BBMP)

Area: About 713 sq. km. (Source: As per primary data shared by BBMP

Population: 10.17 million (2019 estimates)

Reporting period: January 2019 to December 2019 (2019 is taken as the base year to avoid COVID-19 related externalities to calculate emissions)

Bengaluru GHG emissions inventory data collection process

For the three sectors – stationary energy, transportation, and waste –emission estimates are based primarily on aggregated data collected from respective government agencies/departments. The data collected was in various forms and has been utilised to ensure its usage is within the inventory boundaries. Predominant data sources from each sector are mentioned in Table 13 below.

Table 13: Sources of data collected

Sector	Agencies/Departments from whom primary data was collected	Other key sources of data collection (secondary sources, literature review, etc.)
Stationary energy	BESCOM, GAIL, PPAC	GPC, IPCC guidelines and other secondary literature
Transportation	DULT, Transport dept., BMRCL, BMTC	CMP, Parivahan portal, Google EIE, IPCC guidelines and secondary literature
Waste	BBMP, BWSSB, KSPCB	GPC, IPCC guidelines and other secondary literature

Limitations in the data collection process and issues in the data received were broadly addressed as mentioned below:

- In case of a lack of accurate data at the city level, state/national data sets were referred to. In such cases, the data was adapted to align with the inventory boundary by adjusting changes in the activity using a scaling factor.
- In case of a lack of a recent dataset, the most recently updated dataset was used to estimate the inventory.
- Based on dataset records available at the departments, as few departments maintain records in financial year format and few in calendar year format, the data is analysed accordingly.
- As the most recent Census is 2011, the population of the city in 2019 is estimated by WRI India. Various projections prepared by different organisations were analysed and compared and the population was estimated accordingly. *Annexure F* provides a brief on population projections.

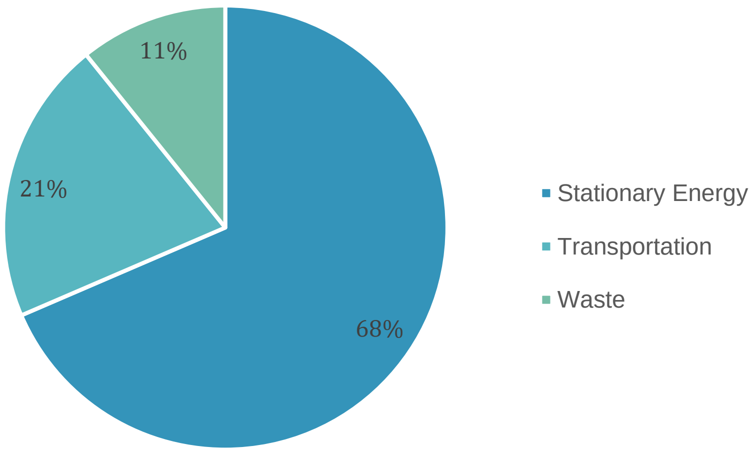
3.2.2 Critical sources

The GHG Inventory for Bengaluru includes an analysis of all the major sectors/sources that emit GHGs into the atmosphere and the major sectors/land uses that absorb (or sequester) GHGs from the atmosphere. The city-wide GHG inventory allows cities to build evidence-based mitigation strategies and policies to form a climate action plan (CAP) and can be a powerful tool for monitoring progress towards emission targets. Hence, the GHG inventory forms a critical piece of any CAP, by establishing the sources and sinks of GHGs.

Bengaluru's total GHG emissions in 2019 were estimated at **18.73 million metric tonnes (MMT) of CO_2e**. This corresponds to 1.84 tonnes of CO_2e per person for the year 2019.

Analysis of Bengaluru's sector-wise breakup of GHG emissions indicates that the stationary energy sector is responsible for 12.83 MMT, which is 68% of the total emissions. This is followed by 3.87 MMT from the transportation sector and 2.02 MMT from the waste sector. Figure 39 illustrates the sector-wise share of GHG emissions for the city.

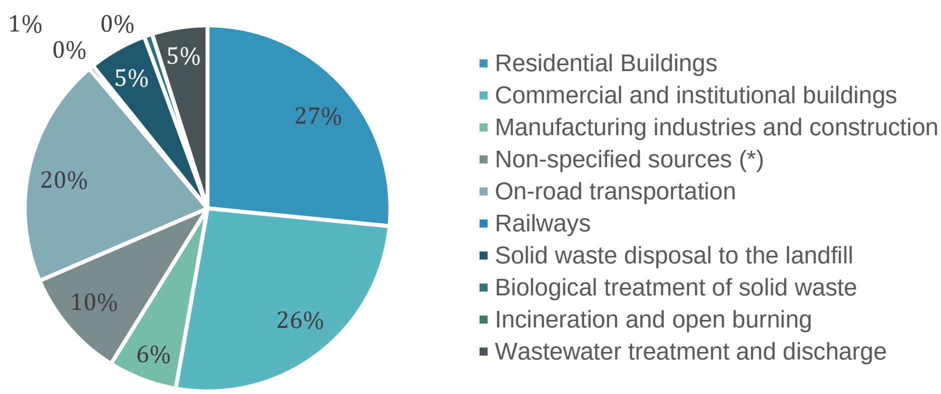
Figure 39 Sector-wise share of total GHG emissions in Bengaluru



Source: WRI India analysis for BBMP jurisdiction based on GHG-GPC framework (BASIC Level)

Figure 40 indicates the sub-sectors responsible for the emissions. A major share of the city's emissions is from energy use in residential buildings, followed by commercial buildings and on-road transportation. Electricity consumption contributes significantly to the total emissions (59%) due to a considerable share of the coal-based grid in the city.

Figure 40 Emissions from sub-sectors



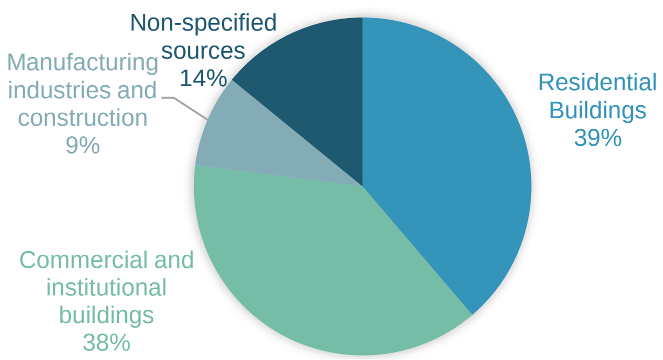
Source: WRI India analysis for BBMP jurisdiction based on GHG-GPC framework (BASIC Level)
(**Description of non-specified sources is mentioned in the following section and glossary*)

Stationary energy

The stationary energy sector consists of electricity and fuel consumption from (i) residential buildings, (ii) commercial and institutional buildings, (iii) manufacturing industries and construction, and (iv) non-specified sources (NSS). This sector accounts for 68% of the city's total GHG emissions. Within this, emissions from electricity consumption account for 86% of total GHG emissions from stationary energy. The major end-use of electricity is for cooling through various technologies, followed by office equipment, lighting, fans, and water heaters. The remaining energy demand is met by the consumption of PNG, LPG, diesel, petrol, charcoal, fuelwood, and kerosene. LPG, PNG, charcoal, and fuelwood fuels are primarily used for cooking and heating water, whereas diesel and petrol are used for backup electricity generators. The public distribution system has stopped the distribution and supply of kerosene, but it is still used by people living below the poverty line and in other low-income groups, mostly for lighting and heating. Residential buildings account for 4.97 MMT of CO_2e (39% of total stationary energy emissions), commercial and institutional buildings accounts for 4.91 MMT of CO_2e (38% of total stationary energy emissions), and the remaining emissions come from manufacturing industries, construction, and non-specified sources as illustrated in the Figure 41. Emissions from non-specified sources for Bengaluru GHG inventory are only from the consumption of grid electricity through the open access market. Electricity consumers with a load requirement above 1 MW can choose their electricity supplier from the open access market, as per the Electricity Act, 2003.[52]

The detailed methodology for calculating emissions from this sector is discussed in <u>*Annexure B2*</u>.

Figure 41 Contributors to the stationary energy sector's GHG emissions in Bengaluru (2019)



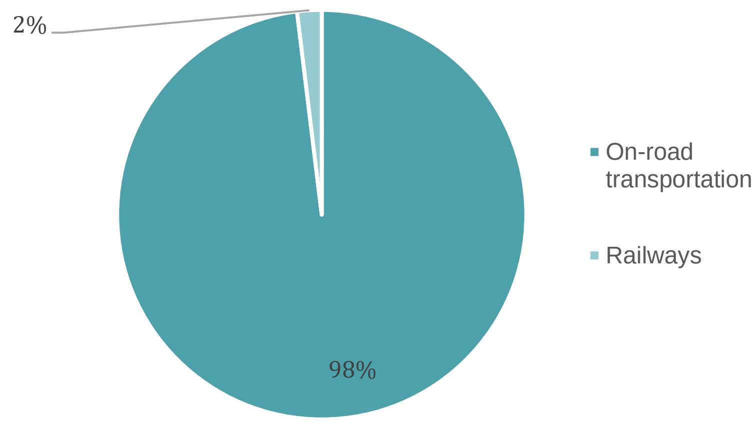
Source: WRI India analysis for BBMP jurisdiction based on GHG-GPC framework

[52] Open Access, 2019, (CEEW 2019)

Transportation

For the purposes of the GHG inventory, Bengaluru's transport sector consists of (i) On-road transport and (ii) Railways. The aviation sector has not been considered in this inventory, as Bengaluru's international airport is located outside the BBMP boundary and transboundary travel is not included within the GPC-BASIC reporting level. Furthermore, Bengaluru does not have a suburban rail system at present, and the share of the city's population that uses railways as an intra-city mode of commute is very small. Considering this, the 'railways' category for this inventory includes only metro rail. *Annexure B2* details the methodology followed to arrive at GHG emissions from the transport sector.

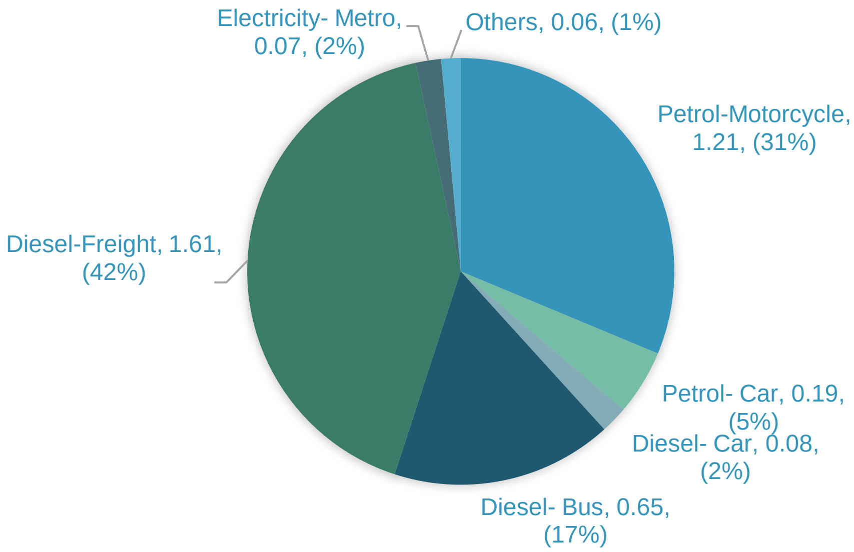
Figure 42 Contributors to the transport sector's GHG emissions in Bengaluru (2019)



Source: WRI India analysis for BBMP jurisdiction based on GHG-GPC framework

As shown in Figure 42, on-road transport accounts for 98% of the transport sector emissions of 3.8 MMT of CO_2e. This is due to the high share of fossil fuel consumption across passenger and freight modes. An analysis of mode-wise contributors shows that diesel-powered freight vehicles, petrol-powered motorcycles, and diesel buses together account for 89.6% of the total GHG emissions in the transport sector, as seen in Figure 43. The railways are responsible for 2% of total transport emissions. Although the metro operates on electricity, the emissions it causes can be attributed to the electricity grid's dependence on coal.

Figure 43 Mode-wise contributors to transport sector emissions (in million metric tonnes of CO_2e and %)



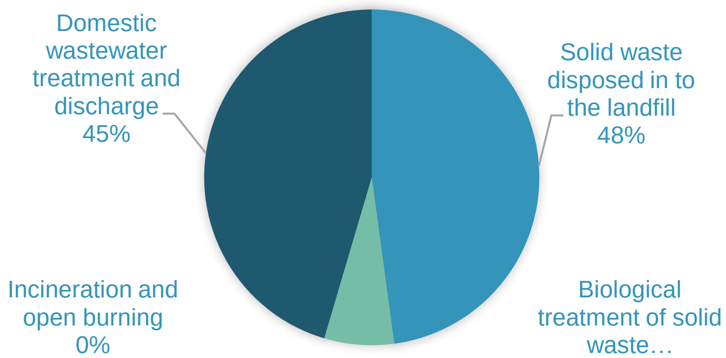
Source: WRI India analysis for BBMP jurisdiction based on GHG-GPC framework

Waste

Cities produce solid waste and wastewater together referred to collectively as 'waste'. The waste sector comprises municipal solid waste (hereafter referred to as solid waste) and domestic wastewater (hereafter referred to as domestic wastewater) that may be disposed of and/or treated at facilities inside the city boundary or transported to other sites for treatment. Waste disposal and treatment produce GHG emissions through aerobic or anaerobic decomposition, or incineration (GHG-GPC 2014).

Figure 44 shows the contribution of waste sector emissions.

Figure 44: Contributors of the waste sector's GHG emissions for Bengaluru (2019)



Source: WRI India analysis for BBMP jurisdiction based on GHG-GPC framework

Within the BBMP boundary, the waste sector contributes to about 2.02 MMT of CO_2e, which accounts for 11% of total GHG emissions of the city.

a. **Solid waste**: Solid waste contributes about 1.04 MMT of CO_2e, which is about 55% of total waste sector emissions. It includes solid waste disposed of in landfills, biological treatment of solid waste, and incineration of biological and hazardous waste. According to BBMP data, approximately 43.76% of mixed (unsegregated) waste is disposed of in the landfill. Of this, 24.55% of the waste is biodegradable, making it the major contributor of methane emissions from the landfill, as the landfill currently does not have a gas capture facility.
According to recent data, there is no open burning[53] of waste within the BBMP boundary, hence this is not considered as part of the city's GHG emission inventory.

b. **Domestic wastewater:** The domestic wastewater treatment/discharge contributes to about 0.98 MMT of CO_2e, accounting for about 45% of total waste sector emissions. The majority of N2O and CH4 emissions come from 36% of waste water because it is untreated, while the remaining 64% of water accounts for a smaller amount of CH4 and N2O emissions. This is mainly due to energy inputs, organic matter degradation and biological nutrient removal (BNR).(Fine and Hadas 2012)

The detailed methodology for calculating GHG emissions and the rationale for data component inclusions and exclusions is discussed in *Annexure B.*

3.2.3 Understanding the linkage between GHG emissions and air quality in Bengaluru

Air pollution and climate change are two sides of the same coin, for they share the same sources of emission. Hence, they need to be addressed together (Bank 2022), with a focus on protecting people's health, particularly for low-income and vulnerable groups. The transport sector is the largest contributor to air pollution (CSTEP 2022) and the second-largest contributor of GHGs in Bengaluru. Short-lived pollutants (for instance, black carbon from burning fossil fuels in transport vehicles and power plants, as well as from burning fuels such as wood and kerosene in households) absorb significant amounts of heat from sunlight, contributing to climate change. They are also associated with public health risks such as respiratory and cardiovascular diseases. By integrating air pollution management and climate action planning, Bengaluru can enhance its climate change mitigation potential, as well as co-benefits for air quality and public health, with minimal trade-offs.

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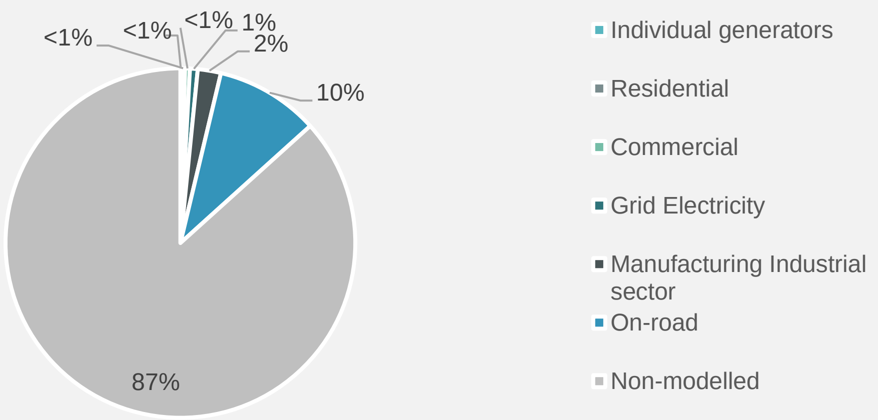
[53] As per GPC, open burning is an uncontrolled, often illicit process with different emissions. Difficulties in accurately estimating the amount of waste being burned, the composition of waste, the effects of external factors, lack of monitoring and reporting capabilities, and the informal nature of the practice make it challenging to completely eradicate open burning.

Findings from C40 Cities analysis of emissions sources and air pollution (Pathway-AQ):

As per the C40 Cities analysis of emissions sources and air pollution (Pathway-AQ), the baseline population-weighted annual average PM2.5 concentration for Bengaluru in 2019 was estimated at 37.9 µg/m³. This concentration was apportioned to sources using the city's GHG inventory, accounting for in-city emissions, and emissions associated with the production of electricity used in Bengaluru. It also included a non-modelled portion, with representing sources not included in the GHG inventory such as industrial processes (non-fuel combustion), sources located outside the city that influence its air quality, and regional natural sources such as dust. This analysis showed that the major contributors to PM2.5 air pollution are on-road transportation and industrial sources, shown in the figure below.

Figure 45: Baseline PM2.5 concentration by sector



Source: C40 Cities Analysis 2023

3.2.4 Carbon sinks

Forests and trees store carbon in pools or reservoirs, such as biomass and soil. The transfer of carbon from terrestrial pools to the atmosphere results in CO_2 emissions, while the reverse – the transfer of carbon from the atmosphere to terrestrial pools – results in CO_2 removal or sequestration (GHG-GPC 2014). Hence, forests and trees can be deemed both net carbon emitters and sinks based on their functionality and characteristics.[54]

IPCC 6AR states that all mitigation pathways compatible with limiting global warming to 1.5°C must also involve significant removal of CO_2 from the atmosphere, highlighting the importance of both maintaining and expanding the ability of forests and trees outside forests to capture and store carbon. Currently, urban areas act as net sources of GHGs, and trends of urbanisation are leading to increased GHG emissions and exacerbating climate change

[54] Trees fix carbon during photosynthesis and store it in form of biomass. Through the tree's lifecycle, whether it dies as it is consumed or decomposes as it ages, the carbon stored is released back into the atmosphere. This cycle repeats itself as a new tree grows and sequesters carbon. Therefore, the dynamics of forests' net long-term CO_2 source and/or sink utility keeps altering over time.

impacts. In this context, having integrated urban environments (blue-green networks) interspersed with built up becomes important to climate-proof cities. Urban blue-green networks and forests can support both adaptation and resilience (by managing the impacts of climate change) and mitigation (by sequestering carbon, hence reducing the GHG emissions that cause climate change).

Despite their unparalleled benefits, urban green spaces are often overlooked due to the complex and enigmatic nature of the ecosystem services they provide. The role and health of urban green spaces are also seriously undermined (creating an imbalance or change in the plant physiology, biochemistry, etc.), especially due to changing climatic conditions. To accelerate climate neutrality at a differential biogeographical scale focusing on cities, the preparation of annual inventories of greenhouse gas (GHG) emissions and carbon stocks at the city level can help facilitate and safeguard actions enhancing carbon storage and sequestration capacities.

As highlighted in previous sections of this report, the GHG emissions inventory prepared for Bengaluru is at the GPC-BASIC reporting level. This level excludes emissions from the following sectors:[55] 1) Agriculture, Forestry and Other Land Use (AFOLU)[56] and 2) Industrial Process and Product Use (IPPU). However, cognisant of the important role played by forests and trees in CO_2 sequestration, an assessment has been done for trees in the city under this section. This has been carried out following the framework prescribed by the *Global Protocol for Community-Scale Greenhouse Gas Inventories: Supplemental Guidance for Forests and Trees*.

The following section seeks to estimate the carbon dioxide dynamics of urban trees using the I Tree Canopy tool developed by the US Forest Service. Refer to *Annexure B3* for details on the methodology. The tool uses Google satellite imagery of the Earth's surface to provide estimates of tree canopy denseness. The removal and emission factors of urban trees are derived using the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines 2006 2019) and the Forest Survey of India's carbon stock reports (FSI Chapter-5).

The analysis is divided into two parts – change in CO_2 stock over an inventory period and recent stock in terms of Carbon emitted and sequestered. With the help of historic and recent imagery, gross changes in the tree canopy and subsequent carbon stock are computed as follows:

- Gross tree canopy denseness lost over the period and resultant carbon emitted; and

[55] AFOLU and IPPU are considered in the BASIC+ reporting level

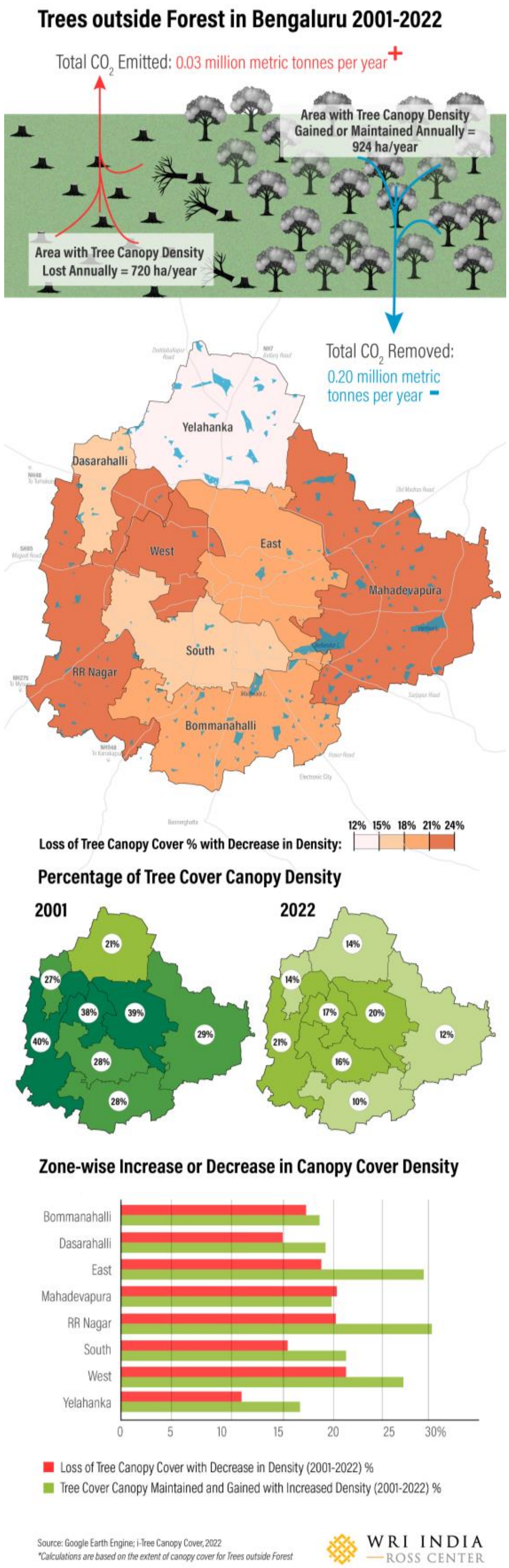
[56] It is the 'Land' sub-sector under the AFOLU sector, which should have accounted for emissions/removal of CO_2 by forests and trees under the BASIC+ reporting level.

- Area of tree canopy cover maintained and/or gained in the horizon year from for the base year of an inventory period[57] and the resultant carbon sequestrated.

For the eight BBMP zones, a tree canopy cover analysis was done using the I-Tree Canopy tool with a standard error of 2% following the methodology prescribed by *Global Protocol for Community-Scale Greenhouse Gas Inventories, GPC supplemental Guidance for Forests and Trees, WRI 2022* (Gibbs, Harris, and Pool 2022). This analysis was done for an inventory period of 21 years, from 2001 to 2022. It indicates that the city is seeing an **annual tree canopy density loss** of about **720 ha/year**, while it has **'standing tree canopy cover and newly planted tree canopy cover'** of annual tree canopy density of **924 ha/year**. The **carbon sequestration potential** of standing tree canopy cover and newly planted tree canopy cover corresponds to 199,285 tonnes of CO_2/year (i.e., around **0.20 MMT of CO_2/year**). The analysis reveals that **15,317 hectares of tree cover canopy was lost** in the BBMP area over the inventory period (2001-2022), which contributed to emissions from this segment. Refer to Figure 46 for illustration of zone-wise tree canopy cover in Bengaluru in 2001 and 2022, and the dynamics of the estimated annual carbon emitted and stored between 2001 and 2022.

[57] Over an inventory period, many growing plants may mature into trees, or may undergo natural processes altering their canopy density and size. Therefore, to avoid statistical conflicts, the tree canopy cover for the horizon year is defined as tree canopy density gained or maintained.

Figure 46 Estimates of carbon emitted and stored annually by Trees outside Forests in Bengaluru between 2001 and 2022, and zone-wise tree canopy cover density (2001 and 2022)



Source: WRI India Analysis 2022, using I-Tree Canopy *(see Annexure B3 for detailed methodology)*

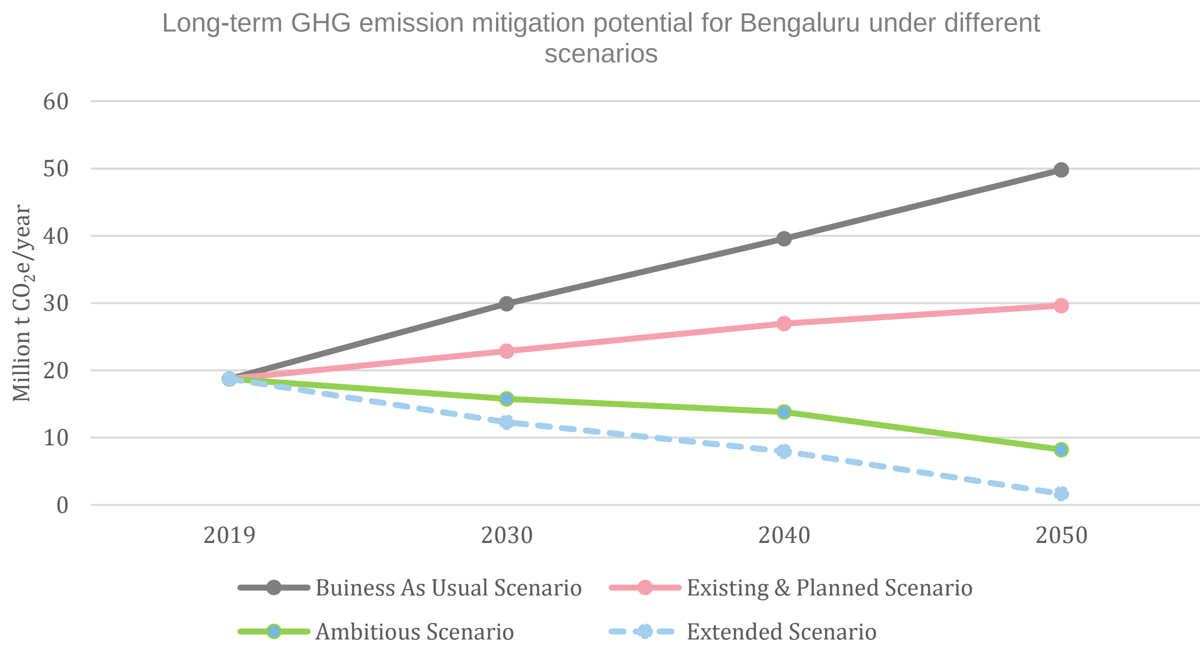
Photo Credit: Praseeda Mukundan/WRI India

4 FUTURE EMISSION MITIGATION PATHWAYS FOR BENGALURU

Bengaluru has embarked on a mission to align its future with the global goal of limiting global warming to 1.5℃ as enshrined in the Paris Agreement. With this plan, the city is striving to adopt a strategic roadmap and implement actions to reduce emissions. In order to develop a credible pathway to achieving a reduction in emissions by 2030, 2040 and 2050, several scenarios were developed to identify strategies that would help Bengaluru meet this ambitious goal. Informed by the baseline emission inventory prepared for the city for 2019 (presented in Chapter 3), emission reduction pathways were developed for the major emitting sectors: energy, transport and waste under various strategic conditions. The strategies identified for each sector broadly encompass technological and systemic changes that influence GHG emissions (for example, decarbonising the grid, or switching to green and low-carbon transport systems).

With this plan, Bengaluru's endeavour will be to implement actions for achieving a set of long-term emission reduction targets of 16% by 2030, 26% by 2040, and 56% by 2050 compared to 2019 baseline emissions (refer to Figure 47). Achieving these ambitious targets will require the implementation of equally ambitious actions under each strategic umbrella in all three sectors, i.e., energy, transport, and waste, which are presented in Chapter 5. Specific targets for important strategies in each sector are presented later in this chapter.

Figure 47 Long-term GHG emission mitigation potential achieved under different scenarios for Bengaluru



Source: WRI India Analysis using Pathways tool developed by C40 Cities

While these are ambitious targets, the city acknowledges that these are not sufficient to meet its ambition of achieving net-neutrality by 2050 due to several systemic barriers that exist along the pathway. Therefore, a set of more ambitious or extended targets were developed (34% by 2030, 58% by 2040, and 91% reduction by 2050, compared to 2019 baseline emissions) which are considered achievable only under conditional circumstances, i.e., if all those barriers are overcome. This is challenging, as it will require the entire technological, economic, political, and social ecosystem within and beyond the city, i.e., at the sub-national, national and global levels, to be positively aligned to the 1.5°C warming scenario. Nevertheless, the city is determined to monitor and report on residual emissions along with a periodic updation of the GHG inventory every two years through a robust monitoring, evaluation and reporting mechanism as mentioned in Chapter-7 of this report.

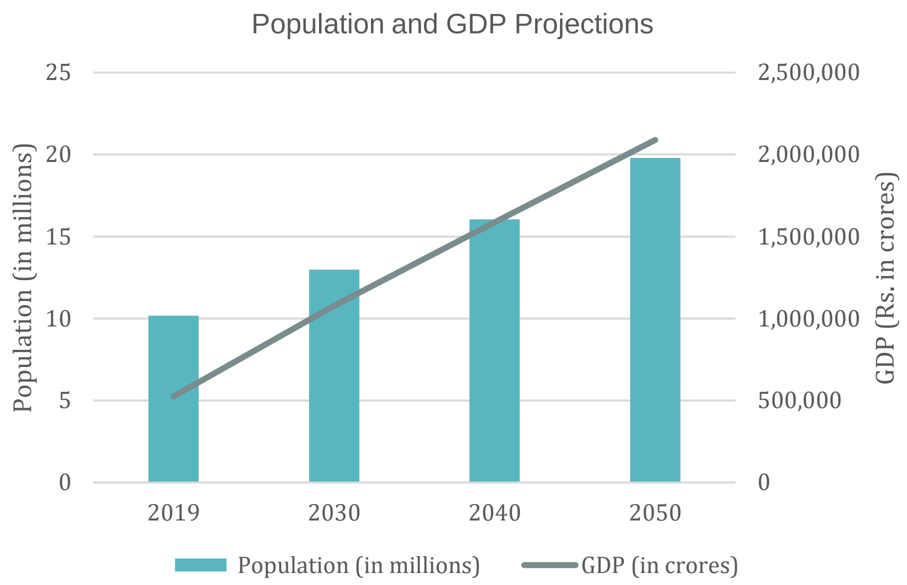
4.1 Future Emission Mitigation Pathways: Methodology

The city has undertaken a scientifically robust yet pragmatic approach to identify strategies which can deliver on the city's ambition to create a cleaner, and more prosperous city. To model a trajectory which could keep within these limits established in the Paris Agreement, four scenarios (Refer to Figure 47) were developed using the Pathways model, an Excel-based scenario planning tool that is flexible and can be tailored to reflect a particular city's context and conditions (Cities 2018a). They were developed over a period of seven months, primarily from with insights gained from desk-based research and consultations conducted for this action plan. All the scenarios were developed in consultation with key departments and stakeholder agencies who play a vital role in the city's emission reduction pathways. Inputs on both existing and planned policies, plans, schemes, initiatives, organisational targets, and many more were collected and duly considered for the scenario development exercise. Each scenario provides an evidence-based roadmap to achieve Bengaluru's emission mitigation goals with certain sets of strategic interventions with varied degrees of intensity.

Some of the basic parameters considered for developing these scenarios included the city's projected population and GDP for the target years. The city's population is projected to be around 19.8 million by 2050, which is almost double the base year population (refer to Section 2.1 and Figure 6 for details). Economic activities corresponding to an increase in population growth would result in an increase in the GDP, which is expected to be almost four times (by 2050) of the base year value[58](see Figure 48).

[58] GDP projections for BBMP were arrived at based on GDDP of Bengaluru Urban District data taken from the Economic Survey of Karnataka's annual reports from 2013 to 2020.

Figure 48 Population and GDP projections from Base Year

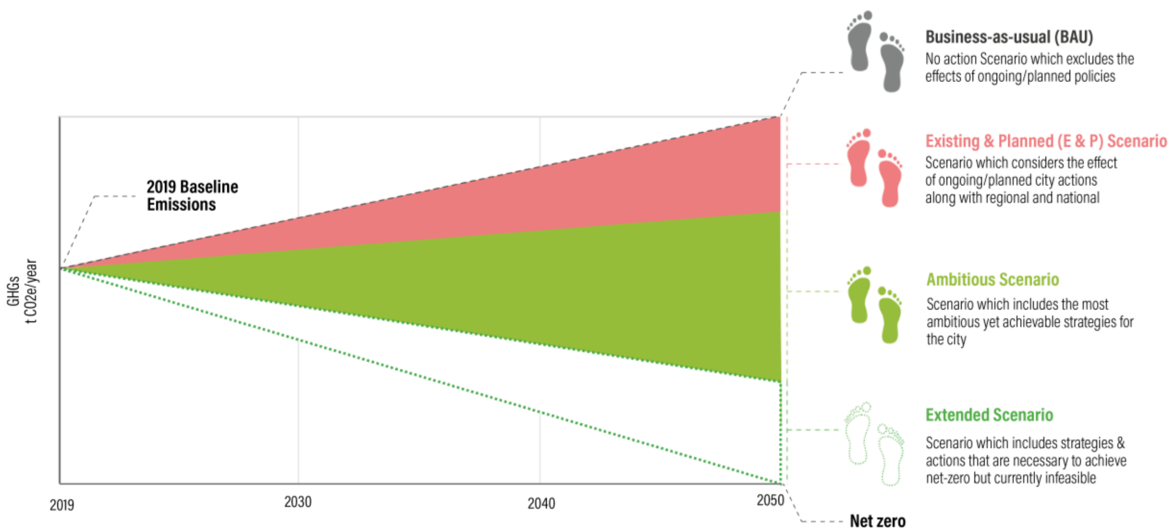


Source: Based on Census 2011, population projections by JICA, and Economic Survey of Karnataka

4.2 Future emission scenarios

Three types of GHG emission scenarios that are relevant to the development of BCAP are illustrated in Figure 49.

Figure 49 Future emission scenarios

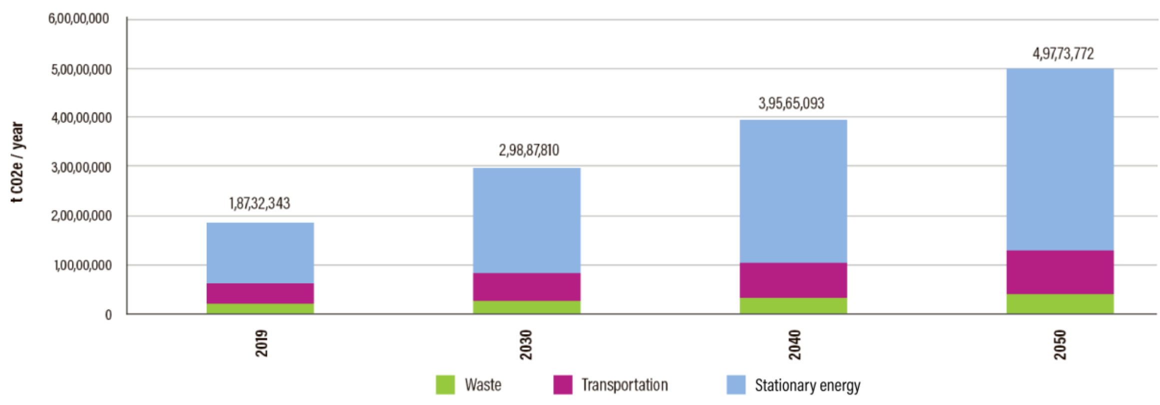


Source: C40 Cities emission pathway's framework

4.2.1 Business-as-usual scenario

The development of a business-as-usual baseline emission forecast for a horizon year describes a 'no-action scenario', where no additional mitigation efforts are implemented by the city or other entities. The baseline forecast serves as a reference from which the impact of emission reduction scenarios is measured.

Figure 50 Business-as-usual scenario emission estimate



Source: WRI India Analysis using Pathways tool developed by C40 Cities

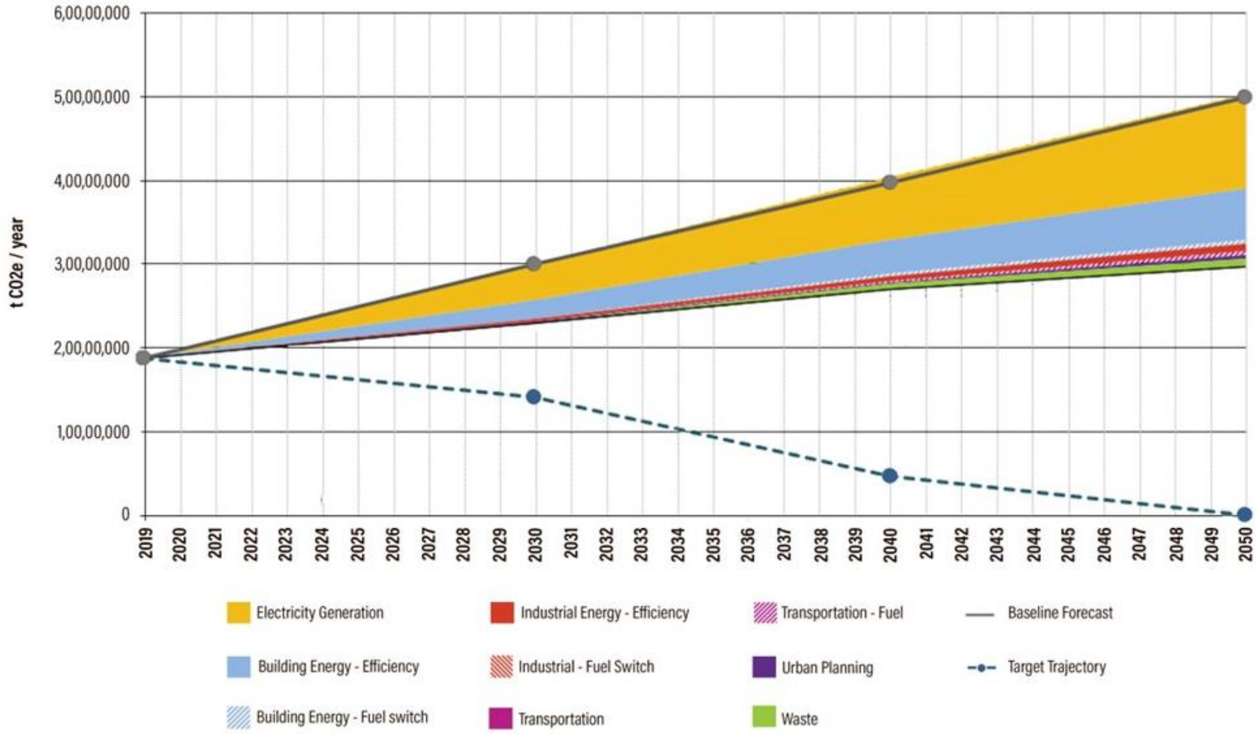
As the above graph indicates, with no actions, the emissions are expected to reach 49.77 million tonnes CO_2e/year by 2050, increasing approximately 165% between 2019-2050, primarily owing to population growth increase in economic activities and improved quality of life.

4.2.2 Existing and planned scenario

Existing and planned scenario is an emission reduction scenario that considers existing or planned city, regional and national actions (e.g., policies, projects, etc.) that are expected to reduce Bengaluru's GHG emissions in future years. 'Planned' actions/initiatives considered in this scenario are activities that are certain to occur. Actions/policies that could be in proposal or in place, but carry some uncertainty, are not considered appropriate for this scenario, because it is supposed to give as close to the 'current' trajectory as possible.

The scenario may also include non-policy driven market trends when there is adequate evidence that such a trend is likely to occur. Information was gathered from existing policies, plans, initiatives, schemes, etc., such as India's National Action Plan for Climate Change (NAPCC), Karnataka's State Action Plan for Climate Change, and relevant sector-specific policies and plans (such as Karnataka Renewable Energy Policy 2022-27, KREDL's Karnataka Energy Conservation and Energy Efficiency Policy 2022-27, Comprehensive Mobility Plan for Bengaluru 2020, and BBMP-SWM Bye-laws, 2020).

Figure 51 Emission reduction potential of actions in the E&P scenario



Source: WRI India Analysis using Pathways tool developed by C40 Cities

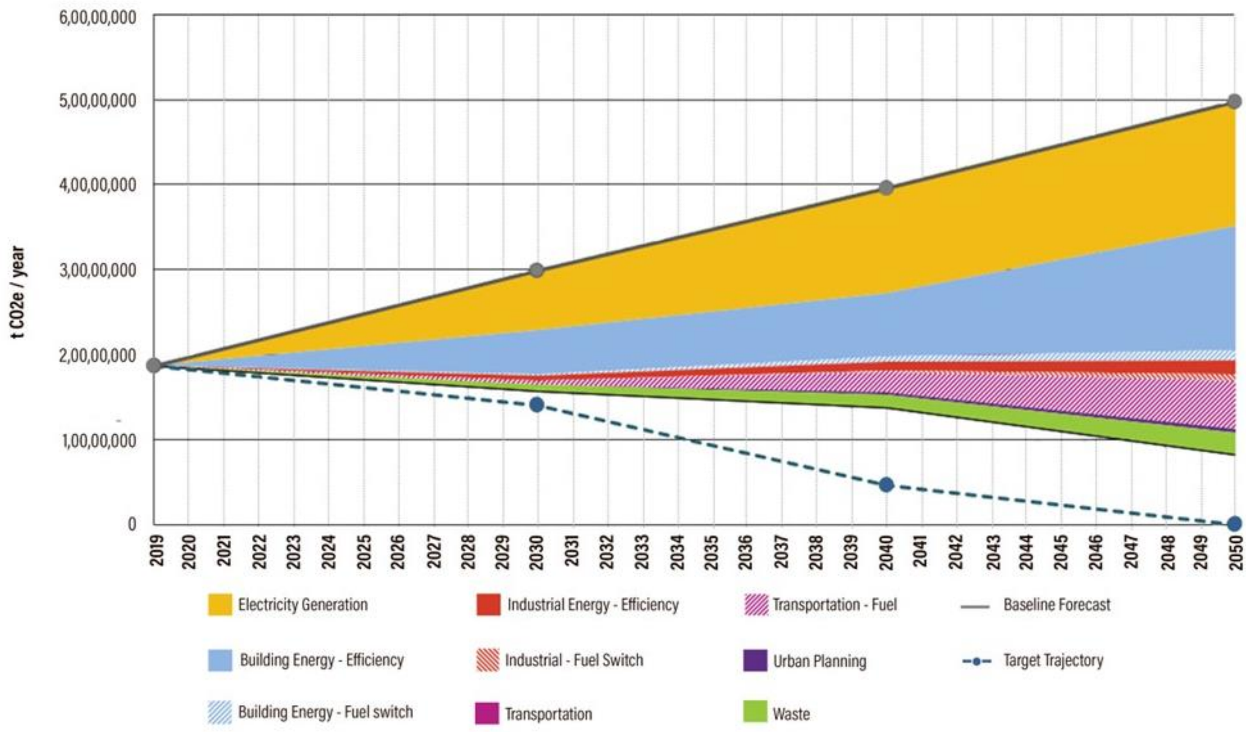
As per this scenario, emissions are expected to reach approximately 29 million tonnes CO_2e/year by 2050, an increase of 58% in comparison to the base year, 2019. Under this scenario, Bengaluru city can achieve a 59% of grid electricity generation[59] from non-fossil fuel by 2050. This scenario also estimates that 26% of buses will switch from fossil fuels to cleaner fuels such as electricity and hydrogen by 2050. The emission trends are not aligned with 1.5°C Paris Agreement and Deadline 2020 emission trajectories.

4.2.3 Ambitious scenario

The Existing and Planned scenario policies leave a significant gap in the 1.5°C Paris Agreement and Deadline 2020 trajectory, indicating that significantly more aggressive action would be required for Bengaluru city to meet a fair share 1.5°C warming scenario. Therefore, an 'Ambitious' scenario was modelled, and the objective of this scenario is to arrive at strategies and actions that are both ambitious and achievable. It includes the strategies that are included in the existing and planned scenario, as well as additional strategies to build on this foundation, to increase the reduction potential of GHG emissions.

[59] Electricity generated from hydro and nuclear power plants are considered non-fossil fuel. India has set a target to have 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. The installed capacity is not the same as electricity generation.

Figure 52 Emission reduction potential of actions in the ambitious scenario

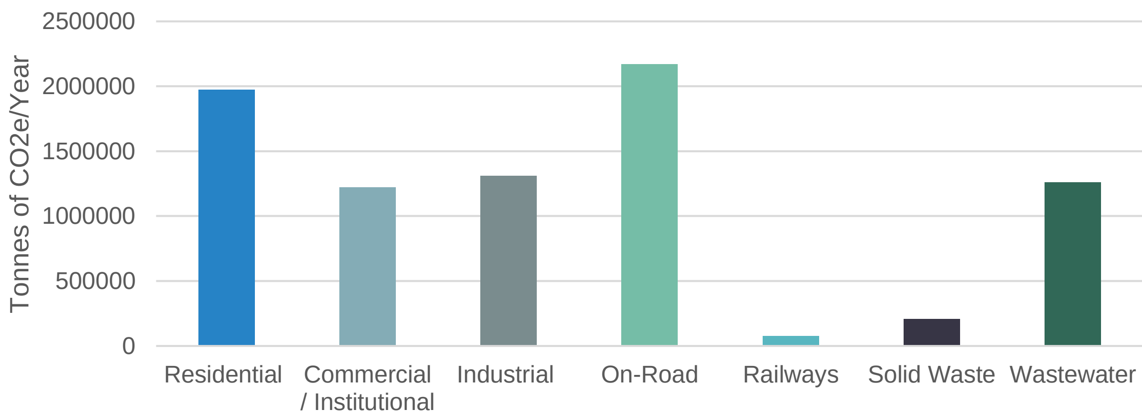


Source: WRI India Analysis using Pathways tool developed by C40 Cities

This scenario also considers India's updated NDCs. India now stands committed to reduce emissions intensity of its GDP by 45% by 2030, compared to 2005 levels, and to achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. These commitments propagate a healthy and sustainable way of living, based on traditions and the values of conservation and moderation, including through a mass movement for 'LiFE' (Lifestyle for Environment) as a key to combating climate change. The decision on enhanced NDCs demonstrates India's commitment at the highest level for decoupling of economic growth from GHG emissions ("Cabinet Approves India's Updated Nationally Determined Contribution to Be Communicated to the United Nations Framework Convention on Climate Change" 2022).

In the ambitious scenario, emissions are forecast to reduce 16% by 2030, and 56% by 2050, compared to 2019-level emissions. This means that the city's remaining emissions amount to a 44% gap in meeting the 2050 target of net zero. The main sources (two-thirds) of residual emissions in 2050 are the transport, energy, and building sectors, as seen in Figure 53. This is mostly attributed to fossil fuel use in on-road vehicles and the electricity grid not being fully decarbonised by 2050 (10% of electricity would still come from coal thermal power plants).

Figure 53: Remaining emissions after ambitious scenario actions



Source: WRI India and C40 Cities analysis 2022, using Pathways tool

The table below shows the summary of GHG emission reduction under the Existing and Planned and Ambitious Scenarios.

Table 14 Summary of GHG emission reduction under E&P and Ambitious Scenarios

Scenario	2030	2040	2050
Exisiting & Planned Considers effects of existing and or planned city actions along with regional and national policies	↑22% 22.8 million tCO_2e/year	↑44% 27 million tCO_2e/year	↑58% 29.6 million tCO_2e/year
Ambitious Includes the most ambitious yet achieveable strategies for the city	↓16% 15.8 million tCO_2e/year	↓26% 13.8 million tCO_2e/year	↓56% 8.2 million tCO_2e/year

Base Year:
18.7 Million Tonnes of CO_2 Equivalent per year (tCO_2e/year)

Unit: Percentage Change below base year level
↑ Increase from Baseline ↓ Decrease from Baseline

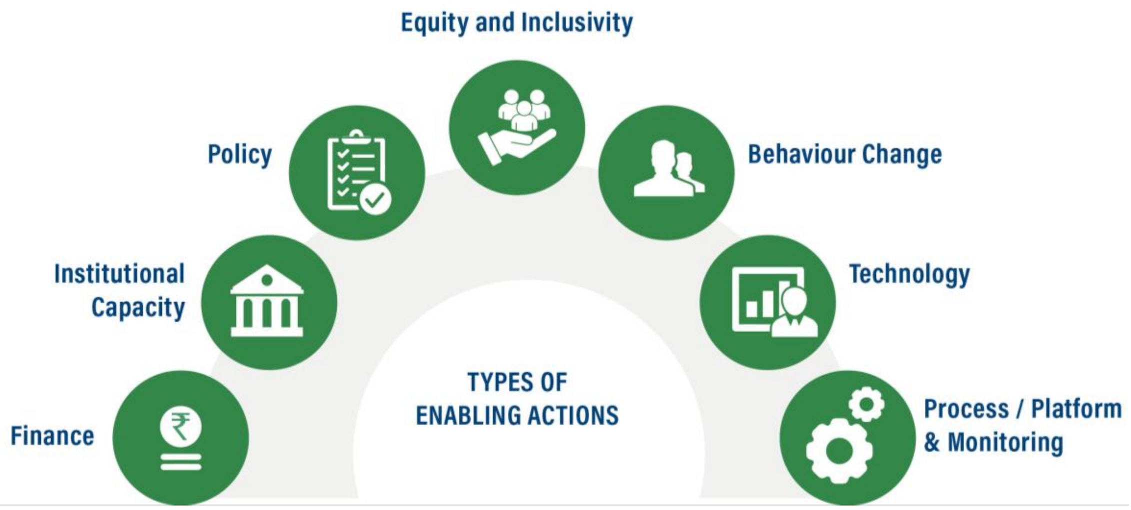
Source: WRI India and C40 Cities analysis 2022, using Pathways tool

Sectoral strategies and targets to achieve the ambitious scenario

In the Pathways scenario exercise, a strategy is defined as a parameter that includes information about the types of technologies involved and the scale or extent of the transformation that the strategy will cause in the community. Enabling actions are interventions that governments and other stakeholders carry out to implement a strategy or set of strategies. Emphasis is placed on the ambitious scenario and its emission reduction potential in the climate action planning process, and the sections below introduce the key strategies and their enabling actions for various sectors.

Consultations with sectoral experts in the city and affiliated agencies were carried out to determine strategies and actions that are fit for the city's conditions and objectives. Apart from the consultations, a thorough secondary research was carried out, and additional enabling actions were proposed.

Figure 54: Types of enabling actions



Source: WRI India analysis

Energy and Building

Bengaluru's GHG emission inventory (Figure 39) reveals that stationary energy is the most emissions-intensive sector, followed by transport and waste. Electricity consumption accounts for 86% of total GHG emissions from stationary energy, while the remainder is from fuel consumption. The sector strategies and actions will primarily focus on having a fully decarbonised electricity grid, improving energy efficiency, and just transition to cleaner fuels. In the ambitious scenario, it is estimated that by 2050, grid electricity generation from renewables will be around 88%. The estimated value has been arrived at by considering India's updated NDCs, which have set a target of about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. Programmes and policies such as Energy Conservation Building Codes (ECBC), Eco-Niwas Samhita (ENS), and Karnataka Energy Conservation and Energy Efficiency Policy 2022-2027, were considered for building energy efficiency strategy inputs. With this, it is estimated that in the ambitious scenario, around 92% of all new residential buildings will have better wall and roof system technology i.e., incorporating insulation in the walls and installing double-glazed windows. For new commercial buildings and major renovations (i.e., transition of existing to new roof/ wall technologies), the implementation of the above-mentioned building energy efficiency strategy is estimated to be 100%. Similarly, transition to clean cooking fuel of about 59% to LPG/PNG and 41% to electric cooking in residential buildings has been assumed. Ongoing initiatives such as the Go Electric campaign for eCooking devices and the Pradhan Mantri Ujjwala Yojna[60] (PMUY) were considered for arriving at clean cooking fuel transition values for 2050.

Transport

Bengaluru's GHG emission inventory reveals that the transport sector is the second largest contributor of emissions in the city. Within the sector, the prominent contributors are freight vehicles, private vehicles (cars and motorcycles), and buses. The sectoral goals of the city focus on three main aspects to reduce future emissions: (a) Mode shift, (b) Fuel switch and (c) Transit-oriented development (TOD)[61]. In the ambitious scenario, the city needs to increase its mode shares of public and non-motorised transport (NMT) to 85% by 2050. This also aligns with the Comprehensive Mobility Plan (CMP) for Bengaluru 2020, which aims to increase the share of public transport to 70% by 2035[62]. The expansion of the metro rail network, the operationalisation of the suburban rail system, and upgrades of the city bus system are positive steps to increase the mode share of public transport and decrease the dependency on private vehicles. The ambitious scenario targets that 90% of private vehicles, 75% of buses, and 47% of freight will switch from fossil fuels to cleaner fuels such as electricity and hydrogen by 2050. The ongoing push for electrification of vehicles by various levels of government and agencies through various schemes, programmes, and initiatives, is expected to enable progress in the desired direction. Additionally, the ongoing active discussions and research could lead to the introduction of hydrogen as a commercial fuel in the near future. The TOD Policy of Bengaluru[63] aims to increase population density around mass transit corridors (in TOD influence zones), thus boosting the mode share of public transport and catalysing the adoption of NMT modes. Specific actions required to achieve this ambitious scenario and its goals are detailed in Chapter 5 of this report. These actions need be taken up by the city and other relevant stakeholder agencies to achieve the ambitious scenario.

Waste

In the GHG emission inventory prepared for the waste sector in Bengaluru, solid waste disposal to landfill, and domestic wastewater treatment and open discharge, contribute about 93% of total waste sector emissions. The sector strategies and actions primarily focus on diverting solid waste from landfills as much as possible, by increasing composting, recycling, and biological wastewater treatment methods to reduce GHG emissions. In the ambitious scenario, by 2050, it is assumed that only 8% of solid waste enters scientific landfills with biogas capture facility and only 5% of wastewater will be openly discharged and the rest will be treated in biological wastewater treatment plants. This is assumed by taking into consideration the provision of SWM Rules 2016 and BBMP SWM Bye-laws, 2020, as well as

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[60] The scheme was launched in 2016, in view of the necessity for clean fuel. In the last six years, the initiative has been fruitful in increasing the use of LPG. The government has been actively promoting piped natural gas (PNG), which is more economically viable than LNG [we should spell it out here].
[61] This urban planning measure has a direct impact on trip characteristics.
[62] 2035 is the target year for CMP 2020,and the 70% share of public transport mentioned there is its share within all 'motorised modes'.
[63] This has been approved by the Karnataka government in November, 2022

BBMP's SWM roadmap and vision document which focuses on the complete segregation of waste at source and less than 15% of solid waste entering landfills. The city is working to augment/upgrade its waste collection infrastructure and treatment facilities in order to reduce mixed waste disposal to landfills. Strategies also take into consideration BWSSB's current efforts towards expanding the sewerage network across the city, and increasing the implementation of biological wastewater treatment methods that may lead to increased wastewater collection and biological treatment by 2050. The city's short-term focus includes increasing public awareness, implementing waste segregation programmes, improving recycling infrastructure, promoting composting initiatives, implementing waste reduction measures, strengthening waste management infrastructure, fostering collaboration, monitoring and evaluating initiatives, enforcing regulations, and conducting pilot projects for innovative waste management technologies.

The key strategies in the ambitious scenario described above inform sector-wise targets and actions for the stationary energy, transport, and waste sectors. An example of Pathways strategies and their targeted implementation for the interim and long-term years is listed in Table 15 below.

Table 15: Ambitious scenario strategy goals and targets for Bengaluru

Sector	Strategic goals	Targets		
		2030	2040	2050
Energy and Buildings	% Share of total grid electricity from non-fossil fuel	69	77	89
	% Transition of predominantly existing LPG cooking technology to electric cooking technology in residential buildings	30	35	41
	% Transition of existing cooling system technology to high efficiency cooling system technology in commercial buildings	38	59	80
	% Transition of existing wall and roof system to insulated wall and roof system in new residential buildings	47	67	92
	% Transition of existing wall and roof system to insulated wall and roof system in new commercial buildings	48	75	100
	% Improvement in industrial energy efficiency – MSMEs	15	20	25
Transportation	% Mode share of public transport and NMT[64]	75	80	85
	% Share of cleaner fuels[65] in cars	10	60	90
	% Share of cleaner fuels in motorcycles	30	60	90
	% Share of cleaner fuels in buses	12	40	75
	% Share of cleaner fuels in freight	8	27	47
	~% of new households in the city (from 2019) that should be in the transit-oriented development areas	20	70	92

[64] Non-Motorised Transport (includes, walking and cycling) [this footnote can be removed]
[65] Includes electricity and hydrogen

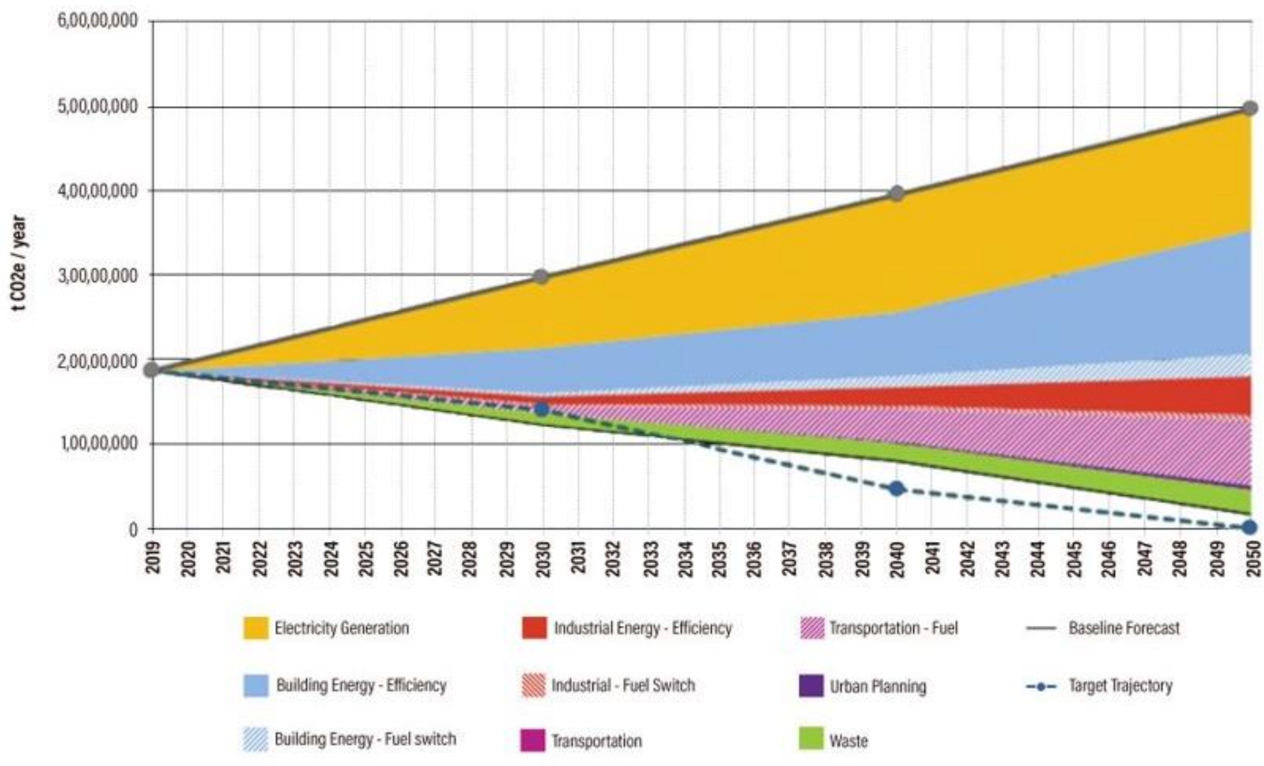
Sector	Strategic goals	Targets		
		2030	2040	2050
Waste	% Of paper waste recycled	61	72	93
	% Of plastic waste recycled	61	72	93
	% Of wet waste composted	68	80	84
	% Of landfill gas capture	25	50	75
	% Of direct discharge	28	23	5
	% Of anaerobic wastewater treatment with biogas capture	23	25	39

Source: WRI India analysis

4.2.4 Extended scenario for achieving net zero emission targets in Bengaluru

For BCAP an extended scenario was prepared, as the ambitious scenario was still presented a gap to achieve net zero by 2050. The extended scenario is intended to: (a) identify key strategies that could reduce the remaining emissions if key barriers to implementation did not exist, and (b) identify the political, financial, governance, technical and market barriers that make the strategy infeasible in current and foreseeable future conditions.

Figure 55 Emission reduction potential of actions in the extended scenario



Source: WRI India and C40 Cities analysis 2022, using Pathways tool

As per this scenario, emissions are expected to reduce to 1.6 million tons CO_2e/year by 2050. This is a 91% decrease from base year emissions, and thus the closest scenario to achieve the net zero target. Key strategies considered here include 100% decarbonisation of the electricity grid by 2050, 50% improvement in industrial energy efficiency, 90% transition to electric cooking, 100% vehicular shift to cleaner fuels, 100% energy recovery from scientific landfills, and increasing anaerobic treatment with biogas capture by 2050.

As mentioned earlier, this scenario is highlighted as 'unfeasible to achieve' considering the current conditions. A summary of the barriers with respect to each of the key strategies is in the section below. Refer to *Annexure C* for detailed barrier analysis.

Barriers to achieving 100% decarbonisation of the electricity grid by 2050

In the global mission to curb GHG emissions, increasing the share of renewable energy plays a prominent role. India's road to renewable energy is promising, as it has committed to ambitious targets such as achieving 500GW installed capacity of non-fossil fuel power plants by 2030. Yet, a just transition at the scale India requires is challenging due to several barriers, and Karnataka is no exception. Among legal and institutional barriers, land acquisition is one of the biggest challenges, as government revenue lands are exhausted. BESCOM continues to pay the fixed charges of long-term contracts, and is unable to void them. Alongside the increase in the procurement of renewable energy, BESCOM also needs to honour the long-term contracts with fossil fuel power plants. This situation has made the total power purchase by BESCOM expensive, creating a financial barrier. The city has no control over the state and national grid. Renewable energy targets are set by state and national government departments, and procurement notices are given by the GoK to BESCOM. Among the practical and technological barriers is the fact that when the renewable sources and other non-fossil fuel sources are integrated to the grid infrastructure, it could lead to grid congestion and disrupt the network. For a fast-growing city like Bengaluru, space availability for large deployments is challenging, and in the absence of domestic production, there will be increasing import dependency for renewable energy, which could threaten energy security.

Barriers to achieving 50% improvement in industrial energy efficiency

Energy efficiency is a low-hanging fruit for limiting the global temperature rise. However, improvements are not fast enough due to several barriers. MSMEs are unorganised in nature and it is challenging to implement regulatory and reporting frameworks. Financial barriers are a major impediment in improving energy efficiency. Most MSMEs have a high capital requirement, as electricity-based technologies invariably require a higher initial investment than fossil fuel-based technologies. The finances available do not consider the complexities of being part of a larger supply chain. Another key barrier is the availability of commercially viable technologies for MSMEs, and they have limited support in terms of active technical assistance in order to adopt new technologies.

Barriers to achieving 90% transition to electric cooking in both residential and commercial buildings by 2050

Transitioning to a future where cooking needs are met in a way that is economically, socially, and environmentally sustainable is an ideal goal. E-cooking concept may offer significant potential for a transition to emission free cooking, however, achieving such transition requires certain barriers to be tackled. Financial barrier to adopt such transition can be highlighted especially in the low-income groups, as the ability to pay the increase in the electricity costs will be challenging if the recently introduced subsidies are not continued. There are cultural and behavioural barriers, such as a resistance to induction cooking due to the belief that modern appliances change the taste of food even if the same condiments and methods are used. There are also technological barriers, such as the aggregation of mass adoption of induction cooking / electric cooktops increasing the demand for electricity and posing a risk to the grid transmission structure.

Barriers to accelerate vehicular shift to cleaner fuel (electric and hydrogen) to 100% by 2050

Although there is a push from the national and the state governments to promote the use of cleaner fuel vehicles (such as EVs), there are multiple hurdles in the realisation of these objectives. Some key legal and institutional barriers include the ineffective implementation of the Karnataka EV Policy 2017, due to the lack of robust institutional mechanisms, expensive or cumbersome processes to get electricity connections for EV charging facilities, the lack of a conducive ecosystem for retrofitting vehicles currently running on fossil fuels, and lack of awareness and policy support for emerging cleaner fuels such as hydrogen. The higher purchase price of EVs, limited subsidies provided to EVs, and customers' lack of awareness on the lifecycle and resale cost of EVs are some key financial and economic barriers holding back this objective. There are also a few social barriers which impact consumer sentiment, including range anxiety, perceived safety concerns, and the availability of an ecosystem for servicing, repair and maintenance. In addition to the above-mentioned concerns, there are some practical and technological barriers as well, such as the limited availability and accessibility of charging infrastructure, limited availability of raw materials required for the production of EV batteries, and technical challenges in the commercial production, storage and transportation of hydrogen.

Barriers to accelerate 100% energy recovery from scientific landfills to achieve net zero waste

Bengaluru's scientific landfill management faces multiple challenges, despite efforts to achieve 100% waste segregation and increased processing. The Mavalipura and Mandur landfills have remained unscientific and closed for over a decade, while the current landfill lacks proper management. The new draft BBMP SWM Bye-laws prioritise bioremediation over scientific landfills and energy recovery, adding to the legal and institutional barriers. Guidelines for buffer zones released in 2014 have not effectively streamlined landfill management. The implementation of provisions from the Municipal Solid Waste (MSW) Rules, 2016, including site selection, monitoring, safety measures, pollution prevention, and water quality monitoring, is crucial. The communication gap between the centre, state, and city further complicates the situation. Financial and economic constraints hinder landfill construction, while the bioremediation of closed landfills requires support from public-private partnerships (PPP). Political and social barriers exist, necessitating stronger capacities within urban local bodies and increased political support for waste management. Limited awareness has led to unutilised funds allocated for awareness campaigns. Citizen engagement, public awareness, and responsible consumer behaviour need to be improved in order to achieve 100% energy recovery. Additionally, technical expertise and land availability pose significant practical challenges.

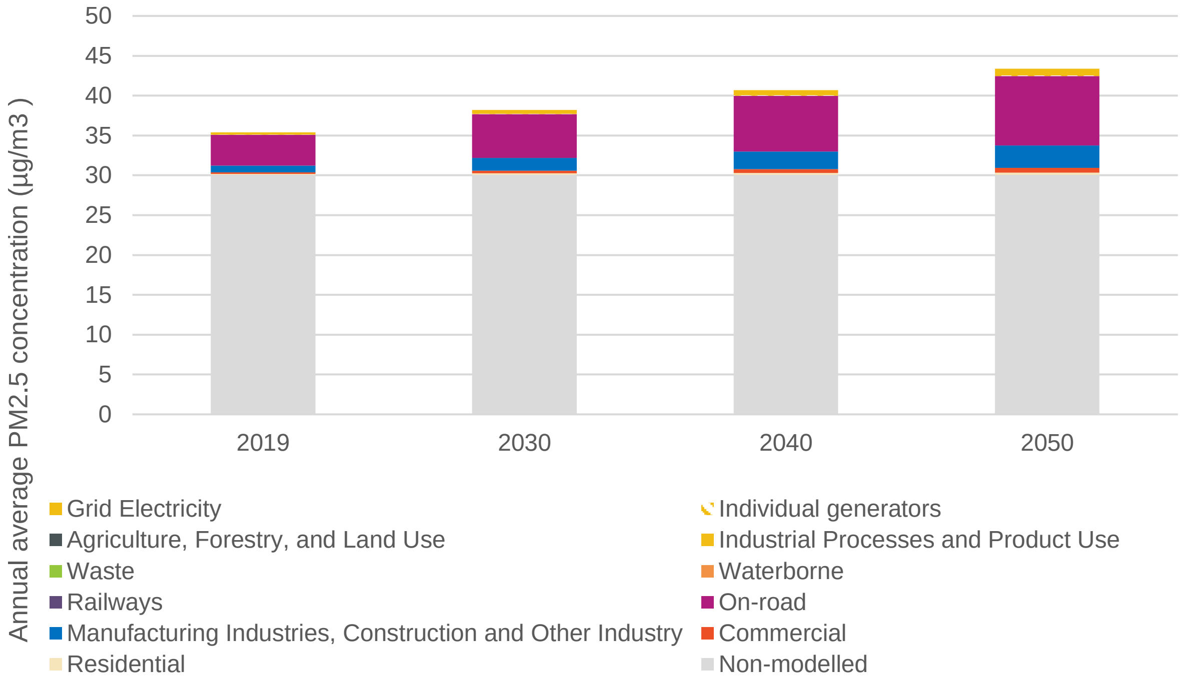
Barriers in increasing anaerobic treatment with biogas capture

Despite increasing centralised wastewater treatment facilities, the major legal and institutional barriers in wastewater treatment in Bengaluru stem from the city's primary focus on basic water and sanitation services, overlooking the potential for mitigation through wastewater treatment. The financial structure for sewage treatment plants (STPs) requires analysis to ensure their proper functioning. The Water Act of 1974 addresses water pollution but lacks emphasis on resource recovery from wastewater. The absence of a central-level policy mandate and regulatory framework for wastewater treatment has led to neglect in this area. The Karnataka State Water Policy of 2019 promotes innovative and cost-effective approaches to wastewater treatment, but implementing less expensive anaerobic treatment and biogas capture presents challenges. Financial and economic barriers hinder the implementation of anaerobic wastewater treatment with biogas capture due to higher capital and operational costs. Political and social barriers involve raising awareness about emission reduction and the lack of skilled labour for STP operation. Upgrading drainage and infrastructure to direct sewage flow to STPs is also challenging. Practical and technological barriers include the feasibility issues of anaerobic treatment with gas capture, which requires more manpower and space. Additionally, the decentralised nature of STPs limits the provision of gas capture, resulting in limited upgrades up to nitrification.

4.3 Impact of future GHG emissions on Bengaluru's air quality and public health

According to an analysis done by C40 using the Pathways-AQ Rapid Scoping Tool, air pollutant emissions are projected to grow. Annual average PM2.5 concentrations under the BAU scenario are expected to increase by 8 % between 2019 and 2030, 7% between 2030 and 2040, and another 7% between 2040 and 2050 (Figure 56).

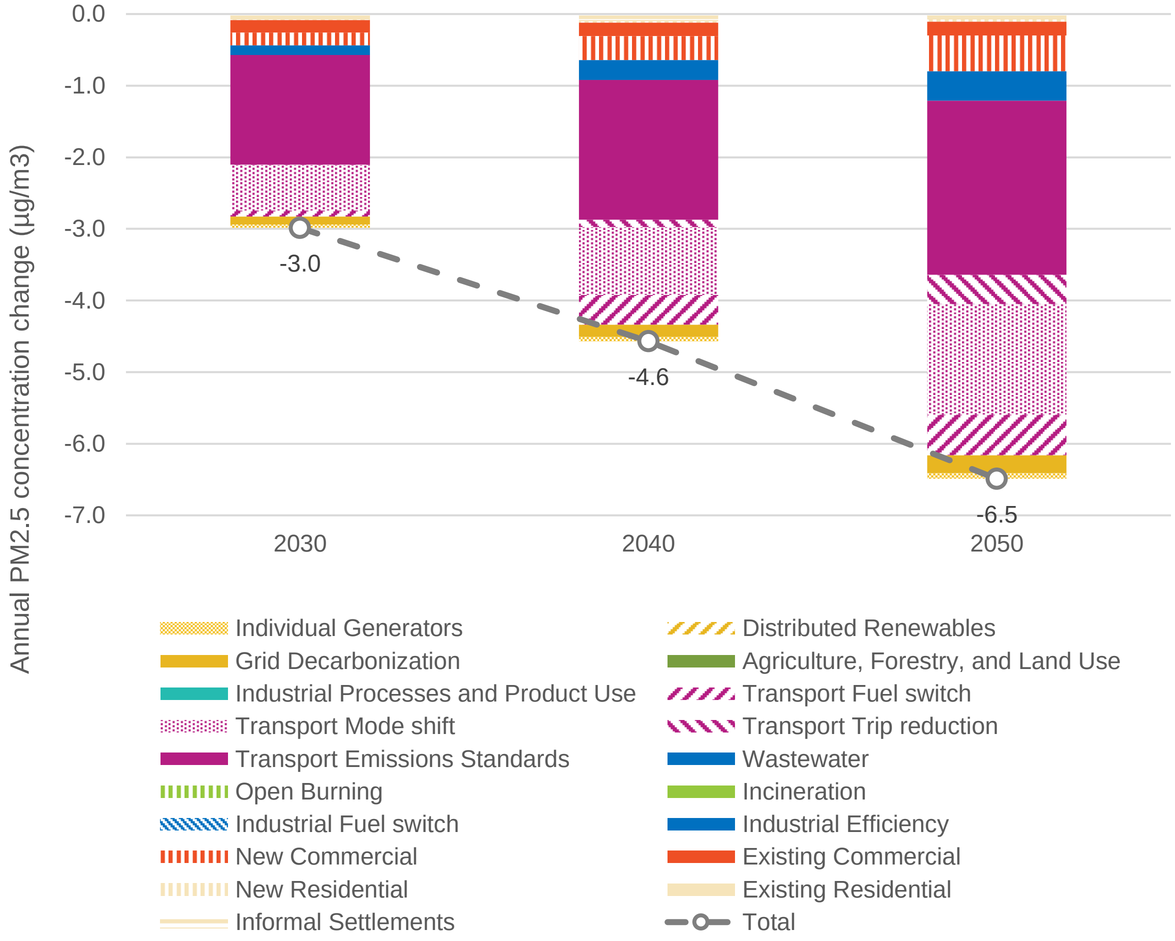
Figure 56 BAU PM2.5 concentration estimate



Source: C40 Cities Pathways AQ Analysis

While the E&P scenario is likely to make a positive impact on air quality and health in Bengaluru by 2050, it will still not do enough to lower PM2.5 concentrations to meet the World Health Organization's (WHO) ambient air quality interim target 3 (35 ug/m3).

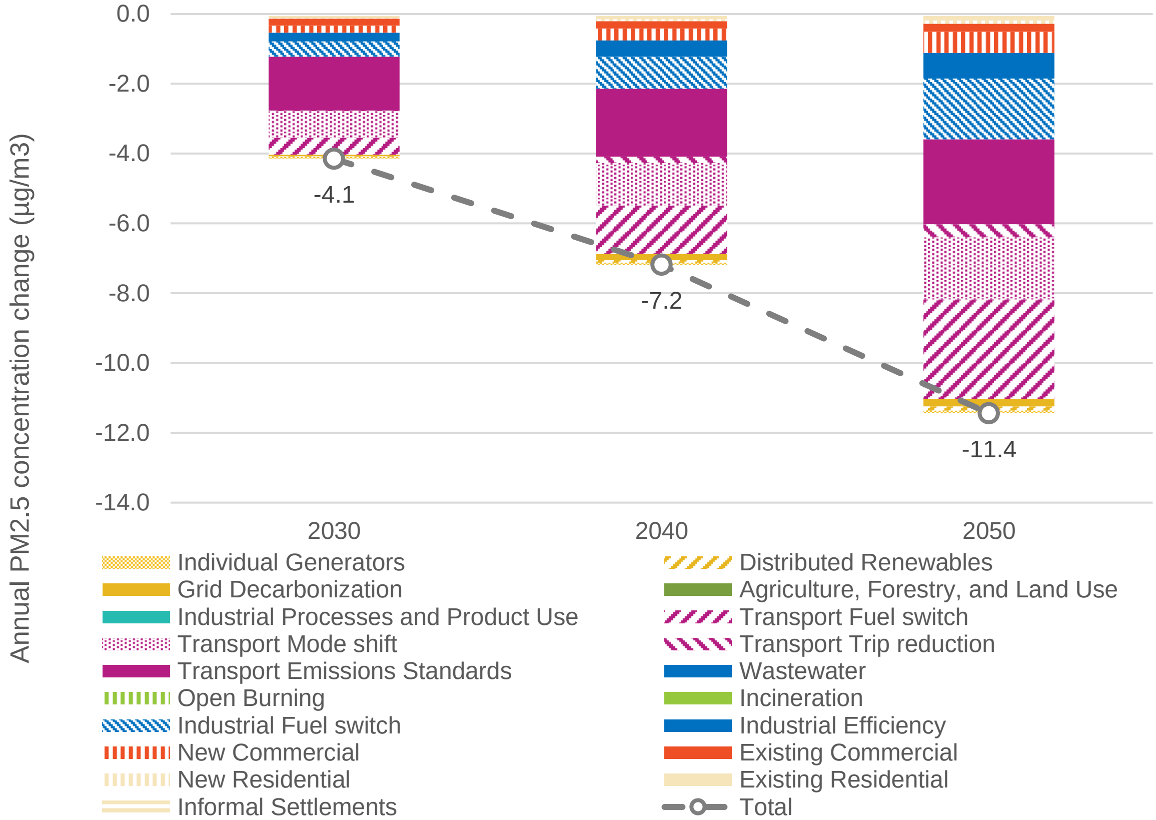
Figure 57 Change in PM2.5 concentration per action for the E&P scenario



Source: C40 Cities Pathways AQ Analysis

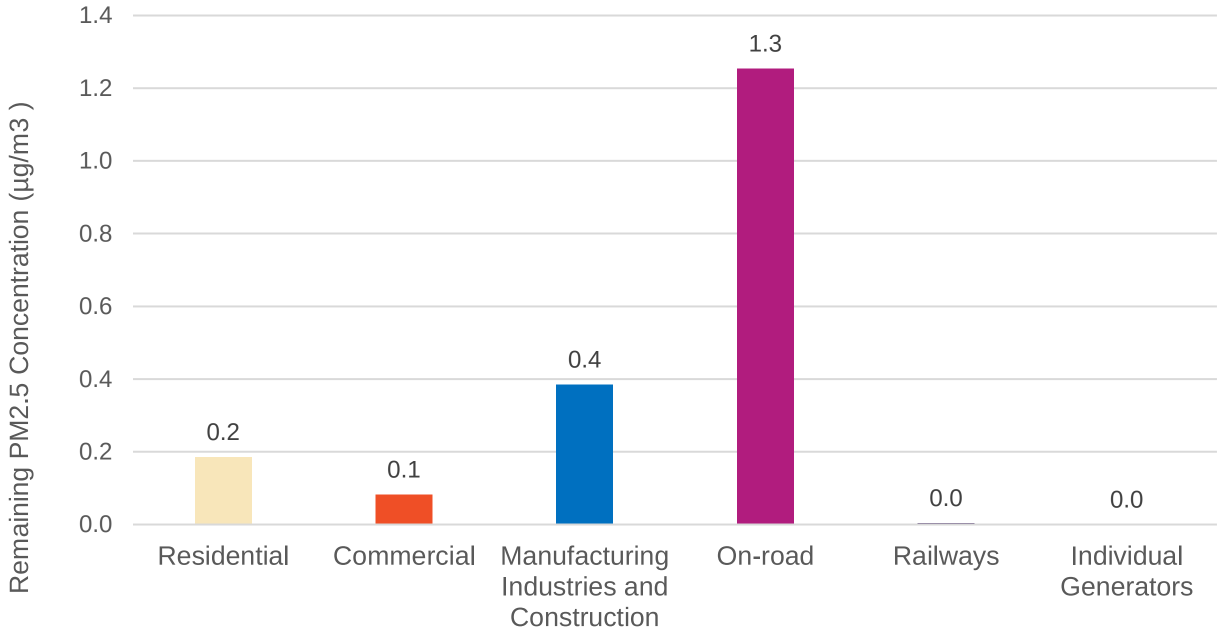
The ambitious scenario is projected to deliver air pollution reductions that are nearly double of those expected under the E&P scenario. PM2.5 concentrations from in-city emission sources are expected to decrease by 4 µg/ m³ (11%) in 2030, 7 µg/m³ (18%) in 2040, and 11 µg/m³ (26%) in 2050, as a result of ambitious scenario implementation (see Figure 58). The reduction in air pollution would prevent nearly 5,500 annual premature deaths in 2050. The largest reductions in PM2.5 emissions and precursor pollutants are expected to come from on-road transportation, mainly by switching diesel buses to natural gas, electricity and hydrogen, and imposing stricter emissions standards on vehicles, and in the industrial sector by reducing diesel generator use. The main source of remaining emissions in 2050 will be on-road transportation, as seen in Figure 59, with the largest contribution being from natural gas and diesel buses that have not been switched to electric, and from tyre and brake wear from all vehicle types. Even under the ambitious scenario, continued diesel use in the industrial sector will continue to create PM2.5 pollution in the city.

Figure 58 Change in PM2.5 concentration per action for the ambitious scenario



Source: C40 Cities Pathways AQ Analysis

Figure 59 Estimated sectoral contributions of PM2.5 air pollution in Bengaluru if ambitious scenario is completely implemented



4.3.1 Summary of Pathways AQ Integration Study results

- By ranking the CAP actions by GHG and PM2.5 reductions, fuel shift in buses has the greatest co-benefits.
- Ambitious and achievable actions are expected to improve air quality by reducing the annual PM2.5 concentration in Bengaluru, from sources included in the GPC inventory, by 11% in 2030, 17% in 2040 and 26% in 2050. The ambitious scenario actions will reduce 11.4 ug/m3 of PM2.5 concentration in 2050 compared to BAU in the same year.
- In the ambitious scenario, most of the total reductions are from the transport (69%) and industrial sectors (21%) by 2050.
- Improved air quality from the selected ambitious and achievable actions are estimated to avoid 5,500 premature deaths (14%) in 2050, as compared to the BAU.

Refer to *Annexure H* for detailed technical specifications and summary of Pathways-AQ rapid scoping tool by C40 cities.


Photo Credit: Praseeda Mukundan/WRI India

5 SECTORAL GOALS AND ACTIONS FOR MITIGATION AND ADAPTATION

5.1 Identifying sectoral priorities and barriers

Based on the assessments discussed in chapters 2, 3, and 4, the strategic approach, priority action areas or vision, and key barriers to implementation of priority action areas for each of the seven sectors were identified. Table 16 summarises these priorities and barriers.

Table 16 Sectoral priorities and barriers identified for each sector

Sector	Sectoral Priority
Energy and Buildings (E&B)	***Strategic approach**: Adopt a multipronged approach to a low-carbon future by decarbonising Bengaluru's grid electricity and promoting energy efficiency, green and low-carbon buildings, and clean cooking fuels.* **Action priority:** Creation of an enabling ecosystem for a higher proportion of renewables in the grid; transition to energy-efficient appliances; affordable cleaner fuels; norms for low-carbon and green buildings. **Key barriers:** Lack of flexibility in energy operation systems; rigid contracting protocols; inadequate policies for assessing the environmental, social, and economic impact of renewables; lack of push and incentives for energy-efficient buildings and energy-efficient appliances; limited capacity and awareness of stakeholders, including citizens.
Transportation (T)	***Strategic approach:** Promote low-carbon mobility solutions, with a strong focus on Public Transport (PT), Non-Motorised Transport (NMT) infrastructure, and cleaner fuels for reducing GHG emissions, improving air quality, and enhancing Bengaluru's liveability.* **Action priority:** Decarbonisation of modes by switching from fossil fuels towards cleaner fuels and shifting from private modes to PT and NMT. The sector should also aim to increase its resilience to climate hazards. **Key barriers:** Lack of integration of land use and transport in city planning practices; inadequate infrastructure; behavioural barriers to shift to public transport; lack of knowledge capacity; and fragmented institutional and governance ecosystem leading to non-implementation of progressive policies.
Solid Waste Management (SWM)	***Strategic approach:** Support and enhance circular economy, improved technology solutions and scientific waste management practices to achieve net zero GHG emissions from the solid waste sector.* **Action priority:** Diversion of waste from landfills, with 100% segregation of waste at source, improvement of resource recovery and the circular economy by promoting decentralised waste management systems; implementation of scientific landfills with gas capture and suitably repurpose closed landfills/dump sites by creating inclusive and hazard-resilient SWM infrastructure and services. **Key barriers:** Inadequate adoption of progressive policies and norms due to lack of awareness and stringent enforcement; deficient infrastructure for

	sustainable waste management; lack of capacity and insufficient working environment for SWM staff, leading to a lapse in waste management value chain.
Air Quality (AQ)	***Strategic approach:*** *Maximise air quality improvement co-benefit opportunities from the BCAP by enabling a shift to clean energy, improved technology, appropriate urban planning and greening solutions, and improved monitoring systems.* **Action priority:** Prevention of air pollution through stringent regulations and protocols; mitigation of air pollution through timely implementation of appropriate measures; building resilience through health check-up drives; and building a robust monitoring network (Ganguly, Kurinji, and Guttikunda 2020). **Key barriers:** Inadequate infrastructure; lack of data and practices for air quality monitoring; lack of norms for indoor air quality management; absence of a complete feedback loop and effective cross-stakeholder engagement; constrained capacity in the city corporation.
Water, Wastewater and Stormwater Management (W, WW, SW)	***Strategic approach****: Enhance Bengaluru's resilience to climate change by adopting an integrated urban water management approach that includes freshwater, wastewater, and stormwater systems.* **Action priority:** Enhancing access to safe, equitable, and affordable water and sanitation to all by diversifying and conserving water sources and promoting the reuse of recycled wastewater by adopting improved technologies and nature-based solutions to ensure water security, social equity, and minimisation of environmental impact. **Key barriers:** Lack of water policy ecosystem; monitoring mechanisms leading to unequal and inefficient distribution; ageing infrastructure, pricing non-reflective of true cost of water; non-diverse water portfolio; lack of awareness and capacity to integrate natural resources in infrastructure and city planning, leading to degradation of resources; lack of awareness and stakeholder consensus hampering progressive policies.
Urban Planning, Greening and Biodiversity (UPGBD)	***Strategic approach:*** *Improve Bengaluru's climate resilience, liveability, and GHG mitigation potential by adopting climate-aware urban planning, greening, and biodiversity management measures.* **Action priority:** Improving the city's GHG mitigation potential through compact growth and land use-transport integration as well as enhancing tree cover to serve as carbon sinks; improving climate adaptation and resilience against climate change risks through nature-integrated planning and nature-based solutions, to further enhance biodiversity conservation and overall liveability. **Key barriers:** Non-aligned planning and policy instruments; siloed operational practices in city agencies; lack of data and inefficient enforcement, leading to unequal distribution of resources and higher risks to certain segments of the population; lack of awareness, knowledge, and capacity to include a climate change lens in urban planning practices; governance complexities hampering integrated urban planning management and climate action.

Disaster Management (DM)	***Strategic approach:*** *Make Bengaluru a proactive city supported by data-led and citizen-centric planning which is well prepared to efficiently reduce vulnerabilities and risks from extreme climate and environmental events, with zero loss of life and minimal loss to its natural resources and local economy.* **Action priority:** Development of a comprehensive data-centric information system to warn people of a disaster; an inclusive disaster risk reduction strategy, taking into consideration location-specific concerns and incorporating them into the strategy guide; a plan for equitable city-level relief and rescue, and post-disaster loss and damage. **Key barriers:** Absence of disaster-related policy and planning tools at appropriate spatial scale; lack of incorporation of risk reduction into the urban planning process; lack of decentralised infrastructure; inadequate coordination between stakeholders; lack of awareness on standard operating protocols among citizens; inequitable and insufficient resources planning and distribution; lacking governance, capacity, and monitoring systems, leading to insufficient assessment of loss and damage.

5.2 Framing of actions under the BCAP: A holistic approach

The identification and detailing of actions comprise the main output of a climate action plan. It is a logical process informed by a series of activities conducted and outputs derived from them, culminating in the identification of areas of intervention to achieve the two key objectives, i.e., the mitigation of GHG emissions and the reduction of risk from climate change by enhancing the adaptive capacity of the city and its population. As illustrated in previous chapters, the mitigation goal of the BCAP is primarily informed by the GHG inventory and Pathways assessment for future emission reduction scenarios. On the other hand, the adaptation and resilience goal of the BCAP is primarily informed by the Climate Change Risk and Vulnerability Assessment (CCRA-VA).

While these exercises offered robust, data-based, and scientific assessments leading to the identification of BCAP targets (mostly quantitative) and action tracks, the identification of actions to reach those targets or address an action track in their entirety involved a deeper assessment of the ecosystem going beyond these measures. The three-pronged consultation conducted to prepare the BCAP (refer section 1.2), along with a dissection of the sector-wise existing and emerging situation (refer section-2.2), provided valuable inputs towards identifying key barriers and challenges in a sector, especially for those to become climate progressive. These offered insights on contextual realities essential for evaluating actions for their sustainability, inclusivity, acceptance, and their merit to align themselves with a just transition.

<u>Barriers that could potentially lead to non-implementation of identified priority climate action strategies in Bengaluru can be broadly bucketed under the following types:</u>

1. **Statutory and regulatory barriers**: These include existing plans, policies, legal and regulatory instruments, and guidelines that govern a sector. The challenges within this barrier are of three types: absence of statutory or regulatory instruments, inadequate or misaligned policies and regulations, and lack of enforcement or

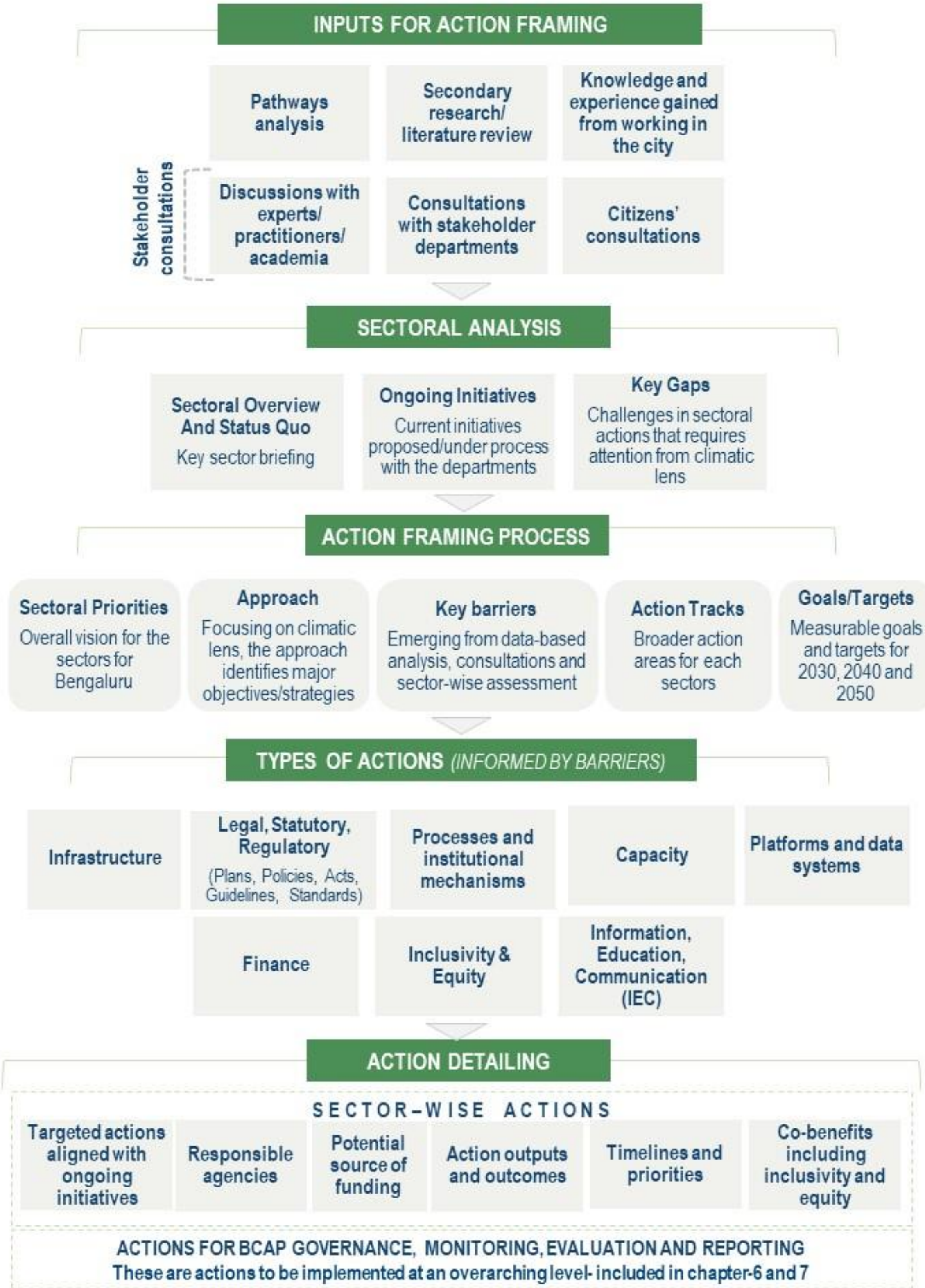
adoption of policies and regulations. While the first two need to be addressed at a design level, the third requires better capacity and awareness.

2. **Inadequate processes and institutional mechanisms**: These include the lack of Standard Operating Procedures (SOPs) and coordination between government departments and agencies as well as between the government and non-government actors involved in implementation. This could lead to non-implementation or delayed implementation of actions resulting in non-achievement of climate action targets.
3. **Infrastructure barriers**: These refer to inadequate hard and soft infrastructure and facilities critical for implementing climate action targets (e.g., improved air quality monitoring equipment and limited availability of waste processing centres).
4. **Capacity barriers**: These include inadequate knowledge, skills, and human resources needed for implementing climate action strategic priorities. Such capacity gaps exist in both state and non-state actors, leading to non-utilisation of funds allotted and non-achievement of milestones against targeted timelines.
5. **Inadequate platforms and data systems**: While limited availability of reliable, consistent, and regular data is a constraint, lack of access to consistent data and analytics could lead to mis-informed decisions and inadequate assessment of outputs and outcomes of actions.
6. **Lack of diversified funding sources**: While there is funding available under programmatic umbrellas in each sector, mostly from government sources (i.e., city, state, and national government funding), lack of diversification of funding portfolio with private and market-based funding instruments could lead to higher risk of stalling of implementation in unforeseen circumstances.
7. **Inclusivity and equity concerns**: These refer to concerns regarding the process of projectivisation and the implementation of climate actions as well as the envisaged climate action outcomes. Issues of vulnerability in resilience actions and unfair transition pathways in mitigation actions could need to greater socio-economic exclusion and inequity, thus leading to the failure of the BCAP as a politically and socially viable policy instrument.
8. **Lack of awareness**: This comprises lack of information, education, and effective communication regarding climate change and its impact, as well as sector-specific progressive policies. This is a critical barrier which, if not addressed, could lead to the lack of ownership, enforcement, and adoption of climate actions by stakeholders, including citizens, businesses, and political representatives.

Understanding these barriers enabled a holistic 360-degree approach to the identification of actions, covering not only specific climate solutions but also specific actions to address the above-identified category of barriers. A mind map was developed for action identification, with an array of possible action categories, spanning policies, capacities, institutional mechanisms, and so on. Further, actions were prioritised based on their relative contribution to achieving respective targets, their chance of success, and the envisaged co-benefits (for example, some clean transport and urban greening actions will also help reduce air pollution). A schematic of the action-framing process is illustrated in Figure 60.

Actions across sectors identify synergies between mitigation and adaptation to actively leverage interdependencies. The BCAP aims to achieve fair and equitable distribution of benefits. However, it is to be acknowledged that inclusion is a continuous process, not a one-time activity. Hence, inclusivity must be enshrined at the projectification stage of certain actions during the implementation of the BCAP. Participation and consensus-building during the climate action project design and implementation process will not only enhance success but also de-risk investments.

Figure 60 Action-framing process



5.3 Sector-wise action recommendations

The actions recommended are prioritised into *high, medium* and *low* based on the following:

Figure 61: Action prioritisation

High priority	Actions that have greater mitigation and adaptation potential, that need to be carried out immediately.
Medium priority	Actions with moderate mitigation and adaptation potential as compared to other actions.
Low priority	Actions that have lower mitigation and adaptation potential as compared to other actions.

The following section presents action tracks, goals, strategies, and actions recommended for each of the seven sectors considered under the BCAP. Minutes of meetings that were conducted with the departmental nodal officers and heads of the departments on March 8 and 13, 2023, to discuss sector-wise draft goals, targets, and actions under the BCAP are attached in *Annexure G.*

Actions pertaining to inclusivity and IEC are highlighted below in the sector-wise action recommendations.

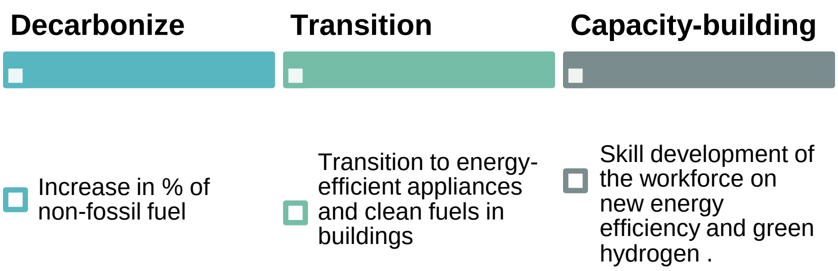
Inclusivity
Information, Education and Communication
Inclusivity and IEC

5.3.1 Energy and buildings

Approach

The energy and buildings sector is the main contributor to GHG emissions, and the interventions proposed are mainly categorised under the decarbonisation of the existing electricity grid, transitioning to energy-efficient appliances and zero-carbon-ready buildings, and capacity-building and development of resources through awareness campaigns and training workshops. Figure 62 summarises the approach.

Figure 62: Approach for energy and buildings sector



Sectoral action tracks

No.	Action track
E&B-1	Achieve higher penetration of energy-efficient appliances and clean fuel transition in all major sub-sectors (residential, commercial, institutional, and industrial).
E&B-2	Promote green and low-carbon buildings with passive and active design strategies.
E&B-3	Increase the proportion of non-fossil fuel sources in the city's grid electricity generation to 68% by 2030 and 89% by 2050.
E&B-4	Implement effective communication methods for nudging behavioural changes by adopting behavioural science principles through IEC programmes.
E&B-5	Develop a programme for affordable clean cooking fuel transition.

Track-wise actions

Priority	S.No	Actions	Aligned with *(ongoing initiatives/other actions)*	Responsible agency *Primary (p) Secondary (s)*	Potential source of funding	Output	Outcome	Co-benefit	Timeline *(Targeted year of completion of action)*
***E&B- 1**: Achieve higher penetration of energy-efficient appliances and clean fuel transition in all major sub-sectors (residential, commercial, institutional, and industrial).*									
Goal/Target: 40% of new appliance technology will be of high-range energy efficiency by 2030.									
	E&B 1.1.	Ensure the use of energy-efficient fixtures and appliances (especially cooling appliances) in all public buildings by 2030.	a. Hosa Belaku Phase II scheme b. Energy Conservation and Energy Efficiency Policy 2022-2027	P: BBMP S: KREDL, BESCOM	a. Grants from Green Climate Fund and Green Energy Fund b. Carbon Cess c. Projects implemented under State Energy Conservation Fund d. Credit line/ loans from banks e. Corporate social responsibility funds	% increase in the energy-efficient fixtures and appliances in municipal and public buildings	% increase in energy savings	Acceleration of Smart Cities Mission	2030

	E&B 1.2	Conduct regular energy audits for all MSMEs consuming a load of 100KW or more, to assess assets and processes, and create an institutional mechanism to make audits mandatory. The nodal agency for the Perform Achieve Trade (PAT) Scheme (KREDL) can prepare and provide the Energy Audit guideline manual as per the notification of the Bureau of Energy Efficiency (BEE) on the manner and periodicity for conducting energy audits.	a. PAT Scheme b. SME division schemes	P: BBMP, Department of Industry and Commerce S: KREDL, MSME Development Institute, KSPCB	a. Technology and Quality Upgradation Support Scheme b. National Small Industries Corporation (NSIC) schemes c. Coir Udyami Yojana	a. Approved institutional mechanism for energy audits b. Number of MSMEs audited	a. Reduced energy and production costs b. Increased lifespan of equipment c. Operational performance improvements in MSMEs d. Increase in low-carbon fuels	a. Improved indoor occupancy comfort b. Reduced GHG and ambient air pollutant emissions c. Improved health	2030
	E&B 1.3	Encourage shift to electric motor-driven systems from fossil-fuel driven systems in all PAT and Non-PAT industries.	a. PAT Scheme b. SME division schemes	P: BBMP, Department of Industry and Commerce S: KSPCB	a. Technology and Quality Upgradation Support Scheme b. National Small Industries Corporation (NSIC) Schemes c. Coir Udyami Yojana d. Credit Linked Capital Subsidy (CLCS) for	a. % increase in electric motor-driven systems in PAT and Non-PAT industries	a. Operational performance improvements in MSMEs (reduced energy and production costs)	a. Improved indoor occupancy comfort b. Reduced GHG and ambient air pollutant emissions c. Improved health	2035

					Technology Upgradation				
	E&B 1.4	Establish 'energy management cells' at the MSME cluster levels to promote 'Zero Defect Zero Effect Manufacturing (ZED)'	a. PAT Scheme b. MSME Sustainable (ZED) Certification	P: BBMP, Department of Industry and Commerce S: KSPCB	a. Technology and Quality Upgradation Support Scheme b. National Small Industries Corporation (NSIC) schemes c. Coir Udyami Yojana	a. Energy Management cell in every MSME cluster within the BBMP boundary b. Number of industries adopting ZED	a. Operational performance improvements in MSMEs (reduced energy, production costs, etc.)	a. Reduced GHG and ambient air pollutant emissions b. Improved health c. Reduce negative effects on environmen t	2030
	E&B 1.5	Ensure the replacement of existing conventional electricity meters with digital ones. Create advanced metering infrastructure to enable a bidirectional flow of information and power. Advanced metering infrastructure includes integrated billing application and user	a. Energy Conservation and Energy Efficiency Policy 2022-2027	P: BESCOM	a. BESCOM Budget	a. Number of houses using electricity meters (digital) b. Integrated customer billing services app	a. Swift billing and robust tracking system b. Improved demand-side management system c. Accurate data available on consumption and load	a. Improved data collection and repository b. Reduced carbon footprint	2027

		interface tracking using IoT.							
	E&B 1.6	Incentivise citizens to achieve a behavioural shift towards energy-efficient appliances especially cooling appliances. Programmes such as the 'exchange premium concept' to increase the uptake of energy-efficient appliances. The premium would provide a higher subsidy to low-income groups. KREDL to provide guidelines and technical support for the BBMP to take up the initiative.	a. Pavan Scheme b. Hosa Belaku II Scheme c. Energy Conservation and Energy Efficiency Policy 2022-2027	P: BBMP S: BESCOM, KREDL	a. Grants from Green Climate Fund and Green Energy Fund b. Carbon Cess c. Projects implemented under State Energy Conservation Fund d. Credit line/ loans from banks e. Corporate Social Responsibility funds	a. Number of programmes or schemes for incentivisation b. Number of people participating in the programme or schemes c. % increase in the number of energy-efficient appliances	a. % increase in energy savings	a. Smart Cities Mission accelerated b. Uptake of circular economy c. Reduced carbon footprint d. Improved standard of living	2035
	E&B 1.7	Develop a low-cost financing scheme for the uptake of energy	a. Pavan Scheme b. Hosa	P: BBMP	a. Municipal corporation budget	a. Number of low-cost financing	a. Improvements in the uptake of	a. Smart Cities Mission	2030

		efficiency projects via a special property tax assessment or utility bill, especially for MSMEs and low-income group households.	Belaku II Scheme c. Energy Conservation and Energy Efficiency Policy 2022-2027	S: BESCOM, KREDL		schemes b. % of people participating in the scheme	energy efficiency appliances b. % increase in energy savings	accelerated b. Reduced carbon footprint c. Improved standard of living	
	E&B 1.8	Conduct mandatory energy audits for all the public buildings with a connected load of 100kW or certain threshold to assess their energy efficiency potential.	a. Smart City Missions	P: BBMP S: PWD	a. Municipal corporation budget	a. Number of public buildings assessed b. % shift to energy-efficient buildings	a. Improved evidence-based analysis and decisions	a. Accelerated Smart Cities Mission b. Reduced carbon footprint	2030
	E&B 1.9	Facilitate private players' involvement in municipal energy efficiency projects by creating a platform for them to be a part of the development, financing, and/or implementation of projects.	a. Smart City Missions	P: BBMP S: KREDL	a. Municipal corporation budget	a. Budget allocation for the platform b. Develop and launch the platform c. Suitable agreements/contracts for the private players drafted	a. Accelerated energy efficiency project uptake b. Improved PPP	a. Accelerated Smart Cities Mission b. Reduced carbon footprint	2030
***E&B-2:** Promote green buildings and low-carbon buildings with passive and active design strategies.*									
Goal/Target: By 2030, 42% of new residential buildings and 48% of new commercial buildings will adopt insulated walls and roofs, improved window technology, and improved building services design									
	E&B 2.1	Revision of BBMP building bye-law to include Eco Niwas Samhita as per the EC	a. Energy Conservation Building Codes (ECBC)	P: BBMP S: KREDL	a. Municipal corporation budget b. Credit line/	a. Approved revision of BBMP building-bye laws	a. Increase in the number of energy-	a. Creation of green jobs	2025

		Act Amendment, 2022 to mandate the implementation of energy-efficient design in residential buildings.	b. Eco Niwas Samhita (ENS) Part 1 and Part 2		loans from banks c. Corporate Social Responsibility funds – General		efficient buildings		
	E&B 2.2	Enforce the Karnataka Energy Conservation Building Code (KECBC) 2018 within BBMP limits, since it is gazetted by the GoK and its implementation is mandatory for commercial buildings.	a. ECBC b. ENS Part 1 and Part 2	P: BBMP S: KREDL	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. % increase in ECBC-compliant commercial buildings	a. Increase in the number of energy-efficient buildings	a. Creation of green jobs	2025
	E&B 2.3	Promote and incentivise the adoption of the 'adaptive reuse architecture' concept to all existing and unused/old buildings to reduce construction and demolition waste disposal to landfills.	a. ECBC b. ENS Part 1 and Part 2	P: BBMP S: KREDL, PWD	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. % buildings adopting adaptive reuse architecture b. % increase in recycled/recyclable material used in building construction c. % reduction in construction waste	a. Increase in the number of green and zero-carbon-ready buildings b. Improved landfill waste management	a. Creation of green jobs b. Improved ambient air quality	2035

	E&B 2.4	Ensure that a portion (50%) of public buildings' energy requirement is met with passive solar design concepts such as rooftop solar power systems and solar water heaters.	a. ECBC b. ENS Parts 1 and 2	P: BBMP S: BESCOM, KREDL	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. % of buildings adopting passive solar design concept b. % reduction in grid-electricity consumption	a. % increase in energy savings	a. Creation of green jobs	2035
	E&B 2.5	Promote implementation of low thermal mass design such as clay and fly ash bricks over thermally massive materials such as concrete in all buildings	a. ECBC b. ENS Part 1 and Part 2	P: BBMP S: KREDL, PWD	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. Number of promotions on ECBC and ENS b. Number of buildings adopting low thermal mass design	a. Improved occupancy thermal comfort b. % increase in energy savings	a. Creation of green jobs b. Better indoor air quality	2035
	E&B 2.6	Revise the BBMP building bye-laws to mandate the implementation/uptake of green roof systems for all new buildings beyond a certain footprint/roof area in line with Eco Niwas Samhita guidelines.	a. ECBC b. ENS Part 1 and Part 2	P: BBMP S: KREDL	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. % green roof cover achieved b. Number of suppliers providing automated irrigation systems for roof tops	a. % increase in green cover b. % reduction in heat island effects	a. Creation of green jobs b. Better indoor air quality	2030

	E&B 2.7	Offer incentives and subsidies to all stakeholders throughout the value chain (consumers, manufacturers, distributors, etc.) to ensure the uptake of non-VOC (volatile organic compound) materials.	a. ECBC b. ENS Part 1 and Part 2	P: BBMP S: KREDL, PWD	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. % of buildings using non-VOC materials	a. Improved occupant health and indoor comfort	a. Better indoor air quality	2030
	E&B 2.8	Promote ECBC/ENS buildings in the city by providing incentives to building owners through instruments such as property tax rebates and increase in FSI/FAR allowance. KREDL to prepare and provide the financial incentives guidelines for initiation.	a. ECBC b. Eco Niwas Samhita Part 1 and Part 2	P: BBMP S: KREDL	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. % increase in ECBC and ENS compliance in the buildings b. % banks that are providing financial support c. Number of buildings in the financial incentives programme	a. Improved occupants' indoor climate comfort b. Improved the standard of living	a. Creation of green jobs b. Better indoor air quality	2030
	E&B 2.9	Mandate all HVAC buildings covered under the scope of ECBC and ENS to implement heat recovery ventilation (HRV) or energy recovery ventilation (ERV) by 2030.	a. ECBC b. Eco Niwas Samhita Part 1 and Part 2	P: BBMP S: KREDL	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. % of HRV/ERV implementation in the buildings	a. % increase in energy savings	a. Better indoor air quality	2030

	E&B 2.10	Subsidise reversible ceiling fans for most vulnerable people and low-income groups; the fans are used to circulate indoor air and can be used in both hot and cold seasons.	a. ECBC b. Eco Niwas Samhita Part 1 and Part 2	P: BBMP S: BESCOM, KREDL	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. Approved subsidisation of reversible ceiling fans b. % users of reversible ceiling fans	a. Improved occupancy thermal comfort b. % increase in energy savings		2030
	E&B 2.11	Conduct IEC campaigns to sensitise all relevant stakeholders on a) low-carbon buildings, b) Smart building concepts, c) green buildings	a. ECBC b. Eco Niwas Samhita Part 1 and Part 2	P: BBMP S: All other agencies	a. Municipal corporation budget b. Credit line/ loans from banks c. Corporate Social Responsibility funds – General	a. % of new buildings complying with ECBC b. % of existing buildings retrofitting buildings to ECBC compliant	a. % increase in energy savings	a. Accelerated Smart Cities Mission	2030
	E&B 2.12	Develop energy auditing guidelines and implement energy auditing measures in all buildings.	a. ECBC b. Eco Niwas Samhita Part 1 and Part 2	P: BEE S: KREDL, BBMP		a. Approved guidelines and measures	a. Increase in ECBC and ENS compliant buildings b. % increase in energy savings	a. Creation of green jobs	2030
	E&B 2.13	Review the scope of ECBC and ENS to assess feasibility of including certain aspects of energy efficiency in the existing building stock. This should be done based on an in-depth study of existing commercial and residential building	a. ECBC b. Eco Niwas Samhita Part 1 and Part 2	P: KREDL	KREDL's Own funds	a. Updated ECBC b. Updated ENS	a. Increase in ECBC and ENS compliant buildings b. % increase in energy savings	a. Better indoor air quality	2030

		stocks in Bengaluru and their present status of energy efficiency.							
E&B-3: *Increase the mix of non-fossil fuel sources in the city's grid electricity generation to 68% by 2030 and 89% by 2050.*									
	E&B 3.1	Ensure that by 2035, 50% of BESCOM's grid electricity is from a decentralised renewable resource network, while enhancing service delivery potential.		P: Energy Department-GoK, KPTCL S: BESCOM	GoK Budget	a. % increase in private suppliers for renewable energy (RE) b. % increase in the expansion of hybrid RE plants c. % of RE energy in the grid mix	a. % GHG emissions reduction b. Accelerated decarbonisation	a. Reduction in ambient air pollution b. Creation of green jobs	2035
	E&B 3.2	Conduct a study to assess the capacity of existing grid infrastructure before tendering out solar and wind projects to BESCOM		KPTCL	GoK Budget	a. % readiness of grid infrastructure for variable renewable energy (VRE) b. % increase in the number of energy storage systems	a. % reduction in curtailment of VRE	a. Creation of green jobs	2030

	E&B 3.3	Develop a roadmap to phase out thermal power plants (TPPs). Prepare a thermal power plant transition plan, under which older and inefficient thermal plants are progressively retired and newly established thermal power plants continue to supply base load.		P: Energy Department-GoK, KPCL S: KPTCL, PCKL	GoK Budget	a. Approved roadmap b. Number of inefficient thermal power plants retired	a. % Improvement in power generation efficiency b. % Improvement in water resource management of TPPs	a. Reduction in ambient air pollution	2030
	E&B 3.4	Establish an Integrated Renewable Energy Resource Management (IRERM) cell for the city through the collaboration of BBMP (town planning and revenue department), BESCOM, KREDL, and other key stakeholders. This cell will develop a roadmap to increase the city's renewable energy potential.	a. Karnataka Renewable Energy Policy b. Har Ghar Solar Mission c. Jawaharlal Nehru National Solar Mission (JNNSM)	P: BBMP S: BESCOM, KREDL	a. Municipal corporation budget b. GoK Budget	a. IRERM cell b. Number of stakeholders in the cell c. Approved roadmap d. % increase in uptake of off-grid renewable energy plants	a. % Improvement in multi-sectoral coordination	a. Reduction in ambient air pollution b. Creation of green jobs	2027
	E&B 3.5	Ensure implementation of utility-scale energy storage for load or supply, to enhance the power generation flexibility of rooftop solar systems and other	a. Karnataka Renewable Energy Policy b. Har Ghar Solar Mission c. JNNSM	P: BESCOM S: KREDL, BBMP, PWD	GoK Budget	a. % increase in utility-scale storage b. % reduction in peak loads	a. % reduction in GHG emissions b. % reduction in power outages	a. Reduction in ambient air pollution b. Creation of green jobs	2030

		renewable energy sources.							
	E&B 3.6	EV charging stations to be mandated to source a portion (50%) of its electricity through rooftop solar energy.	a. Karnataka Renewable Energy Policy b. JNNSM	P: BESCOM S: BBMP, PWD	a. Municipal corporation budget b. GoK Budget	a. % of EV stations with rooftop solar power systems b. % Increase in rooftop solar systems	a. % reduction in peak loads in grid infrastructure b. % reduction in GHG emissions	a. Reduction in ambient air pollution b. Creation of green jobs	2030
	E&B 3.7	Reduce the up-front cost of rooftop solar systems and installation charges by promoting collaborations and developing platforms to facilitate largescale uptake through bulk purchases.	a. Karnataka Renewable Energy Policy b. Har Ghar Solar Mission c. JNNSM	P: BBMP S: BESCOM, KREDL	a. Municipal corporation budget b. GoK Budget	a. Approved bulk purchasing platform b. % of people enrolled in the platform	a. Increased rooftop solar systems uptake	a. Reduction in ambient air pollution b. Creation of green jobs	2030
	E&B 3.8	Develop a roadmap to manage the potentially massive volumes of solar panels and storage battery waste threatening to overwhelm landfills.	a. Karnataka Renewable Energy Policy b. Har Ghar Solar Mission	P: Energy department-GoK S: KREDL, BESCOM, BBMP	a. GoK Budget b. Municipal corporation budget	a. Approval of guidelines	a. % reduction in e-waste b. Improved hazardous waste handling	a. Creation of green jobs b. Better solid waste managemen t	2030
	E&B 3.9	Operationalise Green Energy Open Access (GEOA) rules, so that	a. Karnataka Electricity Regulatory	P: BESCOM, KERC		a. Open access to electricity from	a. Greater access to affordable	a. Creation of green jobs	2025

		smaller consumers can also enter into contracts with RE generators.	Commission (Terms and Conditions for Green Energy Open Access (GEOA) Regulations, 2022	S: Energy Department, BBMP		renewable sources	renewable energy		
E&B-4: *Implement effective communication methods for nudging behavioural changes by adopting behavioural science principles through IEC programs.*									
	E&B 4.1	Conduct IEC campaigns to sensitise financiers such as banks to provide low-cost loans for the uptake of green technologies and business models.		P: BBMP, KREDL S: Financial institutions	GoK Budget	a. Number of trainings and workshops b. Number of banks and financial institutions participating	a. Improvement in financial assistance for RE projects	a. Creation of green jobs b. Accelerate Smart Cities Mission	2030
	E&B 4.2	Conduct an annual flagship event to engage with organisations and people involved in rooftop solar and promote rooftop solar deployment.		P: BESCOM S: KREDL	GoK budget	a. Number of events conducted b. % people participating and organisations attending the events	a. Better informed citizens and stakeholders, with respect to brands and technologies	a. Creation of green jobs b. Accelerated Smart Cities Mission	2027
	E&B 4.3	Conduct regular (half yearly) capacity-building workshops to upskill the technical knowledge of shop floor technicians	a. Building awareness on intellectual property rights (IPRs)	P: Department of Industry and Commerce	GoK budget	a. % MSME clusters covered b. Number of shop floor	a. Improved skills b. Increased energy savings	a. Creation of green jobs b. % reduction in	2030

		pertaining to energy efficiency.	b. Lean manufacturing competitiveness for MSMEs	S: BBMP		technicians participating		GHG and air pollution emissions	
	E&B 4.4	Develop an open access platform and maintain information on different rooftop solar systems and hot heaters vendors/service providers.		P: BESCOM S: KREDL	GoK Budget, BESCOM Budget	a. Approved platform b. % increase in uptake of rooftop solar systems and solar water heater	a. Improved local business	a. Creation of green jobs b. % reduction in GHG and air pollution emissions	2027
	E&B 4.5	Conduct R&D activities to understand the barriers/gaps that hinder households from taking up eCooking. Devise measures to support its adoption accordingly.	a. Go Electric campaign - eCooking devices	P: BBMP S: KREDL, BESCOM	GoK Budget	a. Approved number of R&D activities b. % increase in the uptake of electric cooktops	a. % Increase in energy savings	a. Reduction in indoor air pollution b. Improved women's empowerment and health resilience	2027
***E&B-5:** Develop a programme for affordable clean cooking fuel transition.*									
Goal/Target: 100% transition from solid fuel to clean cooking fuel by 2030.									
	E&B 5.1	Prohibit the use of solid biomass for all purposes. Regulate the usage of solid biomass in hard-to-abate sectors such as eateries (cooking) and kerbside ironing (heating).	a. PMUY	P: BBMP S: Food and Civil Supplies Department, Forest Department	a. GoK fund b. Municipal corporation budget	a. % reduction of types of solid fuels in the city b. % reduction in establishments selling solid fuel	a. Increase in uptake of LPG/PNG and electric cooking	a. Reduction in indoor air pollution b. Improved women's empowerment and health resilience c. Improved	2027

								standard of living	
	E&B 5.2	Ensure newer appliances such as electric rice cookers and induction cookstoves are enrolled in energy star-rated programmes. KREDL to share a proposal with BEE for the enrolment of electric rice cookers and induction cook stoves S and L (Standards and Labeling) programmes.	a. Go Electric campaign – eCooking devices b. Standards and Labelling Schemes	P: BEE S: KREDL	a. GoK fund	a. % increase of electric cookers and induction stoves having energy efficiency ratings		A. Reduction in indoor air pollution b. Improved women's empowerment and health resilience c. Improved standard of living	2035
	E&B 5.3	Monitor and streamline subsidies to focus on clean cooking energy rather than those for a particular fuel.	a. Go Electric campaign - eCooking devices	P: BBMP	a. GoK fund b. Municipal corporation budget	a. Approved subsidy b. Approved monitoring method			2027
	E&B 5.4	Develop a monitoring and evaluation framework that uses mixed methods to monitor clean fuel adoption and use	a. Go Electric campaign - eCooking devices	P: BBMP S: All other agencies	a. Municipal corporation budget	a. Approved framework	a. Increase in clean cooking fuel adoption		2025
	E&B 5.5	Incentivise service providers/vendors to provide free maintenance of cooking stoves to vulnerable communities and low-income groups; this can be done through tax	a. Go Electric campaign - eCooking devices	P: BBMP	a. GoK fund b. Municipal corporation budget	a. Number of service providers/vendors getting incentives b. Number of free	a. Increase in cooking fuel efficiency		2030

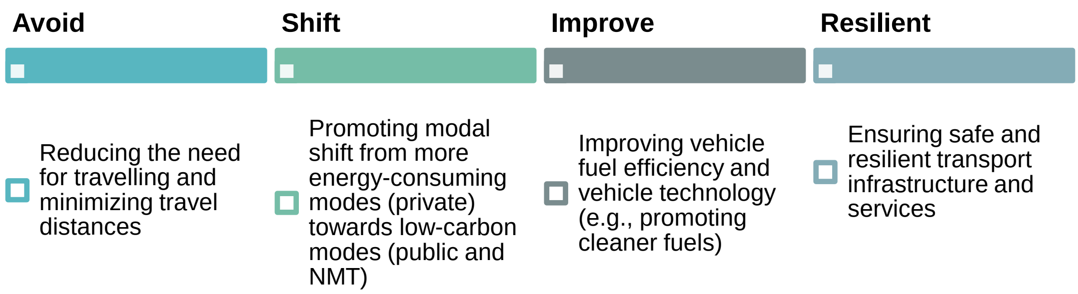
		rebates, government subsidies, and other financial mechanisms.				maintenance provided			

5.3.2 Transportation

Approach

The BCAP has identified a four-pronged approach for arriving at actions to reduce emissions from the transport sector and build resilience against climate change. This is based on the sectoral analysis, gap assessment, and barriers in the transport sector. *Avoid, Shift,* and *Improve* identifies three primary ways to reduce GHG emissions from transport on the demand side.[66] Bengaluru's transport system is vulnerable to various climate hazards faced by the city; hence, it needs a *resilient* transport system to withstand and respond to the same. Figure 63 summarises this four-pronged approach (Mathew 2021) (Phillip 2021).

Figure 63: Approach for sustainable transportation



The action tracks and the actions listed below have been drafted considering the aspects of equity and inclusivity in the sector. A few of these key considerations include strategies relating to age/ability/gender, recognising the needs of marginalised and low-income communities and aimed at ensuring a just transition.

Sectoral action tracks

No.	Action track
T-1	Reducing travel distances and minimising travel needs by adopting suitable urban planning measures, improving transport planning processes, and developing a coherent policy ecosystem.
T-2	Improving public transport ridership through multimodal integration and steering demand away from private vehicles.
T-3	Improving NMT access and infrastructure for a healthier and safer city.
T-4	Transitioning to cleaner and greener vehicles; and improving vehicle efficiencies through increased access to finance, policy enablers, incentives and promoting R&D.
T-5	Transitioning to cleaner and greener freight services through policies, incentives, and fleet management.
T-6	Ensuring a resilient urban transport system to avoid service disruptions and damage of transport infrastructure during extreme weather events, which impact people, nature, and the economy of the city

[66] SUTP Module 5e - Urban Transport and Climate Change – SUTP; GIZ

Track-wise actions

Priority	S.No	Actions	Aligned with *(Ongoing initiatives/other actions)*	Responsible Agency *Primary (P) Secondary (S)*	Potential source of funding	Output	Outcome	Co-benefit	Timeline *(Targeted year of completion of action)*
***T- 1:** Reducing travel distances and minimising travel needs by adopting suitable urban planning measures, improving transport planning processes, and developing a coherent policy ecosystem.*									
Goal/Target: 92% of the new households in the city (from 2019) should be in Transit-Oriented Development areas by 2050.									
	T 1.1	Implement the approved TOD Policy for better land use transport integration.	Integrated Land Use and Mobility Plan of CMP, 2020	P: DULT/BMLTA, S: BDA, Bengaluru International Airport Area Planning Authority (BIAAPA), GoK, BBMP, BMRCL, KRIDE, BIAL, BMTC, KSRTC, BMRDA, BWSSB, BESCOM, KIADB, Bengaluru Traffic Police Other contributing agencies: DTCP, NHAI, PWD, Urban Development Department (UDD), KSDMA, KLCDA, KFD, KSPCB, KSFESD	GoK, BMLTA/ Urban Transport Infrastructure Fund/ planning/ implementing agency resources, PPP, other innovative funding mechanisms	a. Increase in ridership of PT b. No. of households within station areas c. % of commuters walking/cycling to and from metro stations d. Approved RMP 2041 e. No. of TOD Corridor and Zone Plans (TZP) prepared and approved; f. No. of public-sector and private-sector	a. Increase in mode share of PT and NMT modes b. % increase in population/job densities in TOD Zones (against baseline and non-TOD areas) or number of DUs and commercial floor space	a. Reduced air pollution b. Reduced congestion c. Reduction in travel time d. Reduction in urban sprawl	By 2035, TZPs for all mass transit stations in the city should be prepared, integrated with the RMP, and adopted.

T 1.2	Ensure the integration of TOD Policy with the Masterplan (RMP, which is currently being revised).	Integrated Land Use and Mobility Plan of CMP, 2020	P: BDA S: All concerned development, regulating, and sectoral/line agencies	BDA's own funds	TOD schemes/projects approved and implemented			
T 1.3	Prepare ***TOD Zone Plans (TZP)*** to ensure higher FSI, higher densities and mixed-use development around mass transit stations (as per the TOD Policy).	Integrated Land Use and Mobility Plan of CMP, 2020	P: DULT/ BMLTA, S: BDA, BIAAPA, GoK , all concerned development, regulating, and sectoral/line agencies	GoK, BMLTA/DULT's own funds, BDA's own funds				
T 1.4	Design a **Green Credit Scheme** to incentivise employers to adopt remote work policy to reduce work trips		P: GoK S: Transport Department, Finance Department , BBMP, BMLTA/DULT	GoK	a. Green Credit Scheme drafted, approved, and implemented	a. Reduction in number of work trips b. Reduction in total number of trips c. Reduction in number of vehicles on road	a. Reduced air pollution b. Reduced congestion c. Reduced travel time	2025

	T 1.5	Implement the approved BMLTA Bill and establish the authority for coordinated action amongst different transport stakeholders.	Governance Measures mentioned by CMP, 2020	P: UDD S: DULT	GoK, DULT's own funds	a. BMLTA Act b. Functioning BMLT Authority in the city	a. Increased coordination amongst different stakeholders involved in transport plans, projects and policies in the city	a. Efficient and effective transport system in the city	2024
	T 1.6	Establish an **integrated project planning, management, monitoring, reporting and evaluation system** for the transport sector. This system would measure and report the carbon footprint and air pollution data corresponding to each transport project in the city on an annual basis.	Approved BMLTA Bill; Governance measures mentioned by CMP, 2020	P: BMLTA/DULT S: All service operators, transport planning, and regulatory agencies	GoK, BMLTA/DULT's own funds	a. Single platform for coordinated actions in the transport sector b. Identification of major GHG emitting/polluting transport projects	a. Data-driven decision-making and transport planning b. Streamlined transport planning processes	a. Efficient use of time and resources b. Improved transport system c. Reduction in GHG emissions from transport sector	2030
	T 1.7	Create an **integrated spatial database** for transport (parameters and indicators), which is accessible and regularly updated by relevant stakeholder departments. This database will also be	Regulatory measures mentioned by CMP, 2020	P: BMLTA/DULT S: All service operators, transport planning and regulatory agencies	GoK, BMLTA/DULT's own funds	a. Single database for all transport-related parameters and indicators related to the city, which is	a. Data-driven decision-making and transport planning b. Ease of calculating	a. Improved transport system in the city b. Reduction in GHG	2030

		used to measure and report annual GHG emissions from the transport sector.				updated regularly	GHG emissions from transport sector in the city	emissions from transport sector	

	T 1.8	Conduct **capacity-building workshops** for officials of different stakeholder departments on TOD, MMI, and on planning, design, and engineering for more sustainable transport. The objectives of these workshops would vary for different levels of officials. They could focus on need assessment, sensitisation, improving awareness, and/or capacity-building.	Bengaluru TOD Policy	P: BMLTA/DULT S: All service operators, transport planning and regulatory agencies	BMLTA/DULT's own funds	a. No. of capacity-building workshops conducted	a. Informed decision-making/implementation of transport projects/plans/policies b. Adoption of sustainable and improved transport planning framework/approach in the city	a. Optimal use of resources b. Reduction in GHG emissions and air pollution c. Reduction in use of private vehicles d. Increase in PT and NMT usage	2025
***T- 2:** Improving public transport ridership through multimodal integration and demand management away from private vehicles.*									

Goal/Target: The combined share of public transport (PT) and non-motorised transport (NMT) in total no. of trips to be 75% by 2030, 80% by 2040, 85% by 2050.

	T 2.1	Revise, detail and implement CMP's Public Transport Improvement Plan to include the following mandates: improved network connectivity, optimised capacities through rationalisation of services (routes and schedules), accessible and affordable first- and last-mile connectivity, seamless multimodal integration (MMI), enhanced commuter comfort, universally accessible infrastructure, energy efficient and reliability.	Public Transport Improvement Plan of CMP, 2020	P: BMLTA/DULT S: Service operators (BMRCL, BMTC, KRIDE, KSRTC), BBMP, Traffic Police	Own funds of BMLTA/DULT, service operators and BBMP	a. % of population with access to PT stops (bus stops, metro stations, etc.) within 5 minutes of walking distance b. % of buses with ramps, special seats for women and the elderly and other special groups c. PT network density in low-income areas d. level of	a. Increased mode share of PT b. Increased PT ridership (disaggregated by gender and income level) c. Reduced fuel consumption d. Increased average travel speeds (kmph)	a. Reduction in air pollution b. Reduction in congestion c. Reduction in travel time	2028

	T 2.2	Create bus priority lanes as prescribed by CMP and improve services by adding components such as safe and usable bus stops integrated with Passenger Information System (PIS) interface, and clear signages to help commuters navigate to improve efficiency and user experience	Public Transport Improvement Plan of CMP, 2020	P: BBMP S: BMLTA/DULT, BMTC	Own funds of BBMP and BMLTA/DULT	perceived comfort and quality of public transport service (safety, reliability, frequency, crowding, availability of seats) on services and routes used			2026
	T 2.3	Develop a commuter-facing platform for information dissemination (PIS), common ticketing for all PT modes (along the lines of National Common Mobility Card) and establish a commuter helpline to address grievances and gather feedback on safety, access, and reliability.	Technological Measures of CMP, 2020	P: BMLTA/DULT S: BMTC, BMRCL, KRIDE, KSRTC, IPT operators	BMLTA/DULT's own funds	a. Single public PIS interface/platform for common ticketing and common helpline b. No. of users registered/using this interface	a. Increased commuter safety b. Increase in mode share of public transport c. Increased ridership (disaggregated by gender and income level) d. Reduction in waiting time	a. Quick and easy information dissemination during hazards b. Reduction in air pollution	2025

	T 2.4	Create attractive ticket fare structure with targeted incentives to attract more commuters to use PT, especially those from marginalised low-income groups, women, the elderly, children, etc.	Multi-Modal Mobility Plan and Regulatory Measures of CMP, 2020	P: BMLTA/DULT S: BMTC, BMRCL, KRIDE, KSRTC, IPT operators, Transport Department	GoK	a. No. of passes issued for low-income groups, women, and the elderly	a. Increase in mode share of public transport b. Increased ridership (disaggregated by gender, income level) c. Decrease in % of monthly income spent on transport for these groups	a. Increase in employment and education opportunities b. Increase in monthly savings	2025
	T 2.5	Facilitate shift in incentives (provided by employers to employees) away from private vehicles in favour of public transport. The scope of the **Green Credit Scheme** should include this.	Action No. T 1.4 (Green Credit Scheme)	P: GoK S: Transport Department, BBMP, BMLTA/DULT, Finance Department	GoK	a. Public transport allowance provided to employees	a. Increase in mode share of public transport b. Decrease in on-road private vehicles	a. Reduction in air pollution b. Reduction in congestion c. Reduction in fuel consumption	2025

	T 2.6	Chalk out a detailed **IPT plan** for the city (along the lines of CMP), which includes regulatory provisions and operational mechanisms for all IPT modes (autorickshaws, e-rickshaws, app-based taxis, etc.)	Public Transport Improvement Plan of CMP, 2020	P: BMLTA/DULT S: Transport Department	BMLTA/DULT's own funds	a. Accessible and affordable IPT services b. Improved first- and last-mile connectivity	a. Increase in mode share of public transport b. Decrease in on-road private vehicles	a. Reduction in air pollution b. Reduction in congestion	2025
	T 2.7	Identify new funding opportunities/mechanisms /business models (PPP) for PT operations and maintenance.	Fiscal measures of CMP, 2020	P: Transport Department, S: PPP, Finance Department	GoK	a. Increased investment in PT b. Increase in no. of PT vehicles on road	a. Increase in mode share of public transport	a. Reduction in air pollution b. Reduction in congestion c. Reduction in travel time	2026

	T 2.8	Create and implement a plan to restrict private vehicles plying in the city through strategies such as: 1) Creating congestion zones and car-restricted zones, and implementing congestion charges; 2) Disincentivising private vehicles through instruments, such as annual licence fee, additional tax on purchasing vehicles (road/fuel taxes, etc.); 3) Preparing and implementing area parking plans for all zones as per the Parking Policy 2.0 and enforcing on-site parking with stringent measures such as cutting off power or water supply if not followed.	1) Private Transport Management Plan of CMP, 2020 2) Fiscal measures of CMP, 2020 3) Parking Policy 2.0	P:BMLTA/DULT, BBMP S: 1)Traffic Police 2)GoK 3)Traffic Police 4)Transport Department	Own funds of BMLTA/DULT and BBMP. GoK funds	a. Increase in numberof paid parking spots b. Number of congestion/car-restricted zones c. Area parking plans for all zones	a. Reduction in the no. of private vehicles on road b. Reduction in the no. of private vehicles registered c. Increase in the mode share of public transport	a. Reduction in congestion b. Reduction in air pollution c. Revenue generated through parking and congestion fees	2028

	T 2.9	Conduct a study on policy levers to disincentivise owning of more than one vehicle per household.		P: BMLTA/DULT S: Transport Department	BMLTA/DULT's own funds	a. No. of vehicles per household	a. Reduction in the no. of private vehicles on the road b. Reduction in the no. of private vehicles registered c. Increase in the mode share of public transport	a. Reduction in congestion b. Reduction in air pollution	2025
	T 2.10	Under the **Green Credit Scheme**, conduct a study to explore the feasibility of repurposing of large vehicles (e.g., school buses) to ferry corporate employees and vice versa, and to identify appropriate enabling mechanisms (e.g., Revising RTO regulations, tax schemes).	Action No. T 1.4 (Green Credit Scheme)	P: BMLTA/DULT, S: Transport Department	GoK, BMLTA/DULT's own funds	a. Feasibility study on repurposing vehicles for multiple uses	a. No. of vehicles repurposed b. Reduction in the no. of vehicles on road	a. Reduction in congestion b. Reduction in air pollution	2025

	T 2.11	Training women drivers and incorporating components such as panic buttons and women-only compartments to improve women's safety and enhance uptake of PT amongst women.		P: BMTC, BMRCL, KRIDE S: Traffic Police, Transport Department	Service providers' (BMTC, BMRCL, KRIDE) own funds	a. No. of women drivers in PT modes b. Women only compartments or seats reserved for women in PT modes c. Availability of panic buttons in PT modes	a. Increased women's ridership in public transport b. Increased mode share of public transport	a. Increase in opportunities for women (employment, education) b. Reduction in air pollution	2026
***T- 3:** Improving NMT access and infrastructure for a healthier and safer city.*									
Goal/Target: The combined share of public transport (PT) and non-motorised transport (NMT) in total no. of trips to be 75% by 2030, 80% by 2040, 85% by 2050.									
	T 3.1	Approve the Active Mobility Bill and enforce it to create an enabling ecosystem to push for NMT modes.	Draft Active Mobility Bill - Karnataka, 2021	P: UDD S: BMLTA/DULT	GoK	a. Active Mobility Act implemented and enforced	a. Availability of safe and accessible NMT infrastructure b. Increase in the no. of NMT users c. Increased mode share of NMT	a. Reduction in air pollution b. Reduction in congestion c. Decrease in monthly transport expenditure for NMT users d. Reduction in fuel consumption	2024
	T 3.2	The **Green Credit Scheme** should include the aspect of offering incentives to NMT modes. For example, employers could provide benefits to employees in the form of allowances to buy bicycles, credits for walking, etc.	Action No. T 1.4 (Green Credit Scheme)	P: Transport Department S: Finance Department, BBMP, BMLTA/DULT	GoK, Employers funds	a. Approved **Green Credit Scheme** includes incentives offered on NMT modes b. Incentives on using NMT offered by employers to employees			2025

	T 3.3	Revisit the operational and regulatory provisions to encourage more public bike sharing (PBS) operators in the city and ease access to finance for them.	Non-Motorised Transport Plan of CMP, 2020	P: BMLTA/DULT, S: BBMP, Transport Department, Financial Institutions	GoK, PPP	a. More PBS operators in the city b. Improved access to PBS system			2025
	T 3.4	Prepare an **NMT master plan** for creating complete NMT infrastructure network (inclusive of footpaths, cycle tracks, underpass, and junctions) throughout the city, which is accessible by all users irrespective of age/ability. This should be integrated with the proposed **Blue-Green Policy** and associated NBS strategies.	*Aligned with action no. UPGBD 3.1 on **Blue-Green Policy** *Non-Motorised Transport Plan of CMP, 2020	P: BMLTA/DULT S: BDA, BBMP	Own funds of BMLTA/DULT, BBMP, BDA	a. NMT master plan integrated with the CMP and the proposed Blue-Green Policy			2026

	T 3.5	Prepare a **'Complete Street' guideline/standards** (along the lines of TenderSURE standards) and adhere to it for all roads. *(A 'Complete Street' is one that is designed to cater to the needs of all users and activities, through equitable allocation of road space. Some of the main elements of Complete Streets are footpath, cycle track, pedestrian crossing, bus stops, median, utilities, streetlights, signages, etc.)*	TenderSURE Guidelines Draft Active Mobility Bill – Karnataka, 2021 Non-Motorised Transport Plan of CMP, 2020	P: BMLTA/DULT S: BBMP	BMLTA/DULT's own funds	a. Complete Street guidelines for the city – drafted, approved and enforced			2025

	T 3.6	Conduct regular NMT audits at local levels by creating a mechanism which involves public participation using IT-enabled systems/platforms (crowdsourcing mechanisms)		P: BMLTA/DULT S: BBMP	BBMP's own funds	a. Institutional mechanism and platform/interface for conducting regular NMT audits			2026
	T 3.7	Design and conduct IEC campaigns for citizens to encourage behavioural shift in favour of NMT. Potential target groups could be RWAs, NGOs working on the ground, civic platforms, citizen groups, etc.	Travel Demand Management Plan of CMP, 2020	P: BMLTA/DULT, BBMP S: Service providers, NGOs	BBMP's own funds	a. No. of trainings/workshops/activities conducted			2026
***T- 4:** Transitioning towards cleaner and greener vehicles; and improving vehicle efficiencies through increased access to finance, policy enablers, and incentives and promoting R&D.*									

Goal/Target: 90% of cars and motorcycles, 75% of buses to be powered by cleaner fuels by 2050.									
	T 4.1	Offer incentives for EVs such as reduced parking fee and toll charges and waiver on fitness certificates.	Technological measures of CMP, 2020	P: Transport Department S: BBMP	GoK funds, own funds of BBMP	a. No. of incentives offered for cleaner fuels b. Reduction in average TCO for EVs	a. Increase in EV vehicle sales and registrations by vehicle type b. No. of EVs (cleaner fuel vehicles) out of total vehicles registered in the city c. Reduction in the emission load of vehicular tailpipe emissions	a. Reduction in air pollution b. Reduction in monthly expenditur e on fuel consumptio n	2026
	T 4.2	Offer incentives for BSVI (Bharat Stage Emission Standards 6) vehicles, such as road/fuel tax and registration fee reductions and facilitate the scrapping of older vehicles.	Voluntary Vehicle Fleet Modernisation Programme (V-VMP)/Vehicle Scrappage Policy	P: Transport Department S: BBMP	GoK funds	a. No. of incentives offered for BSVI vehicles b. No. of operational Registered Vehicle Scrapping Facilities (RVSFs) and Automated	a. No. of BSVI vehicles registered out of total vehicles b. Reduction in the no. of total BSIV (and older) vehicles registered c. No. of	a. Reduction in air pollution	2030

						Testing Stations (ATSs)	vehicles scrapped		
	T 4.3	Implement an effective emission compliance system. Disincentivise higher-emitting vehicles by imposing Green Tax/Cess based on 'polluter pays' principle.	Pollution Under Control Certificates (PUCC)	P: Transport Department S: MoRTH	GoK funds	a. No. of disincentivising mechanisms imposed b. No. of vehicles in the city with valid PUCC	a. Reduction in the emission load of vehicular tailpipe emissions	a. Reduction in air pollution	2030

T 4.4	Provide accessible EV charging infrastructure: (a) Develop common charging infrastructure standards across vehicle types and manufacturers. (b) Develop city-specific guidelines for setting up EV charging infrastructure in buildings and public places. (c) Pilot EV chargers integrated with urban infrastructure such as streetlights. (d) Identify spaces (such as petrol pumps) for charging larger vehicles (buses, freight, etc.). (e) Encourage and incentivise private participation in EV charging infrastructure development to enhance ease of doing business.	Karnataka Electric Vehicle and Energy Storage Policy, 2017 Handbook of EV Charging Infrastructure Implementation, NITI Aayog (https://www.niti.gov.in/sites/default/files/2021-08/HandbookforEVChargingInfrastructureImplementation081221.pdf)	P: a) GoI b) BESCOM c) BESCOM d) BBMP e) GoK S: a) GoK b) BBMP c) BDA d) Private players e) BESCOM	GoK funds, own funds of BESCOM, BBMP, NCAP grants	a. Common charging infrastructure standards across vehicle types and OEMs b. City-specific charging infrastructure guidelines for buildings and public places c. No. of EV chargers in public spaces, integrated with urban infrastructure d. No. of EV charging yards (for larger vehicles) e. No. of private EV charging stations set up	a. Increase in the no. of total EV charging stations in the city b. Increase in the no. of EVs registered	a. Reduction in air pollution b. Reduction in monthly expenditure on fuel consumption	2026

	T 4.5	Facilitate private players to conduct R&D on battery recycling, retrofitting of fossil fuel vehicles to enable them to use cleaner fuels, etc., by providing seed funds/subsidies, promoting ease of doing business, strengthening start-up ecosystems.	Karnataka Electric Vehicle and Energy Storage Policy – 2017	P: Transport Department	GoK funds	a. No. of new R&D products/processes/concepts developed around switching from ICE to cleaner fuel vehicle	a. Increase in the no. of cleaner fuel vehicles in the city	a. Economic opportunities b. Reduction in air pollution c. Reduction in monthly expenditure on fuel consumption	2028
	T 4.6	Conduct a study to understand the feasibility of using hydrogen as a fuel in public transport (buses).	*National Hydrogen Mission *India's Long-Term Low-Carbon Development Strategy (MoEFCC)	P: BMTC, KSRTC S: DULT/BMLTA	Own funds of BMTC and KSRTC	a. Feasibility study on hydrogen buses in Bengaluru	a. Increase in the no. of hydrogen buses in the city	a. Reduction in air pollution	2026
	T 4.7	Prepare a **Clean Fuel Transition Plan** for Bengaluru with 2040 as the horizon year. This plan should be prepared for all modes, particularly buses and IPT modes (e.g., autorickshaws).		P: BMTC, KSRTC, DULT/BMLTA S: GoK, Transport Department	Own funds of BMTC, KSRTC and DULT/BMLTA; NCAP grants	a. Clean Fuel Transition Plan, 2040, for Bengaluru	a. Increase in the no. of cleaner fuel vehicles registered in all modes (especially buses and IPT) b.Reduction	a. Avoiding carbon lock-in b. Reduction in air pollution c. Reduction in monthly	2026

							in the no. of ICE vehicles	expenditure on fuel consumption d. Improved resource efficiency	
	T 4.8	Make access to finance easier through strategies such as: a) Providing low-income drivers and small businesses with easy loans to reduce up-front costs of EV; and b) Better communication of MUDRA loans.	*FAME 2 *Karnataka Electric Vehicle and Energy Storage (KEVES) Policy-2017	P: Financial institutions (e.g., banks) S: Transport Department	FAME 2, GoK (KEVES Policy), low-interest loans by banks	a. No. of incentives for low-income drivers	a. Increase in the no. of EV registrations	a. Reduction in air pollution b. Financial support to low-income households	2025

	T 4.9	Conduct IEC campaigns to sensitise stakeholders regarding cleaner fuel vehicles (benefits, infrastructure requirements, usage, fuel efficiency, battery recycling, etc.) *(Stakeholder groups include PT operators, potential EV buyers, charging infrastructure developers, actors involved in vehicle servicing, and maintenance.)*	LiFE (Lifestyle For Environment) Mission	P: DULT/BMLTA, BBMP S: NGOs, citizens' groups	NCAP grants, own funds of BBMP	a. No. of trainings/sessions/activities conducted b. No. of people reached through IEC campaigns	a. Increase in the registration of EVs b. Increase in public acceptance and awareness of cleaner fuel modes	a. Reduction in air pollution b. Reduction in monthly expenditure on fuel consumption	2025
	T 4.10	Conduct training programmes targeted for marginalised groups to facilitate a just transition (to avoid externalities of cleaner fuel penetration).	*Karnataka Electric Vehicle and Energy Storage Policy, 2017	P: Commerce and Industries Department (GoK) S: BBMP, private players	GoK	a. No. of training sessions/skill-building workshops, etc. conducted b. No. of women trained c. No. of low-income community members trained	a. Avoiding externalities of cleaner fuel penetration b. Increase in skilled workforce in the sector	a. New job opportunities b. Economic upliftment of marginalised groups	2026

	T 4.11	Give preference to agencies with low-carbon fleet when contracting for government/municipal services, or mandatorily include this requirement in new tenders.		P: BBMP S: All government departments/age ncies	Departments'/agencies' own funds	a. No. of cleaner fuel vehicles used in providing municipal and government services	a. Increase in the total registration of cleaner fuel vehicles	a. Increased acceptance and awareness of cleaner fuel vehicles amongst citizens b. Reduction in air pollution c. Reduced monthly expenditur e on fuel consumptio n, more governmen t funds available for other activities	Contract preferen ce and inclusion in tenders from 2025 (or after current lease expires)
***T- 5:** Transitioning towards cleaner and greener freight through policies, incentives, and fleet management.*									
Goal/Target: 47% of total freight vehicles to be powered by cleaner fuels by 2050.									

	T 5.1	Offer incentives for electric freight such as parking fees reduction, road tax exemptions, flexible timings, relaxations in approvals or rebates for EV-ready warehouse.	City Logistics Plan (under preparation by DULT)	P: BBMP S: Transport Department, freight operators,	FAME 2, own funds of BBMP	a. No. of incentives provided for electric freight b. % of electric 2W, 3W and 4W freight c. No. of warehouses with EV charging infrastructure	a. Reduction in the emission load of vehicular tailpipe emissions	a. Reduction in air pollution b. Reduction in monthly expenditur e on fuel consumptio n	2025
	T 5.2	Prepare a plan to convert the entire SWM fleet to EVs, guided by the pilot implementation activity taken up by DULT and BBMP in 2022	Pilot project conducted by DULT in collaboration with BBMP and Kinetic Green Energy and Power Solutions Ltd, to study the feasibility of EVs in solid waste collection (carried out in 2 blocks of Ward no. 119 for 3 months).	P: BBMP, DULT/BMLTA S: EV manufacturers, charging infrastructure providers	BBMP's own funds, NCAP grants, DULT/BMLT A's own funds	a. % of EV in the entire SWM fleet			2025
	T 5.3	Prepare a **Clean Fuel Transition Plan** for freight vehicles in Bengaluru, with 2040 as the horizon year.	City Logistics Plan (under preparation by DULT)	P: BBMP, DULT/BMLTA S: GoK, Transport Department, freight operators,	Own funds of BMTC and DULT/BMLT A; NCAP grants; GoK funds	a. Clean Fuel Transition Plan for Freight vehicles, 2040, for Bengaluru	a. Increase in the no. of cleaner fuel freight vehicles registered	a. Avoiding carbon lock-in b. Reduction in air	2026

				charging infrastructure providers			b. Reduction in the no. of ICE freight vehicles	pollution c. Reduction in monthly expenditure on fuel consumption d. Improved resource efficiency	
	T 5.4	Allow only EV-powered Light Duty Vehicles (LDVs) in the city, and ensure stringent enforcement of regulations for Heavy Duty Vehicles (HDVs).	City Logistics Plan (under preparation by DULT)	P: Traffic Police S: BBMP, DULT/BMLTA, Transport Department	Own funds of Traffic Police	a. % of EV LDVs inside the city compared with all LDVs b. No. of ICE-HDVs entering the city	a. Increase in the no. of EV LDVs registered b. Reduction in the no. ICE HDV registrations	a. Reduction in air pollution b. Reduction in congestion	2030

	T 5.5	Conduct a study on low-carbon freight under the City Logistics Plan. This should include understanding of gaps (infrastructure, finance, data, regulatory, etc.) in efficient multi-modal integration in collaboration with all stakeholders concerned (e.g., freight operators, railways, e-commerce companies, warehouse operators, and government agencies)	City Logistics Plan (under preparation by DULT)	P: DULT/BMLTA S: GoK, Transport Department, Railways Department, freight operators, charging infrastructure providers	DULT/BMLTA's own funds; NCAP grants	a. Comprehensive study on low-carbon freight aligned with the City Logistics Plan	a. Reduction in the emission load of vehicular tailpipe emissions b. Optimised fleet movement and management of freight vehicles	a. Reduction in air pollution b. Reduction in congestion c. Resource efficiency	2026

***T-6:** Ensuring a resilient urban transport system to avoid service disruptions and damage of transport infrastructure during extreme weather events, which impact people, nature, and the economy of the city.*								
T 6.1	Mandate inclusion of **climate non-negotiables** in all transport sector projects, plans, policies, and value chain's scope. This should include: a) Climate resilience guidelines/standards in transport infrastructure planning, design, and material consideration. b) Provisions for inclusiveness based on age, ability, and gender, and consultative bottom-up planning approaches, which result in higher *adaptive capacity*.		P: DULT/BMLTA, all service operators, BBMP S: Transport Department, GoK	Own funds of all agencies	a. Inclusion of climate non-negotiables in all transport plans, projects, policies, and value chains	a. Higher resilience of transport infrastructure and assets against climate/environmental hazards b. Higher adaptive capacity of transport infrastructure and assets in the face of hazards affecting the transport sector	a. Reduction in casualties, loss of life, and damage to property caused by climate/environmental hazards affecting the transport sector	2026
T 6.2	Conduct a study to build quantitative evidence on degree of loss and damage to transport infrastructure and assets caused by climate-induced hazards.		P: DULT/BMLTA, BBMP S: All service operators	Own funds of DULT/BMLTA and BBMP	a.Comprehensive study on degree of loss and damage to transport infrastructure and assets due to climate-induced hazards			2026
T 6.3	Mandate defensive driving training for new licences.		P: Transport Department S: BBMP	Own funds of Transport Department and BBMP	a. No. of trainings conducted b. No. of people trained	a.Reduction in accidents and fatalities		2025

	T 6.4	Mandate third-party verification of all pothole repair activities as a part of standard quality control protocol.		P: DULT/BMLTA S: BBMP	BBMP's own funds (Funding source for road construction)	a. Appointment of a third-party verifier	a. Improvement in the quality of city roads b. Reduction in the no. of potholes c. Reduction in accidents and fatalities		2025
	T 6.5	Prepare a **Road Network and Movement Plan,** which ensures more than one type of connectivity for every location.	Road Network Development Plan of CMP, 2020	P: DULT/BMLTA S: BBMP	Own funds of DULT/BMLTA	a. Road Network and Movement Plan	a. Improved connectivity for all locations b. Better access during disasters		2025
	T 6.6	Traffic management and hazard monitoring systems should speak to each other. Information dissemination during disasters should be done through the PIS platform.	Technological measures of CMP, 2020 KSNDMC's Hazard Monitoring system	P: KSNDMC S: BMLTA/DULT, all service operators, BBMP	GoK Funds	a. Hazard alerts and real-time updates on disasters provided to the public through the PIS system	a. Better disaster preparedness and response		2025

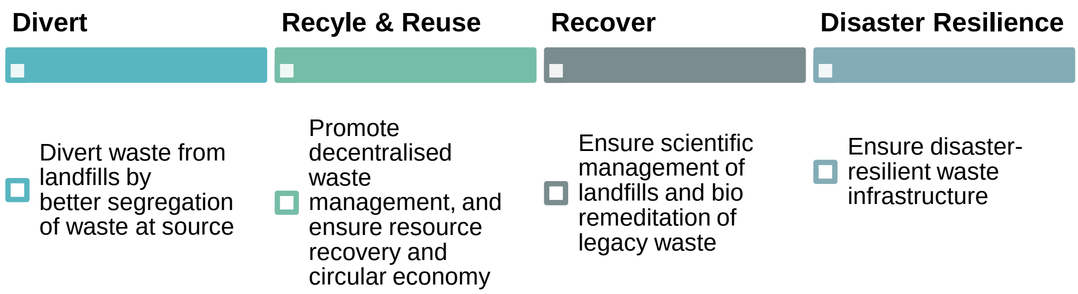
	T 6.7	A single agency should be identified (ideally BBMP) as a nodal agency, responsible for the overarching monitoring of all climate-induced damage to the transport sector. Other stakeholders concerned (service operators, regulatory agencies, etc.) should coordinate with this nodal agency.		P: BBMP S: BMLTA/DULT, all service operators, BBMP, Traffic Police	Own funds of BBMP	a. Selection and appointment of a single monitoring agency	a. Better disaster preparedness, response, and recovery b. Better accountability		2026

5.3.3 Solid waste management

Approach

The solid waste management approach for the BCAP is based on an understanding of emission scenarios for solid waste, the current SWM performance of the city, and the challenges/gaps and opportunities that the sector holds, to reduce emissions and build resilience. Hence, the BCAP adopts an Integrated Solid Waste Management (ISWM) approach to ensure the diversion of waste, recycling and reuse of wet and dry waste, recovery of waste by-products, and disaster-resilient infrastructure. Such an approach ensures a holistic climatic lens of strong mitigative and adaptative measures, and disaster preparedness that adapts itself to a changing climate, to contribute to the 1.5°C target under the Paris Agreement and to help create more resilient waste management infrastructure. Figure 64 summarises this approach to ISWM.

Figure 64: Approach for Integrated Solid Waste Management



The action tracks and the actions listed below have been drafted considering the aspects of emission reduction and energy efficiency, climate resilience, improving human health, inclusion, social and gender equity, creation of green jobs, circular business models, etc., in this sector.

Sectoral action tracks

No.	Action track
SWM-1	Divert waste from landfills by better segregation of waste at source.
SWM-2	Increase resource recovery and circular economy by promoting decentralised waste management systems.
SWM-3	Implement scientific landfills with gas capture systems and suitably repurpose closed landfills/dump sites.
SWM-4	Create inclusive and hazard-resilient SWM infrastructure and services.

Track-wise actions

Priority	S.No	Actions	Aligned with (ongoing initiatives/other actions)	Responsible Agency Primary (P) Secondary (S)	Potential Source of funding	Output	Outcome	Co-benefit	Timeline (Targeted year of completion of action)
***SWM-1:** Divert waste from landfills by better segregation of waste at source.*									
Goal/Target: Achieve 100% segregation of waste by 2025 and achieve over 90% diversion of waste from landfills by 2050 (60% by 2030 & 75% by 2040).									
	SWM-1.1.	Ensure complete implementation of ward micro-plan in all wards to manage and monitor waste in smaller units/blocks to facilitate segregation, increase accountability, and improve planning and governance.	BBMP SWM Manual, 2017	P: BBMP-BSWML S: BBMP-IT Department, Transport department	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Ward micro plan (includes block map, centralised/decentralised facilities, workers and vehicles allotted, and training) b. Per day waste generation from each block.	a. Increased segregation in smaller units	a. Improved service delivery b. Increased accountability and transparency c. Improved living conditions for poor communities d. Improved planning and governance e. Reduced GHG emissions due to transport f. Increased job opportunities	2025
	SWM -1.2	Conduct IEC campaigns to nudge the social behaviour of the citizens in favour of segregation of waste as per the 3-bin system (wet, dry, and sanitary). Additionally, create awareness on	BBMP SWM Manual, BBMP Bye-laws	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – IEC funds	a. No. of awareness campaigns conducted on 3-bin segregation, waste recovery, etc., in the city	Increased 3-bin segregation at source	Improved health, livelihood and well-being	2025

		climatic impacts and opportunities relating to waste recovery/reuse.							
	SWM -1.3	Establish waste management cells in every ward as per ward micro-plan, to conduct regular inspections, address grievances, monitor performance, and strengthen coordination between link worker, bulk waste generators, *pourakarmikas*, waste processing service providers, etc.	BBMP SWM Manual, BBMP Bye-laws	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Waste management cells in each ward b. Total no. of inspections conducted per ward per annum c. Total no. of grievances received/addressed per month d. Status of addressing grievances	Detailed inspection reports for each ward, and performance assessment for solid waste management	a. Improved service delivery b. Increased accountability and transparency c. Increased job opportunities	2025
	SWM 1.4	Ensure that every waste management cell establishes a command centre for 100% GIS digital mapping of waste collection bins and transport vehicles and ensures continuous monitoring through a web-based platform.	BBMP SWM Manual, 2017	P: BBMP-BSWML S: BBMP-IT Department, Transport department	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Integrated command centre b. Efficiency of collection c. Low-carbon waste collection vehicles d. Reduced waste collection trips and distance	a. Increased waste segregation and collection performance. b. Reduced trips by waste collection vehicles	a. Improved service delivery b. Increased accountability and transparency c. Increased job opportunities d. Reduced GHG emissions from transportation	2025
	SWM 1.5	Ensure every ward has sufficient auto tippers and street sweeping machines to reduce travel distance and trips to collect waste. Convert solid waste fleet	BBMP SWM Manual, 2017	P: BBMP-BSWML S: BBMP-IT department, Transport	BBMP SWM Budget, Swachh Bharat Mission – Urban				2030

		to low-emission vehicles for reduced emissions.		Department, DULT					
	SWM 1.6	Ensure C&D waste removal from public places where C&D projects are required to submit waste management plan (including details of recycling methods and use of mechanical sweeping machines to remove road dust/silt/debris caused due to construction/demolition activities) for better waste management, improved air quality, and well-being.	BBMP SWM Manual, 2017	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Project-level C&D waste management plan b. Efficiency of collection of C&D waste	C&D waste removal	a. Improved service delivery b. Reduced emissions c. Improved public health d. Reduced air pollution	2025
	SWM 1.7	Create an open access platform and ensure every waste management cell uploads solid waste information in each ward at regular (quarterly) intervals, to ensure accountability and transparency.	BBMP road map	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Open access platform with ward-level solid waste generation data b. Efficiency in collection of SWM related c. Efficiency in redressal of customer complaints d. Quarterly waste performance reports.	Increased access to solid waste data	a. Increased accountability and transparency b. Improved service delivery	2025

	SWM 1.8	Create standard operating procedures (SOPs)/guidelines, and conduct regular (quarterly/half-yearly) trainings and workshops for *pourakarmikas* to ensure effective segregation of waste at sources (such as household, commercial, open spaces, streets, and public/religious spaces).		P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. SOP for waste segregation b. No. of workshops/awareness campaigns conducted c. Extent of segregation d. Efficiency of collection	a. Increased segregation, segregated collection, and transport to transfer stations b. Improved standard of living	a. Increased accountability and transparency b. Improved service delivery c. Social equity	2025
	SWM 1.9	Create dignity of labour for *pourakarmikas*. Introduce legal status and a licensing mechanism for ragpickers and waste workers to formalise them and provide support to ensure social equity, informal inclusion, and job security.		P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Recognition for *pourakarmikas*. b. List of formalised rag pickers	a. Increased segregation, segregated collection, and transport to the transfer stations	a. Increased accountability and transparency b. Improved service delivery c. Social equity d. Inclusion of informal workers e. Job security f. Gender equity	2030

	SWM 1.10	Develop and maintain mustering centres in every ward (preferable at the transfer stations) across the city (including necessary facilities such as proper toilets, water, soap, or sanitiser) for pourakarmikas and rag pickers, to ensure better working conditions and improved public health.	BBMP SWM Manual, BBMP Bye-laws	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Total no. of mustering centres in every ward b. Improved working conditions c. Extent of segregation d. Efficiency of collection	b. Improved standard of living	a. Improved public health, livelihood, and well-being. b. Gender and social equity c. Job creation	2030
	SWM 1.11	With the support of self-help groups, conduct IEC campaigns and training sessions for women in slums/vulnerable communities/poor pockets to nudge social behaviour in relation to segregation and recycling/reusing waste, to improve waste segregation and create livelihoods.	BBMP SWM Manual, BBMP Bye-laws, road map	P: BBMP-BSWML S: BBMP, Slum development board.	BBMP SWM Budget, Swachh Bharat Mission – IEC funds	a. Total no. of awareness drives conducted in each slum b. Total amount of dry waste recycled per ward c. Total no. of women involved in recycling waste	a. Increased segregation and awareness b. Volume of recycled materials per ward	a. Improved service delivery b. Increased job opportunities c. Improved livelihood, well-being, and health e. Inclusion of informal workers f. Social equity g. Accountability h. Gender equity	2030
	SWM 1.12	Effectively implement the mandate of bulk waste generators to segregate and manage waste at source, identify non-compliance through inspection, and strictly implement penalties under the 'polluter pays'	BBMP SWM Manual, BBMP Bye-laws, road map	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Total number/volume of bulk waste processed through centralised/empanelled service providers processing facilities b. Total amount of penalties collected	Increased segregation of waste and performance of bulk waste generators.	a. Increased accountability and transparency b. Improved service delivery c. Improved planning and governance d. Job creation	2025

		principle to establish improved performance and service delivery.				from bulk waste generators c. Total no. of inspections on bulk waste generators per ward (quarterly/half yearly) d. Volume of bulk waste generation in each ward e. Updated database of vendors (in the portal for the Bulk Generator Network Service and Vendor Empanelment, under the Kasa Vilavaari Sevadararu programme)			
	SWM 1.13	Conduct quarterly/half-yearly workshops on SWM to promote global best practices in ward-level waste management cells and ensure participation and coordination of bulk waste generators, empanelled service providers, other vendors, NGOs, RWAs, self-help groups, etc., to create social cohesion.	Swachh Survekshan	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Total no. of workshops conducted in each ward	Day to day updated SWM best practices across the globe.	a. Improved service delivery b. Increased social cohesion c. Increased job opportunities d. Improved technological advancement	2030

SWM 1.14	Upgrade centralised wet waste processing units to fully functional capacity with optimal operational performance. Ensure that compost plants are fed only source-segregated organic waste to make sure heavy metals in the compost are within the limit, to get the maximum compost from processing.	BBMP SWM Manual, BBMP Bye-laws, Road map	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Total amount of waste processed in centralised wet waste processing units.	Increased centralised wet waste processing	a. Increased technological advancement b. Improved service delivery c. Reduced emissions	2030
SWM 1.15	Ensure accurate ward-wise mapping of locations of open burning of waste, intensify surveillance, and impose fines on defaulters.	Action aligned with air quality action-AQ 5.3 and NCAP b. Swachh Vayu Sarvekshan	P: BBMP-BSWML S: KSPCB	NCAP funds	a. % reduction in harmful and toxic gas emissions from waste b. % reduction in sites for open burning of waste c. Creation of litter-free ambassadors for each ward	a. Improved local health resilience b. Prevention of exposure to unwanted odours	a. Achievement of Swachh Bharat Abhiyan goals	2025
SWM 2: *Increase resource recovery and circular economy by promoting decentralised waste management systems.*								
Goal/Target: Recycling of paper & plastic waste to be >60% by 2030, >75% by 2040 & >90% by 2050.								
SWM 2.1	Conduct IEC campaigns in collaboration with NGOs to nudge social behaviour, and conduct survey to promote decentralised composting and recycling materials in residential communities, *mandis*, public and religious gatherings, parks and	Swachh Survekshan, Namma Kaasa Namma Javabdhari	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Total no. of IEC campaigns conducted in every ward	Increased community engagement	a. Increased accountability b. Social equity and inclusivity	2030

	gardens, through citizen participation to promote resource recovery and reduce waste disposal, and to ensure accountability and green initiatives.							
SWM 2.2	Implement decentralised processing units in each ward (contingent on land and resource availability), and support communities/citizens to implement decentralised units and utilise compost within the premises as fertiliser, to increase in situ processing of waste, resource recovery, and reduced emissions.	BBMP SWM Manual, BBMP Bye-laws, Namma Kaasa Namma Javabdhari	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Total amount of wet waste processed in situ in each ward b. Extent of solid waste recovered	Increased decentralised wet waste processing	a. Increased accountability b. Reduced emissions from waste c. Improved public health d. Social inclusivity and equity e. Creation of green jobs f. Inclusion of informal workers	2030
SWM 2.3	Collaborate with food processing units/restaurants/delivery service units through empanelled service providers to take up initiatives and incentivise food waste reduction. Increase access to goods without plastic packaging by incentivising sellers.		P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Initiatives and incentives for food waste reduction b. Total amount of food and plastic usage per unit c. Extent of solid waste recovered	Volume of reduced food wastage		2030

	SWM 2.4	Increase dry waste collection centres and aggregators in all wards, and set up material recovery facilities (MRF) and facilities for producing refuse-derived fuel (RDF).	BBMP SWM Manual, BBMP Bye-laws, road map	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	c. Total no. of MRF facilities d. Total amount of RDF	Increased organised dry waste facilities		2030
	SWM 2.5	Introduce a waste recovery platform (if possible, in the SWM cell in each ward) and increase visibility/market for businesses that sell recycled materials. Collaborate with waste management service providers, NGOs, etc., to buy/sell waste by-products. Conduct 'waste purchase' drives to encourage citizens to judiciously segregate and sell the household waste that could be recycled, to create opportunities for green businesses and ensure resource recovery.	Solid Waste Management Rules, 2016	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Total no. of waste recovery platforms b. Total number/type of green business in the city c. Total amount of recycled materials created from dry waste	Increased resource recovery	a. Sustainable finance b. Social inclusion c. Gender equity	2030
	SWM 2.6	Work with local materials collectors to recruit or retain recycling manufacturers. Build partnerships to analyse and develop a market for a	Solid Waste Management Rules, 2016	P: BBMP-BSWML S: KSPCB, MSME Development	BBMP SWM Budget, Swachh Bharat Mission –	a. Total number of recycling manufacturers b. Market for plastic waste recycling	Volume of recyclable textile waste	a. Sustainable finance b. Economic growth c. Social inclusion	

		recycled textiles industry (including meeting with stakeholders to determine and overcome barriers, developing standards and specifications, and committing public purchasing contracts to promote the industry.) Focus on materials with persistently low recycling rates.		Institute, Industries Department	Urban, MSME funds				
	SWM 2.7	Ensure that all public/private demolition projects follow C&D waste recycling/recovery practices.	C&D Waste Management Rules, 2016	P: BBMP-BSWML	BBMP SWM Budget, Swachh Bharat Mission – Urban	a. Total C&D waste recycling projects	C&D waste recovery	a. Increased accountability b. Reduced emissions	2030
	SWM 2.8	Replace all plastic packages with recyclable/recycled materials to reduce use of non-recyclables. Strictly ban the sale and use of single-use PVC items and flex banners, and replace with recyclable PE eco-flex.	Solid Waste Management Rules, 2016	P: BBMP-BSWML S: KSPCB, MSME Development Institute, Industries Department	BBMP SWM budget, Swachh Bharat Mission – Urban, MSME funds	a. Total amount of recyclable/recycled waste packaging in the city b. Ban on single-use PVC items	Recycled material packaging and banners	Reduced emissions	2030
	SWM 2.9	All manufacturers of non-recyclable materials must be mandated to pay high penalties under the 'polluter pays' principle, or take up carbon-neutral	Solid Waste Management Rules, 2016	P: BBMP-BSWML S: KSPCB, MSME Development	BBMP SWM budget, Swachh Bharat Mission –	a. Total number of trees planted/other carbon-neutral measures taken up by manufacturers.	Implementation of 'polluter pays' principle	a. Increased accountability b. Reduced emissions	2030

		measures to increase carbon sequestration and create a path to shift towards recycled materials.		Institute, Industries Department	Urban, MSME funds	b. Total amount of penalty paid by non-recyclable material manufacturers.			
	SWM 2.10	Prepare a comprehensive plan and reporting framework for extended producers. This includes revised Extended Producer Responsibility (EPR) norms (Central) by empowering formal and informal waste pickers, Producers (PIBOs) participation in DWCCs to manage and plan the destination of non-recyclable waste in collaboration with informal workers.	EPR guidelines	P: BBMP-BSWML S: KSPCB	BBMP SWM Budget, Swachh Bharat Mission – Urban, KSPCB, GoK	a. City level plan and reporting framework	Number of green jobs and materials produced	a. Inclusion of informal workers b. Creation of green jobs c. Sustainable finance	2030
	SWM 2.11	Set up strict norms for new packaging and ensure that it is certified on the parameter of Life Cycle Assessment. Adopt an ordinance that restricts the use of expanded-polystyrene containers at restaurants and other establishments. Implement a green business programme that	Solid Waste Management Rules, 2016	P: BBMP-BSWML	BBMP SWM budget	a. Life cycle assessment report b. Ordinance restricting polystyrene containers	Opportunities for green business	a. Sustainable finance b. Creation of green jobs c. Reduction of emissions	2035

		rewards local businesses for sustainability measures.							
	SWM 2.12	Mandate SEZs and industries to provide at least 5% of the total plot area for recycling facilities (they can be incentivised for promoting recycled materials, or they can have RDF plants and use the fuel produced in them). Establish technical standards and guidelines for waste activities and develop a permit system for industries concerned.	Karnataka State Policy for Special Economic Zones, 2009	P: GoK S: BBMP	Industries Department	a. Incentives for SEZs and industries for recycling facilities. b. Standards to manage waste in industries.	Reuse of recycled materials within the SEZs to promote circular economy	a. Sustainable finance b. Green jobs c. Reduction of emissions d. Increased accountability	2030
	SWM 2.13	Identify bulk consumers, and inventorise e-waste, conduct monthly e-waste collection drives.	E-Waste Manageme nt Rules	P: KSPCB S: BBMP	GoK	a. List of bulk e-waste consumers b. List of monthly e-waste collection drives c. Total no. of e-waste collection centres	Volume of e-waste generated	a. Improved service delivery b. Inclusion of informal workers	2030
	SWM 2.14	Re-evaluate the feasibility of waste-to-energy plants and of proposals in pipeline, for their operational and economic efficiency.	BBMP's on-going initiatives	P: BBMP-BSWML	BBMP's own funds			a. Reduced cost b. Reduced energy consumption	2025

SWM 2.15	Develop a study to highlight the importance of including plastic recycling in the MSME policy.	MSME Policy 2022	P: MSME, GoI S: BBMP	MSME funding	a. A guideline/provision on bridging the gap between MSME policy and green entrepreneurship	New business opportunities in plastic recycling	a. Sustainable finance b. Economic growth	2035
SWM-3: *Implement scientific landfills with gas capture systems and suitably repurpose closed landfills/dump sites.*								
Goal/Target: Achieve about 25% gas capture from scientific landfill by 2030, 50% by 2040 & 75% by 2050.								
SWM 3.1	Conduct land suitability analysis and develop a scientific landfill with gas capture system.	Solid Waste Management Rules, 2016	P: BBMP-BSWML	BBMP SWM budget	a. Extent of scientific disposal of solid waste b. Amount of gas capture	Scientific facility for mixed waste	a. Reduction of emissions b. Reduced soil and air pollution c. Reduced water contamination d. Increased accountability e. Improved public health	2025
SWM 3.2	Collaborate with gas companies to establish scientific landfill implementation and create sustainable financial incentives by providing landfill gas utilisation. (Gas capture in cylinders, as with LPG, can be considered.)		P: BBMP-BSWML S: Gas agencies	BBMP SWM budget, gas agencies (PPP funds)	a. Amount of gas recovered from landfill b. Amount of gas supplied as LPG c. Extent of cost recovery	Circular economy	a. Reduced emissions b. Social inclusion c. Increased accountability d. Sustainable finance	2025

	SWM 3.3	Create an action plan for managing legacy waste by adopting techniques such as windrows and biomining (do pre/feasibility assessment).	Solid Waste Manageme nt Rules, 2016	P: BBMP-BSWML	BBMP SWM budget	a. Amount of legacy waste bioremediation b. Amount of green cover increase	Increased green spaces	a. Reduction of emissions b. Reduced soil and air pollution c. Reduced water contamination d. Sustainable finance e. Green business	2030
	SWM 3.4	Ensure the closed landfills are turned into green spaces.	Solid Waste Manageme nt Rules, 2016	P: BBMP-BSWML	BBMP SWM budget				
SWM -4: *Create inclusive and hazard-resilient SWM infrastructure and services.*									
	SWM 4.1	Prepare a plan and coordinate and collaborate with various stakeholders to tackle disaster waste as a disaster response action and to raise awareness about sustainable, environmentally friendly and culturally supportive techniques for disaster waste management. Allocate separate funds for climate and disaster-related purposes such as landfill fires.		P: BBMP-Disaster Management Cell	BBMP disaster funds	a. Disaster response action plan b. Funds for waste department to tackle disasters c. Total amount of waste generated/collected due to disaster	Reduced post-disaster waste accumulati on	a. Increased resilience to climatic hazards b. Reduction of emissions c. Reduced soil and air pollution d. Reduced water contamination e. Job creation f. Improved health and livelihood	2035
	SWM 4.2	Build capacity for disaster waste management by providing education and training on disaster prevention and response		P: BBMP-Disaster Management Cell	BBMP disaster funds	a. Training modules, b. Dedicated staff c. List of vulnerable communities exposed to the	Reduced post-disaster waste	a. Increased resilience to climatic hazards b. Reduction of emissions	2035

		to vulnerable communities, in collaboration with relief agencies.				externalities of post-disaster waste effects	accumulation	c. Reduced soil and air pollution d. Reduced water contamination e. Job creation f. Improved health and livelihood	
	SWM 4.3	Ensure effective citizen grievance redressal through the Swachh app.		P: BBMP-Disaster Management Cell	BBMP disaster funds	Efficiency in redressal of customer complaints	Reduced post disaster waste accumulation	a. Resilience to climatic hazards b. Reduction of emissions c. Reduced soil and air pollution d. Reduced water contamination e. Job creation f. Improved health and livelihood	2035
	SWM 4.4	Focus on identification of existing capacities of post disaster waste management with special emphasis on Construction and Demolition (C&D) waste at every ward/zone of the city.				a. Amount of C&D waste due to disaster			
	SWM 4.5	During monsoons, continuously monitor stormwater drains and remove waste dumps to ensure stormwater runoff and avoid floods.				a. Type/location of drains exposed to solid waste dumping			

5.3.4 Air quality

Approach

Based on an assessment of the gaps and barriers in the air quality sector, BCAP has identified a four-pronged approach with aligned actions for reducing both ambient as well as indoor air pollution and building resilience in the city. The approach aims at preventing, mitigating, and building resilience in citizens health and capacity building through monitoring, data management, and developing IECs. Figure 65 illustrates the approach.

Figure 65: Approach for improving air quality

Prevent	Mitigate	Resilience	Capacity Building
Stringent regulations and operating protocols for vehicles carrying construction debris	Ensure timely implementation of the proposed NCAP - micro action plan	Organize annual free health check-ups at ward and city levels	Achieve uninterrupted data collection from ambient air quality monitoring systems

Sectoral action tracks

No.	Action track
AQ-1	Prevent air pollution at source through comprehensive strategies across sectors informed by evidence.
AQ-2	Reduce/maintain ambient air pollution levels to prescribed standards and minimise air pollution impacts through suitable local planning, urban design, and greening efforts.
AQ-3	Ensure implementation of WHO indoor air quality standards and guidelines in all public buildings by 2030 and all other buildings by 2040.
AQ-4	Develop a city-level comprehensive health action plan for tackling health risks posed by short- and long-term exposures to air pollution.
AQ-5	Create/improve infrastructure and capacities to develop a robust evidence-based and result-oriented AQ management paradigm through monitoring, evaluation, feedback loop, and knowledge creation and dissemination to encourage behavioural shifts.

Track-wise actions

Priority	S.No	Actions	Aligned with (ongoing initiatives/ other actions)	Responsible Agency Primary (P) Secondary (S)	Potential Source of funding	Output	Outcome	Co-benefit	Timeline *(Targeted year of completion of action)*
AQ- 1: *Prevent air pollution at source through comprehensive strategies across sectors, informed by evidence.*									
Goal/Target: To achieve 40% reduction in PM10 concentration and 30% reduction in PM2.5 concentration by 2026 from 2017-18 levels as per revised targets prescribed by NCAP.									
	AQ 1.1.	Ensure universal access and adoption of clean cooking fuel as primary fuel in the city through Pradhan Mantri Ujjwala Yojana (PMUY) and other similar programmes/schemes.	a. Pradhan Mantri Ujjwala Yojana	P: Energy Department- GoK S: Food and Civil Supplies Department	PMUY financial assistance	a. % increase in LPG/PNG as primary fuel b. % reduction in solid fuels	a. Reduction in indoor air pollution and health risks	a. Improved residents' lifestyle b. Empowerment women	2030
	AQ 1.2	Incentivise voluntary fleet modernisation adhering to improved emission standards and facilitate scrapping of old vehicles in line with the old-vehicle scrappage programme while encouraging a circular economy market around old vehicle scrappage.	a. Voluntary Vehicle Fleet Modernisation Program (VVMP)	P: Transport Department S: RTO	State government concession on motor vehicle tax	a. % increase in the modern vehicular fleet b. % reduction in tailpipe emissions	Reduction in air pollution	Reduction in GHG emissions	2035
	AQ 1.3	Enforce stringent regulations and operating protocols for vehicles carrying construction debris (such as the use of appropriate cover, and avoiding overload)	a. BBMP Building Bye-Laws - Guidelines for Construction and	P: BBMP	a. GoK budget b. NCAP funds (9th Finance commission)	% reduction in re-suspension of road dust - PM2.5 and PM10	Improved ambient air quality	Improvement in pedestrian health	2030

			Demolition Waste Management						
	AQ 1.4	Mandate annual training for city officials and engineers on the concept and ideation of NCAP using the Clean Air Action Plan (Planning and Implementation) manual developed by the Climate Centre for Cities, NIUA.	NCAP	P: BBMP S: All agencies	a. GoK Budget b. NCAP funds (IX Finance)	a. Number of trainings b. Number of participating staff and departments	a. Improve multi-stakeholder coordination b. Achieve attainment city status under NCAP		2025
	AQ 1.5	Mandate usage of gas-fuelled backup electricity generators and retrofit existing diesel/fossil fuel generators into gas generators	a. NCAP b. Swachh Vayu Sarvekshan	P: KSPCB S: BBMP	a. GoK budget b. NCAP funds (IX Finance)	a. % reduction in diesel generators b. % of retrofits in the city	a. Improved ambient air quality	a. Improved building occupancy comfort b. Reduction in GHG emissions	2030
	AQ 1.6	Conduct mandatory annual mapping of the city's polluting activities in the city to prioritise targeted sector-specific air pollution mitigation measures.	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP, KSPCB S: All agencies	a. NCAP funds (IX Finance)	a. Identification micro-level hot spots b. % improvement in data collection and dissemination	a. Improved ambient air quality b. Assured improvement of public health c. Mapping of most vulnerable people and zones	Improvement in vulnerable people's health	2025
	AQ 1.7	Encourage promotional activities for the adoption of electric/induction cooking	a. Go Electric Campaign	P: BEE S: KREDL	a. GoK funds	a. % increase in the number of users of electric	a. Improvement in residents'	a. Better indoor air quality	2027

		stoves by providing financial incentives to sellers				cooking stoves b. % reduction use of fossil fuel for cooking	lifestyle b. Improved health resilience of residents		
	AQ 1.8	Develop low-emission zone (LEZ), ultra-low emission zone (ULEZ), or zero-emission areas in the identified hotspots and restrict vehicle movement to limit tailpipe emissions, especially by heavy vehicles.	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: KSPCB, BTP	a. NCAP funds (IX Finance)	a. Number of reductions in hot spots b. % reduction in ambient air pollutant concentrations	a. Improved ambient air quality b. Improved public health c. Mapping of most vulnerable people and zones		2030
	AQ 1.9	Reduce transport sector emissions by promoting the use of Public Transport and Non-Motorised Transport.	Transport sector action track no. 3	P: BBMP S: Transport Department, BMRCL, BMTC	a. GoK funds	a. % increase in usage of public transport b. % reduction in ambient air pollutant concentration levels	a. Improved ambient air quality b. Improved public health		2025
AQ-2*: Reduce/maintain ambient air pollution levels to prescribed standards and minimise air pollution impacts through suitable local planning, urban design, and greening efforts.*									
Goal/Target: To achieve 40% reduction in PM10 concentration and 30% reduction in PM2.5 concentration by 2026 from 2017-18 levels as per revised targets prescribed by NCAP.									
	AQ 2.1	Ensure timely implementation of the proposed micro action plan for BBMP jurisdiction under the 15th Finance Commission grant by creating adequate capacity	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: All allocated agencies	a. NCAP funds (IX Finance)	a. % implementation and progress of micro action plans b. % reduction in ambient air pollution levels	a. Improved ambient air quality b. Progress in NCAP goals	a. Better public health	2025

		partnerships and institutional coordination.							
	AQ 2.2	Enforce mandatory installation of water sprinklers/spray, shielding, netting, covers/hoarding for aggregate and sand storage to minimise dust pollution caused by construction or demolition works, and installation of a wash bay for cleaning vehicles before they leave the site. All wash bays must have silt traps and use recycled water.	a. NCAP b. Swachh Vayu Sarvekshan c. BBMP Building Bye-Laws - Guidelines for Construction and Demolition Waste Management	P: BBMP S: KSPCB	a. NCAP funds (IX Finance)	% reduction in re-suspension of road dust - PM2.5 and PM10	a. Improved ambient air quality b. Improvement in residents' health		2030
	AQ 2.3	Improve existing ITS systems to adopt advanced technology including AI to better synchronise traffic flows and to reduce idling time of vehicles, which contributes to air pollution.	a. Transport sector action track 2	P: Transport Department S: BTP	a. GoK funds	a. % reduction in traffic congestion zones b. % reduction in average vehicle idling time	Increased fuel savings	GHG emissions reduction	2030
	AQ 2.4	Create policy instruments and institutional mechanisms for regional airshed management around Bengaluru to address aspects of trans-boundary air pollution.	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: All allocated agencies	a. NCAP funds (IX Finance)	a. Approval of policy and airshed management b. Number of departments in the inter-region coordination cell	Improve emission data repository		2025

	AQ 2.5	Include actions aiming at carbon capture from the environment in the city's Clean Air Action Plan.	a. Carbon Capture Utilisation and Storage (CCUS)	P: Energy Department - GoK, S: KREDL	GoK funds	% of actions proposed on carbon capture	Increase in number of projects on carbon capture	GHG emissions reduction	2035
	AQ 2.6	Promote and implement urban gardens and vegetation cover in the city through plantation drives (NBS).	a. Aligned with urban planning and greening-sector action tracks	P: BBMP S: All allocated agencies	GoK funds	% reduction in ambient air pollutant concentrations	Better public health,	Increased resilience	2027
AQ-3: *Ensure WHO indoor air quality standards and implementation of guidelines in all public buildings by 2030 and all other buildings by 2040.*									
Goal/Target: 30% of commercial and institutional buildings complying with WHO Indoor air quality standards and guidelines by 2030.									
	AQ 3.1	Provide incentives/subsidies to low-income groups to procure air purifiers and exhaust fans to adopt better ventilation within their dwelling unit.	a. WHO indoor air quality guidelines	P: BEE, BBMP S: KREDL, BESCOM	a. GoK funds	a. % people utilising the subsidy	a. Improve residents' lifestyle b. Empower women	a. Improved building occupants' comfort	2030
	AQ 3.2	Conduct sensitisation workshops on benefits of indoor plants for improving indoor air quality. This could be supported with activities such as providing free saplings to low-income groups.	a. WHO indoor air quality guidelines	P: BBMP S: KSPCB	NCAP funds (IX Finance)	Number of workshops conducted	a. Improve residents' lifestyle b. Empower women	Improved building occupants' comfort	2025
	AQ 3.3	Mandate the use of High Efficiency Particulate Air (HEPA) filters in vacuum cleaners, air purifiers, and air conditioners.	a. WHO indoor air quality guidelines	P: BEE S: KREDL	GoK funds	% increase in efficiency of particulate matter absorption	Reduce residents' health risk due to particulate matter, allergens,	Improved comfort of building occupants	2025

							pollen, and bacteria		
	AQ 3.4	Conduct regular indoor air quality assessments of all public buildings, prioritising schools and hospitals, by 2030.	WHO indoor air quality guidelines	P: BBMP S: KSPCB	NCAP funds (IX Finance)	a. % buildings posing health risks b. % buildings compliant with ECBC	Improve residents' lifestyle	Improved comfort of building occupants	2030
	AQ 3.5	Offer incentives and subsidies to all stakeholders in the value chain (consumers, manufacturers, distributors, etc.) to ensure the uptake of non-VOC materials.	a. Aligned with action no. E&B 2.7 b. WHO indoor air quality guidelines	P: BBMP S: KREDL	NCAP funds (IX Finance)	a. % buildings adopting water-based paints b. % buildings using VOC-free materials (for furniture, walls, railings etc)	Reduced resident health risk due to particulate matter, allergens, pollen, and bacteria	Improved comfort of building occupants	2030
AQ-4: *Develop a city-level comprehensive Health Action Plan for tackling health risks posed by short-term and long-term exposure to air pollution.*									
Goal/Target: Preparation of a roadmap for a comprehensive health action plan tackling risks due to air pollution for 2025-2035									
	AQ 4.1	Organise annual free health check-ups at ward and city levels in collaboration with BBMP and the media to raise awareness about the health impacts of exposure to a high concentration of air pollutants.	a. NCAP b. Swachh Vayu Sarvekshan	P: Commissionerate of Health and Family Welfare S: BBMP Health Department	a. Municipal corporation annual budget b. NCAP funds (IX Finance)	a. Number of free health check-ups b. % reduction in health impacts c. % reduction in air pollutant concentrations	a. Improved local health resilience b. Improved ground-level data collection and dissemination	Improved employee productivity and local employment	2025
	AQ 4.2	Create a team of health and non-health stakeholders to evaluate existing health systems and services for the prevention and control of	a. NCAP b. Swachh Vayu Sarvekshan	P: Commissionerate of Health and Family Welfare	a. Municipal corporation annual budget b. NCAP	a. Number of health facilities available for air pollution-related health issues	Improved local health resilience	Improved access to hospitals	2025

		health impacts due to air pollution.		S: BBMP Health Department	funds (IX Finance)	b. Number of tests available to diagnose health issues caused by air pollution			
	AQ 4.3	Conduct training sessions for ground-level health workers, such as ASHA workers, to deal with air pollution-related health concerns and risks. Identify more such volunteers at the local level and train them.	a. NCAP b. Swachh Vayu Sarvekshan	P: Commissionerate of Health and Family Welfare S: BBMP Health Department	a. Municipal corporation annual budget b. NCAP funds (IX Finance)	a. Number of workshops and trainings b. Number of trained health workers	Improved local health resilience management system	Improved local employment in health sector	2027
	AQ 4.4	Raise awareness about impacts of exposure to air pollution amongst street vendors and other informal workers continuously engaged in activities in hotspot zones.	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: BTP	Municipal corporation annual budget	a. % reduction in exposure to air pollutants b. % reduction in public gatherings in hotspot zones	Improved local health resilience		2025
	AQ 4.5	Develop a mechanism for data collection on influenza-like illness (ILI), severe acute respiratory infections (SARI) cases, and related hospital admission data on a daily basis to monitor respiratory illness trends due to poor air quality.	a. NCAP b. Swachh Vayu Sarvekshan	P: Commissionerate of Health and Family Welfare S: BBMP Health Department	a. Municipal corporation annual budget b. NCAP funds (IX Finance)	Approved data collection management system	Improved local health resilience management system	Improved local employment in health sector	2025

AQ-5: *Create/improve infrastructure and capacities to develop a robust evidence-based and result-oriented AQ management paradigm through monitoring, evaluation, feedback loop, and knowledge creation and dissemination to encourage behavioural shifts.*									
Goal/Target: To procure 13 new CAAQMS and transition the existing manual station to CAAQMS systems by 2035.									
	AQ 5.1	Procure nowcasting or forecasting systems and integrate them with CAAQMS to predict accurate air pollution levels at ward/zone levels. This will help the public take necessary precautions and avoid unhealthy exposure.	a. NCAP b. Swachh Vayu Sarvekshan	P: KSPCB S: BBMP	NCAP funds	% CAAQMS systems integrated with nowcast or forecast systems	a. Improved local health resilience	a. Weather alerts can be provided too	2030
	AQ 5.2	Ensure the monitoring systems are well calibrated and maintained to achieve uninterrupted data collection from monitoring systems.	a. NCAP b. Swachh Vayu Sarvekshan	P: KSPCB	NCAP funds	a. % data gaps in CAAQMS systems b. % background noise in CAAQMS systems	a. Strengthening of evidence-based decision-making b. Accurate data dissemination		2025
	AQ 5.3	Ensure accurate ward-wise mapping of locations of open burning of waste, intensify surveillance, and impose fines on defaulters.	a. Action aligned with SWM action-SWM1.15 and NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: KSPCB	NCAP funds	a. % reduction in harmful gas emissions from waste b. % reduction in open waste burning sites c. Creation of litter-free ambassadors for each ward	a. Improve local health resilience b. Prevention of exposure to unwanted odours	a. Achieveme nt of Swachh Bharat Abhiyan goals	2025

	AQ 5.4	Strengthen the monitoring network by adding an adequate number of reference grade CAAQMS and gradually replacing existing manual monitoring stations with these.	a. NCAP b. Swachh Vayu Sarvekshan	P: KSPCB S: BBMP	NCAP Funds	a. % increase in reference monitoring stations b. Determination of the number of stations required	a. Strengthening of evidence-based decision-making b. Better triangulation of hotspots d. Improved airshed monitoring network	a. Achieve Swachh Bharat Abhiyan goals	2030
	AQ 5.5	Promote private sector players' participation in air quality monitoring ecosystem by providing incentives.	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: KSPCB	NCAP funds, PPP funds	Approved promotional activity	Number of private players in AQM network		2030
	AQ 5.6	Activate citizens' groups to monitor and report air pollution-related activities in their local wards/streets at regular intervals. This can be done through programmes such as 'self-monitoring'.	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: KSPCB	NCAP funds, PPP funds	a. % increase in self-monitoring b. % reduction in open waste burning	Creation of a micro-level monitoring network	Achieve Swachh Bharat Abhiyan goals	2027
	AQ 5.7	Institutionalise annual auditing process to evaluate the performance of implemented NCAP measures. Based on the assessment, underperforming initiatives	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: KSPCB	NCAP funds	a. % performance intervention audited b. % improvement in strategies with evidence-based approach	a. Strengthening of evidence-based decision-making b.	Achieveme nt Swachh Bharat Abhiyan goals	2024

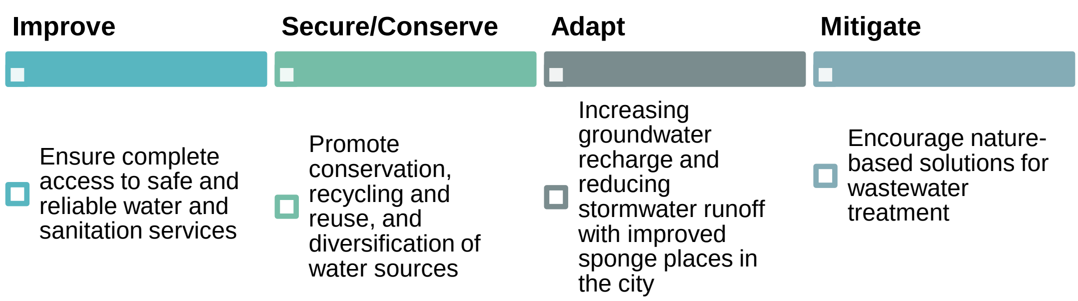
		can be replaced with new or improved versions.					Discontinuation of funding for the actions that are underperforming		
	AQ 5.8	Create awareness about 'Sick Building Syndrome' (SBS) through targeted IEC campaign for all, and prioritise vulnerable populations (children, women, elderly and marginalised groups).	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: KREDL	NCAP funds	% of people experiencing inadequate to zero indoor comfort	Increase in awareness of indoor air quality and thermal comfort	Increase in ECBC- and ENS-compliant buildings	2035
	AQ 5.9	Awareness generation on ambient air quality, through targeted IEC campaigns for vulnerable populations (children, women, elderly, and marginalised groups).	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: KSPCB	NCAP funds	a. Number of awareness programmes conducted b. Creation of suitable public advocacy and awareness materials	Knowledge dissemination on Air Quality Index (AQI) and colour codes	Achievement of Swachh Bharat Abhiyan goals	2025
	AQ 5.10	Develop an open access platform to provide timely issue of alerts/warnings on health risk factors related to the AQI and weather conditions, obtained from IMD / Pollution Control Boards.	a. NCAP b. Swachh Vayu Sarvekshan	P: BBMP S: KSPCB	NCAP funds	a. % increase in outreach activities for vulnerable groups	a. Improved local health resilience b. Prevention of exposure to spikes in air pollution concentration	Achievement of Swachh Bharat Abhiyan goals	2030

5.3.5 Water, wastewater, and stormwater management

Approach

The water, wastewater, and stormwater management approach for the BCAP is arrived at based on an understanding of the performance of the city, wastewater water treatment emissions, and the challenges/gaps and opportunities that the sector faces, to reduce, adapt and build resilience, and to mitigate emissions from treatment. Hence, in the BCAP, this sector is viewed through an 'Integrated Urban Water Management' (IUWM) lens. With this approach, the city can undertake climate actions to ensure *improved services, water security, adaptation and resilience, and emission mitigation*. This approach would enhance water security, manage water to adapt to and mitigate climate change, and close the gap in the water-energy-GHG emissions cycle. Figure 66 illustrates the approach for IUWM.

Figure 66: Approach for Integrated Urban Water Management



The action tracks and the actions listed below have been drafted considering the aspects of improved water access, quality and storage, water and energy efficiency, access to urban commons, enhanced livelihood and well-being, job creation, improved health, social and gender equity, reduced urban heat islands, and flood risk relating to the sector.

Sectoral action tracks

No.	Action tracks
W, WW, SW- 1	Enhance access to safe and reliable water and sanitation services for all.
W, WW, SW- 2	Ensure water security by conserving water resources, recycling and safe reuse of wastewater, and diversifying the city's sources of water.
W, WW, SW- 3	Restore and enhance sponge spaces to increase groundwater recharge and decrease stormwater runoff through green infrastructure technologies.
W, WW, SW- 4	Adopt improved technologies and nature-based solutions for efficient and equitable wastewater treatment that are aligned to the city's mitigation goals.

Track-wise actions

Priority	S.No	Actions	Aligned with (ongoing initiatives/other actions)	Responsible Agency Primary (P) Secondary (S)	Potential Source of funding	Output	Outcome	Co-benefit	Timeline (Targeted year of completion of action)
***W,WW,SW- 1:** Enhance access to safe and reliable water and sanitation services for all.*									
Goal/Target: 100% households to have access to water and sanitation infrastructure and services, which are a combination of networked and decentralised systems.									
	W, WW, SW- 1.1.	Ensure supply of safe water across the city (including 110 villages) by providing piped water supply, ward/community level water storage facilities, and stand posts/public taps located within a 100-m radius, so that the vulnerable wards/slums/poor areas have access to reliable water and improved services.	BWSSB vision documents. Karnataka State Water Policy, BWSSB Act, SDG-6	P: BWSSB S: BBMP Slum Development Board	GoK, Beneficiary Capital Contribution (BCC), Greater Bangalore Water and Sanitation Project (GBWASP) and AMRUT (Atal Mission for Rejuvenation and Urban Transformation).	a. Water supply coverage (% population covered) b. Total number of standposts/public taps in vulnerable communities c. Total number of slums/households dependent on non-piped water facilities.	a. Increased supply of water across the city, including vulnerable communities. b. Reduced transportation of water from far-off water sources c. Reduced dependency on illegal groundwater extraction.	a. Improved health, livelihood and well-being. b. Increased water and energy efficiency. c. Gender equality d. Improved conditions of poor communities e. Reduced use of polluted water. f. Equitable and improved supply of water. g. Reduced GHG emissions from	2025

								transport. h. Increased job opportunities	
	W, WW, SW- 1.2	Publish ward-level data in open access platform on actual consumption of public supply/piped water across the city by different customer groups to plan for better equitable supply.		P: BWSSB	GoK, own funds of BWSSB	a. Ward/community level water consumption data b. Ward/community level data for different water consumers c. Total number of households with piped water supply d. Total number of households with other decentralised systems	a. Actual water consumption data of the city based on various consumer groups/localities.	a. Improved health, livelihood, and well-being b. Increased water and energy efficiency c. Gender equality d. Improved conditions of poor communities e. Reduced use of polluted water f. Equitable and improved water supply g. Reduced GHG emissions from transport h. Increased job opportunities	2025
	W, WW, SW- 1.3	Based on the available data on actual water consumption, revisit service benchmarks for the city and distribute piped water as per actual consumption to improve equitable access to water.		P: BWSSB	GoK, own funds of BWSSB				

	W, WW, SW- 1.4	Collect and publish ward-level data on the actual requirement for public toilets across the city to eradicate open defecation and improve hygiene.	Swachh Bharat Mission, SDG-6	P: BBMP-Slum Development Board	Swachh Bharat Mission, Shubhra Bengaluru Scheme	a. Ward-level data on coverage of toilets b. Total number of public toilets required to be constructed in the city. c. Total number of households connected to sewage system	a. Increased access to sanitation services b. Gender-neutral sanitation facilities	a. Improved health, livelihood and well-being b. Improved sanitation services c. Improved conditions of poor communities d. Increased job opportunities e. Reduced contamination and air pollution	
	W, WW, SW- 1.5	Provide safe sanitation services to all households, construct public/community toilets in urban poor pockets/slums/public places as per universal accessibility standards, including gender-neutral toilets, with adequate sewage treatment and management facilities to ensure improved services and safe access for all vulnerable groups.	Swachh Bharat Mission, SDG-6	P: BBMP-Slum Development Board	Swachh Bharat Mission, Shubhra Bengaluru Scheme	a. Total sewerage network in the city b. Total number of public/community toilets constructed across the city that are accessible for vulnerable communities.	a. Increased access to sanitation services b. Gender neutral sanitation facilities	a. Improved health, livelihood and wellbeing b. Improved sanitation services c. Improved conditions of poor communities d. Increased job opportunities e. Reduced contamination	2025

								and air pollution	
W, WW, SW -2: *Ensure water security by conserving water resources, recycling and safe reuse of wastewater, and diversifying the city's sources of water.*									
Goal/Target: By 2050, aim to reduce non-revenue water to 15%. Achieve reuse of treated wastewater to a minimum of 50% by 2030 and 90% by 2050.									
	W, WW, SW- 2.1	Implement the concept of District Meter Areas (DMAs) in all eight zones (in line with the pilot conducted in 135 sq. km. in the city) by dividing water distribution areas into smaller units (based on availability of funds) to facilitate equitable distribution, better monitoring, reduced T&D loss, and non-revenue water (NRW, such as unbilled or unmetered	BWSSB vision document, Bengaluru Water Supply (Amendment) Regulation, 2020	P: BWSSB	GoK, BWSSB, GBWASP, AMRUT	a. Total metered connections b. Total illegal connections c. Total unbilled connections d. Total unmetered connections e. Data on water distribution units	a. Reduced T&D loss b. Reduced NRW loss c. Increased equitable distribution d. Per capita supply reduction	a. Increased water and energy efficiency b. Reduced water loss and increased water conservation	2030

		connections, illegal connections, and physical water leakages).							
	W, WW, SW- 2.2	Conduct regular audits for water infrastructure by applying advanced technologies to identify the need for upgrades, refurbishment, and replacement, to minimise leakage and contamination during disasters such as floods.	BWSSB vision document, Bengaluru Water Supply (Amendment) Regulation, 2020	P: BWSSB	GoK, BWSSB, GBWASP, AMRUT	a. Water infrastructure audit b. Total infrastructure that needs to be upgraded	a. Reduced leakages b. Improved water infrastructure	a. Reduced water contamination b. Increased job opportunities c. Improved climate-resilient infrastructure	2025
	W, WW, SW- 2.3	Conduct regular energy audits through a participatory approach, to monitor energy intensity of water supply network, and to minimise energy used utilisation for water supply.	Energy audit report – BESCOM	P: BWSSB, BESCOM	BESCOM funds	a. Energy audit of water b. Total expenses on pumping and transporting water from Cauvery to the city.	a. Reduced energy usage for pumping, treatment, and supply	a. Reduced energy usage and GHG emissions	2040
	W, WW, SW- 2.4	In continuation of District Meter Areas (DMAs), make an incremental plan for creating a smart water grid by learning from global best practices, to ensure better network resilience.	Bengaluru Water Supply (Amendment) Regulation, 2020	P: BWSSB	GoK, BWSSB-GBWASP, AMRUT	a. Plan to implement advanced smart water grid for efficient water supply network. b. Complete database on water pressure, availability, contamination, and	a. Improved water distribution and management b. Lower maintenance of distribution system	a. Improved water quality b. Improved climate-resilient infrastructure	2040

						defects/damages in the water distribution system			

	W, WW, SW- 2.5	Get approval from the government to implement a tariff structure for different consumer segments to reflect the true cost of water from different water sources (differential tariff, volumetric tariff, etc.) to achieve socially equitable and financially sustainable utility. For instance, this could mean pricing instruments such as increasing block-rate structures and charges for excess use, so that users pay more for higher levels of consumption, or differentiated tariffs for potable and non-potable water to limit freshwater use for non-potable purposes.	Bengaluru Water Supply (Amendment) Regulation, 2020	P: BWSSB	BWSSB-GBWASP	a. Differential tariff structure b. Total potable and non-potable water consumption data	a. Improved true cost of water b. Socially equitable and financially sustainable utility c. Enhanced water access d. Reduced fresh water use for non-potable purposes	a. Improved accountability and transparency. b. Improved water efficiency c. Reduced GHG emissions from pumping excess fresh water for all types of uses.	2025

	W, WW, SW- 2.6	Encourage/create incentive mechanisms within the water tariff system for greater uptake of water and energy-efficient appliances, fixtures in homes, institutions, etc., to ensure judicious water and energy consumption.	BWSSB vision document, Bengaluru Water Supply (Amendment) Regulation, 2020	P: BWSSB S: BESCOM	BWSSB-GBWASP	a. Increase in water- and energy-efficient appliances and fixtures	a. Reduced indoor potable water use b. Reduced water consumption to save energy c. Improved environmental well-being	a. Reduced energy use b. Reduced water consumption	2025
	W, WW, SW- 2.7	Sensitise consumers and water technicians (plumbers) regarding water conservation and energy-efficient practices by conducting regular (quarterly/half yearly) IEC campaigns at the ward level in partnership with NGOs, civil society platforms, citizens' forums, academic institutions, etc. (Leverage existing outreach facilities such as RWH theme park, Jayanagar.)	BWSSB vision document, Karnataka State Water Policy	P: BWSSB	Jal Jeevan Mission IEC funds	a. Total no. of IEC campaigns conducted b. List/Database of plumbers across the city	Increased awareness on water and energy efficiency and conservation	Increased water conservation through judicious use of water	2025

	W, WW, SW- 2.8	Mandate regular and targeted training programmes (quarterly/half yearly) for officials/engineers/ground workers in water utility and other relevant government departments, on water conservation devices and practices, such as usage of control valves for water pumping to maintain flow pressure in the network to reduce losses and avoid unnecessary energy consumption.	BWSSB vision document, Karnataka State water Policy	P: BWSSB	Jal Jeevan Mission IEC funds	Database on total number of trainings/works hops conducted			
	W, WW, SW- 2.9	Prepare and enforce adequate regulatory instruments to control and monitor groundwater extraction and the private water tanker business, to ensure sustainable use of groundwater and avoid over-exploitation of groundwater resources.	Karnataka State Water Policy, Karnataka Ground Water (Regulation and Control of Development and Management), 2011	P: BBMP, KGWA S: BWSSB, RTO, BESCOM	BBMP, RTO's own funds (Bhoojala Yojana-BWSSB)	Regulatory instrument to control groundwater extraction: a. Total number of trade licensed water tanker operators.b. Total number of permitted domestic borewellsc. Condition of the tankers d. Total	a. Reduced illegal tanker operators b. Reduced illegal borewells c. Database of households dependent on tankers	a. Increased water conservation b. Judicious and safe use of alternative water sources c. Improved quality of water supply d. Improved livelihood and job opportunities	2025

						extraction of water from wells e. Travelling location and distance of tankers f. Total number of metered commercial borewells			
	W, WW, SW- 2.10	Create aquifer plan that includes participatory aquifer mapping of groundwater levels across the city and publish it on the open access platform, to ascertain water resource availability and identify actions to recharge and replenish groundwater sources.	Karnataka State Water Policy, Karnataka Ground Water (Regulation and Control of Development and Management), 2012	P: KGWA S: BWSSB, CGWB, KSPCB, BBMP	PPP	Aquifer plan with maps and water levels: a. Database on total number of borewells, depth, diameter, rate of pumping, etc. b. Database on groundwater levels across the city c. Total current discharge rate, quantity of water extracted per day of the borewell	a. Improved recharge and replenishment of groundwater sources b. Improved conservation of water	a. Sustainable alternative water sources b. Improved groundwater quality and quantity c. Reduced water pollution d. Increased energy efficiency e. Increased job opportunities and improved livelihood and well-being f. Reduced stormwater runoff	2030
	W, WW, SW- 2.11	Integrate renewable groundwater sources as a buffer source to increase freshwater storage and replenish the groundwater aquifer.	Karnataka State Water Policy, Karnataka Ground Water (Regulation and Control of Development and	P: KGWA S: BWSSB, CGWB, KSPCB, BBMP	PPP				

			Management), 2013						
	W, WW, SW- 2.12	Create a plan for constructing groundwater recharge pits across the city to increase groundwater recharge and reduce stormwater runoff to expand fresh water sources.	Karnataka State Water Policy, Karnataka Ground Water (Regulation and Control of Development and Management), 2014	P: KGWA S: BWSSB, CGWB, KSPCB, BBMP	PPP				
	W, WW, SW- 2.13	Rejuvenate existing groundwater wells by involving communities and using local traditional knowledge to enhance access to water, increase groundwater recharge, and create livelihood opportunities.	Karnataka State Water Policy, Karnataka Ground Water (Regulation and Control of Development and Management), 2015	P: KGWA S: BWSSB, CGWB, KSPCB, BBMP	PPP	Rejuvenation of groundwater wells a. Total number and location of borewells to be rejuvenated b. Database on local communities and traditional techniques to rejuvenate groundwater wells	Improved groundwater wells condition and recharge potential	a. Improved livelihood and increased job opportunities. b. Increased water storage and availability c. Improved water quality	2030

	W, WW, SW- 2.14	Rejuvenate and revive the TG Halli reservoir to reduce dependency on other far-off sources and augment the city's water supply (subject to the release of 1.2 TMC of allocated water)	BWSSB vision document	P: BWSSB	GoK, BWSSB-GBWASP, AMRUT	Amount of water that can be supplied through TG Halli reservoir.	Diverse water sources	a. Reduced energy utilisation for pumping water from Cauvery b. Reduced transport of water	2035
	W, WW, SW- 2.15	Ensure strict enforcement of rainwater harvesting at the plot/community level across the city, to increase groundwater recharge and improve water and energy efficiency by reducing dependency on Cauvery piped water supply, pumping, water transportation and unauthorised/illegal water extraction.	Bengaluru Water Supply and Sewerage (Rainwater harvesting) (Amendment) Regulation, 2019; BBMP Building Bye-laws, 2003; and BWSSB Act, 2009 and Regulations, 2015	P: BBMP S: BWSSB	BBMP budget	Citywide total number of rainwater harvesting structures, location, and capacity	Increased groundwater recharge and reduced dependency on municipal water supply	a. Reduced stormwater runoff b. Increased water storage c. Improved water quality d. Increased water and energy efficiency e. Job creation and livelihood opportunities	2025

	W, WW, SW- 2.16	Integrate multiple funding streams to implement extensive rainwater harvesting (RWH), lake rejuvenation projects, etc., through a participatory approach, to promote water and energy conservation, and water security.	Bengaluru Water Supply and Sewerage (Rainwater harvesting) (Amendment) Regulation, 2019; BBMP Building Bye-laws 2003; BWSSB Act 2009, and Regulations, 2016; Karnataka Lake Conservation and Development Authority (KLCDA) Act, 2014	P: BBMP- Karnataka Tank Conservation and Development Authority (KTCDA), Forest Department S: BWSSB, KSPCB	BBMP budget	a. Increased investment in lake rejuvenation and RWH b. List and map of all lakes in the city and their condition	Increased lake rejuvenation and RWH projects, and awareness about water security	a. Improved water quality and storage b. Improved biodiversity c. Access to urban commons d. Enhanced livelihood e. Job creation f. Improved health and well-being	2030

	W, WW, SW- 2.17	Implement participatory and inclusive lake rejuvenation projects by involving the local community in cleaning and maintaining water bodies to secure local watershed with recharge, improved water quality, protect biodiversity, improve access to urban commons, and enhance livelihood opportunities.	Bengaluru Water Supply and Sewerage (Rainwater Harvesting) (Amendment) Regulation, 2019; BBMP Building Bye-laws 2003; and BWSSB Act, 2009 and Regulations, 2016; and Karnataka Lake Conservation and Development Authority (KLCDA), ACT 2014	P: BBMP- Karnataka Tank Conservation and Development Authority (KTCDA), Forest Department S: BWSSB, KSPCB	BBMP budget	a. Increased investment in lake rejuvenation and RWH b. List and map of all lakes in the city and their condition	Increased lake rejuvenation and RWH projects/proposals, and awareness about water security	a. Increased water quality and storage b. Improved biodiversity c. Access to urban commons d. Enhanced livelihood e. Job creation f. Improved health and well-being	2030
	W, WW, SW- 2.18	Prohibit disposal of phosphate-containing fertilisers, detergents and sewage into water bodies, and ensure the recovery of phosphorus from wastewater, to reduce dependency on chemical fertilisers to improve the quality of water bodies.	Karnataka Lake Conservation and Development Authority (KLCDA) ACT, 2014; Zero Liquid	P: KSPCB S: BBMP, BWSSB	GoK	Standards on prohibition on disposal of chemicals in water bodies	Decreased discharge	a. Improved water quality b. Minimal wastewater discharge c. Maximum resource recovery	2025

			Discharge (ZLD) Policy						
	W, WW, SW- 2.19	Build awareness amongst public and private stakeholders on ZLD national-level framework for reuse of treated wastewater.	Karnataka Lake Conservation and Development Authority (KLCDA) ACT, 2014; ZLD Policy	P: BWSSB, Forest Department, KSPCB S: BBMP	GoK	Total no. of awareness programmes conducted	Increased awareness about reuse potential of treated wastewater		2025
	W, WW, SW- 2.20	Enable appropriate market mechanisms/business models to connect bulk wastewater generators that are registered in an open access database, with large consumers to ensure adherence to ZLD policy. (ZLD policy should allow sale of treated wastewater to bulk consumers for non-potable use.)	Karnataka Lake Conservation and Development Authority (KLCDA) ACT 2014, ZLD Policy	P: KSPCB S: BWSSB	GoK	Market/platform for treated water sale a. Database on bulk wastewater generators b. Different types of business models to improve wastewater by-products c. Increased reuse of treated water	Improved usage of wastewater by-products	a. Increased alternate water sources b. Reduced water pollution c. Increased access to water	2030

	W, WW, SW- 2.21	Pilot-test advanced water reclamation systems such as NE Water, Singapore, for the city to ensure recycling and safe reuse of wastewater.	BWSSB vision document	P: BWSSB	BWSSB's own funds	Advanced water reclamation systems in the city	Improved recycling and reuse of treated water	a. Increased reuse of water b. Decreased water pollution c. Improved health and safety d. Reduced water scarcity	2040
	W, WW, SW- 2.22	Enhance uptake of dual piping/plumbing system at the household level to increase reuse of wastewater within the premises, to reduce dependency on fresh water for non-potable purposes.	BWSSB vision document	P: BWSSB	BWSSB's own funds	Database on total dual-piping domestic connections in the city	Increased recycling and reuse of treated wastewater		2030
	W, WW, SW- 2.23	Mandate a percentage of daily use of treated wastewater by bulk generators at large residential complexes, commercial, industrial zones, public parks/gardens/green spaces and all corporate gardens by 2026. Enforce increased usage of treated wastewater for bulk generators (as per ZLD policy).	BWSSB vision document	P: BWSSB	BWSSB's own funds	a. Percentage of daily use of treated water b. List of customers using treated wastewater			2025

	W, WW, SW- 2.24	Use treated wastewater to rejuvenate lakes, especially in peripheral/adjoining areas of the city. This can be used for cultivation by farmers and other appropriate purposes to ensure groundwater replenishment, reduced nutrients for farmers, alternative livelihood opportunities, and social cohesion.	BWSSB vision document	P: BWSSB	BWSSB's own funds	a. Increased treated water usage by farmers for cultivation b. List of lakes in peripheral areas c. Farming activities that are dependent on lakes	Increased recycling and reuse of treated wastewater	a. Increased reuse of water b. Decreased water pollution c. Improved health and safety d. Reduced water scarcity e. Improved livelihood	2030

W, WW, SW- 3: *Restore and enhance sponge spaces to increase groundwater recharge and decrease stormwater runoff through green infrastructure technologies.*									
Goal/Target: 40% of city's surface area to become permeable by 2040 by reclaiming ecologically sensitive spaces and adopting nature-based solutions. Convert 75% of the city's footpaths to permeable surface material by 2050.									
	W, WW, SW- 3.1	Prepare a policy on stormwater management (such as promoting best practices for stormwater management in urban areas, including the need for stormwater catchment) that enables effective integration of blue-green network of the city and enhances opportunities for nature-based solutions and hybrid infrastructure.		P: BBMP-Stormwater Drainage Department S: BDA	BBMP-SWD annual maintenance fund	A policy on stormwater management	Opportunity to use stormwater runoff as a water supply source	a. Decreased runoff b. Improved public health c. Social equity d. Decreased water pollution e. Climate-resilient infrastructure f. Increased water recharge g. Reduced urban heat islands h. Reduced flood risk	2025

	W, WW, SW- 3.2	Develop and enhance sponge spaces, implement low-impact development and NBS in stormwater management for the city (such as wetland development that can absorb rainwater and floodwater, green roofs, urban gardens (open green spaces and plantation), permeable low concrete surfaces, stormwater tree trenches to ensure recharge of rainwater and to create small- and large-scale capture, from retention vaults under parks to ponds in community gardens).	Aligned with action no. UPGBD- 3.3			Provides hydrologically functioning landscape	Low-cost and energy-efficient infrastructure		2025
	W,WW,SW - 3.3	Prepare a complete spatial database (open access) on the stormwater drainage network indicating the type/ hierarchy of drains (primary/secondary/tertiary) and update the SWD master plan.	Aligned with action no. DM-1.4	P: BBMP-Stormwater drainage department S: BDA	BBMP-SWD annual maintenance fund	Coverage of stormwater drainage network (primary, secondary, and tertiary) with lengths.	Complete stormwater drainage network map	a. Decreased runoff and increased stormwater collection b. Reduced pollution c. Improved climate-resilient infrastructure	2025

	W, WW, SW- 3.4	Assess the capacity and extent of existing drainage network to evaluate its functioning in various extreme rainfall scenarios.	Aligned with action no. DM- 1.4	P: BBMP-Stormwater Drainage Department S: BDA	BBMP-SWD annual maintenance fund	Analysis of drainage network capacity to hold stormwater a. Precipitation and Rainfall intensity/runoff b. characteristics of catchment areas c. Pollutant load d. data on incidence of water logging/floods	Detailed performance assessment of stormwater network	Flood control	2025
	W, WW, SW- 3.5	Upgrade, improve, and expand the existing stormwater drainage network as per the SWD policy informed by spatial database.	Aligned with action no. DM-1.4	P: BBMP-Stormwater drainage department S: BDA	BBMP-SWD annual maintenance fund	Improved drainage network a. Total number of stormwater drains that are encroached b. Total number of drains that need upgrades	Increased drainage network condition	a. Decreased runoff and increased stormwater collection b. Reduced pollution c. Improved climate-resilient infrastructure	2025
W, WW, SW- 4: *Adopt improved technologies and nature-based solutions for efficient and equitable wastewater treatment that are aligned to the city's mitigation goals.*									
Goal/Target: 95% wastewater treatment with a combination of centralised and decentralised system with about 61% low-carbon wastewater treatment technologies by 2050.									

	W, WW, SW- 4.1	Implement low-carbon/energy wastewater treatment plants with resource recovery facilities, including nutrient recovery, which recover elements from wastewater, apart from treated wastewater, such as nutrients (nitrogen removal and phosphorus recovery), and energy.	BWSSB vision document, Draft National Policy on the Safe Reuse of Treated Wastewater	P: BWSSB	AMRUT	Total list and capacities of low-carbon/energy wastewater treatment plants in the city	a. Water quality standards b. Level of DO, phosphorous, nitrates, nitrites, faecal matter c. Level of sedimentation in freshwater and marine water bodies	Reduced GHG emissions	2030
	W, WW, SW- 4.2	Upgrade existing public STPs to meet CPCB's revised treated effluent standards and ensure the new STPs that are going to be constructed are meeting the standards (Treatment to the level required).	BWSSB vison document, Draft National Policy on the Safe Reuse of Treated Wastewater	P: BWSSB S: KSPCB	AMRUT	a. Coverage of wastewater treatment network services b. Quality of wastewater treatment c. Collection efficiency of wastewater d. Adequacy of wastewater treatment capacity	Efficiently functioning STPs	a. Reduced pollution and odour b. Improve health	2030
	W, WW, SW- 4.3	Conduct regular energy audits through participatory approach to monitor energy intensity of sewerage network and wastewater treatment plants.	Energy audit report – BESCOM	P: BWSSB, BESCOM	BESCOM funds	a. Energy audit of water b. Total expenses on pumping and transporting water from Cauvery to the city.	Reduced energy usage for pumping, treatment, and supply	Reduced energy usage and GHG emissions	2040

	W, WW, SW- 4.4	Conduct regular IEC campaigns on low-carbon/energy wastewater treatment and reuse potential, in partnership with stakeholders such as NGOs, civil society platforms, citizens' forums, RWAs, academic institutions, and Pollution Control Board, to sensitise citizens about treated water reuse and to nudge social behaviour change.	Draft National Policy on the Safe Reuse of Treated Wastewater	P: BWSSB	Jal Jeevan Mission IEC funds	Database on ward-level IEC campaigns	Increased awareness on wastewater reuse, and recycling potential, and energy efficiency	Reduced untreated wastewater discharge	2025
	W, WW, SW- 4.5	Prepare a plan for incremental shift towards improved and more efficient technologies to minimise GHG emissions from wastewater and encourage and incentivise low-carbon/energy solutions for decentralised wastewater treatment in neighbourhoods/large residential complexes/public places/ institutional complexes, especially with biological treatment with low energy consumption and enhanced mitigation benefits (need to meet the	Draft National Policy on the Safe Reuse of Treated Wastewater	P: BWSSB	AMRUT, BWSSB own funds	a. Incentives for low-carbon wastewater treatment plants b. A detailed plan to shift towards low-carbon treatment c. Total number of centralised and decentralised wastewater treatment d. Total number of low-carbon wastewater treatment plants	More decentralised low-carbon wastewater treatment facilities	a. Reduced GHG emissions b. Increased low-carbon water treatment	2030

		standards for irrigation/fit for purpose).							
	W, WW, SW- 4.6	Maintain a complete open access database on private STPs across the city.		P: KSPCB	KSPCB's own funds	List of private STPs across the city		Increased job opportunities	2025
	W, WW, SW- 4.7	Conduct regular inspections of private STPs and revisit STP approval process to ensure effective performance of private STPs.		P: KSPCB	KSPCB's own funds	List of inspections conducted to check installation and performance of STPs	Effective performance of STPs		2025

	W, WW, SW- 4.8	Conduct mandatory training sessions for operators and service providers on the operation and maintenance of private STPs, as a part of the approval process.		P: KSPCB	KSPCB's own funds	a. O&M training session modules b. List of consumers and service providers c. Manpower dataset	Improved wastewater treatment	a. Improved skilled labour b. Reduced water pollution c. Increased energy efficiency d. Improved livelihood and job opportunities	2025
	W, WW, SW- 4.9	Ensure implementation of NAMASTE Scheme, to eradicate unsafe sewer and septic-tank cleaning practices introduced in February 2023 by the Ministry of Social Justice and Empowerment.	NAMASTE Scheme, 2023	P: BBMP	NAMASTE Scheme	a. IEC campaign b. Livelihood assistance c. Identification of sewer/septic tank workers (SSW) d. Occupational training and distribution of PPE kits to SSWs	Ensure safety of sanitation workers	a. Improved livelihood and health of workers b. Reduced pollution	2025
	W, WW, SW- 4.10	Create a market for by-products of wastewater treatment, making wastewater treatment plants more environmentally and financially sustainable. (Enforce ZLD and build in flexibility.)		P: BWSSB	BWSSB's own funds	Market for wastewater by-products and a. list of business models supporting wastewater by-products sale b. List of consumers and sellers	Recovery of water, energy, and nutrients	a. Reduced GHG emissions b. Improved energy efficiency c. Improved health d. Improved livelihood and job creation	2030

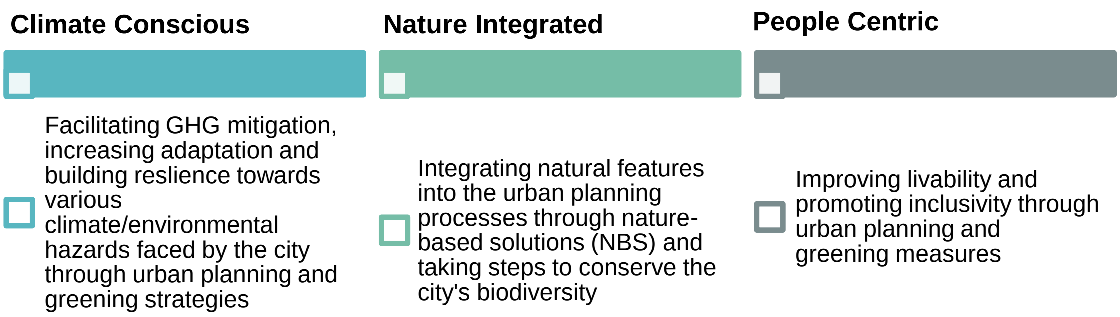
						c. Price of by-products d. Type of by-products and usage			
	W, WW, SW- 4.11	Explore innovative financing mechanisms/business partnerships (such as micro-contributions, taxes, public-private partnerships, and market-based financial transactions) that can encourage the development of and investment in wastewater systems to deliver cost-effective wastewater infrastructure.		P: BWSSB	BWSSB's own funds	a. PPP b. Incentives and sufficient financial sources	Cost effective delivery of wastewater treatment		2030

5.3.6 Urban planning, greening, and biodiversity

Approach

A three-pronged approach has been identified for arriving at the action tracks and actions for the urban planning, greening, and biodiversity sector. This is based on the sectoral analysis and gap assessment carried out for this sector. Climate-conscious, nature-integrated, and people-centric are the major lenses through which this sector should be seen. Urban planning and greening activities can address climate change and its impacts by reducing emissions and building resilience. Urban planning should respond to the natural context and facilitate the preservation of natural features and conservation of the existing biodiversity. The sector also has the potential to improve the quality of life of the city's residents, along with ensuring equity and inclusivity in accessing various services and infrastructure. Figure 67 summarises this approach.

Figure 67: Approach to urban planning, greening, and biodiversity



What are nature-based solutions (NBS)?

Nature-based solutions are actions to protect, sustainably manage, or restore natural ecosystems, that address societal challenges such as climate change, human health, food and water security, and disaster risk reduction effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. For example, a common problem is the flooding in coastal areas that occurs as a result of storm surges and coastal erosion. This challenge, traditionally tackled with manmade (grey) infrastructure such as sea walls or dikes, can also be addressed by actions that take advantage of ecosystem services such as tree planting. Planting trees that thrive in coastal areas – known as mangroves - reduces the impact of storms on human lives and economic assets, and provides a habitat for fish, birds, and other plants, supporting biodiversity.

Estimates suggest that nature-based solutions can provide 37% of the mitigation needed until 2030 to achieve the targets of the Paris Agreement. How can this be done? If you plant trees, they're going to soak up carbon. For example, restoring native forests at the margins of the river to avoid landslides can also act as a carbon sink. Climate-smart agriculture is another example that enables farmers to retain more carbon in their fields as they produce crops. Decreasing deforestation is another way to benefit from nature-based solutions – for example, by paying farmers not to cut down the forest preserves ecosystem services such as carbon sequestration, provision of clean drinking water, and reduction of river sedimentation downstream.

Nature-based solutions also play a key role in climate change adaptation and building resilience in landscapes and communities. Several nature-based solutions are being used by the World Bank to help manage disaster risk and reduce the incidence and impact of flooding, mudslides, and other disasters. They are a cost-effective way of addressing climate change while also addressing biodiversity and land degradation. You can address several problems at once.
But it's not automatic that everything you plant becomes a nature-based solution that contributes to biodiversity – for example, planting trees that are not from the region and are toxic to local animals would not generate biodiversity benefits.

Source: World Bank, 2022; What You Need to Know About Nature-Based Solutions to Climate Change (C. Explainer 2022)

Sectoral action tracks

No.	Action track
UPGBD-1	Promote compact development through mixed use, walkable neighbourhoods.
UPGBD-2	Develop climate-resilient and nature-integrated plans for the city and city-region through participatory planning practices.
UPGBD-3	Adopt nature-based solutions (NBS) as an urban planning and design tool to improve resilience and liveability.
UPGBD-4	Conserve, restore, and manage the city's biodiversity.
UPGBD-5	Improve access to essential services and infrastructure, including safe and affordable housing for all.

Track-wise actions

Priority	S.No.	Actions	Aligned with (ongoing initiatives/other actions)	Responsible Agency Primary (P) Secondary (S)	Potential Source of funding	Output	Outcome	Co-benefit	Timeline *(Targeted year of completion of action)*
UPGBD-*1:* *Promote compact development through mixed-use, walkable neighbourhoods connected by public transport.*									
Goal/Target: Prepare and adopt the RMP 2041 and set up the Master Plan Coordination Committee by 2025.									
	UPGBD-1.1	Revise the city's master plan based on compact development principles and incorporate provisions of the approved Bengaluru TOD Policy.	*Approved Bengaluru TOD Policy, BMLTA Bill, CMP 2020 and Parking Policy 2.0 * Pilot project planning for TOD and MMI along Phase 2A-2B metro corridor * RMP 2041 under preparation	P: BDA S: BMLTA/DULT; all development, regulating, and sectoral/line agencies concerned	BDA's own funds	Approved RMP 2041; institutional set-up for master plan implementation + monitoring	a. % increase in population with access to a public transport stop/station, public open space, primary education and healthcare facility within 10/12-min walking distance. In TOD Zones (against baseline and non-TOD areas): b. % increase in street and NMT	a. Improved accessibility, liveability and resource efficiency b. Reduction in use of private vehicles and shift to PT and NMT modes c. Reduction in vehicular fuel consumption, traffic congestion, air pollution, and crashes	2025

	UPGB D-1.2	Prepare and adopt the 'TOD Vision and Corridor Plan' and TOD Zone Plans (TZPs) for all stations along metro Phases 2A-2B by 2025. Prepare and adopt TZPs for all mass transit stations in the city by 2035 based on a TOD phasing strategy.		P: DULT/BMLTA, BDA, S: BIAAPA, UDD, GoK, BBMP, BMRCL, KRIDE, BIAL, BMTC, KSRTC, BMRDA, BWSSB, BESCOM, KIADB, BTP	BMLTA/ UTIF Fund; planning and implementing agency's own resources	a. No. of TOD Corridor and Zone Plans prepared and approved b. No. of public-sector and private-sector TOD schemes/projects approved and implemented	network density and connectivity. c. % increase in population and job densities d. % increase in affordable housing DUs (under 60 sqm)		2025 (Prepare TOD Vision and Corridor Plan' and TOD Zone Plans [TZPs] for metro corridors 2A and 2B) 2035 (Prepare and adopt TZP for all transit stations)
	UPGB D-1.3	Implement strategic public-sector led TOD schemes and catalytic projects in a time-bound manner (based on TOD phasing strategy and plans).							2030; 2035; 2040 (target years to implement the projects)

UPGBD-2: *Develop climate-resilient and nature-integrated plans for the city and city-region through participatory planning practices.*									
Goal/Target: All spatial plans and DCRs to adopt climate action as a lens by 2030.									
	UPGBD-2.1	Revise the Karnataka Town and Country Planning Act (KTCPA) to mandate land suitability based carrying capacity assessment and vulnerability assessment including climate parameters, along with the preparation of spatial master plans for all statutory towns. In addition, a greenhouse gas inventory should be mandated for all Class 1 towns/cities. Provisions for Town Planning Schemes (and Local Area Plans, if included) within the KTCPA should mandate an	*The Karnataka Town and Country Planning (KTCP) Act, 1961	P: DTCP S: UDD, GoK	GoK	a. Updated, revised and approved KTCP ACT b. No. of master plans revised/prepared based on suggested reforms and approved c. No. of TPS/LAPs prepared based on the suggested reforms and approved d. No. of Class 1 towns/cities that have prepared a GHG inventory	a. Climate- and environment-conscious master plans and TPS preparation process is institutionalised	a. Mitigation and management of adverse social and environment impacts b. Improved natural infrastructure management and resource efficiency c. Reduction in climate hazards and vulnerability	2026

		assessment of infrastructure carrying capacities and augmentation potential, environmental and social impacts of development proposals, along with appropriate management plans.							
	UPGB D-2.2	Revision of the BMRDA Structure Plan (RSP 2031) should align with the regional imperatives of CAP.	Revised Structure Plan 2031 (RSP 2031) for Bengaluru Metropolitan Region, prepared under provisions of the BMRDA Act, 1985	P: BMRDA S: DTCP	BMRDA's own funds	a. Revised BMRDA Structure Plan (with CAP imperatives)	a. Climate- and environment-conscious regional planning in BMRDA area		2031
	UPGB D-2.3	Create institutional mechanisms to address new forms of governance for managing regional growth and resource sheds.		P: GoK S: BMRDA, MPC	GoK				2028

	UPGB D-2.4	The city's master plan revision should integrate economic development strategies for growth areas/corridors in the metropolitan area. Land use planning must protect natural infrastructure and demarcate ecologically sensitive areas.	*RMP 2041 under preparation	P: BDA S: BMRDA, MPC, DTCP	BDA's own funds	a. Revised and approved master plan b. Clearly demarcated ecologically sensitive areas in the city	a. Climate- and environment-conscious planned urban growth b. Sustainable economic development of the city c. Decrease in encroachment of environmentally sensitive areas	a. Reduction in GHG emissions b. Increased resource efficiency c. Reduction in climate hazards and vulnerability	2025
	UPGB D-2.5	Embed CAP imperatives into RMP urban design guidelines and ZRs.	*RMP 2041 under preparation	P: BDA S: DTCP	BDA's own funds	a. Revised master plan's urban design guidelines and ZRs embedded with CAP imperatives			2025
	UPGB D-2.6	All plan preparation, particularly at the local area/ward level, should ensure participation from the informal sector, and vulnerable and marginalised communities.	*RMP 2041 under preparation * Approved Bengaluru TOD Policy and Pilot TZPs preparation	P: BDA, BBMP S: All development, regulating, and sectoral/line agencies concerned	Own funds of all agencies concerned	a. No. of public discussions and citizens' consultations held b. No. of discussions/consultations specifically including informal sector workers, and vulnerable and marginalised groups' representatives	a. Better understanding of ground-level issues, challenges and opportunities b. Bottom-up participatory planning processes are institutionalised	a. Amplified public voice in plan-making, better acceptability and ownership of plans amongst citizens b. Improved transparency, accountability, and trust	(As per the timelines of the plans)

	UPGB D-2.7	Create an integrated spatial database for the city, which is periodically updated, and make it publicly accessible through a dashboard.	* RMP 2041 under preparation * Pilot project for TOD and MMI planning along Metro Phases 2A-2B corridor * BBMP's location-based dashboard, ward level information	P: KSRSAC S: All development, regulating, and sectoral/line agencies concerned	GoK	a. Integrated spatial database is prepared, regularly updated, and dashboard is accessible to public	a. Better visualisation of existing status and issues at different scales b. Informed decision-making by public and private stakeholders c. Improved co-ordination in planning and implementation amongst stakeholder agencies d. Efficient monitoring and evaluation	a. Improved transparency, accountability, and trust	2025
	UPGB D-2.8	Ensure stringent enforcement of all plans, revised to accommodate CAP imperatives. Strengthen review and monitoring systems for all schemes/projects (at approval and implementation stages), through the integrated spatial database		P: BDA, BBMP S: Department of Personnel and Administrative Reforms (DPAR)	Own funds of all agencies concerned	a. Strict enforcement of revised master plan, structure plan, TZPs b. Reduction in the no. of building violations and non-adherence issues from approved schemes/projects c. Updated integrated spatial database	a. Environment- and climate-conscious planned urban growth b. Sustainable economic development of the city c. Decrease in encroachments of environmentally sensitive areas d. Efficient	a. Resource efficiency b. Increased economic growth c. Reduction in climate hazards d. Reduction in GHG emissions	2025-2050

		and e-governance measures.					project monitoring and evaluation, leading to efficient decision making e. Adoption of e-governance measures for review and monitoring f. Effective plan implementation/ enforcement		
UPGBD-3: *Adopt nature-based solutions(NBS) as an urban planning and design tool to improve resilience and liveability.*									
Goal/Target: Conserve and restore all blue-green networks in the city. All urban infrastructure schemes and projects should adhere to disaster resilience standards.									
Increase the city's tree cover (canopy) from the baseline by 10% by 2030 and 20% by 2040.									
Increase the city's green (vegetation) cover and permeable surfaces to 40% of the city's area by 2040, to tackle flood- and heat-related disaster risk reduction.									
Convert 75% of the city's footpaths to permeable surface material by 2050.									
	UPGBD-3.1	Create a **Blue-Green Policy** for BUD. It should incorporate strategies and guidelines for public streets and spaces, eco-mobility/recreation networks, sustainable urban drainage systems,		P: BMRDA S: Local Planning Area Authorities within BMR, Forest Department (BUD),	GoK, BMRDA's own funds	a. Blue-Green Policy for Bengaluru Urban District is prepared	a. Restoration and enhancement of blue-green networks, city streets and spaces. b. % of street network integrated with NBS c. No. of public spaces integrated	a. Reduction in total GHG emissions and air pollution b. Improved environmental and public health	2026

		and the built environment. Integrate NBS within long-term disaster risk management and prevention protocols.		BBMP, UDD			with NBS d. Reduction in the impacts of climate related hazards and vulnerability		
	UPGBD-3.1a	Spatial master plans or working plans of various local authorities/departments should incorporate Blue-Green Policy imperatives.	Aligned with action no. UPGBD-3.1	P: Local Planning Area Authorities within BMR, S: UDD, Forest Department (BUD), BBMP	Agencies' own funds	Spatial master plans and department working plans incorporate Blue-Green policy imperatives			2025-2030
	UPGBD-3.2	Complete the ongoing Tree Census exercise in the city by 2025 and update periodically.		P: BBMP S: Forest Department (BUD)	BBMP's own funds, NCAP grants	a. Comprehensive and updated Tree Census for Bengaluru is prepared	a. % change in number of trees/ tree cover (carbon sinks) b. % change in native species	a. Increased awareness on need for conservation and enhancement of tree cover b. Reduction in total GHG emissions c. Reduction in climate hazards and vulnerability	2025

	UPGBD-3.3	Map the city's blue-green cover, including natural drainage, water bodies, floodplains, trees outside forests (TOF), etc., to create a baseline and integrate into the city's spatial database to facilitate regular updating.	Aligned with action no. UPGBD-2.7 (Integrated Spatial Database)	P: KSRSAC S: BBMP, BDA, Forest Department (BUD), KLCDA, Revenue Department	Agency's own funds, GoK	a. Integrated spatial database with specific layers on various natural features and types of blue-green cover	a. Informed decision-making by public and private stakeholders b. Co-ordinated planning and implementation amongst stakeholder agencies c. Effective monitoring and evaluation d. No. of types of natural assets conserved and restored	a. Increased awareness on need for conservation of natural infrastructure. b. Improved transparency, participation, accountability and trust c. Reduction in total GHG emissions d. Reduction in climate hazards and vulnerability	2025

	UPGB D-3.4	Adopt changes to DCRs/Building Bye-laws to incorporate NBS and hybrid infrastructure to increase permeable areas (for instance, reserved area for parks/open spaces), and incentivise them.	* Aligned with action no. UPGBD-2.5 * RMP 2041 under preparation * BBMP Building Bye-laws 2003	P: BDA, BBMP S: All development, regulating, and sectoral/line agencies concerned	Agencies' own funds	a. Revised DCRs and Building Bye-laws incorporating NBS	a. Volume of water retention capacity created (cu. m.) b. % increase in permeable surface area and recharge potential c. Volume of collected rainwater available (cu. m.) d. Decrease in % of heavy rainfall events leading to flooding e. % of vulnerable areas covered by NBS f. Temperature difference/ reduction between permeable and non-permeable areas g. % change/increase in public open spaces	a. Reduction in total GHG emissions b. Reduction in air pollution c. Reduction in climate hazards and vulnerability, especially in low-income neighbourhoods	2025
	UPGB D-3.5	Prepare and adopt public works (engineering) standards and SOPs to incorporate NBS and hybrid infrastructure requirements, including for low-income neighbourhoods.		P: BBMP S: PWD, BDA	Agencies' own funds, GoK, NCAP grants, PPP	a. Public works/engineering standards and SOPs incorporating NBS			2025

	UPGB D-3.6	Undertake conversion of footpaths and on-street parking spaces to permeable surface material.	*Aligned with action no. UPGBD-3.5; *TenderSUR E road standards	P: BBMP S: PWD, BDA	Agencies ’ own funds, GoK, PPP	a. % footpaths (km) and on-street parking spaces (sq. m.) converted to permeable surfaces.			2024 to 2040
	UPGB D-3.7	Prepare and adopt a **greening guideline** for the city with a list of suggested species, based on context and planting area. Compensatory greening initiatives should also refer to this.		P: BBMP, S: KBB, Forest Departmen t (BUD)	Agencies ’ own funds, GoK, NCAP grants, PPP	a. 'Greening Guidelines approved	a. % increase in green cover, tree cover b. % increase in plantation area with native species, and reduction in non-native c. % increase in number of native trees, captured through the Tree Census d. % target achieved for urban greening sector		2025
	UPGB D-3.8	Identify neighbourhoods, streets, public/semi-public and private spaces to take up suitable NBS initiatives, through a participatory	*Aligned with action No. UPGBD-2.7 (integrated spatial database) *CCRA-VA Analysis	P: BBMP, S: BDA, KSRSAC, Forest Departmen t (BUD)	Agencies ’ own funds, NCAP grants, funds under greening schemes	a. Total area identified for NBS initiatives b. No. of stakeholder consultations conducted to identify spaces for NBS initiatives	a. % increase in green cover b. % increase in tree (canopy) cover (in sqm.) c. % increase in blue cover d. % increase in permeable		2024-2030

		process. This can be informed by the CCRA (including VA) to ensure targeted action in high-risk locations. Demarcate identified areas in the city's spatial database and track ongoing initiatives.			(GUA, AOA, RSP schemes), PPP and other innovati ve mechani sms.	c. Periodic updating of city's integrated spatial database with identified areas for NBS initiatives	surfaces e. % of population within 15 minutes from green cover (disaggregated)		
	UPGB D-3.9	Define implementation and funding mechanisms for these NBS initiatives, for e.g., PPP, link to compensatory greening, etc. Identify government funding sources (budget allocations) and other innovative financing such as green bonds and CSR.	*Aligned with action No. UPGBD-3.8 (NBS activities)	P: BBMP, S: BDA, EMPRI, GoK, Forest Departmen t (BUD)	Agencies ’ own funds, NCAP grants, funds under greening schemes (GUA, AOA, RSP schemes), PPP and other innovati ve mechani sms.	a. Implementation and financing strategy and mechanisms are defined b. No. of existing and new/innovative funding sources identified for NBS initiatives c. Total funds available for NBS initiatives			2025

	UPGB D-3.10	Design an **urban employment scheme** with a three-pronged objective of economic development, ecological/biodiversity protection, and employment generation. This can include cleaning and maintenance of water bodies and drains, tending urban greens, urban agriculture, environmental mapping and monitoring, etc)	Deendayal Antyodaya Yojana-National Urban Livelihoods Mission (DAY-NULM); Self-employment Scheme of KMDC; proposed National Urban Employment Guarantee Scheme	P: GoK S: BBMP, Forest Department (BUD), UDD	GoK, Agencies' own funds	a. Urban Employment Scheme is prepared and approved b. No. of green jobs created c. No. of people employed for green jobs through this scheme	a. % increase in incomes from green jobs b. Improved quantity and quality of blue-green infrastructure	a. Increase in employment/livelihood opportunities b. Improved biodiversity and other ecosystem services c. Reduction in climate hazards and vulnerability	2026
	UPGB D-3.11	Promote participatory processes for planning and implementing NBS in the city. Take up IEC campaigns to elicit local participation.	*Aligned with action No. UPGBD-3.8 (NBS activities)	P: BBMP. S: EMPRI, Forest Department (BUD)	Agencies' own funds, NCAP grants	a. IEC materials/toolkits prepared b. No. of IEC sessions/activities conducted	a. % increase in green cover b. % increase in tree (canopy) cover (in sq. m) c. % increase in blue cover d. % increase in permeable surfaces	a. Reduction in total GHG emissions b. Reduction in air pollution c. Reduction in climate hazards and vulnerability	2025 onwards
	UPGB D-3.12	Conduct capacity-building activities for:	*Aligned with action No. UPGBD-	P: BBMP,	Agencies' own funds,	a. No. of capacity-building workshops conducted	a. Increase in budget allocation for NBS initiatives		2025 onwards

		(a) Actors involved in NBS initiatives, to promote scientific approach towards implementation and maintenance (b) Sensitise and empower officials to case-build for adequate budget from diverse sources for NBS initiatives	3.8 (NBS activities)	S: EMPRI, Forest Department (BUD)	NCAP grants	b. No. of people (including officials) trained	b. Increase in number of NBS initiatives approved and implemented c. % increase in permeable surfaces, tree canopy, green and blue cover		
UPGBD-*4:* *Conserve, restore, and manage the city's biodiversity.*									
Goal/Target: Operationalise the (recently re-constituted) BMC by 2023 and prepare the People's Biodiversity Register by 2025.									
	UPGBD-4.1	As per the Biological Diversity Act, 2002 and Karnataka Biological Diversity Rules 2005: 1) Ensure functionality of the Biodiversity Management Committee (BMC) within the BBMP by providing them a conducive ecosystem (funds/functionaries). 2) Prepare the	Biological Diversity Act, 2002 and Karnataka Biological Diversity Rules 2005	P: BBMP - BMC (for preparation of PBR and setting up of fund) S: Forest Department (BUD), KBB - technical support and guidance for preparation of PBR	Agencies' own funds; institutional grants; CSR; GoK	a. Rules and SOPs for BMC established b. No. of stakeholder/citizen engagement sessions conducted c. PBR prepared, shared publicly, and periodically updated d. Biodiversity Fund set up for the city/district	a. Improved local biodiversity (species) and other ecosystem services b. Active involvement of citizens	a. Increased adaptive capacity and resilience in the face of climate hazards	2024 (1); 2026 (2 and 3)

		People's Biodiversity Register (PBR) through a multi-stakeholder participatory process at the zone level (8 BBMP Zones) and update it periodically. 3) Set up a Local Biodiversity Fund.							
	UPGBD-4.2	Develop a Local Biodiversity Strategy and Action Plan (LBSAP). Apart from ecological, cultural, recreational, and aesthetic aspects, it should consider biodiversity from a livelihood lens.	Biological Diversity Act, 2002, and Karnataka Biological Diversity Rules 2005	P: BBMP - BMC S: Forest Department (BUD), KBB- technical support	Agencies' own funds; institutional grants; CSR; GoK	a. Strategic Action Plan for conserving, restoring, and managing city's biodiversity prepared			2025

	UPGB D-4.3	Prepare a City Biodiversity Index and make it publicly available. As part of the index, spatially map biodiversity hotspots and habitat degradation. Develop a mobile application and QR code-based toolkit for interactive biodiversity conservation and management.	Biological Diversity Act, 2002, and Karnataka Biological Diversity Rules 2005	P: BBMP - BMC S: Forest Department (BUD), KBB - technical support	Agencies' own funds; institutional grants; CSR; GoK	a. City Biodiversity Index prepared, shared publicly, and periodically updated			2026
UPGBD-5: *Improve access to essential services and infrastructure, including safe and affordable housing for all.*									
Goal/Target: By 2050, provide safe and affordable housing for 100% urban poor and vulnerable groups in locations having access to public transport stops/stations within a 5-minute walk.									
By 2050, increase the city's publicly accessible per capita open space from the existing 2.2 sq. m to 6 sq. m.									
	UPGB D-5.1	Identify and demarcate safe and accessible affordable housing locations (land use zones and public land parcels) for the urban poor (EWS-LIG) in the city's master plan.	*RMP 2041 under preparation *CCRA-VA Analysis	P: BDA, S: BBMP, KSDB, KHB, KSRSAC	Agencies' own funds	a. RMP 2041 demarcates safe and accessible locations for affordable housing	a. Increase in adaptive capacity and resilience of urban poor households towards climate hazards and vulnerabilities. b. Improved quality of life	a. Resource efficiency b. Reduction in economic costs due to hazard/disaster-related loss of life and damage to property, particularly for	2025

	UPGBD-5.2	Based on the CCRA-VA, identify and prioritise slums and other low-income settlements for targeted action. Prepare a strategy for climate-proofing and improving resilience in these settlements, including appropriate retrofitting and upgrades (low-cost NBS), in situ redevelopment, disaster management and response facilities, etc. Illegal/unauthorised slum and squatter settlements in demarcated no-development buffer zones and high-risk locations should be rehabilitated in safe and accessible affordable housing	* Aligned with Action Track 3 of UPGBD (Action no. UPGBD-3.4, 3.5 and 3.8) * CCRA-VA analysis	P: BBMP S: KSDB, KHB, BDA, KSNDMC, KSRSAC	Agencies' own funds, GoK - various urban housing schemes	a. Slums, low-income settlements in hazard-vulnerable locations identified and notified for improvement schemes b. Climate-proofing strategies for hazard-resilient, affordable housing for the urban poor defined.	conditions for urban poor households	urban poor households and government agencies	2025

		locations (identified above).							
	UPGB D-5.3	Remove illegal/unauthorised developments in demarcated no-development zones (ecologically sensitive areas, buffers and other high-risk locations).	Connected to demarcation of ecologically-sensitive/ buffer areas and stringent enforcement points above, and 5.2 (Identification of high-risk locations)	P: BBMP, BDA S: Police Department	Agencies' own funds	a. Reclamation of illegally encroached areas	a. % increase in ecologically sensitive/buffer areas conserved and restored b. % decrease in population adversely affected due to climate hazards	a. Increase in green and blue cover b. Reduction in climate hazards and vulnerabilities c. Reduction in total GHG emissions	2035
	UPGB D-5.4	Ensure access to mass transit stations, public open spaces, daily needs markets, primary education, and healthcare	* RMP 2041 under preparation * Approved Bengaluru TOD Policy * Disaster	P: BDA S: BBMP, BMRDA	Agencies' own funds	a. Spatial plans include enabling proposals and regulations to improve access to basic infrastructure for all - based on a	a. % of population having access to amenities/services within a 15-minute walking distance b. Reduction in	a. Reduction in GHG emissions and air pollution b. Increase in resilience and adaptive capacity in the face of	2025-2040

		facilities within a 15-minute walking distance for 100% of the population. Promote this through spatial plans and DCRs.	Resilience Actions			mapping and assessment of current accessibility levels.	number of trips, trip distances and vehicle km travelled	climate hazards and vulnerability	
	UPGB D-5.5	Mandate adoption of universal accessibility standards in urban design (public streets, spaces) guidelines and development regulations.	* TenderSURE guidelines * DULT's policies and guidelines for TOD, NMT, pedestrian infrastructure, road safety, Draft Active Mobility Bill, etc.	P: BBMP, DULT S: BDA, PWD	Agencies' own funds	a. Design guidelines and development regulations mandate adherence to universal accessibility standards	a. % of public streets and spaces, public transport facilities and buildings that are universally accessible b. Services, infrastructure, and amenities accessible to all irrespective of age/ability/gender	a. Inclusive development b. Improved liveability c. Increase in resilience and adaptive capacity towards climate hazards and vulnerability	2026
	UPGB D-5.6	Recognise urban ecosystems (water-bodies, green spaces, etc.) as **'urban commons'** and allow local communities to access them for their livelihoods and subsistence, apart from	*Aligned with action No. UPGBD-3.1 (Blue-Green Policy)	P: BBMP S: KLCDA, BDA, Forest Department, GoK	Agencies' own funds	a. Guidelines for inclusive design and access to urban commons and ecosystem services defined within the Blue-Green Policy b. No. of IEC sessions conducted to spread awareness	a. Improved access to public open spaces and commons b. % increase in per capita public open space c. % of population within 15 minutes' walking distance from public open spaces		2025

		recreation/leisure and educational purposes.					(disaggregated by income level)		
	UPGB D-5.7	Map, plan, and provide public open spaces based on the demand and availability gap analysis for equitable distribution of open spaces.	*RMP 2041 under preparation * Approved TOD Policy	P: BDA, BBMP S: Forest Department, public/semi-public institutions	Agencies' own funds, PPP	a. Mapping of public open spaces and civic amenity sites integrated into the spatial database and periodically updated b. Appropriate proposals and regulations for creation and equitable distribution of public open spaces incorporated into spatial statutory plans.			2025-2040

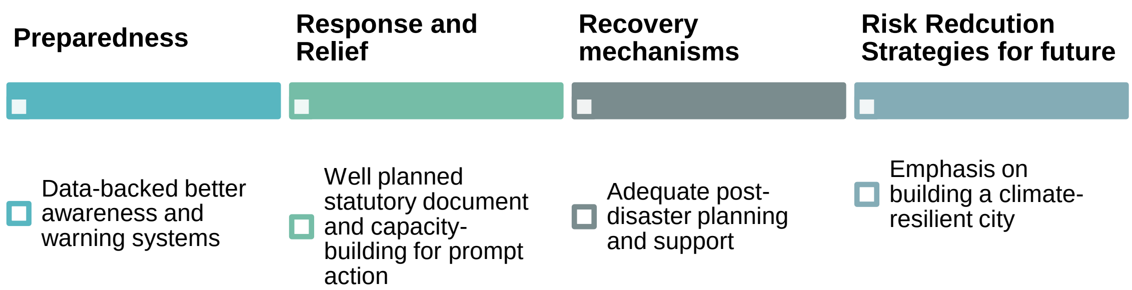
5.3.7 Disaster management

Approach

Climate change is a global phenomenon, and its impacts are being seen across the world at multiple levels. The city of Bengaluru is no different, and a detailed report on the climate and environmental hazards the city could potentially be subject to has been elaborated in a separate document, i.e., the Climate Change Risk and Vulnerability Assessment. Recent trends in the city suggest an increase in occurrences of hazards both in terms of intensity and frequency. This is exacerbated by Bengaluru's ever-increasing population as more and more people migrate to the city for better opportunities and a higher standard of living.

The primary approach towards identifying action tracks and actions for the sector is a four-pronged approach (refer Figure 68), i.e., robust data-backed statutory preparedness, a comprehensive planning document along with prompt rescue and relief operations, followed by faster recovery after a disaster, and building a climate resilient city by disaster risk reduction as per the Sendai Framework for Disaster Risk Reduction. The action tracks and actions have been listed in the table below, keeping the above-mentioned factors as the primary premise.

Figure 68: Approach for disaster risk reduction



Sectoral action tracks

No.	Action track
DM- 1	Create a comprehensive spatio-temporal database pertaining to climate hazards, impacts, and vulnerabilities.
DM-2	Create a robust policy framework for disaster management including policies for addressing loss and damage from climate and environmental hazards.
DM-3	Empower citizens, civil society, and local platforms to adopt a decentralised and inclusive approach towards DRR.
DM-4	Enhance ecosystem capacity to reduce disaster risk through faster and better response.

Track-wise actions

Priority	S.No	Actions	Aligned with (ongoing initiatives/other actions)	Responsible Agency Primary (P) Secondary (S)	Potential Source of funding	Output	Outcome	Co-benefit	Timeline *(Targeted year of completion of action)*
DM- *1:* *Create a comprehensive spatio-temporal database pertaining to climate hazards, impacts, and vulnerabilities.*									
Goal/Target: A comprehensive and regularly updated data repository for the city.									
	DM - 1.1.	Assess available datasets pertaining to climate and environmental hazards, identify gaps, and create a list of the complete repository of datasets needed for a comprehensive city-level database.	a. Forecasting and early warning systems as per National Disaster Management Policy. b. KSNDMC and KSRSACs data-driven exercises towards comprehensive state-level data availability	P: BBMP S: BUD, KSNDMC, and KSRSAC	Included in the budget of National Data Governance Policy State Budget for Bengaluru city BBMP budget	Creation of a data repository along with spatial maps of disaster occurrence	Better preparedness for future disasters	Reduction in loss and damage during disasters	2024

DM - 1.2	Prepare a comprehensive city-level database that is regularly updated and that comes under the purview of a unified body. It should include: - Climate datasets including temperature, precipitation, humidity, windspeed, etc. - Data-sets on hazard occurrence history and its impact, including loss and damage of lives, livelihoods, and economy - Systemic evaluation and recording of the social, health, environmental, and economic impacts of the disaster - Datasets on demographics and the socio-economic scenario, migrant population, gig workers, etc. - Encourage the use of technology to crowdsource data on disasters	a. KSNDMCs current data-driven exercise on climate-related datasets as per the Karnataka State Disaster Management Plan 2020-21 b. Other datasets to be included as needed in the city-level action plan	P: BBMP S: BUD, KSNDMC, and KSRSAC	Included in the budget under the National Data Governance Policy State budget for Bengaluru city BBMP budget	Creation of a data repository, along with spatial maps of disaster occurrence	Better preparedness for future disasters	Reduction in loss and damage during disasters	2025
DM - 1.3	Conduct yearly detailed assessments of loss and damage from all types of disasters occurring in the city. This should include datasets on: - Loss of lives/fatalities due to disasters - Injuries/health impacts that can be attributed to disasters - Economic loss due to disasters.	a. Aligned with different sector action tracks, including energy, transport, water and wastewater, solid waste management,	P: BBMP S: BUD, KSNDMC, KSDMA, and other sector-specific department, including the Health	Included in the budget of National Data Governance Policy State Budget for Bengaluru city	Creation of a data repository of loss and damage occurrence due to disasters	Better preparedness for future disasters	Reduction in loss and damage during disasters	2025

		This should also include loss of livelihoods of vulnerable communities and migrant workers - Loss of assets and infrastructure including electric poles, water, water lines, etc., as well as individual loss of property, due to disasters - Tree fall and loss of other green cover	urban planning, greening, and biodiversity.	Departmen t	BBMP budget				
	DM - 1.4	Spatial mapping of access to basic services within the city: Spatial mapping of natural network and, networked infrastructure such as the capacities of storm water drains in the city. This could be a data-based approach taking into account past rainfall trends, vulnerable locations, natural topography, etc.		P: BBMP S: BUD, KSNDMC, and KSRSAC	Included in the budget of National Data Governance Policy State budget for Bengaluru city BBMP budget	Creation of a data repository along with spatial maps of disaster occurrence	Better preparednes s for future disasters	Reduction in loss and damage during disasters	2025

	DM - 1.5	Regular update of the CCRA-VA document once in two years, including: - Spatio-temporal mapping of existing disasters, along with projections for the near future, on a regular basis, especially when there is an expected rise in occurrences of a particular disaster - Spatial mapping of specific vulnerable communities will give a glimpse of those that are more vulnerable than others. - Spatial mapping of locations of informal settlements, migrant workers, gig workers, etc.		P: BBMP S: BUD, KSNDMC and KSRSAC	Included in the budget of National Data Governance Policy State budget for Bengaluru city BBMP budget	Regularly updated ~~CCRAVA~~CCRA-VA document	Better preparedness for future disasters	Loss and damage reduction	2025
	DM - 1.6	Create a citizen-faced disaster dissemination information system with a multi-pronged approach. In addition to available systems, this could be achieved by exploring the use of existing PIS systems and other outreach mediums in a more efficient manner to enhance the reach of the information itself.	a. Existing mobile application called Megha Sandesha, which gives real-time local weather conditions, including the possible occurrence of disasters b. Call centre called Varuna	P: BBMP S: BUD, KSNDMC, and KSDMA	Included in the budget of National Data Governance Policy State budget for Bengaluru city BBMP budget	An effective, inclusive, and equitable disaster dissemination system	Greater awareness about disasters and their occurrence, across all social groups	Loss and damage reduction	2025

			Mitra, which also gives this information c. Other PIS systems of other agencies						
DM- *2:* *Create a robust policy framework for Disaster Management including policies for addressing loss and damage from climate and environmental hazards.*									
Goal/Target: A comprehensive disaster management plan.									
	DM - 2.1	Frame a robust city-level policy framework in the form of a Disaster Management Plan to strengthen disaster risk governance for prevention, mitigation, preparedness, response, recovery, and rehabilitation. The plan should incorporate the key findings from CCRA-VA with regular updates, with every new iteration of the CCRA-VA document.	a. National Disaster Management Act b. Karnataka State Disaster Management Plan	P: BBMP S: BUD, KSNDMC, and KSDMA	BBMP budget	A robust planning system in place during disasters for better preparedness, and prompt action at all levels	Enhancement of the city's planning systems for prompt action	Reduction in loss and damage during disasters	2024

	DM - 2.2	Develop a Disaster Risk Reduction Plan that would enhance the city's long-term resilience using the principles of the Sendai framework. This is in addition to the Disaster Management Plan that the city would have. This should ideally include the following: -Frame a multi-hazard-level plan for the city, incorporating findings from the CCRA-VA document -Establish a mechanism for a well-coordinated system across line departments at the ward/zonal level for disaster preparedness and disaster response -Conduct a detailed assessment of the impact on mobility of various groups of people during disasters, and impact on access to services and opportunities. Sector plans for infrastructure and mobility to be informed by this plan (see 2.3) -Develop and strengthen a mechanism to protect livelihoods and assets of individuals, especially of those from lower socio-economic strata and low-income groups.	a. Karnataka State Disaster Management Plan	P: BBMP S: BUD, KSNDMC and KSDMA	BBMP budget Infrastructure for disaster management	A city-level planning system to enhance the resilience of people, infrastructure and the economy	Enhanced the city's resilience to disasters	Reduction in loss and damage during disasters	2025

		-Partner with local organisations and citizen-level initiatives to build individual and community resilience capacities -Streamline the mechanism for post-disaster recovery activities including faster disbursement of funds.							

	DM - 2.3	Incorporate Disaster Risk Reduction Planning in the planning, operation, and management of various sectors such as energy; water supply; wastewater management; transport; solid waste; and urban planning, greening and biodiversity.	Aligned with different sector action tracks, including energy; transport; water and wastewater; solid waste management; and urban planning, greening, and biodiversity	P: BBMP S: Sector specific departments such as BESCOM, BWSSB, Transport, SWM, Urban Planning, Forestry, and Horticulture	Infrastructure for disaster management	Enhanced resilience of basic services against disasters	Improved chances of uninterrupted access to services during disasters	Better access to services	2026
	DM - 2.4	Ensure compliance with norms pertaining to land use, resource management, and health and safety, to enhance disaster resilience. Strengthen the sustainable use and management of natural resources and blue-green networks in the city to enhance resilience.	Aligned with multiple actions in the Urban Planning, Greening and biodiversity sector, such as UPGBD-1.1, 3.1, 3.3, 3.8, 5.5, 5.6	P: BBMP S: BDA, BMRDA, LDA	Infrastructure for disaster management	A proactive governing structure that regularly monitors and evaluates the city's land use patterns in accordance with the Town and Country Planning Act	Enhanced resilience of the city's infrastructure	Better planned city leading to better livability and economic efficiency	2026

	DM - 2.5	Encourage disaster-resilient design and construction techniques, especially for critical facilities such as hospitals, fire stations, and schools, informed by the critical disasters identified for Bengaluru as per CCRA-VA, to ensure that they remain safe, effective and operational during and after disasters.	a. Developing a Disaster Resilience Responsibility Framework, and Preparedness and Response, under the Karnataka State Disaster Management Plan, 2020-21 b. Karnataka State Action Plan for Climate Change and Human Health	P: BBMP	Health sector disaster preparedness and response, and human resource development for emergency medical services	Resilient infrastructure of emergency services	Better access to emergency services	Enhanced resilience of the city's infrastructure	2026
	DM - 2.6	Mainstreaming disaster risk reduction into the city's master plan	Aligned with action no. UPGBD-2.5	P: BDA	RMP 2035	A robust infrastructure system at the planning stage, ensuring better preparedness	Enhanced Resilience of the city	Reduction in loss and damage during disasters	2031

	DM - 2.7	Conduct an assessment of the impact of climate hazards on public health and the preparedness of the city's health care systems, to manage the same for all segments of the population	a. Enhance the resilience of State health systems by integrating DRM into primary, secondary and tertiary health care, as per Karnataka State Disaster Management Plan, 2020-21 b. Karnataka State Action Plan for Climate Change and Human Health	P: BBMP S: Department of Health	Health sector disaster preparedness and response, and human resource development for emergency medical services	Comprehensive understanding of the interlinkage between disasters and health	Well-developed health infrastructure that incorporates disaster-related health risks into its work	Reduction in severe health-related risks due to disasters	2025
	DM - 2.8	Mandate integration of disaster risk management into business models of organisations across the supply chain, to increase business resilience and protection of livelihoods and productive assets throughout the supply chain within the city, across sectors and communities, so as to ensure continuity of services.	a. Karnataka State Disaster Management Plan, 2020-21	P: BBMP S: Government and non-government stakeholders	PPP models	Planned businesses that are prepared to handle disruptions due to disasters	Reduction in economic loss during disasters	a. Better resilience during disasters b. Faster recovery from disasters	2026

	DM - 2.9	Encourage private sector participation to promote innovations for solution-driven research technology advancement in disaster risk reduction. PPP models can be adopted to establish, disseminate, and share good practices.	a. Karnataka State Disaster Management Plan, 2020-21 b. Climate-resilient and disaster-safe development	P: BBMP S: Government and non-government research institutes, start-ups, etc.	PPP models	Technological advancement and innovations leading to better management of disasters	Loss and damage reduction	Increased economic efficiency	2027
	DM - 2.10	Create enablers for insurance and other financial protection mechanisms, to reduce the burden of disaster-related financial losses on governments, communities, and individuals.	a. Karnataka State Disaster Management Plan, 2020-21 b. Manual on administration of State and National Disaster Response Fund	P: BBMP S: Department of Finance	PPP models	An elaborate financial protection mechanism for disasters	Reduction in economic losses during disasters	a. Better resilience during disasters b. Faster recovery from disasters	2026
DM- 3: *Empower citizens, civil society and local platforms to adopt a decentralised and inclusive approach towards DRR.*									
Goal/Target: Empowered ward committees for better localised preparedness for, response to, and recovery from disasters.									

	DM - 3.1	Set up zone- or ward-level Disaster Management Cells empowered with regulatory and financial means, to work and coordinate with civil society, communities, and other locals in the region, for disaster risk management at the local level. This should include: - Plan of action to improve and strengthen the capacity at the local level - Identification of localised shelters/safe zones that can be accessed by all - Evacuation of persons living in disaster-prone areas when essential - Prompt action to meet locals' needs when they lack access to services.	a. Karnataka State Disaster Management Plan 2020-21	P: BBMP S: Sector-specific departments such as BESCOM, BWSSB, Transport, SWM, Urban Planning, Forestry, and Horticulture	BBMP budget	A local responsible agency will be created for ease of access by local residents	A decentralised approach will be initiated, making wards self-reliant to a great degree	Enhance inclusivity through greater local involvement	2025
	DM - 3.2	Equip local wards with regular and updated information systems to deal with disasters within their ward boundaries.	Karnataka State Disaster Management Plan 2020-21	P: BBMP	BBMP budget	A local responsible agency will be created for ease of access by local residents	A decentralised approach will be initiated, making wards self-reliant to a great degree	Enhance inclusivity through greater local involvement	2025

	DM - 3.3	Establish a local-level disaster help and redressal system by setting up community centres that could be a one-point contact for creating public awareness, having the necessary materials to implement rescue and relief activities and to implement relief measures or compensations that the government proposes.	Karnataka State Disaster Management Plan, 2020-21	P: BBMP	BBMP budget	Easy access to local resources, instead of going through a centralised system	Better access to information	Equitable access to a local redressal system	2025
	DM - 3.4	Partner with local SHGs, citizen action groups, NGOs, etc., to disseminate information and awareness on disaster preparedness, response, and recovery mechanisms.	Karnataka State Disaster Management Plan, 2020-21	P: BBMP S: Local citizen action groups, NGOs, SHGs etc	BBMP budget	A well networked governance system with local groups	Better access to information and faster response and recovery	Enhance inclusivity and equitable access through a decentralised system	2026
DM- *4:* *Enhance ecosystem capacity to reduce disaster risk through better response.*									
Goal/Target: Reduction in loss of life, livelihoods, and assets due to climate and environmental hazards.									
	DM - 4.1	Conduct regular capacity-building workshops and training for personnel across agencies responsible for disaster response and strengthen their logistical capacities to better respond to disasters.	a. Karnataka State Disaster Management Plan, 2020-21 b. DC Handbook on Climate Resilience	P: BBMP S: KSDMA	BBMP budget	Greater awareness amongst locals on better management of disasters	Better preparednes s by residents to deal with disasters	Overall increase in local confidence in the ability to manage efficiently and inclusively during disasters	2024

	DM - 4.2	Conduct regular sensitisation workshops in ward committees and relevant stakeholders at ward levels on disaster management.	Karnataka State Disaster Management Plan, 2020-21	P: BBMP S: KSDMA	BBMP budget	Greater awareness amongst locals on better management of disasters	Better preparednes s by residents during disasters	Overall increase in local confidence in the ability to manage efficiently and inclusively during disasters	2024
	DM - 4.3	Create a localised knowledge repository on disasters through expediential sharing across different stakeholders.	Karnataka State Disaster Management Plan, 2020-21	P: BBMP S: KSNDMC, KSDMA and other stakeholder s such as research institutes, and local citizens' groups	BBMP budget	A detailed and inclusive knowledge repository system for sharing	Means and mechanism for knowledge-sharing, creating a comprehensi ve knowledge base at the ward level	Greater awareness and understanding of local concerns	2025

5.4 Fostering inclusivity in climate action

Inclusivity is vital for the success of a climate action plan, as it creates an environment that values diversity, promotes equal access, and embraces diverse contributions. By including the perspectives and interests of diverse stakeholder groups, climate action plan can be more effective, equitable, and sustainable. Inclusivity enables diverse stakeholders to participate, leading to increased engagement, resilience, adaptation, collaboration, and innovation. To foster inclusivity, the city will engage diverse stakeholders, ensure accessible communication, address participation barriers, build capacity, prioritise inclusivity, support community-led initiatives, collaborate with partners, and evaluate strategies regularly.

Guidance from the inclusive community engagement playbook developed by C40 cities

Inclusive community engagement plays a crucial role in the development and success of climate action plans. This playbook highlights the implementation of a comprehensive community engagement that can help a city foster inclusivity and effectively address climate change challenges. Key engagement approaches of the playbook:

- Importance of citizen involvement: Emphasise engaging citizens in climate initiatives for addressing societal inequality, gaining public support, minimising unintended consequences, and encouraging community-led action.
- Challenges and core principles: Address challenges in community engagement and highlight core principles such as ongoing process, transparency, and diversity and inclusivity.
- Vision setting: Set a clear agenda for engagement strategy development.
- Mapping and analysis: Identify priority stakeholders, understand their interests and influence, and devise effective communication strategies.
- Design and implementation: Utilise inclusive techniques and tools to engage key stakeholders, including hard-to-reach groups.
- Feedback and evaluation: Assess the effectiveness of engagement strategies, identify areas for improvement, and enhance future efforts.

By performing these engagement approaches, the city can achieve inclusivity, effective community involvement, improved public support, and equitable climate strategies.

Achieving inclusivity in and through the BCAP will be based on a comprehensive approach spanning the stages of planning, designing, and implementing climate actions. This entails a four-pronged approach that enables informed participation, diverse perspectives, equitable engagement, and prioritise social and environmental justice, resulting in sustainable and equitable outcomes.

- Awareness and access to information: Raise awareness and provide accessible information on climate change and action through campaigns, education, and digital platforms.
- Inclusive processes: Encourage meaningful participation of all stakeholders through workshops, consultations, and public meetings to incorporate diverse perspectives.

- Enhancing the capacity of ecosystems to embed inclusivity: Build the capacity of stakeholders through training and knowledge-sharing to effectively integrate inclusivity into climate action plans.
- Inclusive policies: Prioritise social and environmental justice, considering vulnerable communities' needs and preventing inequalities through policies such as financial support, equitable pricing, and inclusive job creation.

Monitoring and evaluation mechanisms will also be established throughout the implementation stage, to assess the effectiveness and inclusivity of climate actions (see Chapter 7). Regular assessments and feedback loops will help Bengaluru identify gaps or shortcomings and make necessary adjustments, to ensure that inclusivity remains at the forefront of the city's climate initiatives.

Adopt Information, Education, and Communication (IEC) initiatives

During the preparation of the BCAP, special attention was focused on ways to ensure effective information dissemination, through the Information, Education, and Communication (IEC) process. To educate the target audience on climate change concepts, mitigation strategies, and adaptation measures, a consultation toolkit consisting of videos, posters, an instruction manual, and a feedback form was created and distributed. Enhancing inclusivity, the toolkit included a bilingual video and feedback form to incorporate community concerns and perspectives in the climate action plan. The materials were easily accessible in both English and Kannada, maximising their reach. Access the toolkit here.

Additionally, each sector has placed emphasis on implementing relevant actions outlined in the BCAP to foster IEC. For instance, in Section 5.3.3, Action 2.1 highlights the significance of collaborating with NGOs to conduct IEC campaigns. These campaigns aim to influence social behaviour and to conduct surveys in order to promote decentralised composting and recycling in residential communities, markets, public and religious gatherings, parks, and gardens. Active citizen participation is encouraged to enhance resource recovery, minimise waste disposal, and ensure accountability for green initiatives. Likewise, every sector has integrated actions that prioritise raising awareness and facilitating access to information, thus promoting inclusivity during the design and planning stages of climate actions.

To ensure the inclusive and effective implementation of climate action, a user-friendly bilingual website will be created as the central hub of information and resources. This website will serve as a platform for disseminating information and raising awareness about climate action. Additionally, a digital Monitoring, Evaluation, and Reporting (MER) platform will be implemented to cater to all stakeholders. It will have a publicly accessible interface in the form of a dashboard to ensure wide dissemination of information and key performance indicators for the BCAP, with a specific focus on inclusivity parameters. Stakeholder departments can also play a crucial role in facilitating access to relevant information, resources, and technologies. This may involve providing information about available funding, grants, and support programmes, as well as connecting them with local organisations and networks that can assist in climate action efforts.

Establish inclusive processes

Ensuring inclusive climate actions requires engaging diverse stakeholders, including representatives from various communities, especially marginalised groups, in decision-making processes. This is achieved through public consultations, community meetings, and workshops, to gather inputs and feedback on climate action plans. During the preparation of the climate action plan, a range of stakeholder consultative sessions was implemented to ensure that the voices of all stakeholders, including departments, subject matter experts, Resident Welfare Associations (RWAs), non-governmental organisations (NGOs), and others were heard. These sessions incorporated bilingual feedback forms and a combination of virtual and in-person consultations to strengthen the relationship between the government and the community. Further details on the series of consultations can be found in Chapter 1.

Additionally, each sector has emphasised the implementation of relevant actions outlined in the BCAP to foster inclusive processes. For instance, in Section 5.3.6, Action 2.6 highlights the significance of this, by saying that all plan preparation, particularly at the local area/ward level, should ensure the participation of the informal sector, and of vulnerable and marginalised communities. Likewise, every sector has integrated actions that prioritise inclusive processes, thus promoting inclusivity during the design and planning stages of climate actions.

To ensure inclusive processes in climate action implementation, departments must conduct comprehensive assessments to understand the needs, challenges, and priorities of vulnerable communities. This entails gathering data about their living conditions, vulnerabilities to climate change impacts, and existing knowledge and practices related to climate action. Active engagement of these communities is crucial, fostering participatory processes that empower them to contribute to decision-making. This can be achieved through community meetings, focus group discussions, and workshops, which provide platforms for sharing diverse perspectives, ideas, and concerns. Incorporating these inputs into the climate action plan helps elevate diversity, equity, and inclusion in the overall process.

Enhance ecosystem capacity

To enhance the capacity of the ecosystem to embed inclusivity in the implementation of the BCAP, several measures are proposed. Firstly, an assessment of climate action planning and implementation capacity will be conducted in stakeholder departments, identifying gaps in knowledge, human resources, skills, and financial resources. This assessment will be carried out by the Climate Action Cell (CAC), with the assistance of a technically equipped institute. Sensitisation, training, and capacity-building programmes will be designed and implemented by the CAC, focusing on modules such as mitigation, adaptation, GHG inventory, climate change risk assessment, climate budget reporting, and inclusive climate action. Collaboration with government and private players will be sought for the successful implementation of these programmes.

Moreover, each sector within the BCAP recognises the importance of inclusive processes and has incorporated relevant actions. For example, Section 5.3.2, Action 2.11 highlights the training of women drivers and the inclusion of safety features like panic buttons and women-only compartments to improve safety and promote the use of public transport by women. Similar efforts have been integrated across sectors to ensure the embedding of inclusivity during the design and planning stages of climate actions.

To further foster inclusivity, partnerships and networks will be established with various government agencies, non-governmental organisations, community-based organisations, and other stakeholders involved in climate action and poverty alleviation. These collaborations will help create a supportive ecosystem and facilitate the involvement of urban poor migrants in the planning, implementation, and monitoring of climate action initiatives.

Design inclusive policies

Inclusive policies are crucial for achieving inclusive climate action, as they promote fairness, address inequalities, empower marginalised communities, maximise climate solutions, strengthen resilience, and enhance social cohesion. The BCAP recognises the significance of inclusivity in every sector and incorporates relevant actions. For instance, in Section 5.3.1, Action 2.10, the city aims to subsidise reversible ceiling fans for vulnerable and low-income groups, improving indoor air circulation and providing heating and cooling options. Similar actions are integrated across sectors to ensure inclusivity in climate actions from the early design and planning stages. The city can achieve inclusive policies by conducting assessments, engaging diverse stakeholders, and developing targeted initiatives, as highlighted in the action tracks of each sector. As stated in Section 5.3.5, Action 2.15, community participation, monitoring mechanisms, and continuous policy improvement should be prioritised. By focusing on improving policies towards inclusivity, the city can promote social equity, enhance climate action outcomes, and improve overall well-being. Inclusive policies address disparities, tap into diverse knowledge, and foster resilient and prosperous urban environments.

Photo Credit: Praseeda Mukundan/WRI India

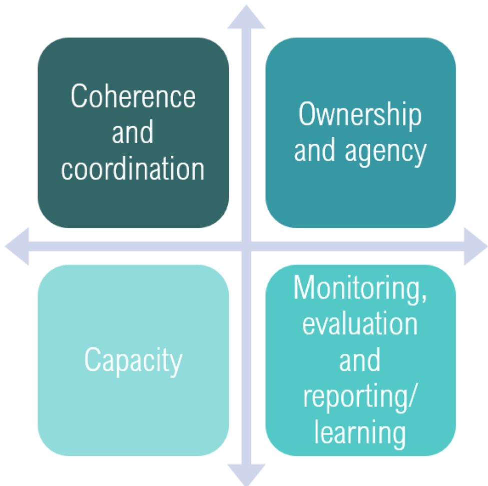
6 GOVERNANCE OF BCAP AND INSTITUTIONAL STRUCTURES

6.1 Aligning BCAP governance with existing institutional structures

From a sectoral perspective, the functioning of Bengaluru is managed and governed by various agencies over and above the key functions performed by BBMP. For the seven sectors identified under the BCAP for action orientation, a sector-wise mapping of institutional responsibilities was done (see *Annexure I*). Figure 29 in Chapter 2 presents a summary of relevant sector-wise departments/agencies and their key responsibilities across four thematic buckets, i.e., a) visioning strategising, planning, and governance, b) implementation and enforcement, c) monitoring, and d) others. This exercise helped identify suitable agencies against the various responsibilities for the governance of the BCAP.

The objective of the governance structures for the BCAP is to put in place institutional structures and mechanisms for: a) effective implementation of the CAP as a cross-sectoral agenda, b) foster ownership amongst a diverse set of stakeholders (both state and non-state), and c) mainstream climate action in city planning and governance. While the first objective is to enhance the success of the CAP in the short term, the latter two are complementary to each other in ensuring the sustainability of city climate action in the long term. The governance-related actions therefore emerge from the four tenets (illustrated in Figure 69) to foster implementability with a feedback loop, as summarised below.

Figure 69 Tenets of BCAP governance



1. **Ensure coherence across sector policies and plans, and seamless coordination amongst agencies**

The objective of the actions under this tenet is to ensure a policy and planning ecosystem that is coherent, with a shared vision to build climate action as a common aim, and to ensure regular coordination of activities spanning multiple sectors led by different agencies.

The recommended actions for ensuring coherence are summarised in Table 17 below:

Table 17 Actions recommended to ensure coherence

Action		Description	Responsible office
1.1	Constitute a high-level committee on climate action for Bengaluru.	Will include heads of key stakeholder departments, representatives of academia, NGOs and practitioners who will, from time to time, give direction for implementation/ periodic revision/ governance/ way forward of the BCAP.	GoK in consultation with BBMP
1.2	Create and operationalise a climate action cell (CAC).	Will be suitably organised to be responsible for day to day coordination activities, collation of data and information for MERL, support in project preparation and implementation and periodic updating of GHG inventory and CCRA-VA for Bengaluru. Refer to section 6.3 for further details.	BBMP in coordination with stakeholder departments
1.3	Mandate and start climate budget reporting	Departments to report spending on activities/projects taken up in/for Bengaluru which directly contribute to climate change mitigation and/or adaptation goals suggested in the BCAP. Refer to section 6.5 for further details.	GoK and individual departments. The proposed CAC will facilitate sensitisation and training of departments on climate budgeting.
1.4	Include climate change as a key aspect in all departmental mandates.	Departments will clearly identify and acknowledge their role in climate change mitigation and/or adaptation, include the same in their mandate, and publish it on their website.	GoK, individual departments relevant for Bengaluru
1.5	Designate/appoint a nodal officer in each department/agency for ensuring the inclusion of climate change agenda in policies/plans/ programmes/ projects.	The nodal officer will be the main point of contact for the CAC, will be responsible for coordinating with the cell for all activities pertaining to the implementation of the BCAP identified for that department, and share data and status updates.	Individual departments relevant for Bengaluru

2. Catalyse ownership and agency across stakeholder groups on city climate action agenda

The intent of the actions under this tenet is to foster a sense of ownership to commit to climate actions in both letter and spirit by stakeholder agencies, and to create an enabling ecosystem for participation by non-state actors in taking forward the climate action agenda in Bengaluru. The idea is to not only encourage institutional tools and platforms for making climate action as a local agenda, but also nudge radical partnerships across stakeholder groups.

Table 18 summarises the recommended actions for achieving the above.

Table 18 Actions recommended to catalyse ownership

Action	Description	Responsible office
2.1 Prepare local/ward-level plans with climate action as a mandatory component.	This resonates with the need for a micro-level planning tool, which is missing from present hierarchies of spatial plans governing the growth and development of Bengaluru.	Joint exercise with inputs from Ward Committees, community-based organizations, BBMP, CAC, BDA and with support from suitable technical organisations
2.2 Include climate action as an agenda in ward committee mandates.	Will be included as a part of the mandate for ward committees.	BBMP, GoK
2.3 Create a climate working group at zone-/ward-level.	These should include representatives from all citizen groups, especially vulnerable communities (poor, women, elderly), and NGOs to capture the impacts of climate change, discuss potential solutions, and monitor the implementation of projects.	BBMP zonal offices. The working groups can interact with the CAC periodically
2.4 Create a collaborative and shared platform for spatial data/analytics.	To visualise climate change risks and vulnerabilities at different scales, and to map loss and damage including crowd-sourced data.	Climate Action Cell
2.5 Create a forum for locally-led climate action in Bengaluru.	To build a consensus on the priorities of climate action in Bengaluru, empowered by dialogue and informed knowledge.	Non-state

3. Build adequate capacity amongst all actors for planning and implementing the BCAP

This is one of the most critical enablers for implementing the actions proposed under the BCAP and also ensuring their long-term sustainability. The recommended actions under this tenet are mentioned in Table 19.

Table 19 Actions recommended to build capacity for implementing the BCAP

Action	Description	Responsible office
1.1 Assess climate action planning and implementation capacity in stakeholder departments identified for BCAP.	To assess gaps in knowledge, human resource, skills and financial resources in all stakeholder departments and agencies, and identify areas for improvement.	CAC with support from an institute technically equipped to carry out such assessment
1.2 Design and conduct sensitisation, training, and capacity-building on climate action	With specific modules on mitigation, adaptation, GHG inventory, climate change risk assessment, climate budget reporting, inclusive climate action, amongst others.	CAC in partnership with government and private partners

1.3 Establish a knowledge dissemination platform on the BCAP.	An open access digital platform with toolkits and training modules on climate action in both English and Kannada (videos, posters, manuals, guidelines, best practices, other useful references).	Climate Action Cell in partnership with private sector
1.4 Create a pool of partner agencies.	Partner with academia and NGOs to conduct awareness campaign and sensitisation/training sessions on climate action for government agencies, citizen groups, ward committees, ward-level climate action working groups, NGOs working at the ground level.	Climate Action Cell in partnership with private sector
1.5 Set up a project preparation facility	A designated wing to be formed in partnership with a private-sector institute of repute, equipped to help translate climate actions in to bankable projects, forge partnerships and identify sources of funding.	BBMP and GoK
1.6 Allocate budgets for climate action gap funding for Bengaluru.	A funding source to bridge gaps in finance to implement projects identified for recommended climate actions under the BCAP, after exploring available funding sources from existing central/state/city level schemes. Departments should prepare budget requirements for identified actions and indicate need for extra funding.	GoK

4. Create structures and tools for an effective and efficient MERL system for BCAP implementation

This is one of the most critical enablers for assessing the progress of both planned climate actions and the achievement of larger BCAP goals and targets. An integrated digital platform for monitoring, evaluation, reporting and learning on the BCAP will be created and operationalised to facilitate collaboration and coordination with efficiency and transparency. Details of the MERL framework are discussed in Chapter 7.

6.2 Setting up a Climate Action Cell and support mechanisms for the BCAP

Considering the multi-sectoral and multi-stakeholder nature of the BCAP, a dedicated and capacitated institutional apparatus is required to implement it and to institutionalise the climate action agenda as a permanent part of the city's planning and governance system. Setting up a Bengaluru Climate Action Cell (CAC) is considered critical for this purpose. The CAC will be primarily anchored in BBMP, with collaboration and participation from other departments/agencies as discussed below.

The key responsibilities of the CAC will be as follows:

1. Coordinate with nodal officers (designated by each stakeholder department) for status updates on climate action in line with the suggested MERL framework described in Chapter 7.

2. Handle operation and management of the MERL platform, flagging discrepancies, and reporting them to the authorities concerned.
3. Take necessary approvals, channelise funds for climate action implementation, and facilitate training and capacity building activities.
4. Coordinate collection of data for regular updating of GHG inventory, loss and damage inventory and climate change risk and vulnerability assessment to support the technical wing of the CAC.
5. Facilitate coordination of stakeholder departments with the BCAP Project Preparation Facility.

The basic structure of the CAC will be constituted in line with this (see Figure 70). Headed by the Chief Commissioner, BBMP, the operations of the CAC will be spearheaded by an officer of Special Commissioner rank who will report to the Chief Commissioner. A Chief Scientist, Climate Action, (similar to the rank of a chief engineer or above) would report to the Special Commissioner, and will be supported by suitable staff tasked with facilitating the administrative activities of the CAC. The Chief Scientist, Climate Action, will act as the CAC's nodal officer and will lead all its activities. At a higher level, the CAC will be guided by a high-powered advisory committee, whose members will include Bengaluru's Development Minister, Development Commissioner, eminent experts, representatives of civil society and of the MPC, and political representatives.

In addition to the Climate Action Cell, two more important facilitation centres are recommended to be created for the effective implementation of the BCAP, as described below.

Technical support and knowledge centre for climate action

The intent of creating this facility is two-fold: one, to keep day-to-day administrative activities and core knowledge-based activities seperate; and two, to leverage existing resources within the city that can support the independence of the core knowledge-based activities. Collaboration with public and private centres of excellence or reputed institutions with expertise relevant to climate change will be encouraged. This centre will further collaborate with other government departments and non-government organisations, to perform the following core activities:

1. Update the GHG inventory for Bengaluru every two years (if required in collaboration with other knowledge-based organisations, such as IISc).
2. Create an annual report with analysis and insights from loss and damage data collected by the CAC.
3. Assess the city's climate change risks and vulnerabilities every three to five years.
4. Be the anchor agency for conducting training and capacity-building activities under the BCAP.

Project preparation facility (PPF)

This is another collaborative structure to facilitate the implementation of the BCAP with the following primary responsibilities:

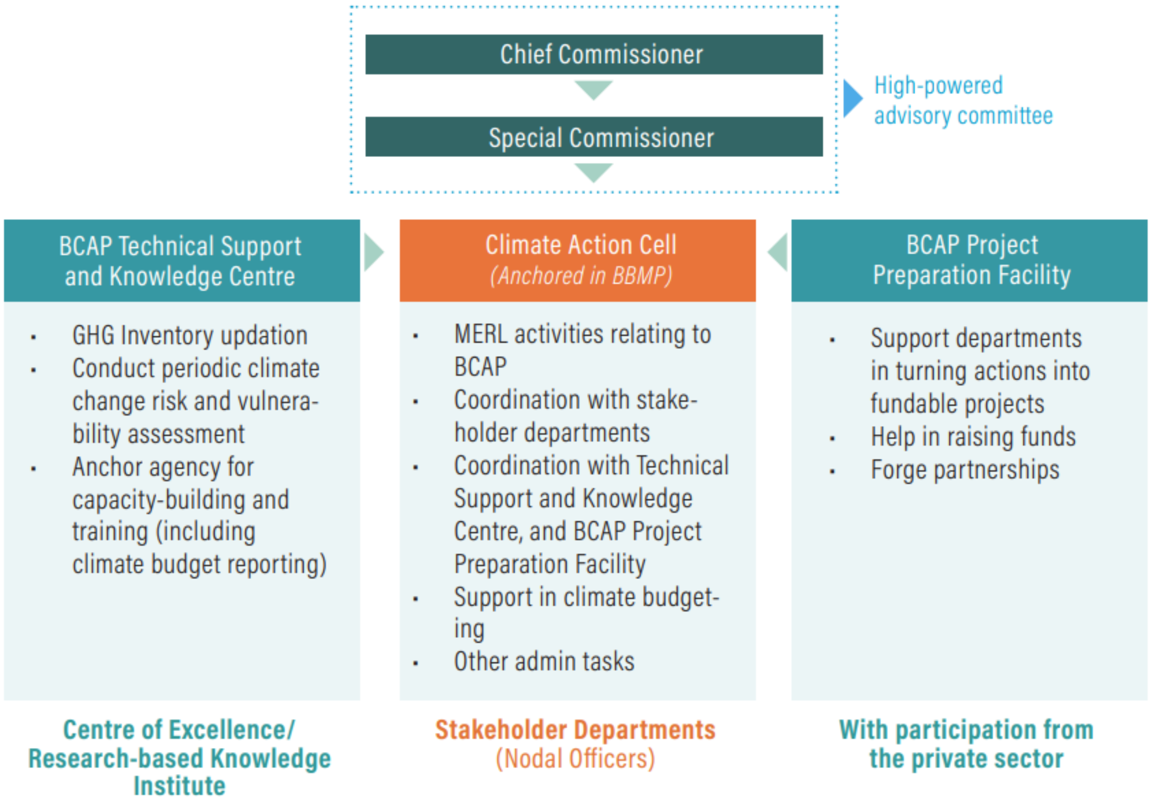
1. Supporting government departments and non-state stakeholders in creating bankable projects, contributing to mitigation and/or adaptation goals of the BCAP.

2. Identifying funding sources from ongoing government schemes/budgetary allocations.
3. Tapping potential funding opportunities from private donors.
4. Forging partnerships and collaborations with a diverse set of stakeholder organisations across both state and non-state actors.

The PPF will need to collaborate with organisations from the private sector (NGOs and consultants) with adequate experience and expertise in project formulation, budget preparation, fundraising, and partnership-building.

The BCAP governance framework with the CAC and the other two wings is illustrated in the figure below.

Figure 70 BCAP governance structure



Source: As identified by BBMP with the technical support of WRI India

The box below gives an idea of the focus areas, mandate and staffing of the CAC set up in Mumbai.

Mumbai Climate Action Cell

Mumbai has been working towards setting up a Climate Action Cell (CAC) as recommended by the Mumbai Climate Action Plan (MCAP), to be housed within the Environmental Department of Brihanmumbai Municipal Corporation (BMC) since it was the nodal coordinating agency for MCAP and related projects. This department will report to the Additional Municipal Commissioner (AMC) Western Suburbs, and be headed by the Deputy Municipal Commissioner (DMC) – Environment. A group of honorary advisors (which can be expanded as the plan progresses) will support the Cell for the effective implementation of the MCAP. This department has five objectives:

- To introduce new technical capacities in the corporation, which is currently staffed with professionals trained to execute engineered projects;
- To introduce innovation – use of smart technologies, locally-led solutions, service delivery based on artificial intelligence and machine learning, and urban management – in order to meet climate targets;
- To develop stringent guidelines for new infrastructure or building projects that align with climate goals and encourage line departments to use these for project approval, and to ensure regulatory enforcement;
- To coordinate across departments within the corporation, and to mainstream climate resilience in existing and proposed projects; and
- To monitor MCAP progress, close data gaps, evaluate outcomes, and report on targets at city and local levels.

The CAC will have a Scientific wing and a Planning wing. The Scientific wing will be responsible for environmental protection and pollution control, knowledge management and innovations, and green finance. The Planning wing will be responsible for sustainable urban landscapes, vulnerable communities, climate-resilient buildings, and integrated mobility. They will be supported by experienced professionals such as Senior Climate Scientists, Sustainable Innovations and Finance Experts, Senior Landscape Planners, Senior Development Scientists, Senior Architects and Senior Transportation Planners. These senior professionals will be supported by junior professionals/fellows having expertise in urban water resilience, GIS, civil engineering, climate finance, data analysis, equity and inclusion, energy efficiency and green buildings, road safety and street design and environmental communications.

Learnings through the process of establishing the CAC in Mumbai:

- The existing institutional structures, bureaucratic protocols, the lack of a precedent, and the need for a strict hierarchy were challenges in getting approvals for most of the new staffing positions for the CAC. A few of these positions had to be renamed/modified to align with the existing hierarchical structure of the municipal corporation, which is currently more engineering-focused. For instance, the position of the *Deputy Chief Scientist* had to be modified to *Deputy Chief Engineer* – *Climate Change and*, *Chief Planner* was renamed Deputy *Municipal Architect – Climate Change*.
- The positions in the CAC are partly permanent and partly contractual. The top positions (i.e., Chief and Deputy Chief) are permanent. Senior experts and fellows are technical experts, who will be recruited on a contractual basis. This allows flexibility in hiring, as this is a new institutional entity, so that the structure and positions can be altered based on need and feedback. Also, there are several entry barriers for permanent government positions, and they often have a lower pay range for expert positions such as planners and, data analysts, compared to market rates. Thus, contractual positions allow for greater flexibility in terms of hiring and modifying the structure based on learnings and feedback.

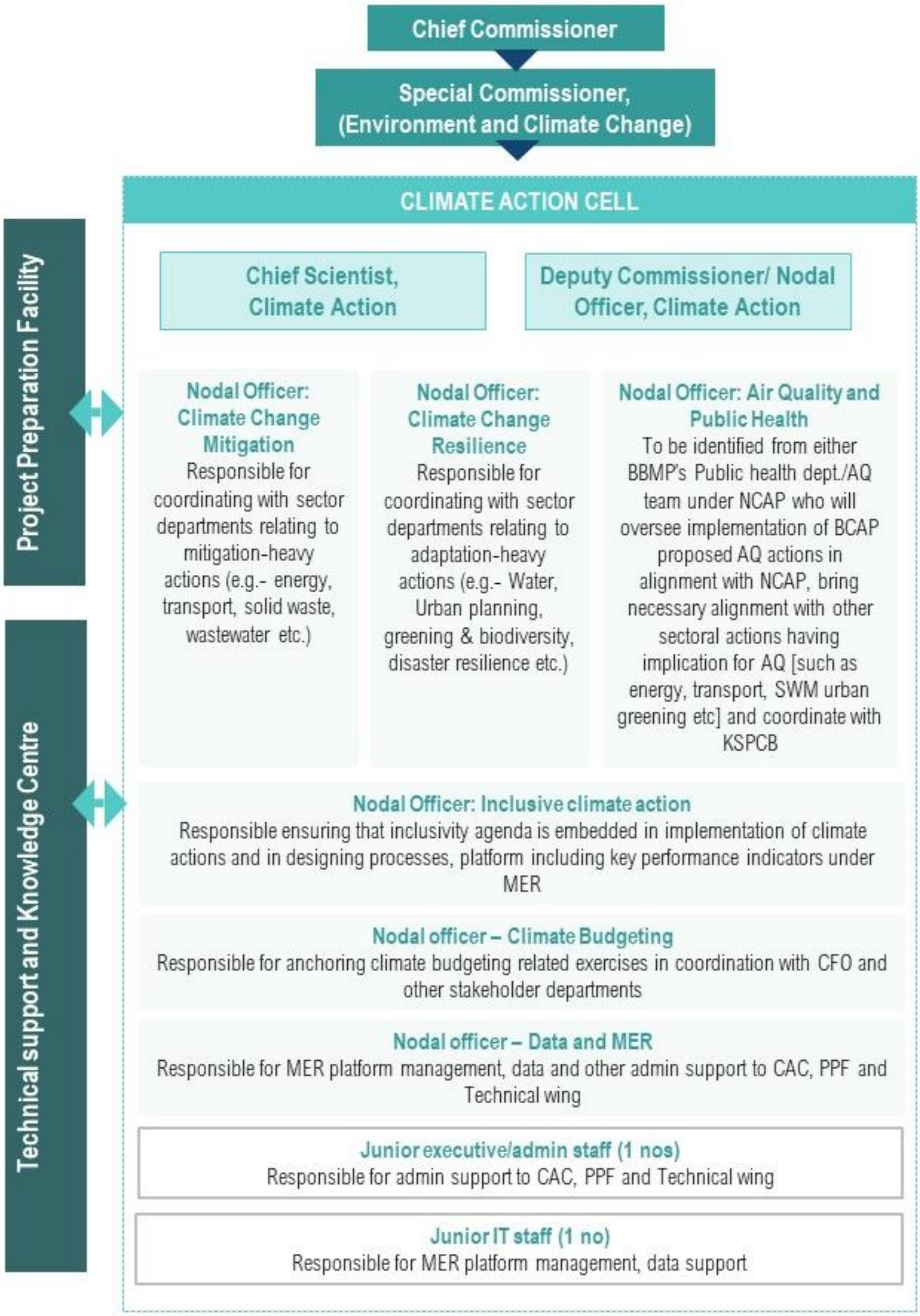
- The BMC's Environment Department is currently attached to the SWM Department, and is exploring how they can define and strengthen their role in improved environmental governance.
- Considering the lengthy bureaucratic process for the recommended positions, as a short-term plan, the BMC is in the process of hiring consultants to take up activities such as developing the GHG inventory, data management, and climate budgeting, to fulfil Mumbai's commitments as a C40 city and towards operationalising the MCAP.

Source: Mumbai Climate Action Plan, 2022, Insights from the MCAP team

Considering the growing need for environment- and climate-related actions to be spearheaded by BBMP (such as climate action and, air quality management), the idea of a new Department of Environment and Climate Change within BBMP is being considered. This department will have the mandate to carry out functions relating to environment and climate change. Once functional, the CAC will be instituted under this department.

Figure 71 shows the proposed structure and staffing of CAC.

Figure 71: Constitution of the Bengaluru Climate Action Cell



Source: As identified by BBMP with the technical support of WRI India

Transition plan

In the absence of a separate environment department within BBMP, this CAC will be initially set up in an existing department which has experience in handling matters related to the environment. It is expected to take the shape of a separate wing with dedicated staff, in a time frame of one to two years, once the resources and operations of the CAC are streamlined.

6.3 Funding climate action for Bengaluru

6.3.1 Existing budgetary provisions for financing climate action in cities

Cities in India receive funding for planning and executing their responsibilities from three primary sources aligned with the three-tier governance structure of India. The Central government allocates funds under various schemes and missions, some of which are directly targeted at cities (such as AMRUT and Smart Cities Mission). In addition, cities or sectoral agencies can access funds allocated under sector-specific programmes and schemes, which contribute to sustainable urban development (such as energy sector allocations under the Ujjwala Mission, National Clean Air Programme). State governments also allocate funds in a similar fashion, i.e., targeted urban sector programmes, and sectoral allocations which can benefit cities. Moreover, state governments such as Karnataka allocate specific funds for improving quality of life in megacities such as Bengaluru, as it is a major contributor to the state's GDP. The third and most direct source of funding for cities is the municipality's own sources of revenue earned from taxes and other sources. More recently, cities in India have also been exploring non-conventional sources of funding, such as municipal bonds and borrowing from multilateral funding organisations on a case-to-case basis. The following sections summarise the highlights of the recent Union Budget, Karnataka State Budget and BBMP's own budget, to understand provisions that can directly or indirectly contribute towards actions proposed under the BCAP.

Key highlights of Union Budget 2023–24

Several provisions made in the Union Budget 2023–24 align directly or indirectly towards India's nationally declared climate goals and Sustainable Development Goals while prioritizing inclusive development (Sitharaman 2023). A few provisions which could be explored to unleash potential sources of funding for implementing climate actions in Bengaluru are as following:

- **Green growth:** India is moving towards net zero carbon emissions by 2070, to usher in a green industrial and economic transition.
    - Energy transition towards the net zero objective: Rs 35,000 crore is allotted for priority capital investment by MoPNG, for energy transition and net zero objectives.
    - National Green Hydrogen Mission: To facilitate the transition to a low-carbon economy and to reduce India's dependence on fossil fuel imports, Rs 19,700 crore is allocated towards this mission.
    - Enhancement of battery energy storage: To further steer the country towards sustainable development, battery energy storage systems are being promoted

with the goal of setting up such storage of 4,000 MwH with viability gap funding.
    - Green Credit Programme: To be notified under the Environment Protection Act of 1986, to incentivise and mobilise additional resources for environmentally sustainable and responsive actions.
    - GOBARdhan scheme: A total investment of Rs 10,000 crore to develop 500 new waste-to-wealth plants across the nation, which includes 75 plants in urban areas. A five percent compressed biogas (CBG) mandate will be introduced promoting a cleaner and more sustainable energy mix.
    - Amrut Dharohar: To promote wetlands and biodiversity, this scheme will be implemented for the next three years.
    - Vehicle replacement: States will receive support in scrapping old vehicles, including ambulances.
- About Rs 23,153 crore is allotted for metro projects nationwide, about Rs 450 crore for Bengaluru suburban rail projects.
- The national budget encourages states and cities to undertake urban planning reforms and actions to transform cities by enhancing urban infrastructure, TOD, etc.
- Through property tax reforms, cities will be incentivised for municipal bonds.
- An Urban Infrastructure Development Fund (UIDF) of Rs 10,000 crore will be provided to sectors facing a shortfall of funds. The states can leverage this through 15th Finance Commission grants.
- An integrated online training platform (iGOT) called Karmayogi was launched to conduct capacity-building sessions for government employees to upgrade their skills.

Important urban sector central schemes through which some of the climate actions could be taken up for implementation are mentioned below:

- Prime Minister's Awas Yojana-Urban (PMAY-U)- Address urban housing shortage amongst the EWS/LIG and MIG categories to create climate-resilient communities.
- National Urban Livelihood Mission (NULM)- Provides universal financial inclusion for the urban poor, thereby enhancing the city's resilience.
- Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Smart Cities Mission- Provides basic services (e.g., water supply, sewerage, urban transport) to households, and build amenities in cities to improve the quality of life.
- Swacch Bharat Mission-Urban (SBM-U)- Eliminate open defecation, conversion of unsanitary toilets to pour flush ones, eradicate of manual scavenging, municipal solid waste management, and bring about behavioural change.

Highlights of Karnataka state budget 2023-24

The State Budget 2023-24 presented on July 2023, directly or indirectly have few provisions for tackling climate change related challenges. Following are some of these provisions which could be further explored to act as potential sources of funding towards implementing the actions recommended through the BCAP.

- *Brand Bengaluru:*

- "**Brand Bengaluru**" as a theme was launched which is centered on safety and convenience of the residents of Bengaluru city. The Brand Bengaluru theme is focused on addressing the nine major challenges facing the city namely, traffic management, environment, solid waste management, proper utilization of public places, public health, animal health, people friendly e-Governance, water security and flood management.

- Energy:
  - **Gruha Jyothi** scheme provides energy guarantee (and affordable electricity) to every household and citizen of the state. Under this scheme, up to 200 units of free electricity is provided to every household every month. Whilst the scheme provides free electricity, this is also an endeavor to bring awareness among the people about judicious use of electricity. This scheme is implemented at an estimated annual cost of Rs. 13,910 crore.
  - A **City Gas Distribution Policy** will be developed to facilitate the distribution network of natural gas in the state. The policy will facilitate uniform laying charges across the state.
- Transport:
  - **Shakti scheme** provides free bus travel to women and gender minorities in the four state-run road transport corporations - BMTC, KSRTC, NWKSRTC and KKRTC. An annual expenditure of Rs. 4,000 crore is estimated for this scheme.
  - In the next three years, **Namma Metro** will be expanded to 2.5 times its present network coverage. Additionally, DPRs for few more lines will be submitted to government of India for approval.
  - To implement the **Bengaluru Suburban Rail Project**, Rs. 1,000 crore has been allocated this year.

- Solid Waste Management:
  - Scientific disposal of waste in Bengaluru city will be prioritised. Legacy waste of 97 lakh tons will be treated through bio-mining and bio-remediation and in the coming 5 years, 256 acres of land will be converted into parks in Bengaluru city.
  - Rs. 3,400 crore is allocated for effective disposal of legacy waste, liquid waste management and to control the flow of pollutants into rivers and lakes. The project will prioritize adoption of modern systems of processing drainage water. Out of the total allocation, Rs. 1,250 crore is provided for Bengaluru city.
  - Bengaluru Solid Waste Management Corporation Limited (BSWMCL) has been established to collect, treat and dispose waste in a scientific and sustainable manner. Rs.100 crore is provided for the effective operation of this corporation.
- Air Quality:
  - Various programs will be undertaken to enhance air quality in the state. An action plan will be prepared and implemented at a cost of Rs. 35 crore in year 2023-24 using funds available under Green Tax Fund created for this purpose.
- Water & Sanitation:
  - Bengaluru Water Supply and Sewerage Board (BWSSB) will upgrade 20 Sewage Treatment Plants by March, 2026 at a cost of Rs.1,411 crore. BWSSB will execute this project using their own funds.
- Greening:

- An innovative program called 'Sasya Shamala' will be launched. Under this program, in the current year, 50 lakh saplings will be planted in and around schools. This will be done in collaboration with the Education and Forest Department.

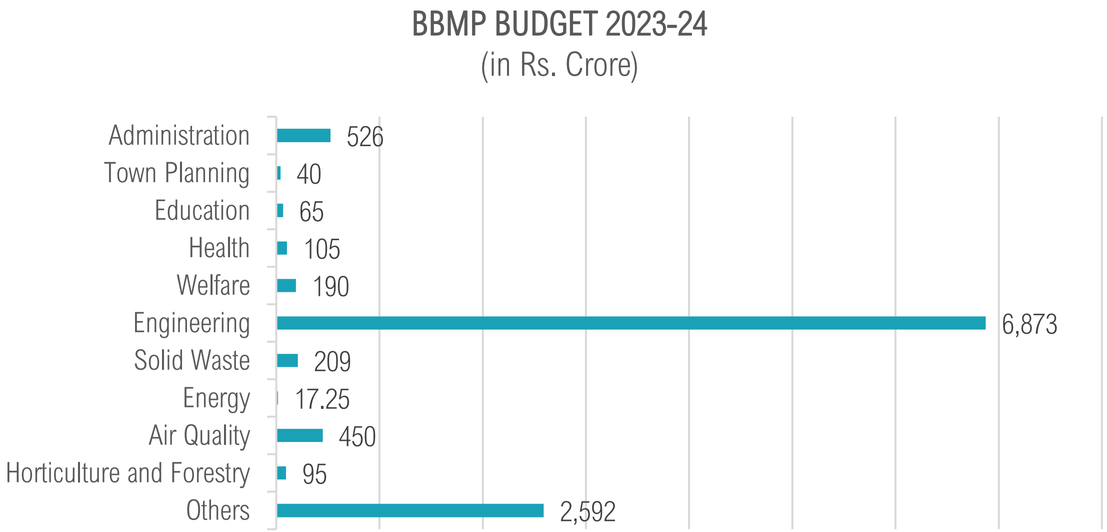
- Disaster Management:
    - To mitigate the consequences of climate change such as flood, drought and erosion of river banks, it is proposed to undertake works in the current year at a cost of Rs. 422 crore from State Disaster Mitigation Fund.
    - To reduce disaster risks and strengthen fire and emergency services, it is proposed to take up works at a cost of Rs. 721 crore from National Disaster Mitigation Fund (NDMF) such as flood control in Bengaluru, landslide risk mitigation in Kodagu, Chikkamagaluru, Dakshina Kannada and Hassan districts.
    - Under K-SAFE project of Department of Fire and Emergency Services, a grant of Rs. 100 crore will be provided in 2023-24 for purchasing fire-fighting vehicles and to undertake construction work of 3-Bay fire station buildings in Soopa, Yelahanka, Bhatkala, Arakera, Nagarabhavi, N.R. Pura, Shirahatti, Honnavara, Narasapura (Kolar District) industrial areas and Devanahalli aerospace industrial area.
- For Centrally sponsored schemes such as **Swachh Bharat 2.0** and **Amrut 2.0**, state's share has been allocated for projects under these.
- Startup & innovation:

    a. Multiple programmes and projects are proposed to enable innovation and Start-Ups. These could facilitate innovation in the solving the climate challenge. Some of these are:
    - 'INNOVERSE'- a world class incubation centre with hi-tech facilities for Start-Ups. For this, grant of Rs.10 crore has been earmarked in the current year.
    - 'Propel' a program to accelerate the adoption of solutions of Start-Ups which have been funded by the government under the 'Start-up Policy'. Rs. 1 crore has been set aside for this in the current year.
- To reduce carbon footprint, Environmental Management and Policy Research Institute (EMPRI) will undertake assessment of all major schemes of government and ensure environmental balance.
- To promote decarbonisation of economy and encourage green growth, a scheme will be commenced for the voluntary disclosure of Green House Gases (GHGs) by the organisations in the state.

Highlights of BBMP budget 2023–24

The fiscal outlay of BBMP's 2023–24 budget is Rs 11,163 crore. This budget (Opencity 2023) focuses on major sectors such as engineering (for roads, stormwater, lakes, slums, etc.), town planning, air quality, solid waste, energy, health, and welfare. Refer to Figure 72 below.

Figure 72 BBMP budget 2023–24



(Engineering includes roads, stormwater, lakes, and slums)
Source: BBMP budget highlights

Bengaluru can utilise the budget provisions outlined in the 2023-24 budget of BBMP to implement various climate actions. Here are some ways in which these provisions can be used:

- **Town planning:** The BBMP allocated Rs 40 crore to determine and identify the agency's properties, including geo-tag GPS marking of lakes, digitisation of records, chain-link fencing and installation of nameplates. This will give impetus to the scheme to preserve BBMP's assets and turn them into sources of income. Allocation of these funds for identifying and preserving BBMP's properties can be used to prioritise and protect green spaces, including lakes and parks, within the city. This will contribute to enhancing the city's resilience to climate change and preserving biodiversity.
- **Engineering:** Over Rs. 9000 crore is allotted for improving roads, the stormwater drain network, lakes, slums, etc. Of this amount, in continuation to the 2022–23 budget allocation of Rs.6,000 crore (for the three implementation years from 2022), budgetary allocations are being utilised for actions in the current year, such as the following:
    - **Roads:** Development of high density corridors, grade seperators, road-widening projects, reconstruction of BWSSB excavated roads (in line with State budget), and decongestion of traffic junctions.
    - **Stormwater drains:** Owing to continuous rainfall and floods in the city, BBMP allotted a total of about Rs 120 crore from the Rs 3,000 crore state budget allocation to create resilient infrastructure towards flood management. Actions such as primary, secondary and tertiary drain repair and maintenance; repair of roads/pavement and desilting of drains can be taken up.
    - **Lakes:** Comprehensive development of 12 lakes for Rs 35 crore. To utilise Bengaluru's big lakes for flood control by installing sluice gates, an additional amount of Rs 15 crore has been allocated.

- **Slum development:** Rs 80 crore is earmarked to redevelop all the slums in the city.

These provisions provide an opportunity to incorporate climate-resilient design principles. This includes developing green corridors and integrating nature-based solutions to mitigate urban heat island effects and enhance water management.

- **Air quality:** About Rs 450 crore is allotted for air pollution control projects, which is also part of the mandate under the 15^{th} Finance Commission grants to reduce air pollution. It includes various projects to be implemented by different stakeholders such as BBMP, BWSSB, BESCOM, BMTC, KSPCB, DULT, etc. These projects can be utilised to implement measures aimed at reducing vehicular emissions and can help in dust suppression and improving air quality.
- **Energy:** BBMP has also earmarked approximately Rs 17.25 crore to reduce power consumption by proposing to replace sodium vapour lights with LED fittings. This can lead to energy savings and reduced greenhouse gas emissions. BBMP's budget also included the provision that solar rooftop net metering would be taken up in 2023-24 on all BBMP buildings under the 15th Finance Commission grant. This will promote renewable energy generation and help reduce the city's carbon footprint.
- **Waste:** The BBMP budget states that 22 lakh metric tonnes of waste in four dumping yards will be bio-mined at a cost of Rs 209 crore. There is a specific mention in the BBMP budget on managing C&D waste, provision of new waste-segregated auto tippers, a bio-CNG unit, and a 100-acre integrated solid waste management centre which will be developed to make Bengaluru a zero-waste city. This includes promoting waste segregation, recycling, composting, and the generation of bio-CNG from organic waste. However, details on fund allocation for these activities have not been elaborated in the budget.
- **Horticulture and forestry:** Rs. 15 crore is allotted to develop 15 new parks across the city, while around Rs. 80 crore is earmarked to maintain existing parks. These funds can be utilised to enhance the city's green cover, which contributes to improving air quality, mitigating heat, and providing recreational spaces for citizens.
- **Welfare and inclusive growth:** BBMP has allotted Rs 40 crore to provide health insurance to *pourakarmikas*, Rs 65 crore for improved quality education, over Rs 100 crore to improve health and medical conditions, etc. Under the Onti Mane scheme, the city has allotted 100 crore to provide housing to 1,500 beneficiaries. About 67,385 street vendors have been identified by BBMP under the Prime Minister Swanidhi scheme and Rs 25 crore is earmarked to develop street hawking zones across the city. These allocations can contribute to improving the overall well-being and resilience of vulnerable communities in the face of climate change impacts.

For effective implementation of BCAP, city agencies must align city projects to support climate action as a strategic option and investment. Along with the existing budget allocation, the departments must align climate actions with current implementation mechanisms to attract additional funding from private-sector, especially in innovative green solutions.

6.4 Preparing a climate budget for Bengaluru

'A climate budget is a governance system that offers a way for cities to turn climate commitments into funded and measurable actions across city government. It embeds climate targets, measures and considerations into decision-making as part of a city's ordinary budgeting process.' ('Climate Budgets' C40 Cities) About 13 cities around the world, including Mumbai, are developing their own climate budgets as part of a C40 pilot project.

Below are two case examples of how cities have been working towards accommodating climate action in their budgets.

Case 1: Oslo's climate budget

The city of Oslo incorporates the climate budget as a tool for governance, aiming to prioritise its climate-related efforts. The climate budget outlines specific goals for emission reduction and proposes measures to be implemented within the municipality. It also highlights key initiatives necessary to achieve the emission reduction targets outlined in the climate strategy. The responsibility for executing these measures is assigned to the relevant municipal entities, who are required to report on their progress in a manner similar to financial reporting. Spanning the entire 2023–2026 economic plan period, the climate budget is an integral part of Oslo's financial budgeting process, overseen by the finance department. Its inclusion signifies that the city council can only approve spending plans that align with Oslo's climate objectives, firmly placing climate goals at the forefront of the financial budgeting process.

Case 2: Mumbai's climate budget

During the preparation of Mumbai's climate action plan, a climate budget of Rs 1 crore was set aside to establish a Climate Action Cell (CAC) and implement projects. This budget included various financial resources from BMC, state and centrally sponsored schemes, green bonds, and international funds. The goal was to use the budget as a governance tool to overcome institutional barriers and involve parastatal agencies in climate actions within their control.As the climate budgeting process evolved, in February 2022, the allocation was made to establish the climate action cell, and was then carried forward to 2023. A climate budgeting exercise was conducted using instruction sheets and templates to assess the budget for climate action plans. The exercise involved analyzing the existing municipal budget, identifying climate-relevant departments, and mapping each budget item to the Mumbai Climate Action Plan (MCAP) actions. Additionally, an ex-post assessment was conducted as part of the C40 climate budget pilot, analyzing the climate budget and assessing the positive and negative impacts of current expenditures. The assessment included a detailed analysis of the climate sensitivity and relevance of each budget item. The findings were shared with relevant departments involved in climate initiatives. The exercise aimed to not only understand the allocation of funds but also gain insights into the governance structure of the corporation. The assessment was submitted to the departments of environment and finance, leading to collaboration in developing a climate budgeting instructions template/manual. This template was circulated amongst climate-relevant departments, gathering inputs to ensure its acceptance and identify necessary modifications for incorporating climate budget information. Currently, the template is further being developed by applying it in the context of the storm water drainage department to understand its application.

Source: MCAP, Oslo's Climate Budget (c40knowledgehub.org), Source: C40 Climate Budget Pilot

Summarised below are four key steps of the climate budgeting exercise (Cities 2021) that Bengaluru will take up as it adopts its first-ever Climate Action Plan.

Four steps of preparing a climate budget for Bengaluru

Step 1: Conduct start-up activities.

This will include the following:

- Identify a set of people in the city administration who will own the climate budget. Ideally, this would be the chief financial officer (CFO) of the municipality, supported by a working group of people from relevant stakeholder departments.
- A nodal officer for climate budgeting can be appointed to support the CFO in managing climate project budget allocations, expenditures, and outcomes.
- Identify the boundaries of the climate budget, i.e., which jurisdiction it will apply to. In the case of Bengaluru, the CAP jurisdiction is the BBMP area, and hence the climate budget should ideally apply to this area. However, considering the spatial overlap of natural-based elements strongly influencing the city's resilience, there may be a need for budgeting for actions that will be implemented outside the BBMP limits.
- Allocate the initial budget for constituting the CAC.

Step 2: Assess alignment of budgets with climate action.

To align city budgets with climate action goals, the city must undertake the following steps:

- Assess the current state of its climate-related initiatives, policies, and corresponding budget practices. This will help identify gaps and opportunities to include climate considerations in budgeting.
- Start embedding climate considerations in the budgeting process by conducting the following assessments:
    - **Ex-ante assessment:** This involves evaluating the potential impact of a city's budget decisions on climate action before they are implemented. It helps identify whether the proposed budget aligns with the city's climate goals and objectives.
    - **Ex-post assessment:** This component involves evaluating the actual impact of budget decisions on climate action after they have been implemented. It assesses whether the budget allocations and expenditures have effectively contributed to the city's climate targets.
    - **Project climate assessment:** This aspect focuses on assessing the climate impact of specific projects funded through the city budget. It aims to ensure that projects are aligned with climate objectives and contribute positively to reducing greenhouse gas emissions or enhancing climate resilience.
    - **Carbon budget framework:** A carbon budget sets a limit on the total amount of greenhouse gas emissions a city can emit within a specific timeframe. The pilot assesses the alignment of city budgets with their carbon budgets to ensure that financial decisions are consistent with emission reduction targets.

More details on the C40 climate budget pilot programme and its key components/assessment methods are provided in *Annexure J1.*

Step 3: Prepare a climate budget.

- Earmark budgets specifically targeting climate action goals outlined in Chapter 5 for each sector, including goals, targets, action tracks for emission reduction, and resilience building. *Annexure J2* contains a draft climate budget template provided by Mumbai as a reference sample. (The template is currently undergoing further development and is meant to be used for reference purposes only.)
- State estimated impact of budgets on emission reduction and resilience building over time.
- Identify yearly projects from the proposed actions in the CAP and earmark budgets against those including source of finance and responsibility for implementing the same.
- Regular updates of climate budgets in alignment with city budgets will be necessary on an annual basis.

Step 4: Reporting and follow-up

- Incorporate the climate budget into the MERL (Monitoring, Evaluation, Reporting, and Learning) framework. Reporting of climate budgets by agencies is an essential tool to understand spending to achieve CAP goals and targets and adhere to necessary MERL protocols and evaluate the climate budget.
- Once the climate budget is prepared, the city should publish it. The summary of the climate budget should be made easily accessible to the general public through the public interface of the MERL platform.
- Within the MERL platform, regularly monitor and track expenditures to ensure they align with the prepared climate budget. This allows for ongoing assessment and tracking of spending in accordance with climate goals and targets.
- Conduct regular reviews and refine the climate budgeting framework based on lessons learned, emerging best practices, and changing climate priorities. Adapt the process to evolving climate goals and integrate new assessment methods as they become available.

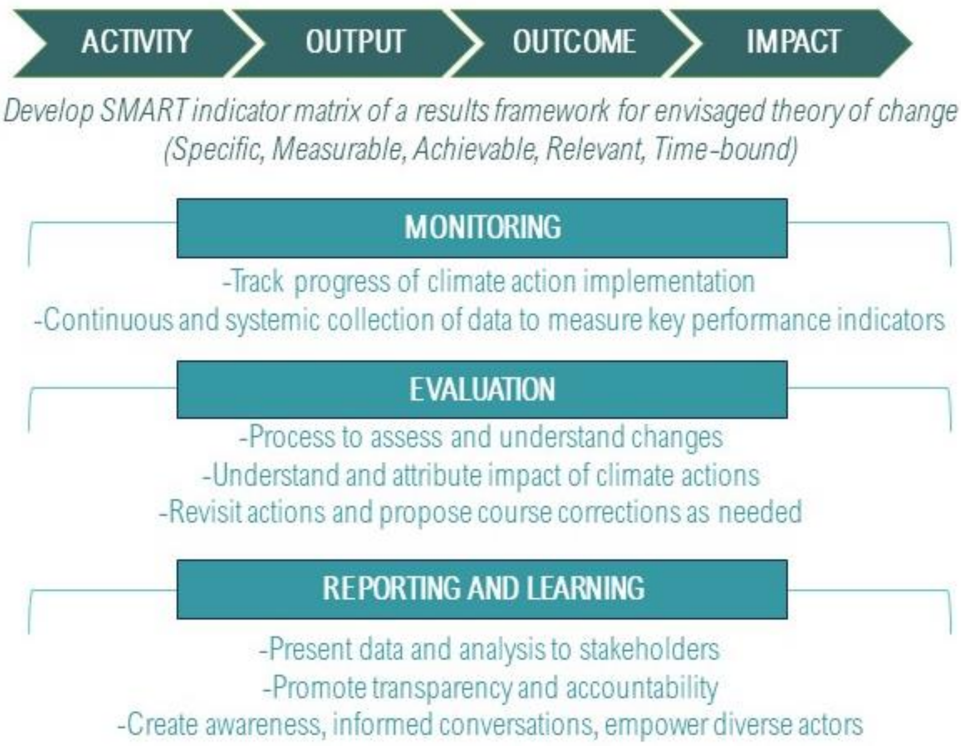
Photo Credit : Rajeev Malagi/WRI India

7 MONITORING, EVALUATION, REPORTING AND LEARNING FOR BCAP

Climate action planning involves the integration of monitoring, evaluation, and reporting (MER) to track and assess progress towards the targets set in the plan, thereby demonstrating the effectiveness of implemented actions. MER establishes structured processes and systems that enable cities to effectively monitor and evaluate their progress, aligning it with the envisioned Theory of Change at the project's outset. This crucial component of climate action plans brings several benefits, including accountability, standardised measurement and reporting, learning and improvement, transparency and communication, compliance with international commitments, and efficient resource allocation. By implementing MER, cities can systematically track their progress, ensure transparency, learn from their experiences, and optimise their climate actions.

This section builds upon the governance structure recommended for the implementation of the BCAP in the previous chapter, and lays down the objective, structures, and mechanisms for a comprehensive and outcome-oriented MER process. While developing a MER framework, it is important to emphasise that development is an iterative process. Each step of MER builds on the others, to complete a feedback loop and help establish a planning process that continuously revisits its actions based on outcomes and initiates necessary course correction. Figure 73 summarily presents the three components of MER and how they should be ideally aligned to the theory of change or results framework envisaged for BCAP.

Figure 73 Monitoring, evaluation, and reporting (MER) framework



Source: WRI India

7.1 Monitoring

Objective

Monitoring generally refers to the systematic and continuous collection of data, quantitative and/or qualitative, about the progress of a project or intervention against its planned deliverables, outputs and outcomes. It plays an essential role in understanding where to focus resources, which actions are progressing as planned, and which ones are not. Comprehensive and efficient monitoring mechanisms also help create the basis for a platform to document continuous progress and performance, which enables learning from experience to the maximise effectiveness of an action.

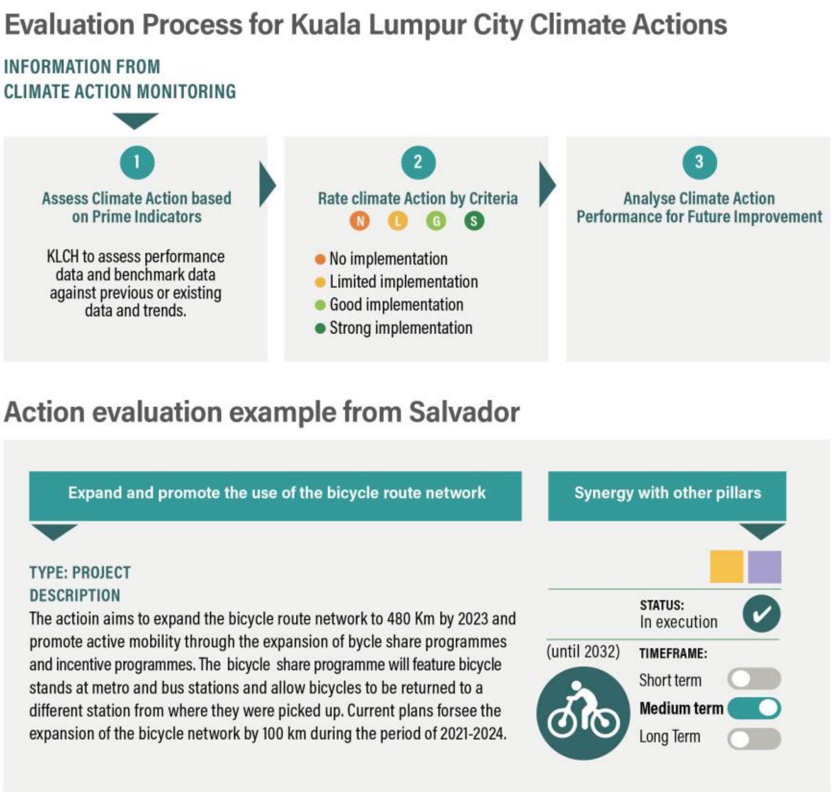
Monitoring framework

Three levels of monitoring are required for the timely implementation of actions and ensuring their effectiveness.

a) <u>Progress of action implementation</u>

To understand and effectively communicate the progress of an action or goal set out in the climate action plan, it is important to establish a method to determine the type of measurement required to assess the progress in implementing the action. This will be developed by the CAC in consultation with key stakeholders. Below are examples of types of metrics considered by other C40 cities.

Figure 74 Example from Kuala Lumpur's and Salvador's CAPs



Source: C. P. Department 2021; Salvador 2019

Table 20 below is an illustration of arriving at a template for identifying the data and information to be collected for action.

Table 20: Illustrative example of CAP action implementation monitoring template

Action	Activity (Only examples are given. More activities may be required to implement an action.)	Implementation status	Output indicators and data required
Ensure the use of energy-efficient fixtures and appliances in all public buildings by 2030.	Departments/ offices in charge of public buildings tocreate a policy for replacing older fixtures and appliances with new energy saving ones, and all new appliances to be energy-efficient, and execute the same.	Not yet started /in preparatory stage/ partially implemented (indicate % implementation)/ implementation completed	- % increase in the energy-efficient fixtures and appliances in municipal and public buildings *Monitoring frequency: Half-yearly*
Increase dry waste collection centres and aggregators in all the wards and set up Material Recovery Facilities (MRF) and facilities for producing refuse-derived fuel (RDF).	BBMP/BSWML should increase DWCCs at every ward, include the material recovery facility within the centre, and encourage dry waste packing manufacturers and waste collection agencies to collaborate and execute resource recovery.	Not yet started/ in preparatory stage/ partially implemented (indicate % implementation)/ implementation completed	- Total no. of MRF facilities - Total amount of RDF *Monitoring frequency: Annual*
Design a 'Green Credit Scheme' to incentivise employers to adopt a remote work policy to reduce work trips.	The governing bodies and regulators of the transport sector, along with the key finance-related stakeholders, should jointly develop a policy that identifies and recommends ways to nudge institutions, agencies, private employers, etc., to promote adoption	Not yet started /in preparatory stage/ partially implemented (indicate % implementation)/ implementation completed	Green Credit Scheme - drafted, approved, and implemented *Monitoring frequency: Per project*

Action	Activity (Only examples are given. More activities may be required to implement an action.)	Implementation status	Output indicators and data required
	of PT/NMT amongst their employees/staff by providing financial incentives. The scope of this policy can be defined beyond the above and can be designed to come up with a financial model to support PT and NMT operators (to provide services at an attractive cost). This policy should be adopted by all employers in the city.		
Enforce shift to electric motor-driven systems from fossil fuel-driven ones in all PAT and non-PAT industries.	Design improvements of PAT schemes.	Not yet started /in preparatory stage/ partially implemented (indicate % implementation)/ implementation completed	% Increase in electric motor-driven systems in PAT and non-PAT *Monitoring frequency: Annual*
Create attractive ticket fare structure with targeted incentives to attract more commuters to uptake PT modes, especially marginalised communities such as lower-income groups, women, elderly, and children.	Develop a comprehensive ticketing strategy for all PT modes in the city by involving all the service operators. This strategy should identify marginalised communities and provide targeted incentives/subsidies to them. The strategy should also find ways to compensate PT operators for the subsidies they provide (this could be linked to the	Not yet started /in preparatory stage/ partially implemented (indicate % implementation)/ implementation completed	No. of passes issued for low-income groups, women, and the elderly *Monitoring frequency: Quarterly*

Action	Activity (Only examples are given. More activities may be required to implement an action.)	Implementation status	Output indicators and data required
	proposed Green Credit Scheme).		

Note: The examples shown in the table are for illustration purposes, and do not cover all the actions suggested under BCAP. For output indicators against each action, refer to sector-wise action tables in Chapter 5

b) Climate action outcome monitoring:

The purpose of measuring outcomes is to understand whether a desired change is seen in a particular system compared to its original state. For the BCAP, it would translate to a set of key performance indicators that can help measure the goals and targets adopted in each sector, as the collective outcome of a set of actions. Hence, while it is often possible to attribute outcomes at the action level, in the case of the BCAP, the goals and targets will rather be achieved as the cumulative outcome of a range of actions. It is thus advisable to design an evaluation matrix at an appropriate level. For the BCAP, a set of key performance indicators aligned to the sector goals or targets or action tracks (in the absence of a quantitative target for certain ambitions) for each sector can comprehensively help the city and sector agencies assess the impact of actions being implemented to achieve the goals and targets set for that sector. It is important to assess these KPIs at a sector level and not against individual actions so as to avoid inappropriately attributing success or failure. For example, mode shift in the transport sector would be a cumulative outcome from a range of actions under the particular action track or goal. Hence a set of KPIs for each sector has been derived from sectoral action tracks/goals/targets, which can help evaluate progress towards that target/action track as attached in *Annexure F*. The table below illustrates a suggested template for evaluation against those KPIs.

Table 21: Sample of BCAP action outcome monitoring template

#	Evaluating indicators	Target	Baseline value *(Year)*	Evaluation frequency	Value year				Change observed	Assessment (Satisfactory/ slow but positive change/ negative)
					Y_1	Y_2	Y_3	Y_4		
1	% New appliances with 5-star label	40% by 2030, 61% by 2040, 83% by 2050	2024	2 years						
2	% Annual reduction in physical air pollutants (PM10 & PM2.5) concentration from 2017-18	40% by 2026 for PM10, 30% by 2026 for PM2.5 (NCAP Targets)	2024	Half-yearly						

#	Evaluating indicators	Target	Baseline value (Year)	Evaluation frequency	Value year				Change observed	Assessment (Satisfactory/ slow but positive change/ negative)
					Y_1	Y_2	Y_3	Y_4		
3	% of waste segregation at source	100% by 2025	2019	1 year						
4	% reduction in water loss	15% by 2030	2019	2 years						
5	% of new households in the city (added from 2019) in TOD areas (approx.)	20% by 2030, 70% by 2040, 90% by 2050	2024	3 years						

c) *BCAP impact monitoring:*

The objective of BCAP impact monitoring is to enable the city with data on a select set of overarching indicators to understand whether the envisaged end goal of a climate action plan is being achieved at the city level. The overarching indicators and exercises through which impact will be monitored are summarised in the table below.

Table 22: Indicators for BCAP impact monitoring

Impact indicator	Tool/activity	Frequency of measurement	Responsible nodal agency
Reduction in annual GHG emissions from the city (CO2e)	Update GHG Inventory and monitor residual emissions	Every 2 years	Technical wing of CAC, with inputs from all departments
Reduction in loss of lives, economy, and property annually due to climate- and environment-related hazards	Make and update loss and damage inventory for the city (loss of lives, property, assets, GDP, workdays from climate- and environment- related hazards)	Annual	BBMP, with inputs from ward- andzonal-level platforms and other departments
Reduction of risk to the city and its citizens from climate change	Climate change risk and vulnerability assessment	Every 3-5 years	Technical wing of CAC with inputs from all departments

It is important to acknowledge that while GHG emissions inventory, loss and damage inventory and CCRA-VA provide useful estimates of change being achieved at an aggregate level, they do not provide a disaggregated understanding of where the city is falling short, or, in other words, attribute the city's performance to a certain set of actions. A comprehensive outcome indicator matrix thus needs to be laid out at a disaggregated level, to help agencies understand whether the desired outcome or impact is being achieved by implementing one or more sets of actions.

7.2 Evaluation

Objective

Evaluation can be defined as the 'systematic and objective assessment of an ongoing or completed project, programme, or policy, as well as its design, implementation, and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact, and sustainability'.[67] Such assessments help agencies and cities make informed decisions on revising the allocation of resources and gain a deeper understanding of the actions that are underperforming. They also help the city understand the level of support required from key stakeholder groups. The process of evaluation is built on the data collected for monitoring physical progress of activities, outputs, and outcomes, and is conducted periodically to answer questions such as 'How and why did the change occur? Did it occur due to the action or other factors? Why could the envisaged change not be achieved?' It is important to assess if sufficient and reliable data is collected in the monitoring phase before conducting the evaluation process.

For BCAP, the evaluation will need to take into account all three categories or scales of monitoring, evaluate each one of them for their success, and importantly, carefully link the performance of all three levels of monitoring indicators to attribute observed changes. There is more than one way to conduct an evaluation from a methodological perspective. It is relatively easier to evaluate activities and outputs, as those are generally planned in a series of tangible deliverables in a results framework. Outcomes and impacts, however, are more complex functions, which have more than one line of attribution. Hence, it requires deeper scientific knowledge of causal loops, established and emerging theories of change, and a deep understanding of the context.

The aim of an evaluation exercise is to take note of the shift observed in the performance or outcome and impact indicators and trace the reason for that shift in the value chain of activities as objectively as possible. Below is an illustrative example of the flow of reasoning in an evaluation exercise.

A mid-term evaluation of BCAP goals and targets will be done every three years based on insights provided by monitoring exercises described in the previous section. The goals and targets will be revised if required based on the evaluation exercise. The entire BCAP will be revisited every five years based on updated evidence and progress on goals set.

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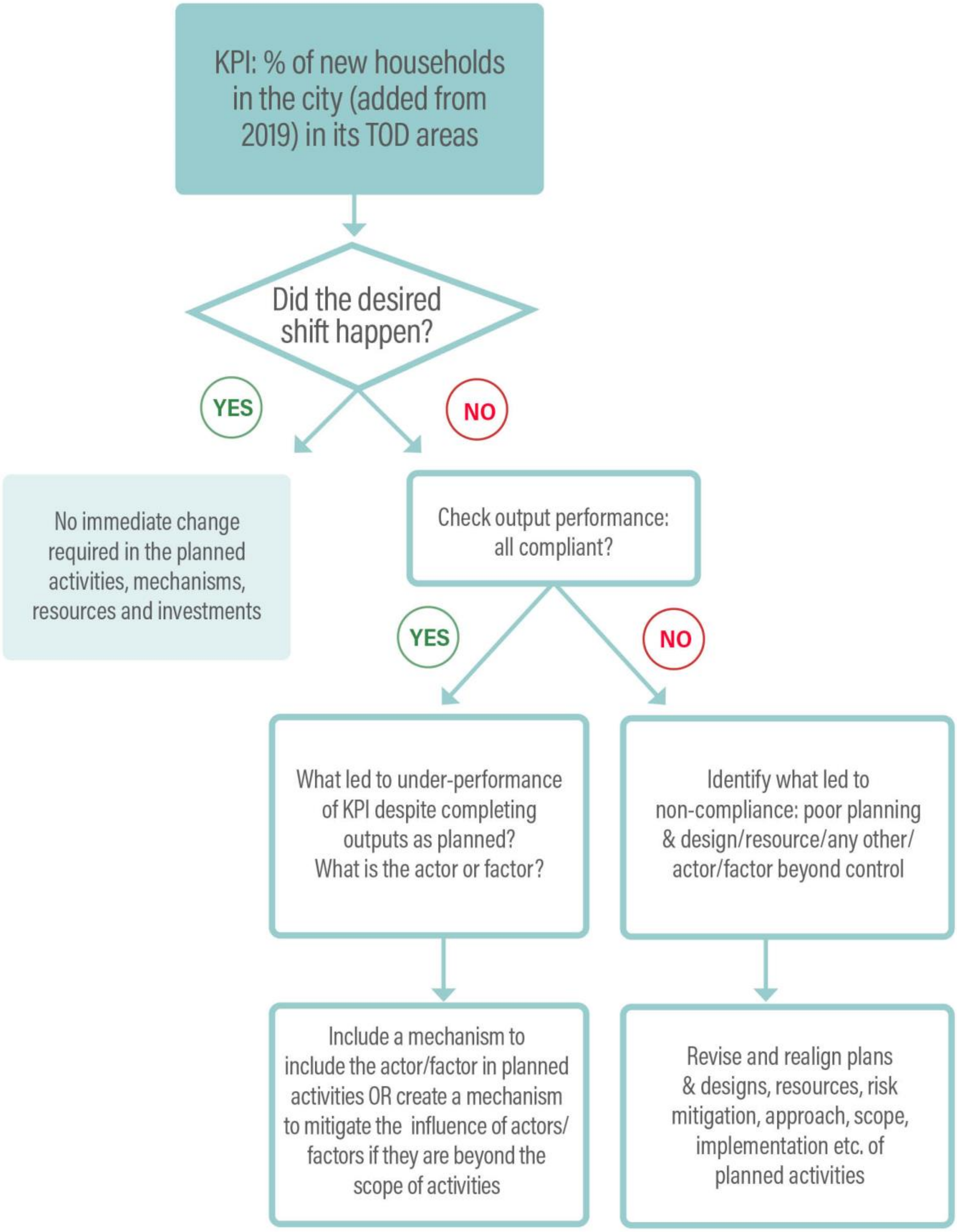
67 The OECD defines evaluation as "The systematic and objective assessment of an ongoing or completed project, program, or policy, its design, implementation, and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact, and sustainability."(OECD 2009)

Figure 75: Monitoring to evaluation reasoning flow-chart



Source: WRI India

The outcome KPIs provided in Table 21, Annexure F, and the impact indicators mentioned in Table 22 will provide useful reference points for designing evaluation approaches for BCAP sectoral actions.

7.3 Reporting and learning

There will be two levels of reporting. First, at the top stakeholder leadership level, where the progress of the proposed actions will be reported by the respective agencies to the nodal agency by recording the implementation status of actions with the help of the indicators, inventories and assessments suggested in monitoring and evaluation. The second is the overall city-level reporting, which includes non-governmental agencies and citizens. Here, the evaluation results will be tailored to the diverse audience group by providing updates on the city's performance towards net zero, adaptation, and resilience goals.

Publication of the GHG inventory, loss and damage inventory and CCRA-VA at prescribed frequencies are critical steps in awareness-building, creating informed discourse on climate change and accelerating climate actions with participation from both state and non-state stakeholders.

A consistent and regular reporting process will allow BCAP to highlight its achievements in implementing climate action, while also identifying issues and opportunities to adapt and improve existing approaches. The CAC will update progress and achievements on the actions in a manner that is comparable to the baseline year as well as the set targets. Regular reporting meetings with the CAC will be set, though recommended frequencies depend on the audience and the actions being reported. Live dashboards will be enabled for the stakeholders to monitor progress against indicators at their leisure.

7.4 Operational framework for the BCAP-MER: Structures and tools

This section gives a broad schematic of the processes, protocols, and institutional responsibilities that will be put in place and operationalised for achieving the objectives of MER. The CAC will create detailed MER protocols, formats, and design of tools based on this framework, and in discussion with all key stakeholder departments, as the BCAP goes for implementation.

Structures will include frameworks, roles, reporting systems, and communication channels, enabling objective-setting, data collection, analysis, and stakeholder communication. Tools will encompass methods for data collection (surveys, interviews, observations), progress monitoring, evaluation (impact assessments, case studies), and data analysis (statistical software, spreadsheets). Well-defined structures and appropriate tools improve the efficiency of MER, generating reliable information for decision-making and accountability.

The box below illustrates two case studies on the MER operational mechanisms adopted for climate action plans in two cities.

Case Study 1: MER for Salvador Climate Action Plan

The Brazilian city of Salvador has implemented a policy mandating the development of a management system for climate change mitigation and adaptation, enabling monitoring of plan implementation by a dedicated committee. Regular evaluations are conducted to assess measures, identify gaps, and make necessary adjustments. Action reviews occur at least every four years. Integration of climate data with other plans and programmes, such as the Smart City Technologies Master Plan and Data Salvador, enhances data accessibility and sharing. The plan incorporates specific indicators, including GHG emissions reduction and renewable energy deployment, to measure performance. Reporting frameworks ensure transparent communication and stakeholder engagement throughout the process.

Case study 2: MER for Mumbai Climate Action Plan

The Department of Environment and Climate Change in Brihanmumbai Municipal Corporation (BMC) encompasses seven verticals, one of which is Knowledge Management. Within this vertical, the MERL (Monitoring, Evaluation, Research, and Learning) cell is being established, consisting of a team of 24 climate officers representing the administrative wards and 11 departmental MER analysts linked to DMC offices within BMC. The Chief Scientist will lead the MERL cell, reporting to the DMC-Environment and the AMC-City. About Rs. 1 crore was allocated for the establishment of Climate Action Cell in February 2022. The cell's responsibilities include biennial updates of the GHG inventory and climate risk assessment. The cell will also monitor the progress of the Municipal Climate Action Plan (MCAP) against set targets, report on key performance indicators, and develop a system to capture learnings and progress. A nodal officer is appointed to coordinate with the departments. A data monitoring template is being prepared to monitor the performance of the department on climate actions. To ensure accountability and inclusivity, evaluations involving various stakeholders, including external organisations and impacted communities, will be conducted every five years. The results will be published for transparency and used to revise the baselines, targets, and trajectories in MCAP. The climate cell will also update the GHG inventory and climate risk assessment every two years, monitoring the city- and sector-wide impacts of CAP implementation, including residual emissions in meeting the 2050 net-zero target. A progress report on MCAP will be prepared every three years, evaluating indicators at multiple levels, and an updated MCAP will be developed every five years to maintain focus on the 2050 net zero target.

The Climate Action Cell will be responsible for managing the MER operations of the BCAP, and an Officer for Data and Knowledge Management will be in charge of the MER operations within the CAC. For the BCAP, the entire MER operational structure and tools will be designed based on three primary levels of MER operations, as follows.

1. **Action level:** This will be designed to monitor, evaluate and report progress of specific actions recommended under the BCAP against their planned outputs (see Table 20). The nodal officers for each sector in the CAC will coordinate with the departments/agencies responsible for a particular action to source necessary data,

information, and documentation required for monitoring progress from time to time, and update the same in the MER. The CAC should also put in place mechanisms to send updates on the progress of action to heads of agencies responsible for respective actions.

2. **Outcome level:** This is meant to monitor the desired outcome of climate actions against a set of KPIs for each sector (see Table 21). One nodal agency per sector can be identified, which will be responsible for collecting and collating data through primary and secondary sources to measure outcome KPIs. This agency will coordinate with other agencies associated with that sector as required and share KPI data inputs with the sector nodal officer in the CAC. The CAC will also put in place mechanisms to send sector-wise updates on the performance of outcome indicators to the heads of all stakeholder agencies from time to time.

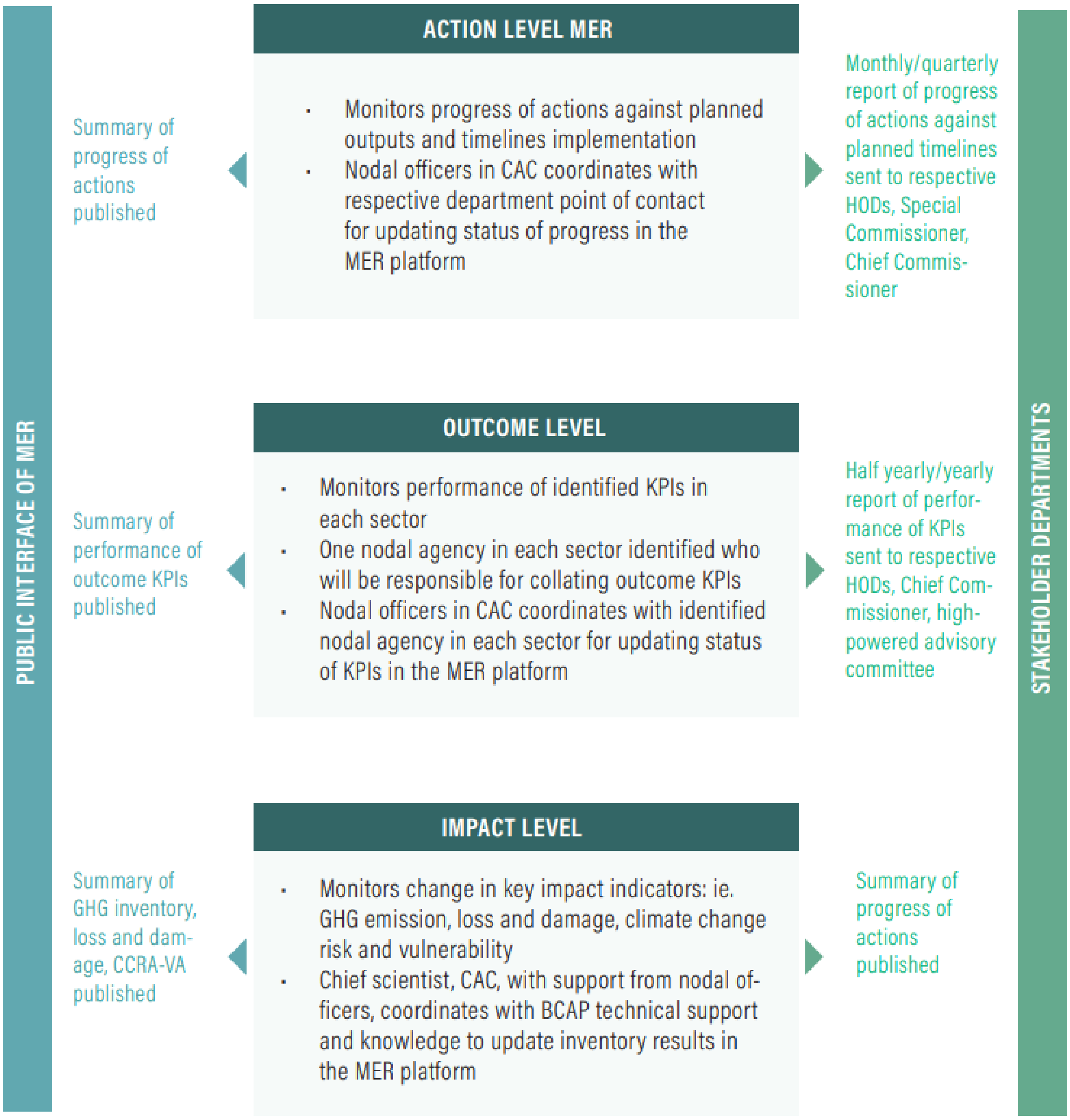
3. **Impact level:** This is meant for monitoring changes in the GHG footprint, climate change risks, and loss and damage from climate hazards that occur in the city from time to time (see Table 22). These activities (i.e., preparation of GHG inventory, CCRA-VA, and loss and damage inventory) are fairly technically heavy, time-consuming, and require their own sets of tools and methods. Hence, these activities will be anchored by the Technical Wing of the CAC. The CAC will coordinate with the technical wing to source data against select indicators from these exercises and update the same in the MER system.

The MER platform will be operationalised as a digital tool and will be managed by the Climate Action Cell. The data officer in the CAC will be overall in charge of the MER platform. The MER platform should have different interfaces for different users, with different access protocols such as below:

1. **Interface for entering data inputs and analyses** to be primarily accessible for CAC.
2. **Interface for tracking action progress, outputs, and outcome KPI performances,** a dashboard accessible to stakeholder departments. It should also send periodic notifications to heads of departments and senior executives on action and outcome KPIs and highlight issues relating to non-performance.
3. **Public interface,** a dashboard with select KPI performances (mainly impact indicators such as GHG emissions baseline, targets, risks, loss, and damage) to be commonly accessible by everyone.

The figure below provides a schematic illustration of this operational framework.

Figure 76 Schematic illustration of MER operations of the BCAP



Source: As identified by BBMP with the technical support of WRI India

It is to be noted that MER is a data-heavy process. Each stakeholder agency must identifiy a data officer in charge for coordination on all such data requirements for updating GHG inventory, loss and damage inventory, and for assessment of sector-wise KPIs. The nodal agencies responsible for sector-wise KPI evaluation will have to not only coordinate with relevant departments but make the process participatory to collect the inputs of external stakeholders such as community-based organisations, NGOs, research agencies, and other groups affected by the action. This step is critical to understanding progress on implementing climate actions (measured outputs), and their real outcomes and impacts relative to goals and objectives.

Photo Credit: Praseeda Mukundan/WRI India

8 WAY FORWARD

The Bengaluru Climate Action and Resilience Plan is not an end in itself, but a step towards mainstreaming climate action in the political, economic and civic discourse, that shapes the city's future. A strong political commitment to governance and financing of the BCAP in its early years will largely determine its success in the long term. The adoption of the BCAP by diverse stakeholders will require institutional alignment, coherence, and capacity across the decision-making value chain. Preparation of the BCAP saw a three-pronged consultative exercise involving a diverse range of stakeholders, at every stage of the process. Supported by an evidence-based approach, the BCAP is not restricted to mere notional suggestions on what needs to happen in the city but adopts a more critical data/research lens. The BCAP lays out an actionable roadmap that city agencies and ward committees could use to carve out localised interventions.

The seven sectors that have been identified to orient actions reflect the existing institutional set-up of the city, as well as the strong interdependencies certain sectors have on others. While such bucketing is useful for attributing action implementation responsibilities to one or more agencies, it is not sacrosanct and may need to be reoriented in line with future governance systems of the city as they evolve.

The identified actions have been framed carefully to make them implementable. At the same time, some of the actions will require further detailing to make them fundable projects. This is an important step where the suggested Project Preparation Facility would play an important role and help align those projects to available sources of finance.

Lastly, an informed discourse on city-level climate action is extremely critical for consensus-building amongst diverse actors who influence decisions and perceptions but who are not essentially aligned. It forms the foundation for a continuous process of dialogue and collective consensus-building that aims to make climate action a civic agenda by involving the bottom tier of government and other non-state local actors. Enabling access to resources and information on the BCAP, and to platforms for participation, will help aid this process, bring transparency and accountability, and instil a greater sense of ownership of climate actions amongst citizens of Bengaluru.

Photo Credit : Rajeev Malagi/WRI India

ANNEXURES

A. List of stakeholder departments/agencies consulted

1. Directorate of Urban Land Transport (DULT)
2. Bengaluru Metro Rail Corporation Limited (BMRCL)
3. Bengaluru Metropolitan Transport Corporation (BMTC)
4. Transport department
5. Karnataka State Road Transport Corporation (KSRTC)
6. Rail Infrastructure Development Company (Karnataka) Limited (KRIDE)
7. Bengaluru traffic police department
8. Bengaluru Police department
9. Indian Institute of Science (IISc)
10. Bangalore Water Supply & Sewerage Board (BWSSB)
11. Ground Water Directorate (GWD)
12. Water Resource Department (WRD)
13. Urban Development Department
14. Karnataka Forest Department
15. Karnataka Biodiversity Board
16. Environmental Management & Policy Research Institute (EMPRI)
17. Bangalore Development Authority (BDA)
18. Bangalore Electricity Supply Company Limited (BESCOM)
19. Karnataka Power Corporation Limited (KPCL)
20. Karnataka Power Transmission Corporation Limited (KPTCL)
21. Petroleum Planning and Analysis Cell (PPAC)
22. Karnataka Renewable Energy Development Limited (KREDL)
23. GAIL (India) Limited
24. Power Company of Karnataka Limited (PCKL)
25. The Energy & Resources Institute (TERI)
26. Karnataka Solar Power Development Corporation Limited (KSPDCL)
27. Department of Industries and Commerce
28. MSME Development Institute (DI)
29. Karnataka State Pollution Control Board (KSPCB)
30. Commissionerate of health and family welfare
31. Karnataka State Natural Disaster Monitoring Centre (KSNDMC)
32. India Meteorological Department (IMD)
33. District Disaster Management Authority (under Revenue Dept)
34. Karnataka State Remote Sensing Applications Centre (KSRSAC)
35. Central Ground Water Board (CGWB)

List of participants in the expert consultation

Session 1

- **Dr. A. Ravindra**, Former Chief Secretary, Government of Karnataka
- **Dr. J. Srinivasan**, Divecha Centre for Climate Change, Indian Institute of Science (IISc) (two articles on energy sent by email)
- **Dr. Kala Seetharam Sridhar**, Professor, Institute for Social and Economic Change
- **Meera K.**, Cofounder, Citizen Matters
- **Leo Saldanha**, Coordinator, Environment Support Group
- **Aneesh Mugulur**, Janaagraha
- **Dr. Krishna Raj**, Professor, Institute for Social and Economic Change
- **Dr. Indu K. Murthy**, Center for Study of Science, Technology and Policy (CSTEP)
- **Seema Mundoli**, Azim Premji University
- **V. Ramprasad**, Convenor of Friends of Lakes
- **Mahesh Kashyap**, Air Pollution Expert
- **Vishwanath S.**, Biome Trust
- **Jaya Dhindaw**, Program Director, Integrated Urban Development, WRI India

Session 2

- **Almitra Patel**, National Expert, Swachh Bharat Mission; Member, Supreme Court Committee for Solid Waste Management
- **Shekhar Prabhakar**, Hasiru Dala
- **Malini Parmar**, Solid Waste Management Round Table (SWMRT)
- **Som Narayan,** Carbon Masters
- **Poonam Kasturi**, Daily Dump
- **Sobia Rafiq**, Sensing Local
- **Siddharth Hande**, The Kabadiwala
- **V. Ramprasad**, Convenor of Friends of Lakes
- **B.S. Shivprasad**, The Engine Doc Energy Co.
- **Jaya Dhindaw**, Program Director, Integrated Urban Development, WRI India

Session 3

- **Dr. Lasya Gopal**, Area Convener, Centre for Impact, Evaluation and Energy Access (CIEEAB) Bangalore, The Energy and Resources Institute (TERI)
- **Saptak Ghosh**, Senior Policy Specialist, leads the Energy Efficiency and Renewable Energy domain, CSTEP
- **Anurag Tamhankar**, Director/Senior Architect, Biome Environmental Solutions
- **Kiran Bhagavatula**, Senior Manager, Technology Informatics Design Endeavour (TIDE)
- **Salman Dawood**, Governing Body Member, Confederation of Real Estate Developers Associations of India (CREDAI)
- **Deepak Krishnan**, Associate Director, Energy Program, WRI India

Session 4

- **Ashish Verma**, IISc Sustainable Transportation Lab (IST Lab), IISc
- **Satya Sankaran**, Founder Member, Urban Morph, Citizens For Sustainability (CiFoS) and Praja Research Analysis and Advocacy Group (Raag)

- **Shaheen Shasha**, Bengaluru Bus Prayanikara Vedike (BBPV)
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- **K.S. Aishwarya**, Consultant, Climate Policy, Shakti Sustainable Energy Foundation
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- **Almitra Patel**, National Expert, Swachh Bharat Mission; Member, Supreme Court Committee for Solid Waste Management
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Session 7

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- **Dr. Anjali Mohan**, Integrated Design
- **Brinda Sastry**, Adjunct Faculty, R V School of Architecture
- **Dr. Champaka Rajagopal**, Visiting faculty, Azim Premji University
- **Suhail Rahman**, MD & CEO, CoEvolve Estates and Governing Body Member of CREDAI
- **Dr. Harini Nagendra**, Azim Premji University (sent comments by email)
- **Dr. Priya Narayanan**, Program Manager – Urban Forestry, WRI India
- **Jaya Dhindaw**, Program Director, Integrated Urban Development, WRI India

Other experts consulted during the BCAP preparation process

- **Kathyayini Chamaraj,** Executive Trustee, CIVIC (sent comments by email)

B. GHG emission inventory

B.1. GHG accounting and reporting standards for cities

GHG and Global Warming Potential (GWP)

GHG is any gas compound in the atmosphere that is capable of absorbing infrared radiation and trapping heat. GHGs are responsible for the greenhouse effect, leading to global warming and climate change. Human activities result in increased GHG emissions. Every greenhouse gas has a global warming potential (GWP), which is a measure of how much heat the GHG can trap within the atmosphere and how much of an environmental impact it is expected to have. The GWP and the abundance of these gases staying in the atmosphere influence climate change (Connection 2014).

Table 23 provides the GWP as per 5AR.

Table 23: GHG and GWP as per 5AR

Name of the GHG	GWP (5AR)
Carbon Dioxide (CO2)	1
Methane (CH4)	28
Nitrous Oxide (N2O)	265

Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (*GHG-GPC)*

Every GHG has a different GWP, due to which it is difficult to rely on the typical air emission report to calculate the total GHG output. So, in order to calculate the emissions for the GHG inventory, conversion of the warming impact of the GHGs into one single metric is recommended. This is called the carbon dioxide equivalent (CO_2e) (Rabo 2020). The formula of CO_2e is mentioned below in *Equation 1*.

Equation 1: CO2 equivalent

$$CO_2e = GHG \times GWP$$

Here GHGs are – CO2, CH4, and N2O, which means - (mass of CO2 emitted x its GWP)+(mass of CH4 emitted x its GWP) + (mass of N2O emitted x its GWP)

GHG inventory operational boundaries

Scope framework: The GPC requires cities to report their emissions attributable to activities taking place within the geographic boundary of the city by categorising the emission sources into boundary sources. As per the GPC protocol, emissions are categorised into three scopes, as seen in

Table 24.

Table 24: Categorisation of emissions by scope

Scope 1 (Direct emissions)

- GHG emissions from sources located within the city boundary

Scope 2 (Indirect emissions)

- GHG emissions resulting from the use of grid-supplied electricity, steam, heating and/or cooling within the city boundary

Scope 3 (Indirect emissions)

- All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (*GHG-GPC)*

GHG reporting requirement

The framework provides two reporting levels demonstrating different levels of completeness as shown in Table 25 below.

Table 25: GPC framework reporting levels

BASIC LEVEL	BASIC+ LEVEL
Scope 1: Stationary Energy, Transportation and Waste (solid waste and wastewater)	**Scope 1:** Industrial Processes and Product Use (IPPU)
Scope 2: Energy and Transportation	**Scope 2:** Agriculture, Forestry and Other Landuse (AFOLU)
Scope 3: Exported waste	**Scope 3:** Stationary Energy and Transportation

Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (*GHG-GPC)*

GHG emission sources

The GPC identifies the sectors that should be applied to classify the GHG emission from cities as shown in Table 26 below.

Table 26: Sectors and sub-sectors

Sector	Sub-sector
Stationary Energy and buildings	Residential buildings
	Commercial and institutional buildings and facilities
	Manufacturing industries and construction
	Energy industries
	Agriculture, forestry and fishing activities
	Non-specified sources
	Fugitive emissions from mining, processing, storage and transport of coal
	Fugitive emissions for oil and natural gas systems
Transport	On-road Transport
	Railways
	Waterborne navigation
	Aviation
	Off-road Transport
Waste	Solid waste disposal at the landfill
	Biological treatment of waste
	Incineration and open burning
	Wastewater treatment and discharge (Domestic and Industrial)
Industrial processes and product use (IPPU)	Industrial processes
	Product use
Agriculture, Forestry and Other Land Use (AFOLU)	Livestock
	Land
	Aggregate sources and non-CO2 emission sources on land
Other Scope 3	

Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (*GHG-GPC)*

GHG emission inventory methodology

Emission calculation methodologies define the calculation formulas and necessary activity data and emission factors to determine total emissions from specified activities. The formula for calculating GHG emissions as per GPC is given in *Equation 2*.

Equation 2: GHG emission calculation

GHG emissions = Activity data x Emission factor

Here,

- Activity data is a quantitative measure of a level of activity that results in GHG emissions taking place during a given period (e.g., the volume of gas used, kilometres driven, tonnes of solid waste sent to landfill, etc.)
- An emission factor is a measure of the mass of GHG emissions relative to a unit of activity. Emission factors should be relevant to the inventory boundary, specific to the activity being measured, and sourced from credible government, industry, or academic sources. Emission factors may be activity-based, or life cycle-based.

B.2 Detailed Methodology of Sector-wise GHG Emission Calculations

Stationary Energy

Scope and Methodology

General overview of activity data and emission factors used that was appropriate for Stationary Energy sector was based on The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). GPC is a robust and clear framework that builds on existing methodologies for calculating and reporting city-wide GHG emissions (GPC GHG 2014).

Table 27: Methodology Reference

Sector	Emission Sources	Scope	Approaches	Activity Data	Emission Factors
Stationary Energy	Fuel consumption within BBMP boundary	1	Fuel consumption	Amount of fuel consumption	Mass GHG emissions per unit of fuel
	Consumption of grid supplied electricity within BBMP boundary	2	Grid electricity consumption	Amount of grid supplied electricity consumption	Mass GHG emissions per unit of grid supplied (Grid specific emission factor)

The GHG emissions from stationary energy is estimated by multiplying the activity data by an emission factor associated with the activity being measured as depicted in the above table. GHG emission estimation depends on the quantity and quality of data that are made available.

$$GHG\ Emissions = Activity\ X\ Emission\ Factor$$

Activity Data

The activity data was collected from three key agencies, BESCOM, PPAC, and GAIL. BESCOM is the distributor of the grid-electricity and GAIL is the supplier of the PNG and CNG. PPAC is the authentic official source for data on hydrocarbon sector in India and provides data on different types of fuel supplied in TMT[68] for Bengaluru Urban District. With the help of CSTEP's research paper CSTEP-RR-2022-4 (CSTEP 2022) we have gathered information on consumption of wood and charcoal/coal in Bengaluru.

All the activity data collected were aligning with the defined inventory period 2019. However, some activity data were not aligning with the defined inventory boundary. In this scenario, the data was adapted to meet the inventory boundary by adjusting for changes in the activity using a scaling factor. For instance, data provided by PPAC, and GAIL was for Bengaluru Urban District, and this was adapted to meet the inventory boundary using a suitable scaling methodology to scale down the data from Bengaluru Urban District to the BBMP boundary.

Population is one of the most common factors used to scale data because, in the absence of major technological and behavioural changes, the number of people is a key driver of GHG emissions, particularly in the residential sector. Whereas, to scale down the data pertaining to manufacturing industries and construction sector, the number of employees was considered. Data sets used for scaling methodology were estimated 2019 BBMP population and employee data from district industries centre.

Scaling methodologies were employed only in the scope 1 emission category, while for scope 2, i.e., consumption of grid electricity, the data was furnished and if not aligned with 100% accuracy but was closely aligned to BBMP boundary by BESCOM. Hence, no down scaling was considered for the data pertaining to scope 2 category.

Emission Factor

Emission factors should be relevant to the inventory boundary, specific to the activity being measured, and sourced from credible government, industry, or academic sources. If no local, regional, or country-specific sources are available, cities should use IPCC default emission factors or data from the Emission Factor Database(IPCC 2021).

Similarly, for Bengaluru GHG inventory there were no country-specific emission factors and it was necessary to rely on default IPCC emission factors. However, the emission factor for grid electricity has been calculated by the WRI and C40 team as the BESCOM had a good energy mix, and BESCOM was importing only an average of 26% electricity from the national grid in 2019. The table below lists all the emission factors used to calculate the GHG emissions for all activities included in the Bengaluru GHG inventory. The GWP value from the fifth assessment report (AR5) is used to convert quantities of GHGs to a shared unit (carbon dioxide equivalent, CO_2e) for direct comparison.

Table 28: Emission Factors used to Calculate Scope 1 GHG emissions

Fuel Type / Activity	Sectors	Default Emission Factors in Kg/TJ			Remarks
		CO_2	CH_4	N_2O	
LPG	Residential, Commercial / Institutional	63,100	5	0.1	-

[68] TMT is Thousand Metric Tonnes

Fuel Type / Activity	Sectors	Default Emission Factors in Kg/TJ			Remarks
		CO_2	CH_4	N_2O	
	Manufacturing Industries and Construction	63,100	1	0.1	-
PNG	Residential, Commercial / Institutional	56,100	5	0.1	-
	Manufacturing Industries and Construction	56,100	1	0.1	-
Petrol	Residential, Commercial / Institutional	69,300	10	0.6	-
Diesel Oil	Residential, Commercial / Institutional	74,100	10	0.6	-
	Manufacturing Industries and Construction	74,100	3	0.6	-
Kerosene	Residential, Commercial / Institutional	71,900	10	0.6	-
LNG	Manufacturing Industries and Construction	64,200	3	0.6	-
Residual Fuel Oil	Manufacturing Industries and Construction	77,400	3	0.6	-
Charcoal	Residential, Commercial / Institutional	*	200	1	(*) is not included in the total GHG emissions. As per GPC guideline, **biogenic CO2** shall be reported separately.
Wood	Residential, Commercial / Institutional	*	300	4	(*) is not included in the total GHG emissions. As per GPC guideline, **biogenic CO2** shall be reported separately.

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories - Chapter 2: Stationary Combustion

Table 29: Emission Factors used to Calculate Scope 2 GHG emissions

Fuel Type / Activity	Sectors	Calculated Emission Factor in Kg/kWh	Remarks
		CO_2e	
Electricity	All sub-sectors	0.6984	Emission factor for BESCOM grid electricity has been calculated by WRI India and C40 team

Limitations

- Gathered fuel data from PPAC was for Bengaluru Urban District and had to be scaled down it to BBMP boundary.
- Census data is available only until 2011 and the population 2019 was estimated and the same was used for scaling methodology.

- Limited information on the open access consumer and their respective supplier information. Hence, they are categorised in non-specified sources.
- Wood consumption by crematoria has been excluded due to lack of data.

Validation

During April 2022, BBMP had organised Departmental Convenings to review the GHG Emissions Inventory. The authors had presented the methodology and results of the stationary energy sector, which were validated by the departments, BESCOM, GAIL, and PPAC.

Results

The stationary energy sector accounts for 68% of total city GHG emissions, i.e., 1,28,39,662 metric tonnes CO_2e, and the contributions from its sub-sectors are listed in Table 30 below.

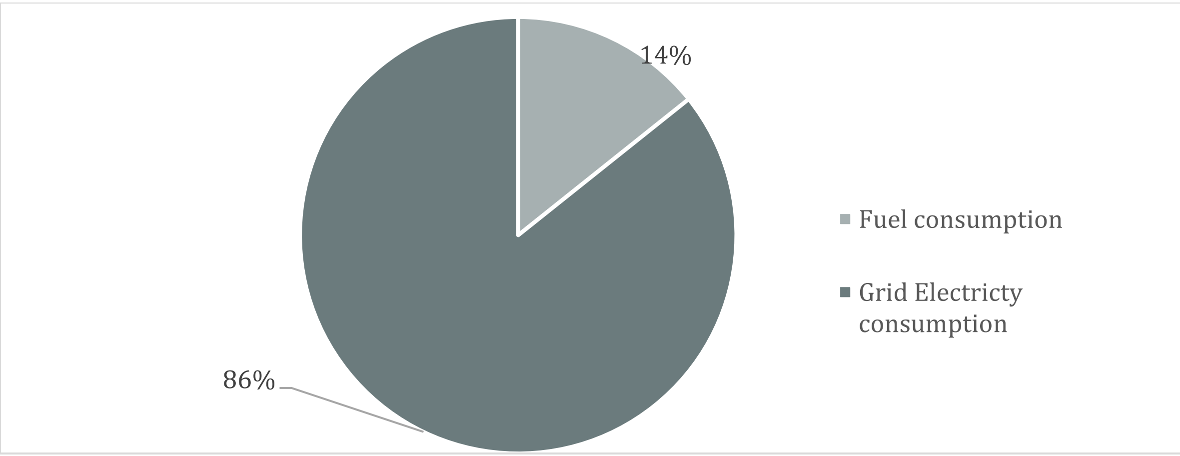
Table 30: Stationary Energy sector's GHG emissions

S.No.	Sub-Sectors	GHG emissions in metric tonnes CO_2e
1	Residential Buildings	49,74,844
2	Commercial and institutional buildings	49,14,976
3	Manufacturing industries and construction	11,37,093
4	Non-specified sources	18,12,749

Source: WRI Analysis based on Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GHG-GPC)

The major activity contributing to the GHG emissions in this sector is shown in the below Figure 77.

Figure 77: Key Activity contributing GHG emissions in Stationary Energy Sector



Source: WRI Analysis based on Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GHG-GPC)

Transport

Scope of the sector

The GPC categorises emission sources in the transport sector by transit mode. The modes are: on-road transport, railways, water-borne transport, aviation, and off-road transport. The city should identify the applicable transit modes and report emissions for these based on data available. GPC groups emissions into three categories based on where they occur. These categories are the three scopes mentioned in Table 31. For the BASIC reporting framework followed in Bengaluru, the city shall report all GHG emissions from combustion of fuels in transport occurring within the its boundary in scope 1; and GHG emissions from grid-supplied electricity used for transport within the city boundary for transport in scope 2.

For Bengaluru the transit modes applicable are on-road transport, railways, and aviation. However, the aviation sub-sector is not considered in this GHG inventory, as the Bengaluru International Airport is situated outside the study area i.e., BBMP jurisdiction (and it falls in scope 3 category, which is not considered in the BASIC reporting framework). Bengaluru doesn't have a suburban railway system at present and the share of city's population using railways as an intra-city mode of commute is very small. Considering this, the 'railways' category for this inventory includes only the Metro. Table 31 summarises the scope of transport sector in this GHG inventory for Bengaluru.

Table 31 Scope of Transport Sector for Bengaluru's GHG Inventory

Emission Source - Transport	Scope 1 *(From fuel combustion for transport occurring in the city)*	Scope 2 *(From consumption of grid-supplied energy for in-boundary transport)*	Scope 3 *(From portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid supplied-energy)*
On-Road Transport	Yes	Yes	No
Railways *(only metro included)*	Yes	Yes	No
Water Transport	Not Applicable	Not Applicable	No
Aviation	Not Applicable	Not Applicable	No
Off-Road Transport	Not Applicable	Not Applicable	No

Source: WRI Analysis based on Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GHG-GPC)

Legend:	
Yes	Included in the inventory
Not Applicable	Not applicable to Study Area
No	Not included in the Basic reporting framework

Railway System in Bengaluru:

- Bengaluru doesn't have a Suburban Railway system at present. The Bengaluru Suburban Rail Project (BSRP) is an upcoming project, implemented by Rail Infrastructure Development Company (Karnataka) Limited (K-RIDE).
- At present there are **22 Railway Stations** within BBMP area extending from:
    - Kengeri to Whitefield (in the East-West direction; length is approx. 35 km)
    - Yelahanka Jn, Chikkabanavara to Carmelaram (in the North-South Direction; length is approx. 33 km)
- For the FY 2019-20, only **16% of the passenger trips** within Bangalore Railway Division covers a **trip distance below (and equal to) 35 km**. Trip distance of rest of the trips are more than 35 km[69].
- Additionally, Bangalore Railway Division – the area to which the above data corresponds – is vast compared to the BBMP area (which covers other towns and cities).
- These implies that the 16% of passenger trip distance which covers 35 km or less is not the figure for the BBMP area specifically. From this, it can be assumed that for BBMP area this figure will be much lower than 16%. Hence, the share of population using Railways as a mode of intra-city commute within BBMP limits is very low.

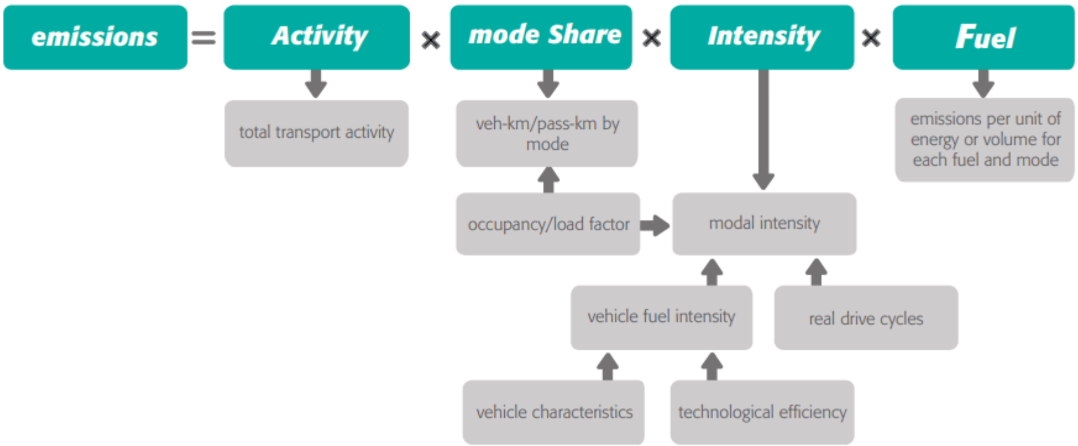
Approach

The methodologies for estimating transport emissions can be broadly categorised as top-down and bottom-up approaches.

- **Top-down** approaches start with fuel consumption as a proxy for travel behaviour. Here, emissions are the result of total fuel sold multiplied by a GHG emission factor for each fuel.
- **Bottom-up** approaches begin with detailed activity data. Bottom-up approaches generally rely on an ASIF framework for determining total emissions (see Figure 78).

Figure 78 ASIF Framework

[69] Based on the RTI response (No. C. 180/RTI/Corres. 130/AM/2021-22) on distance slab-wise detail of net tickets issued (suburban/non-suburban) in UTS Report of Bangalore Division financial year 2019-2020

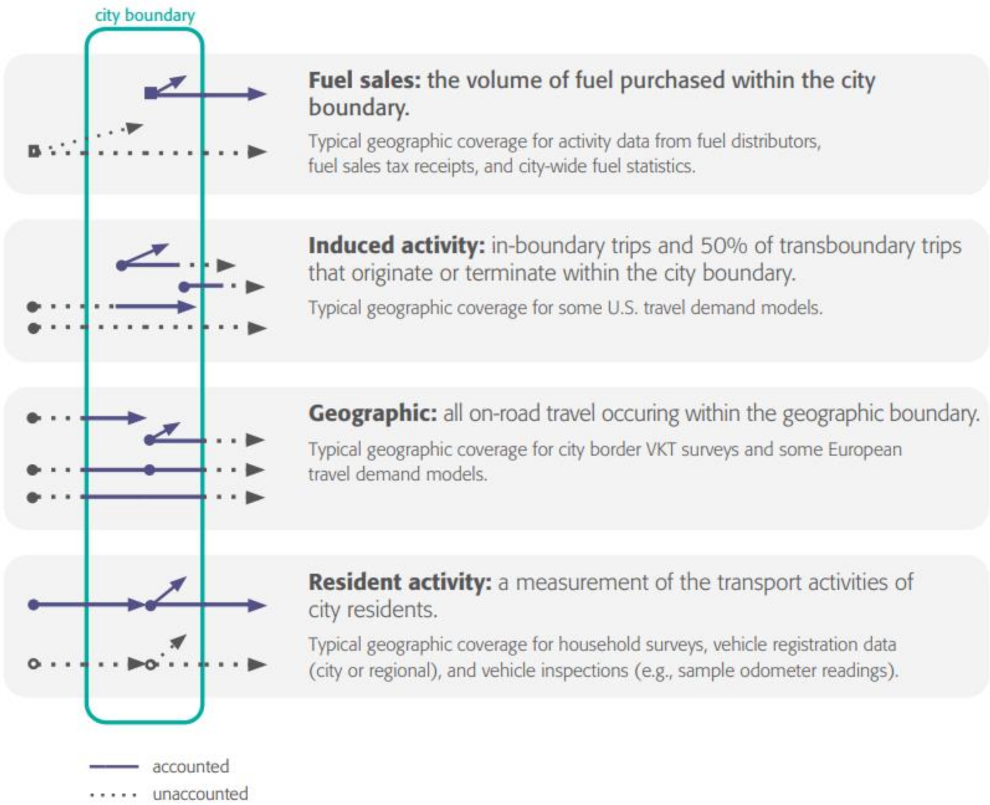


Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (*GHG-GPC)*

Figure 79 illustrates the types of transport activity reflected in each of the above methods. Fuel sales method is a top-down approach. The bottom-up approach includes: 1) Induced Activity, 2) Geographic and 3) Resident Activity methods. The methods followed for calculating GHG emissions for the modes considered in Bengaluru's GHG inventory are:

- *Fuel Sales Method* for Railways, and
- *Induced Activity Method* for On-Road Transport

Figure 79 Methodology system boundaries



Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (*GHG-GPC)*

Methodology

1. ***Formula:***

In general, emissions are calculated by multiplying 'Activity Data' with respective 'Emission Factor'.

For *Fuel Sales(/consumption) Method*, the following formula (Equation 3) was applied:

Equation 3 Emission calculation using Fuel Sales Method

$$E_i = \Sigma \underbrace{Fuel_{j,k}}_{\text{Total Fuel consumed by all modes}} \times \underbrace{E_{i,j}}_{\text{EF (fuel based)}}$$

E_i=Emission of compound (i)
$Fuel_{j,k}$= Consumption of fuel (j) for transport type (k)
$E_{i,j}$=Emission factor for compound(i) emitted from fuel (j)

Source: (T. V. Ramachandra and Shwetmala 2009)

For *Induced Activity Method*, the formula given below (Equation 4) is applicable. However, since there were challenges in arriving at the 'Vehicle based' Emission Factors for all vehicle categories, the VKT[70] for modes were converted to corresponding fuel consumed. This volume of fuel consumed was then multiplied with the 'Fuel based' Emission Factor to arrive at the emissions from On-Road Transport.

Equation 4 Emission calculation using Activity Method

$$E_i = \underbrace{\Sigma(Veh_j \times D_j)}_{\text{Total VKT of all modes}} \times \underbrace{E_{i,j,km}}_{\text{EF (vehicle based)}}$$

E_i=Emission of compound (i)
Veh_j=No. of vehicles per type (j)
D_j=Distance travelled in a year per different vehicle type (j)
$E_{i,j,km}$=Emission of compound(i) from vehicle type (j) per driven kilometre

Source: (T. V. Ramachandra and Shwetmala 2009)

2. ***Data Sources and Limitations:***

Data on transport activity and fuel consumption were arrived at based on the following sources:

- Comprehensive Mobility Plan for Bengaluru, 2020 (CMP)
- Vehicle registration data from the Parivahan portal of the Transport Department
- Google Environmental Insights Explorer (EIE)
- Primary data provided by BMRCL and BMTC

[70] Vehicle Kilometres Travelled

- Secondary sources (published reports and papers)

The fuel-based emission factors considered here are given in Table 32.

Table 32 Emission factors used for calculating transport sector GHG emissions

Fuel Type / Activity	Default Emission Factors in Kg/TJ		
	CO_2	CH_4	N_2O
Diesel	74,100	10	0.6
Petrol	69,300	10	0.6
CNG	56,100	5	0.1
LPG	63,100	5	0.1
Electricity	Electric vehicular modes (on-road and railway-metro) are powered by electricity generated at stationary power plants as well as other sources. Hence, the emissions factor for this will be same as that of Stationary Energy sector (refer to Stationary Energy section for the factors)		

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories - Chapter 2: Stationary Combustion and Chapter 3: Mobile Combustion

Since data required were taken from multiple sources, there were few limitations in the datasets. The year and the area for which the data was sourced were different for each of the sources (Table 33 depicts this). Additionally, the nomenclature of vehicle modes were different in each of the sources. These were tackled by adopting the most pragmatic way such as extracting data for RTOs within BBMP boundaries, following the nomenclature prescribed by the CMP, proportionately scaling the values down to CAP study area and similar.

Table 33 Features of Data Sources

Data Source	Data/Study Area	Data Year
CAP requirement	BBMP	2019
CMP	BMA*	2016
Parivahan portal (Transport Department)	RTOs	Till date (year-wise data available)
Google EIE	(1,649.252 km^2)	2019

Source: Compiled by WRI India

3. ***Methodology:***

The steps involved in calculating the GHG emissions from Bengaluru's transport sector are given in Table 34 below.

Table 34 Methodology adopted for calculating transport sector GHG emissions for Bengaluru

Step No.	Description	Data Sources
Step 1:	Arrive at the Total no. of trips for each mode	EIE, CMP
Step 2:	Arrive at Average Trip Length for all modes	CMP
Step 3:	Calculate the Annual VKT for each mode [VKT = No. of Trips for each mode x Average Trip Length]	EIE, CMP, primary data from BMRCL and BMTC
Step 4:	Distribute the Annual VKT for each mode into different fuel categories with each mode	Parivahan portal
Step 5:	Arriving at fuel efficiencies for all modes (based on fuel type)	Secondary sources – Literature review, market estimates, international proxies
Step 6:	Calculating the Total Fuel Consumed by each mode (based on fuel type) [Total Fuel Consumption = Annual VKT each mode (with Fuel breakup) ÷ Fuel Efficiency (for each category)]	Calculations based on above sources; primary data from BMRCL and BMTC
Step 7:	Calculating emissions for each mode (based on fuel type) using CIRIS tool [Emissions = Total Fuel Consumption * Emission Factors]	Calculations based on above sources

Source: WRI India Analysis

4. ***Validation:***

The methodology and results were validated by Prof. Ashish Verma (Indian Institute of Science, Bengaluru), who co-authored the *Climatrans study* (Verma, Vajjarapu, Hemanthini 2018)[71]. The author also validated the results at intermediate stages with published studies and reports[72]. During April-May 2022, BBMP had organised Departmental Convenings to review the GHG Emissions Inventory. The author had presented the methodology and results of the transport sector, which were validated by the departments[73].

Results

The total GHG emissions from Bengaluru's transport sector are **3.87 MMT CO_2e** for 2019. On-road transport is responsible for 98% of this and Railways are responsible for the remaining 2% of the transport sector emissions (refer to Table 35). Analysing the mode-wise contributors, it is the diesel-run freight, petrol-run motorcycle and diesel-run buses which are the major emitters. Figure 80 illustrates this.

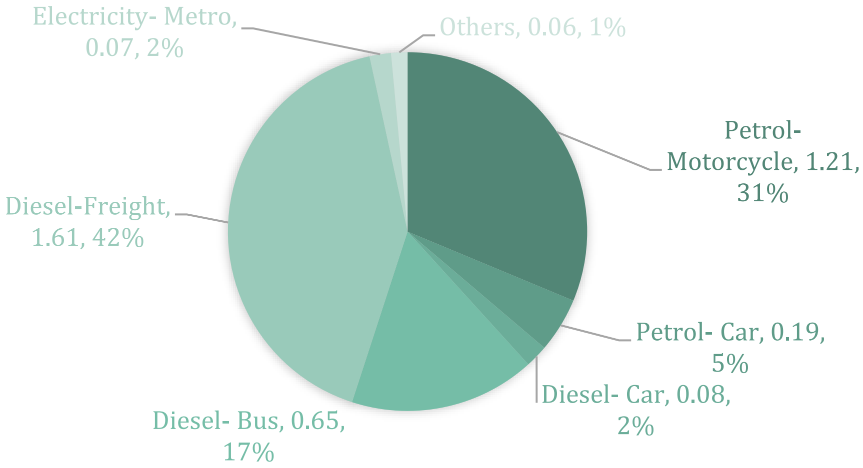
Table 35 Transport sector GHG emissions

Sub-Sectors	GHG emissions in metric tonnes CO2e
On-road transport	38,00,004
Railways	74,861
TOTAL	38,74,865

[71] Climatrans was the only other study that calculated Bengaluru's transport sector emissions based on 2008 data for BMR. This was referred to by the authors to validate the VKT and emissions.
[72] VKT calculated was cross checked by validating with other published studies/reports such as Climatrans paper, Emissions data published by Google EIE, Bangalore Mobility Indicator, CTTS.
[73] BMRCL, BMTC, Transport Department, DULT

Source: WRI India analysis for BBMP jurisdiction based on GHG-GPC framework

Figure 80 Mode-wise contributors of transport sector emissions (in MMT CO_2e)



Source: WRI India analysis for BBMP jurisdiction based on GHG-GPC framework

Waste

Scope of the sector

Waste management contributes to GHG emissions in the form of CH4, N2O, and CO2 gases due to activities like collection, treatment and disposal of solid waste and wastewater. Methane is responsible for around 30% of the current rise in global temperature(IEA 2022) Landfills contribute to higher methane emissions due to the anaerobic decay of organic material in landfills. Large historic methane emission reductions reported to the United Nations Framework on Climate Change Convention (UNFCCC) have been related to landfills. his shows that presence of biodegradable waste in the municipal solid waste landfills is the major contributor if methane emissions. Hence, there is a need to reduce emissions from landfills that contribute to most of the methane emissions from the waste sector. Wastewater emissions are due to aerobic treatment and discharge of untreated water. Hence, to understand the scale of emissions from the waste sector in Bengaluru, the emissions from municipal solid waste (major focus on biodegradable waste) and domestic wastewater treatment methods and discharge were assessed for the preparation of GHG emission inventory. This inventory is prepared in accordance with "The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)" The emission sources and approach categorised in the GPC for waste sector are considered to prepare the inventory for Bengaluru city.

Table 36: The emission sources and approach categorised in the GPC for waste sector:

Emission source	Scope	Approach	Activity data	Emission factor
Solid waste disposal into landfills	1	Methane commitment method	Amount of waste received at landfill sites and its composition	Methane generation potential of the waste
Biological treatment of solid waste	1	Waste composition approach	Mass of organic waste treated	Mass GHG emission per unit of organic waste treated, by treatment type
Incineration and Open Burning	3	Waste composition approach	Mass of waste incinerated	Oxidation factor, by type of treatment
Domestic wastewater treatment and discharge	1	Organic content-based approach	The organic content of wastewater per treatment	Emission generation potential of such treatment type

The scopes mentioned in the above table are categorised based on the scope framework mentioned in the Chapter 2. Bengaluru waste sector GHG emission inventory is based on the BASIC reporting framework provided by GPC. The GHG emissions from waste sector are estimated by multiplying the activity data by an emission factor associated with the activity being measured as depicted in the above table. GHG emission estimation depends on the quantity and quality of data that are made available.

Activity data

The GHG emission inventory is prepared in line to the reporting tool requirements of the waste sector for Bengaluru city. The activity data requirements in the reporting tool focuses on municipal solid waste disposal to landfill, biological treatment of waste, incineration or open burning of waste and wastewater treatment and open discharge. Hence, the data collection for the emission inventory was focused on reporting tool requirements alone. No other sub-sector beyond the above-mentioned sub sectors was considered.

Data inclusions

- Municipal solid waste generated within the city is considered for emission inventory. The definition and components of municipal solid waste mentioned in the GPC that is consistent with IPCC guidelines only are considered for the inventory.
- Composting and Anaerobic digestion of biodegradable waste.
- Clinical waste and hazardous waste incineration
- Domestic wastewater generated in the city. This includes waste water being treated in the public STPs and untreated water discharge.
- Census data is available only until 2011 and the population 2019 was estimated and the same was used
- Only public STPs data was available to perform domestic wastewater treatment inventory.

Data exclusions

- Any other waste beyond what is mentioned in the data inclusion is excluded from the GHG emission inventory due to a lack of substantial emissions from other wastes. Also, legacy waste disposal is not included as the inventory is prepared for annual generation alone.
- As the city does not have solid waste incineration, this is excluded. As there is no substantial data on sewage sludge and fossil liquid, these have not been attempted. As per BBMP, there is no open dump of waste with in the BBMP boundary, hence this is not considered.
- Industrial waste water treatment was not considered because to perform industrial wastewater emission estimates, total product production per annum, COD per annum, CH_4 recovery, sludge removal and treatment methods etc. of each industry with in the city was required and the date for each component could not be made available. Without even a single component, the inventory could not be performed in the reporting tool due to its standard mandatory requirements.

Data points considered for the GHG emission inventory are provided in the Table 37

Table 37: Data points considered for the GHG emission inventory

Sub-sector	Component	Data point	Source
Solid waste disposal into landfills	Solid waste disposed into the landfill	2363 Tons per day (TPD) (43.76% of total waste generated) (includes bulk waste generators)	BBMP, 2019

	Solid waste composition	Vegetable waste – 35% Garden/park waste – 26% Plastic – 12% Paper – 8% Debris – 5% Textiles – 4% Cardboard – 4% Glass – 3% Sanitary – 2% Rejects – 1%	(Naveen and Puvvadi 2020)
	Type of Landfill	Uncategorised Only one active landfill in Mitaganahalli, Bengaluru (quarry pit with lack of scientific gas capture)	IPCC guidelines, Chapter-3
Biological waste treatment	Total wet waste generated	3294TPD (61% of total waste generated) (includes bulk waste generators)	BBMP, 2019
	Composting	1933TPD	BBMP, 2019
	Anaerobic digestion	35 TPD	BBMP, 2019
Incineration and open burning	Clinical waste incineration	34.6 TPD	KSPCB, 2019
	Hazardous waste incineration	13.3 TPD	KSPCB, 2019
Domestic wastewater treatment and open discharge	Wastewater treatment	64%	BWSSB, 2019
	Untreated wastewater discharge	36%	BWSSB, 2019
	Predominant treatment method	Aerobic treatment (well managed)	

GHG sources and sinks

As per GPC requirements,

- Solid waste disposed into the landfill leads to emissions driven by increasing population with higher waste generation, changing waste composition and lack of scientific landfill with gas capture. Wet waste predominantly contributes to GHG emissions and without scientific landfill gas capture, the emissions from the landfills are higher as 24.55% of total 43.76% of landfill waste is wet waste in Bengaluru.
- The biological treatment of waste refers to composting and anaerobic digestion of organic waste, such as food waste, garden and park waste, sludge, and other organic waste sources. Biological treatment of solid waste reduces overall waste volume for final disposal (in landfill or incineration) and reduces the toxicity of the waste.

- Incineration is a controlled, industrial process, often with energy recovery where inputs and emissions can be measured and data is often available and refers to clinical, industrial, solid waste , sewage sludge, fossil liquid. By contrast, open burning is an uncontrolled, often illicit process with different emissions and can typically only be estimated based on collection rates. Compared to solid waste disposal, incineration has lesser GHG emissions.
- Domestic wastewater and discharge leads to emissions driven by increasing population, lack of adequate management of aerobic treatment and wastewater discharge (untreated), septic tanks etc.

Predominant GHG: The reporting tool analyses three predominant GHGs: methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2).

Emission factor

As there are no specific emission factors, standards or related coefficients for emission calculation for Bengaluru city/state wide/nationwide, the emission estimates were prepared using the reporting tool (CIRIS) by relying on the GPC and default IPCC Guidelines, Volume-5: Waste(IPCC 2006), Chapters-3, 4, 5 and 6 respectively.

Validation

In the month of April-May 2022, BBMP had organised Departmental Convenings to review the GHG emissions inventory for waste sector. The authors had presented the methodology and results of the waste sector to respective agencies for validation. BBMP acknowledged the inventory and BWSSB has validated the inventory. KSPCB requested to submit a detailed methodology of the inventory. The methodology was prepared by the author, reviewed by C40 cities and was submitted to KSPCB.

Results

The waste sector contributes to about 2.02 million metric tonnes of CO_2e (which is 11 percent of the total GHG emissions of the city). Table 38 provides the waste sector emissions in Bengaluru, 2019.

Table 38: Outline of waste sector emissions in Bengaluru, 2019

S.No	Sub-Sectors	GHG emissions in metric tonnes CO_2e
1.	Solid waste disposed into landfill	9,67,363
2.	Biological treatment of solid waste	1,35,458
3.	Incineration and open burning	297
4.	Domestic wastewater treatment and discharge	9,18,108

Source: WRI India analysis for BBMP jurisdiction based on GHG-GPC framework

B.3 Methodology for estimating carbon sinks using I-Tree Canopy Tool

The general steps for calculating the GHG fluxes associated with trees outside forests is prescribed in Global Protocol for Community-Scale Greenhouse Gas Inventories, GPC supplemental Guidance for Forests and Trees, WRI 2022 (GPC GHG 2014) . The document consists of case studies from different countries like Brazil, Mexico, Indonesia, India (Mumbai). It involves the calculation of activity data (Gross tree canopy denseness lost over the period and Area of tree canopy cover maintained and/ or gained in the horizon year from for the base year of an inventory period), development of emission and carbon removal factors and the calculation of GHG fluxes. Preparation and assigning of activity data is done using I-Tree Canopy (i-Tree tool), a web application.

[1] **Background:** I-Tree Canopy is a web tool that allows users to simply photo-interpret Google aerial photographs to provide statistically valid estimates of tree, as well as calculate the uncertainty of their estimations (Standard Error, SE). I-Tree Canopy can be used wherever in the world where high-resolution, cloud-free Google pictures are available.

Methodology: Random points are placed in the defined area of interest and the user identifies the land cover class at the point centre. The application will provide estimation results during the interpretation process, and the user is free to define any cover classes they like. The results and point data can be exported for use in other applications.

Caveats: Analysis only focuses on tree canopy cover as a reference to biomass and does not take into consideration the entire biome - terrestrial ecosystems including soils, tree species, biodiversity etc. The user's capacity to accurately assign each point to its appropriate class determines the analysis's reliability. In order to be appropriate for analysis, the classes must be interpretable from an aerial photograph. The precision of the estimate will improve as the number of points increases, while the estimate's standard error will drop. The standard error will be too high if there are not enough categorised points in order to have any actual certainty about the estimate. Another drawback of this method is that due to relatively low image resolution (e.g., image pixel size), environmental conditions, or poor image quality, the Google imagery may be challenging to understand in all locations.

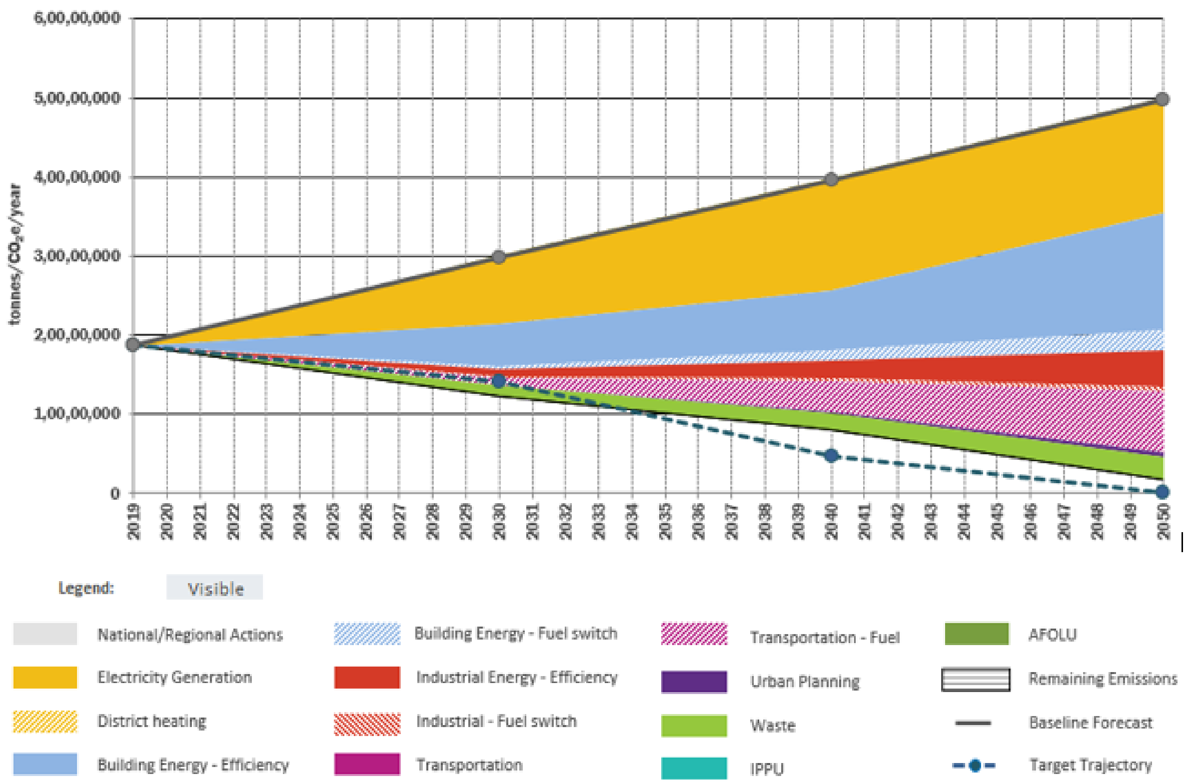
The emission factor derived from Forest Survey of India's Carbon Stock reports (MoEFCC) of urban trees in Bengaluru is 9.96 MgC/ha. IPCC default settlement chapter of 2019 refinement, Table 8.1 states that urban trees remove carbon at a rate of 2.8 MgC/ha/year. Standing tree canopy cover (maintained) over the inventory period and the newly planted tree canopy cover (gained) over the inventory period have the ability to remove atmospheric carbon. Both standing tree canopy cover and newly planted tree canopy cover are therefore evaluated collectively for the purpose of calculating total carbon removed from atmosphere. However, the removal/loss of tree canopy cover also contributes to carbon emissions.

C. Extended Scenario and Sector-wise Barrier Analysis

GHG emission reductions relative to the base year:

Year	Existing and Planned	Ambitious Scenario	Extended Scenario
2030	- 22 %	16 %	34 %
2040	- 44 %	26 %	58 %
2050	- 58 %	56 %	91 %

Extended Scenario Pathways Result:



Barrier Analysis

__Barrier description table:__ Complete a barrier description table for each extended strategy. Identify for each strategy, the types of barriers that could potentially affect the strategy implementation and provide further detail for each type.

Strategy #1	Achieve 100% Decarbonisation of the Electricity Grid by 2050. A three-fold rise in nuclear-installed capacity by 2032)(UNFCCC 2022b)
Status Under Ambitious Scenario	Under the Ambitious Scenario, the proportion of the city's grid electricity is derived from non-fossil fuels: By 2030: 68 % By 2040: 78.87 %

	By 2050: 89.76 %
Strategy description/ Assumptions	For an extended scenario, an increase in the share of non-fossil fuel in the city's grid electricity is considered to be: By 2030: 73.03 % By 2040: 88.87 % By 2050: 100 %
Barrier	**Description of Barrier**
Legal and Institutional	• Land acquisition has been a challenge for the state over the past decade despite this being pointed out as one of the main barriers to Renewable Energy growth in Karnataka (Sudhakar, Pooja Vijay Ramamurthi, and Radhika Sharma 2014). • Government revenue lands are exhausted. • Presently, agricultural land cannot be bought by private players without conversion to non-agricultural land.
Financial and economic	• Increased procurement of renewable power in the power purchase mix of BESCOM (a distributing company) in recent years, has led to the backing down of long-term thermal stations, wherein BESCOM would continue to pay the fixed/agreed charges in long-term contracts, which in turn could lead to increase in power purchase cost per unit (ICRA 2022). Most distribution utilities are making major losses as a consequence of expensive long-term power purchase agreements (Regy et al. 2021). • Financing a just transition will require supporting social and physical infrastructure, ecological restoration of affected areas, building capabilities of communities, and seeding new livelihood-generating activities. The challenge is compounded by the high capital requirements of other sectors and the relatively high cost of capital in India.
Political and social	• India's target date for net zero is 2070 and Karnataka State does not have any plan for full decarbonisation of the grid before 2070. • City / BBMP has no control over the state and national grid. Renewable energy targets are set by state and national government departments and procurement notices are given by the Government of Karnataka to BESCOM.
Practical and technological	• Potential grid congestion between power production sites and load centres. • Decentralised grid-connected renewable power stations are difficult as current national and global experience shows the key importance of the large-scale deployment of RE installations in areas where conditions are favourable. • .In the absence of domestic production, higher dependence on renewable energy can lead to higher import dependence which consequently can threaten energy security.
Other (please specify)	NA
Actions proposed in CAP to mitigate barriers	• Ensure implementation of utility-scale energy storage for load or supply, to enhance the power generation flexibility of rooftop solar systems and other renewable energy (RE) sources. • Ensure by 2035, 50% of BESCOM's grid electricity is sourced by a decentralised renewable resource network while enhancing the service delivery potential. • Conduct IEC campaigns to sensitise financiers such as banks to provide low-cost loans for the uptake of green technologies and

	business models. (For example, renewable energy projects have been included under Priority Sector Lending (PSL), including off-grid renewable energy solutions for households, solar power generators, windmills, micro-hydel plants, and non-conventional energy-based public utilities (RBI, 2021)

Strategy #2	Achieve 50% improvement in industrial energy efficiency
Status Under Ambitious Scenario	Under the Ambitious Scenario the % improvement in industrial energy efficiency: By 2030: 15 % By 2040: 20 % By 2050: 25 %
Strategy description/ Assumptions	For an extended scenario, an increase in % improvement in industrial energy efficiency is considered: By 2030: 25 % By 2040: 40 % By 2050: 50 %
Barrier	**Description of Barrier**
Legal and Institutional	• Difficult affair to implement regulatory and reporting frameworks and implement compliance-based targets for MSMEs that is unorganised in nature.
Financial and economic	• Despite many schemes and programmes to financially support MSMEs to transition to greener alternatives, most are, firstly, unaware of these opportunities, and secondly, do not consider the change a priority. Challenging due to smaller scales of production. • The provisions that have been made to make finance available for the MSMEs to improve energy efficiency and promote the use of renewable energy do not take the complexities of being part of a larger supply chain. • CAPEX requirement for energy efficiency projects (especially for MSMEs). High capital requirement - electricity-based technologies invariably require a higher initial investment in comparison to fossil fuel-based technologies.
Political and Social	• Although institutions have been created to operate independently, political intrusion often makes them weak. There are challenges that emerge due to the federal political structure of the country and the positioning of energy as a concurrent item in the Indian constitution(ADBI 2020).
Practical and technological	• Availability of commercially viable technologies for MSMEs is a critical issue. • MSMEs have limited handholding in terms of active technical assistance in order to adopt new technologies.
Other (please specify)	• Many industries are so fragmented that incentives to build end-to-end circular and efficient value chains are ineffective. • MSMEs are an unorganised and informal nature sector. There are several MSMEs that are not registered and functional.
Actions proposed in CAP to mitigate barriers	• Enforcing mandatory shift to electric motor-driven systems for both PAT and Non-PAT industries.

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- Skill development of the workforce on new energy efficiency, sustainable mobility, and green hydrogen technologies will be needed. Stakeholders' knowledge of climate finance structures, policies, and the various instruments across MSME clusters is limited.
- Build the knowledge capacity of the shop floor technicians pertaining to energy efficiency practices in the MSME units.
- Developing and installing waste heat recovery and co-generation units specifically developed for MSMEs.
- Mandatory audits on MSME heavy machinery and assess motor body temperature, vibration, rpm, etc., on monthly basis.
- Subsidising high-cost imported technology for the direct consumers who opt and implement the Energy Efficiency technologies.
- Establishing ‘energy management cells’ at the MSME cluster levels and promoting the development of an Ecosystem for “Zero Defect Manufacturing” in MSMEs.

</td></tr>
</table>

<table>
<tr><th>Strategy #3</th><th>Achieve a 90% transition to electric cooking in both residential and commercial buildings by 2050</th></tr>
<tr><td>Status Under Ambitious Scenario</td><td>Under the Ambitious Scenario the % transition to electric cooking:
<table>
<tr><td>Year</td><td>Residential</td><td>Commercial</td><td>Informal</td></tr>
<tr><td>2030</td><td>26%</td><td>42%</td><td>20%</td></tr>
<tr><td>2040</td><td>32%</td><td>47%</td><td>22%</td></tr>
<tr><td>2050</td><td>38%</td><td>52%</td><td>26%</td></tr>
</table></td></tr>
<tr><td>Strategy description/ Assumptions</td><td>For an extended scenario, an increase in % transition to electric cooking:
<table>
<tr><td>Year</td><td>Residential</td><td>Commercial</td><td>Informal</td></tr>
<tr><td>2030</td><td>50%</td><td>62%</td><td>28%</td></tr>
<tr><td>2040</td><td>75%</td><td>81%</td><td>36%</td></tr>
<tr><td>2050</td><td>90%</td><td>90%</td><td>50%</td></tr>
</table></td></tr>
<tr><th>Barrier</th><th>Description of Barrier</th></tr>
<tr><td>Legal and Institutional</td><td></td></tr>
<tr><td>Financial and economic</td><td>

- One major challenge is the ability to pay for the increase in electricity costs for low-income groups.
- eCooking is more cost-effective than LPG only for households getting cheap electricity(CEEW 2021).

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<tr><td>Political and Social</td><td>

- Cultural resistance to induction cooking, there’s a belief that even if you use the same cooking condiments modern appliances change the taste of food.
- There are groups of people who want to retain the traditional cooking methods along with the traditional cooking stoves.

</td></tr>
<tr><td>Practical and technological</td><td>

- Absence of responsive after-sales services.
- Aggregation of mass adoption of induction cooking / electric cooktops increase the electricity demand and poses a risk to the grid transmission structure.

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<tr><td>Other (please specify)</td><td></td></tr>
</table>

Actions proposed in CAP to mitigate barriers	• Incentivise with higher subsidies for faster adoption of eCooking • Develop policies concentrating on reducing the upfront cost of eCooking devices • Ensure reliable electricity supply at affordable tariffs to drive the eCooking transition • Promote health benefits and a healthy cooking lifestyle of eCooking • Promote the uptake of electric cooking by demonstrating electric cooktops don't alter the flavours of the cooking

Strategy #4	Accelerate vehicular fuel shift to increase cleaner fuel (Electric and Hydrogen) adoption to 100% by 2050
Status Under Ambitious Scenario	Under the Ambitious Scenario, by 2050, the following are the projected shift to cleaner fuels (Electric and Hydrogen)

Mode	2030		2040		2050	
	EV	H2	EV	H2	EV	H2
Car	10%	0%	58%	2%	85%	5%
Freight (MDT)	6%	2%	22%	5%	37%	10%
Motorcycle	30%	0%	60%	0%	90%	0%
Taxi	10%	0%	58%	2%	80%	5%
Autorickshaw	20%	0%	50%	0%	85%	0%
Bus	10%	2%	35%	5%	65%	10%

Strategy description/ Assumptions	Accelerate vehicular fuel shift actions to accelerate adoption of cleaner fuels (Electric and H2) in the city and achieve 100% shift away from fossil fuels by 2050

Mode	2030		2040		2050	
	EV	H2	EV	H2	EV	H2
Car	15%	1%	65%	5%	90%	10%
Freight (MDT)	10%	5%	40%	15%	50%	50%
Motorcycle	35%	0%	70%	0%	100%	0%
Taxi	15%	1%	65%	5%	90%	10%
Autorickshaw	25%	0%	60%	0%	100%	0%
Bus	20%	5%	50%	15%	60%	40%

Existing Policy at state level	• Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME 2) scheme by MHI (GoI) • Subsidy provided by Government of Karnataka for purchase of EV to public bus operators • Grand challenge for deployment of E-buses by Convergence Energy Services Limited (CESL), a PSU under Ministry of Power • Karnataka Electric Vehicle and Energy Storage Policy 2017 • Green Hydrogen Policy, 2022 under the National Hydrogen Mission Other plans/initiatives for fuel switch (city level): • BMTC's plans to switch to E-buses based on above schemes/subsidies/financial assistance • Freight Smart Cities- City Logistics Plans (CLP) that DULT will be preparing • Pilot project by DULT and BBMP to check the feasibility of using electric vehicles for Solid Waste Management.
Barrier	**Description of Barrier**

Legal and Institutional	• Karnataka Government bought out the EV Policy in 2017, but it has not been implemented effectively. Robust implementation mechanisms need to be developed(Desai 2022). • Getting access to electricity is another challenge in EV penetration. Either new transformers are needed to cater to this demand, or a separate (dedicated) electrical connection is needed for EV charging infrastructure. Both processes are very expensive and cumbersome in Karnataka for third parties (charging infrastructure investors) hence government intervention here in the form of subsidies/connections etc. is required(Desai 2022). • A conducive ecosystem for retrofitting of vehicles is yet to be developed in the state. • Freight vehicles are mostly private operated. Hence it will be difficult to shift to electric vehicles compared to public transport modes (e.g. BMTC buses). • Since Hydrogen is an emerging fuel, policy supports would be needed to achieve cost reductions that make it competitive with other fuels(Kelly and Zhou 2022)
Financial and economic	• Higher purchase price of EVs- Indian customers are very price sensitive and higher upfront costs make EVs unattractive to many(TERI 2020). EVs will need to come down in price over time, whether by market trend or subsidy or a combination of both. • In Karnataka, only road tax exemption with no registration fee is given to EV customers, unlike other states where consumers get additional financial subsidies on purchasing EV (Kanuri, Rao, and Mulukutla WRI India). The state is currently focussing more on providing incentives to EV makers and investors. • Lock-in of fossil fuel vehicles purchased in recent years. To get the maximum cost-benefit, the owners will use these recently purchased vehicles for a longer period. [For the case of buses, to reduce the share of fossil fuel buses (due to lock-in), a 'Transition fuel' could be introduced.] • Access to finance for purchasing/procuring cleaner fuels should be made easy • Unknown re-sale value of EVs-Due to lesser awareness on EV performance on longer life, acceptance of EV as re-sale option is relatively uncertain(Tarei, Chand, and Gupta 2021).
Political and social	• Range anxiety- The perceived notion that EVs have a limitation in terms of the distance it can cover in a single charge. Having adequate charging infrastructure and advances in vehicle technology might improve this. • Consumer perception of high battery replacement cost and lack of skilled manpower in the EV sector (lack of skilled local mechanics)(TERI 2020) is a deterrent in EV adoption • Inferior quality of EVs in the market and safety concerns associated with these could be another deterrent in terms of impacting consumers sentiments(B. B. Bureau 2022).
Practical and technological	• Shortage of charging infrastructure - Availability and accessibility of charging infrastructure. Few barriers here are ease of availability of land/space for EV chargers, building/public spaces doesn't have any regulations/mandate on EV chargers, barriers faced by the private

	players in EV charging ecosystems, etc. The city has to address these to ensure availability of charging infrastructure. • Low availability on maintenance, service, and repair (Tarei, Chand, and Gupta 2021) • Agencies like BMTC are procuring E-buses through GCC model. Since these are new procurement model in the city's context, its challenges are yet to be recognised/realised which could be a potential barrier in scaling it up. • India needs to depend on other countries for the procurement of raw materials for production such as Lithium and Cobalt. • Limited availability of raw materials required for EV batteries creates significant dependence on external sources for sourcing these. Despite there being production incentives in place, this will be major constraint in EV production. • Technical challenges in hydrogen productions- Commercial scale of production on green hydrogen is yet to be developed. The cost of green hydrogen production is much higher than what is produced from fossil fuels(Aayog 2022). • Transporting and storing hydrogen remain a big challenge and will require massive investment in infrastructure upgrades. Storage and transport of hydrogen have traditionally been difficult due to the unique characteristics of the gas—flammability, low density, ease of dispersion, and embrittlement(IEA 2020) • Standards around hydrogen use either do not exist or have not been updated (Aayog 2022)

Actions proposed in CAP to mitigate barriers	• Offer incentives for EVs such as reduced parking fee and toll charges, waiver on fitness certificates
	• Provide accessible EV Charging infrastructure:
	    ○ Develop common charging infrastructure standards across vehicle types, OEMs
	    ○ Develop city-specific guidelines for setting up EV charging infrastructure in buildings and public places
	    ○ Pilot EV chargers integrated with urban infrastructure such as streetlights
	    ○ Identify spaces (such as petrol pumps) for charging larger vehicles (e.g. buses, freight, etc.)
	    ○ Encourage and incentivise private participation in EV charging infrastructure development for enhancing ease of doing business
	• Facilitate private players to conduct R&D on battery recycling, retrofitting of fossil fuel vehicles to cleaner fuels, etc. by providing seed funds/subsidies, promoting ease of doing business, strengthening start-up ecosystems.
	• Conduct a study to understand the feasibility of using Hydrogen as a fuel in public transport (buses)
	• Prepare a Clean Fuel Transition Plan for Bengaluru with 2040 as the horizon year. This plan should be prepared for all modes with specific focus on Buses and IPT modes (Autorickshaws, etc.).
	• Make access to finance easier through strategies such as:
	        ▪ Providing low-income drivers and small businesses with easy loans to reduce upfront costs of EV
	        ▪ Better communication of MUDRA loans

	• Conduct IEC campaigns to sensitise stakeholders on cleaner fuel vehicles (its benefits, infrastructure requirements, usage, fuel efficiency, battery recycle, etc.) *(Stakeholders groups- PT operators, potential EV buyers, charging infra developers, actor involved in vehicle servicing and maintenance etc.)* • Conduct training programmes targeted for marginalised groups to facilitate just transition (to avoid externalities of cleaner fuel penetration)

Strategy #5 *Solid waste*	**Accelerate 100% energy recovery from scientific landfill to achieve net zero waste**
Status Under Ambitious Scenario	In the ambitious scenario, the city could achieve maximum results in terms of 100% waste segregation, processing and recycling. The primary focus was to achieve organic waste recovery coupled with the expansion of recycling of inorganic waste. The wet waste processing in 2019 was just 59%, which had increased to about 91% with greater waste diversion. The city implements a scientific landfill and reaches about 75% of energy recovery. Ambitious scenario achievements: • Over 90% of waste processing and recycling – implementation of IEC to nudge behavioural change, ward level SWM micro plan, increased decentralised waste management, awareness on material recovery etc. • About 75% of gas capture from scientific landfill – implementation of scientific landfill in the city with gas capture facility. Some other parallel benefits due to the above ambitious scenario actions are: • 100% segregation of waste and maximum diversion of waste • Legacy waste bioremediation • Domestic sanitary waste incineration • Removal of garbage-vulnerable hotspots • Increased informal recycling • Decreased dependency on waste-to-energy plants • Improved life cycle assessment and extended producer responsibility performance.
Strategy description/ Assumptions	Globally, for the world to have any chance at reversing the climate crisis, methane emissions must be slashed by 33 percent by 2030, the latest report from the Intergovernmental Panel on Climate Change (IPCC) 1 warns. Methane is an 80 times more potent greenhouse gas than carbon dioxide, and its reduction is critical to preventing climate catastrophe. Large historic methane emission reductions reported to the United Nations Framework on Climate Change (UNFCCC) by Annex-I countries are related to landfills. However, landfill waste is expected to grow at more than double the rate of population growth between now and 2050, mainly driven by countries in the tropics. As a result, global municipal solid waste methane emissions could nearly double by 2050. Conversely, these emissions could be reduced using technically feasible reduction strategies including active landfill covers, energy recovery, and omitting organic waste from landfills.

	To achieve 100% energy recovery and ensure decreased global warming potential along with environmental and socio-economic benefits, the city requires to accelerate 100% gas capture from scientific landfills. • By 2030: 25% |50% • By 2040: 50% l 75% • By 2050: 75% l 100% Additional actions that could be taken in parallel are: • C&D debris recovery and e-waste management.
Barrier	**Description of Barrier**
Legal and Institutional	Scientific landfill management: • In 2012, BBMP came up with a draft solid waste management policy for Bengaluru city highlighting the need for scientific landfill management and suggested having scientific landfills in the city such as Mavalipura, Mandur etc. It is been over 10 years, and the Mavalipura and Mandur landfills remained unscientific and were closed. The current function landfill is also unmanaged. • The new draft BBMP SWM Bye-laws, 2020 focuses on the bioremediation of closed landfills and there is a lesser emphasis on scientific landfills and energy recovery. • In 2014, KSPCB released guidelines for no development zone/buffer zone around MSW landfill sites in Karnataka and EC clearances for the site. The city is yet to explore a way to streamline landfill management. • The city needs to build a structure to ensure the implementation of provisions from the MSW rule, 2016 in terms of site selection, inspection facilities, monitoring mechanisms, safety provisions, operation and maintenance, criteria for pollution prevention and water quality monitoring for scientific landfill. • Another major barrier is the communication gap between the centre, state and the city. C&D debris recovery and e-waste management: • Recovery of Construction and Demolition debris: Yet to have a structure in the implementation of C&D Waste Management Rules, 2016 at the city level. The city is working on the application of materials made from construction and demolition waste and its products to meet the parameters and compliance criteria. The city is pursuing increased source separation and reuse of construction and demolition building materials at construction sites. Source separation can be challenging for general contractors due to scheduling and space availability, and may have a cost impact. • E-waste management: Even after improved EPR performance, there is still a lack of formalising informal recyclers, a lack of awareness amongst the consumers and financial incentives.
Financial and economic	Scientific landfill management: • Challenges in allotment of funds in the annual budget for the construction of landfills is leading to unmanaged landfills in the city. For the past 10 years, the city has been planning to bioremediate the closed landfills which still need PPP support and are still under process.

Political and social	• Swachh Bharat Mission aims to provide sanitation facilities to scientific municipal solid waste management and liquid waste management to every citizen. SBM stipulates building the capacities of urban local bodies strong to design, execute and operate all systems related to service provision. This requires close linkage between planning, operationalising and sensitising of the sanitation and waste management services within the departments as well as the citizens for achieving the overall goal of SBM, this yet needs political strength. It is noted that large funds under IEC have not been availed due to a lack of awareness. • Lack of citizen engagement, public awareness and responsible consumer behaviour: To achieve 100% energy recovery, it is essential that communities understand the importance of scientific landfills, and have political support in ensuring stringent implementation of compliance criteria.
Practical and technological	• Technical know-how and • Availability of land.
Other (please specify)	NA
Actions proposed in CAP to mitigate barriers	*Achieve 100% energy recovery from scientific landfill* • Ensure land allotment and financial mechanism • Increase technical manpower • By ensuring active participation and formalising informal recyclers through providing improved working conditions so that they do not have to sort materials in the landfill itself. • Encourage PPP models • Streamlining of operations and a focus on best practices in waste management solutions. For instance, Brazil has established a strong public policy using clean development mechanism projects to reduce methane emissions from landfills. An important component of these projects is the sale of avoided emissions by the private market to generate revenue. Also, similar to EPA established the landfill methane outreach programme. This programme was developed to reduce methane emissions from landfills in a cost-effective manner by encouraging the development of environmentally and economically beneficial landfill gas-to-energy projects • Regularise the market for landfill gas end users. Encourage landfill operators to capture methane by favouring landfill gas as a fuel source, offering incentives for landfill gas utilisation projects, and providing tax advantages for technologies that use biogas from landfills or anaerobic digestion.

Strategy # 5 *Wastewater treatment*	**Increase anaerobic treatment with biogas capture**
Status Under Ambitious Scenario	In the Ambitious scenario, the city could achieve 95% of open discharge removal and implementation of anaerobic treatment with biogas capture to 38.55% along with Activated sludge process (ASP) with nitrification and anaerobic digesters at 23.4% by 2050.

Strategy description/ Assumptions	Along with GHG emission reduction, water quality also plays a prominent role when it comes to wastewater treatment. Considering both as equally important we understand that - a) Anaerobic treatment with biogas capture contributes towards lesser energy requirement, nutrient demand and biological sludge. This also provides the market with a potential energy source and reduces GHG emissions. Because the energetics of anaerobic processes result in lower biomass production by a factor of about 6 to 8 times(Community 2020), sludge processing and disposal costs are reduced greatly when compared with the aerobic alternative. b) ASP with nitrification and anaerobic digesters ensures the removal of biological nutrients and phosphorus to meet discharge standards. So, when it comes to domestic/municipal wastewater, where the concentration of biodegradable COD and temperature are lower, and there is a need for higher effluent quality and nutrient removal, a combination of both the above-mentioned technologies is required (unlike Industrial wastewater). Hence, <u>Anaerobic treatment with biogas capture</u> 2030: 23.27% | 54.69% 2040: 25.09% | 57.73% 2050: 38.555 | 65.47% <u>ASP with nitrification and anaerobic digestion</u> 2030: 20.24%| 35.31% 2040: 21.82% | 37.27% 2050: 23.64% | 34.53% <u>Open discharge</u> 2030: 28.40% | 10% 2040: 22.80% | 5% 2050: 5% | 0%
Barrier	**Description of Barrier**
Legal and Institutional	• City's primary focus is to achieve basic water and sanitation services to the citizens and the complete resources are towards the improvement of adaptive capacity and resilience of the city and less/ignored focus on mitigation potential from wastewater treatment (as the mitigation potential is comparatively less to other sectors) • Also, the city is working towards treating wastewater to ensure water quality. As the construction, operation and maintenance of STPs are a costly affair, there is a need for a financial structure where the expense, power, staff/manpower etc. are analysed to ensure the complete functioning of STPs. In this scenario, technological innovation takes a back seat. • Water act, 1974, the first legislative measure taken to directly address the issue of water pollution and conservation in the country. The construction of STPs has been an objective under several of the government's programmes such as Swachh Bharat Abhiyan and Atal Mission for Rejuvenation and Urban Transformation (AMRUT). All these provisions address wastewater discharge as a matter of pollution alone but not as a resource recovery facility. • Lack of policy mandate at the central level for wastewater treatment and regulatory framework leads to triviality towards the same. • Karnataka State Water Policy, 2019 promotes innovation in technologies and planning for alternative approaches to wastewater treatment that are neighbourhood scale, encourage biological solutions that are financially less expensive and have lower energy

	consumption, separate grey and black water, linked to markets for sludge, and passive technologies where possible. Less expensive anaerobic treatment is a major challenge for the city. • BWSSB vision document mentions reimagining wastewater treatment plants as water resource recovery facilities but there is no focus to elevate the need for anaerobic treatment with biogas capture.
Financial and economic	• According to BWSSB, it is difficult to convert and propose 100% wastewater treatment technology as anaerobic treatment with a biogas capture system in Bengaluru. Currently, the capital cost of water and sanitation services is primarily focused towards 100% water and sanitation services and reduction of NRW, allotment of extra funds towards this treatment is seen to be difficult as this technology requires higher capital and operational costs.
Political and social	• Challenges in creating awareness: The city is yet to realise the prominence of emission reduction as most of the legal provisions still emphasise effluent standards/pollution levels rather than balancing the concerns on both mitigation and adaptation actions. • Challenges in having sufficient skilled labour: To operate the STPs it is important to have skilled labour and the contractors who install the STPs lack technical expertise and end up hiring unskilled labours. • Acquisition of land and directing the sewage flow to STPs is a major challenge as the city's drainage and infrastructure are old that need upgradation. Despite these issues,
Practical and technological	• Anaerobic treatment with gas capture requires more manpower and space which is currently not feasible in Bengaluru. • Anaerobic treatment has a longer start-up time (months) for the anaerobic digestion process compared to aerobic (days), this puts a lot of pressure in terms of space, time, money and manpower to favour aerobic. • As most of the STPs are decentralised with around 10-30MLD, it is difficult in terms of manpower, area and operations to provide gas capture at the STPs leading to maximum STPs upgradation only till nitrification.
Other (please specify)	NA
Actions proposed in CAP to mitigate barriers	GHG in wastewater systems can be attributed to sewage sludge treatment and disposal processes, hence anaerobic treatment of wastewater is the primary action towards mitigation. • Focus on wastewater policy with not just effluent standards but with provisions towards energy efficiency and resource recovery technologies. • Upgrade wastewater treatment: minimise pollution of receiving wastewater through effective primary, secondary and tertiary treatment of raw sewage. Change household cleaners to ones that do not damage septic tanks and are easily biodegradable to reduce nutrients getting into systems rather than needing complex and expensive treatment. • Improve data availability and model complexity on GHG emissions from biological processes in wastewater treatment plants, information that will be increasingly important. • Energy recovery during wastewater treatment leading to net-positive energy generation from wastewater.

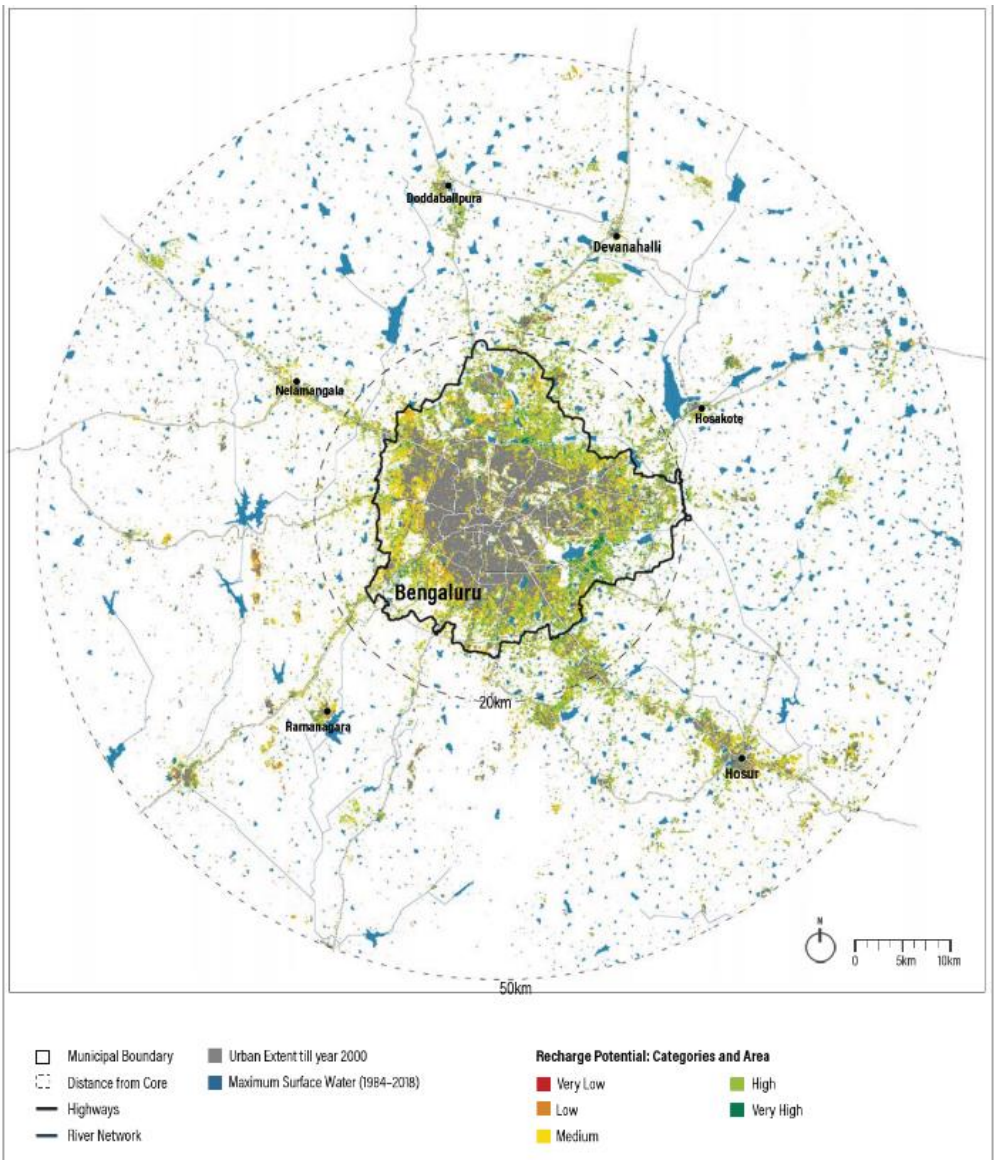
	• Fully recover nutrients such as phosphorus and nitrogen from wastewater and reduce dependency on fossil-based chemical fertilisers. The agricultural utilisation of sludge can be promoted in the regions where the sludge contains an acceptable level of pollutants (e.g. heavy metals, persistent organic pollutants)

D. Details on change in Blue-Green Network in Bengaluru

The information in this annexure is based on a WRI India paper- *Urban Blue-Green Conundrum: A 10-City Study on the Impacts of Urbanisation on Natural Infrastructure in India*(Goswami et al. 2022).

- Vegetation loss is primarily seen in the outer developing and new growth areas (10-20 km band from the city centre), while there has been some vegetation gain in central/inner city areas and in the 20-50 km range.

Figure 82 Maps Showing Groundwater Recharge Potential in Bengaluru Indicating Substantial New Development Sited on High and Very High Recharge Potential Zones



Notes: Urban development of the year 2000 in gray, and new urban development overlaid over various recharge potential zones (areas where urban development has not taken place are not highlighted here).
Sources: Recharge potential - Farr 2007, NASA n.d.; Built-up Area - European Commission 2016; Maximum surface water- EC JRC/Google n.d.; River Network - FAO n.d.; Basemap - Esri, DeLorme, HERE, MapmyIndia.

Bengaluru: Land Use / Land Cover Changes and Estimated Groundwater Loss

Note: The 0-20 km region roughly corresponds to the urban area in municipal and metropolitan limits.

1. **Between 2000-2015, built-up area increased by 76% in the 0–50 km region, with a higher rate in peri-urban areas**

0-20 km: Built-up area increased from 316 sq. km. to 520 sq. km. (165% increase)
20-50 km: Built-up area increased from 86 sq. km. to 188 sq. km. (219% increase)

2. **Between 1997-2017, blue cover decreased by 74% in the 0–50 km region, with a higher rate in peri-urban areas**

0-20 km: Blue cover decreased from 21 sq. km. to 10 sq. km. (52% decrease)
20-50 km: Blue cover decreased from 133 sq. km. to 30 sq. km. (78% decrease)

3. **Between 1997-2017, total green cover decreased in urban areas and increased in peri-urban areas**

0-20 km: Green cover loss was 351 sq. km. and gain is 218 sq. km. – net loss of 133 sq. km.
20-50 km: Green cover loss was 599 sq. km. and gain is 1465 sq. km. – net gain of 866 sq. km.
Note: Gains in green cover may indicate a shift in land use or land cover e.g., from barren to cultivated land, woodlots or rooftop and individual gardens. Improved water supply or groundwater availability, leakages from older underground water supply and sewerage networks and increasing unsewered discharge of urban wastewater can also contribute to increase in green cover.

4. **Between 2000-2015, 64% of new development was sited on high and very high recharge potential zones**

0-20 km: Close to 200 sq. km. of new development on medium to very high recharge potential zones; estimated groundwater lost is 62 mld

20-50 km: Close to 100 sq. km. of new development on medium to very high recharge potential zones; estimated groundwater lost is 30 mld

Note: The estimated groundwater lost in the 0-50 km region (92 mld), could have potentially met 17% of the water demand of the urban population added during this period.

Source: (Goswami et al. 2022)

E. Sector-wise Evaluation Indicators

The detailed format for evaluation is given for the Energy and Building sector. For the other sectors the evaluating indicators are listed in the subsequent tables.

Sector: Energy and Building										
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency	Value year				Change Observed	Assessment *(Satisfactory/ slow but positive change/ negative)*
					Y_1	Y_2	Y_3	Y_4		
1	% New appliances with 5-star label	40% by 2030, 61% by 2040, 83% by 2050	2024	2 years						
2	Transition to clean fuel technologies in manufacturing industries	100% by 2040	2024	2 years						
3	% Increase in energy efficiency in manufacturing industries	15% by 2030, 20% by 2040, 25% by 2050	2024	2 years						
4	% Penetration of insulated walls and roofs in new residential building stocks	33% by 2030, 52% by 2040, 71% by 2050	2024	2 years						
5	% Penetration of insulated walls and roofs in new commercial or institutional building stocks	38% by 2030, 56% by 2040, 75% by 2050	2019	2 years						
6	% Of non-fossil fuel source generation in the city's grid electricity	68% by 2030, 77% by 2040, 89% by 2050	2019	1 year						

Sector: Energy and Building										
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency	Value year Y_1	Y_2	Y_3	Y_4	Change Observed	Assessment *(Satisfactory/ slow but positive change/ negative)*
7	% Transition to clean cooking technologies from solid fuel cooking stoves	100% by 2030	2024	1 year						
8	Household average hot water demand met by the electricity-solar water heater	68% by 2030, 73% by 2040, 96% by 2050	2024	1 year						
9	Affordable electricity access to low-income people	100% by 2025	2024	Half-yearly						
10	% Penetration of efficient appliances and fixtures in low-income houses	41% by 2030, 63% by 2040, 86% by 2050	2019	1 year						
11	Availability of climate-resilient affordable housing		2024	2 years						

(Only the indicators are listed for the succeeding sectors)

Sector: Air Quality				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
1	% Annual Reduction in physical air pollutants (PM2.5 and PM10) concentration	46% by 2026 (NCAP targets)	2024	Half-yearly
2	% Annual average reduction in gaseous criteria pollutants (NOx, SO2, CO and O3) concentration		2024	Half-yearly
3	% Commercial and institutional buildings complying WHO Indoor air quality standards and guidelines	30% by 2030 70% by 2050	2024	2 years
4	Roadmap for a comprehensive health action plan tacking risks due to air pollution	By 2030	2024	1 year

Sector: Air Quality				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
5	New CAAQMS and transition the existing manual station to CAAQMS systems	13 new CAAQMS and transition of the manual system to CAAQMS by 2035	2025	2 years
6	# Of Low emission zone (LEZ), ultra-low emission zone (ULEZ), or zero emission areas	By 2030	2024	1 year
7	Creation of regional Airshed Management Cell	By 2030	2024	2 years
8	Potential change in premature mortality (Deaths avoided per year)	790 in 2030, 5,495 in 2050	2025	2 years
9	Emissions of criteria pollutants in key areas of the city (e.g. near hospitals, schools, care homes, or low-income neighbourhoods)		2024	1 year

Sector: Solid Waste				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
1	% of waste segregation at the source	100% by 2025	2019	1 year
2	% of waste transported using a low-emission fleet	100% by 2030	2024	1 year
3	Total no. of daily trips for waste collection and transport	2025	2024	1 year
4	Total secured jobs created, increased wages, and social security schemes availed by *pourakarmikas*	2025	2024	2 years
5	%/total amount of wet waste composted (centralised and decentralised, diverted from landfill)	70.31% by 2030, 85.29% by 2040, 91.55% by 2050	2019	2 years
6	%/total amount of dry waste recycled (diverted from landfill)	61.11% by 2030, 71.8% by 2040, 93.1% by 2050	2019	2 years
7	%/total amount of wet waste limited to landfill	29.69% by 2030, 14.71% by 2040, 8.45% by 2050	2024	2 years
8	%/total amount of dry waste limited to landfill	38.89% by 2030, 28.13% by 2040, 6.90% by 2050	2024	2 years
9	Total amount of dry waste recycled by women from vulnerable communities	2030	2025	2 years
10	% of gas capture at the landfill	25% by 2030, 50% by 2040 and 75% by 2050	2025	2 years

Sector: Solid Waste				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
11	% of tree plantation at the closed landfills	2030	2025	2 years
12	% of C&D waste removed, recycled and recovered	2030	2025	2 years

Sector: Water, Wastewater And Stormwater				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
1	% reduction in water loss	15% by 2030	2019	2 years
2	Total groundwater recharge/storage at the community level	2030	2024	1 years
3	% of water stored as rainwater (RWH)	2030	2024	1 year
4	% change in the rejuvenation of existing groundwater wells with the involvement of local communities (Need to check this)	2030	2024	1 years
5	Total no. of freshwater lakes rejuvenated (Need to check this)	2030	2019	1 years
6	Total water being recycled across the city	2030	2019	2 years
7	% of recycled water reuse	15% by 2030, 30% by 2040	2019	2 years
8	% of ASP with BNR wastewater treatment	48% by 2030, 51% by 2040, 56.5% by 2027	2019	2 years
9	% of open discharge of wastewater	29% by 2030, 22% by 2040, 5% by 2050	2019	2 years
10	% of anaerobic wastewater treatment with biogas capture	23% by 2030, 27% by 2035, 38.5% by 2035	2019	2 years
11	Total no. of occasions of flooding in a year (water logging/flooding incidence)	2030	2024	1 year

Sector: Transport				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
1	% of new households in the city (added from 2019) that should be in its TOD areas (Approx.)	20% (by 2030) 70% (by 2040) 90% (by 2050)	X% in 2024	Every 3 years

Sector: Transport				
#	**Evaluating Indicators**	**Target**	**Baseline value** *(Year)*	**Evaluation frequency**
2	Mode share of Public Transport (Bus+ Metro+ Suburban Rail) amongst all modes (inclusive of NMT modes)	62% (by 2030) 66% (by 2040) 70% (by 2050)	43% in 2019 (Based on WRI Analysis for GHG inventory of 2019)	Every 2 years
3	Mode share of NMT (walking +Cycling) amongst all modes	13% (by 2030) 14% (by 2040) 15% (by 2050)	11% in 2019 (Based on WRI Analysis for GHG inventory of 2019)	Every 2 years
4	% of total buses running on cleaner fuels (Electric, Hydrogen)	12% (by 2030) 40% (by 2040) 75% (by 2050)	<1% in 2019 (Based on vehicle registration data from Parivahan portal)	Every 2 years
5	% of total private vehicles (cars +motorcycles) running on cleaner fuels (Electric, Hydrogen)	10% for cars (by 2030) and 30% for 2W (by 2030); 60% for both (by 2040) 90% for both (by 2050)	<1% in 2019 (Based on vehicle registration data from Parivahan portal)	Every 2 years
6	% of total freight vehicles running on cleaner fuels (Electric, Hydrogen)	8% (by 2030) 27% (by 2040) 47% (by 2050)	<1% in 2019 (Based on vehicle registration data from Parivahan portal)	Every 2 years
7	No. of potholes in the city roads	0 (by 2035)	Y nos. in 2024	Annually
8	No. of annual road accidents and fatalities	0 (by 2035)	Y nos. in 2024	Annually
9	Multiple *climate resilient*-road network connectivity to all locations in the city	100% (by 2035)	Z% in 2024	Every 3 years
10	No. of transport services stopped/paused due to different climate and environmental hazards	0 (by 2035)	Y nos. in 2024	Annually
11	Total annual cost of repair/maintenance of transport infrastructure and assets due to different climate and environmental hazards	Rs. 0 Lakh (by 2035)	Rs. X Lakh in 2024	Annually
12	% of city's population having access to public transport (bus, metro, suburban	100% by 2035	Z% in 2024	Every 3 years

Sector: Transport				
#	**Evaluating Indicators**	**Target**	**Baseline value** *(Year)*	**Evaluation frequency**
	rail) stops/stations within 5 minute walking distance from their residence			
13	Service coverage of public transport in the city	100% by 2035	Z% in 2024	Every 3 years
14	Transport sector's contribution to the city's Air pollution	<5%(minimum) by 2050	Z% (of PM2.5, PM10, Sox,NOx, etc.) in 2024	Every 3 years
15	No. of new jobs created in the domain of cleaner fuel vehicles (to facilitate shift from fossil fuel run vehicles)	X nos. by 2050		Every 3 years
16	Per capita Average monthly expenditure on transport	Rs. Z by 2035	Rs. N by 2024	Annually
17	Public transport ridership figures-disaggregated by gender, age, ability, income category			
18	Average travel speed of all modes			Every 3 years

Sector: Urban Planning, Greening, Biodiversity				
#	**Evaluating Indicators**	**Target**	**Baseline value** *(Year)*	**Evaluation frequency**
1	Prepare and adopt the RMP 2041, and set up the Master Plan Coordination Committee	By 2025	2024	Half-yearly
2	% of new households in the city (added from 2019) that should be in its TOD areas *(Referring to Transport sector's evaluating indicator No.1)*	Around 20% (by 2030) 70% (by 2040) 90% (by 2050)	X% in 2024	Every 3 years
3	All spatial plans and DCRs to adopt a climate-resilience lens and mandatorily follow consultative planning processes	Mandatorily followed for all plans and DCRs	(Yes/No/Partially followed) in 2024	Annually
4	No. of urban infrastructure schemes/projects adhering to disaster resilient standards	Mandatorily adhering to it for all projects	X nos. in 2024	Annually
5	Increase in the city's tree cover (tree canopy) from the baseline	From baseline-10% by 2030; 20% by 2040	In 2024	Every 3 years
6	Share (%) of city's total vegetation cover and permeable surface area to the total city area	40% of the city's surface area by 2040	Y% in 2024	Every 3 years

Sector: Urban Planning, Greening, Biodiversity				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
7	Operationalise the Biodiversity Management Committee (BMC)	By 2023	(Yes/No) in 2023	Every 3 years
8	% of footpaths converted to permeable surface material	75% by 2050		
9	Total area recovered and restored, which are demarcated as environmentally-sensitive, no-development buffer areas in the RMP 2041	By 2035		
10	Provide safe and affordable housing for 100% urban poor and vulnerable groups in locations having access to public transport stops/stations within a 5-minute walk	100% by 2050		
11	Per capita open space in the city (to ensure equitable distribution of open spaces)	6 sqm. by 2050	2.2 sqm(Correspondent 2017) in 2017	Every 3 years
12	% increase in affordable housing DUs of particular size (say under 60 sqm) in TOD areas			
13	Increase in budget allocation for NBS activities			

Sector: Disaster Management				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
1	Regularly updated Data Repository system for the city	Presence of a detailed city level data repository including climate data, hazard data and other demography related datasets along with a mechanism for regular update.	Assessment and Compilation of datasets (for the year 2024) as mentioned in the action track 1.1	Once in two years
2	Revisit ~~CCRAVA~~CCRA-VA document with relevant modifications at regular intervals	Comprehensive ~~CCRAVA~~CCRA-VA document once on every two years	Current ~~CCRAVA~~CCRA-VA document	Once in two years

Sector: Disaster Management				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
3	Robust policy level document on Disaster Management at the city level	Frame a comprehensive Disaster Management Plan	Disaster Management Plan for Bengaluru in 2024	Once in two years
4	Inputs from ward unit on gaps in existing regulatory powers and budget availability for the ward.	An empowered Ward level disaster management unit with adequate regulatory powers and financial budget.	Ward wise - Regulatory powers and budget for year 2025	Annual
5	Capacity building training workshops: twice a year for ward level representatives and once a year across other stakeholder groups	Regular Capacity building workshops across different stakeholder groups to increase resilience	List of trainings/capacity building workshops conducted with number of attendees, duration of training and training material conducted in 2024	Twice a year minimum with regular updated training content
6	Loss of life due to such disasters by 2030	Zero loss of life due to climate and environmental disasters identified in ~~CCRAVA~~CCRA-VA by 2030	Baseline needs to be done in 2024	Yearly
7	Injuries and other health-related concerns due to climatic and environmental hazards	Reduction in 50 percent of injuries and other health related concerns by 2030 due to climate and environmental disasters identified in ~~CCRAVA~~CCRA-VA	Baseline needs to be done in 2024	Yearly

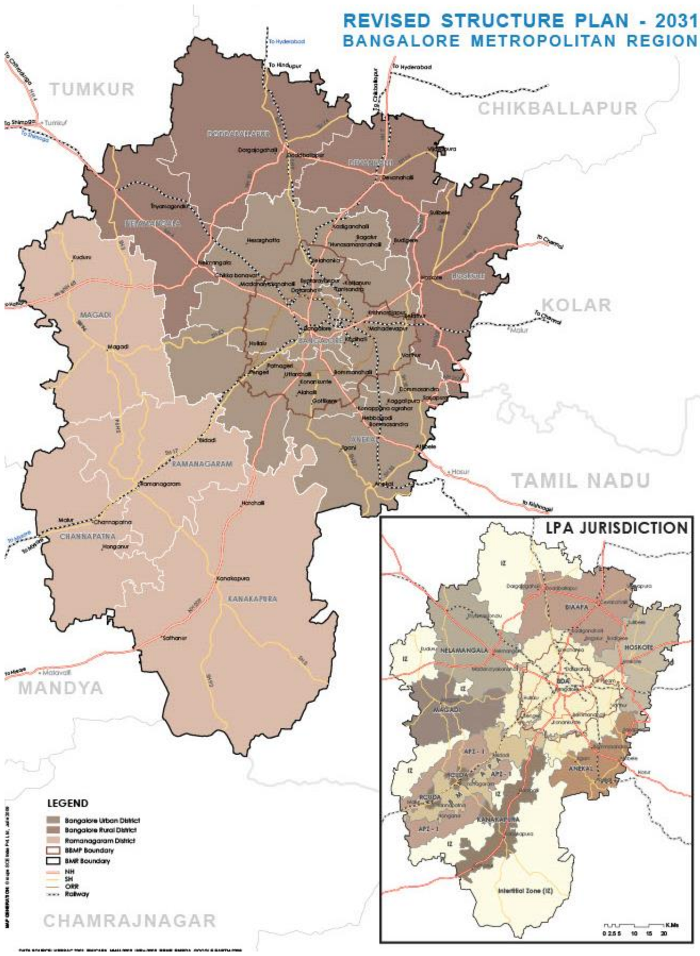
Sector: Disaster Management				
#	Evaluating Indicators	Target	Baseline value *(Year)*	Evaluation frequency
8	Economic loss due to the occurrence of climatic and environmental disasters to be less than 70 per cent by 2030	Reduction of 70 percent of economic loss by 2030 due to climate and environmental disasters identified in ~~CCRAVA~~CCRA-VA	Baseline needs to be done in 2024	Yearly
9	Loss of assets or property to be less than 70 per cent by 2030.	Reduction of 70 percent on loss of property and assets by 2030 due to climate and environmental disasters identified in ~~CCRAVA~~CCRA-VA	Baseline needs to be done in 2024	Yearly
10	Urban flooding: Area under flooding	Reduction in area under flooding by 80 percent by 2030	Baseline needs to be done in 2024	Yearly
11	Urban flooding: Population affected by flooding	Reduction in population affected by flooding by 80 percent	Baseline needs to be done in 2024	Yearly
12	Urban Heat: Area under LST greater than 35°C in summer months	Reduction in area under LST greater than 35 deg C in summer months by 50 percent by 2030	Baseline needs to be done in 2024	Yearly
13	Urban Heat: Area under LST greater than 30°C in winter months	Reduction in area under LST greater than 30°C in winter months by 70 percent by 2030	Baseline needs to be done in 2024	Yearly

F. Brief on population projections

Growth of Bengaluru and past population trends

As per the 2011 census, Bangalore, officially known as Bengaluru had a population of 8,443,675 (84.43 lakh). The Bruhat Bengaluru Mahanagara Palike (BBMP, Greater Bangalore Municipal Corporation) is in charge of the civic administration of the city. The municipal corporation area is about 713 sq. km. The population density of the BBMP area is 12,000 persons per sq. km. BBMP falls within the local planning area of the Bengaluru Development Authority (BDA). Bengaluru has different jurisdictional boundaries shown in the Figure 83 below:

Figure 83: Planning Jurisdictions



Source: BBMP restructuring committee

Bengaluru Metropolitan Region (BMR): BMR extend over 8005 sq. km and is constituted by three districts namely Bangalore Urban, Bangalore Rural and Ramanagaram (Ramanagaram is a newly created district carved out from Bangalore Rural district that includes Ramanagaram, Channapatna, Magadi and Kanakapura taluks). The local Planning Area of BDA falls within BMR.

Bengaluru Metropolitan Area (BMA): BMA is spread over an area of about 1294 sq. km which comprises of local planning area of BDA and part of the local planning area of

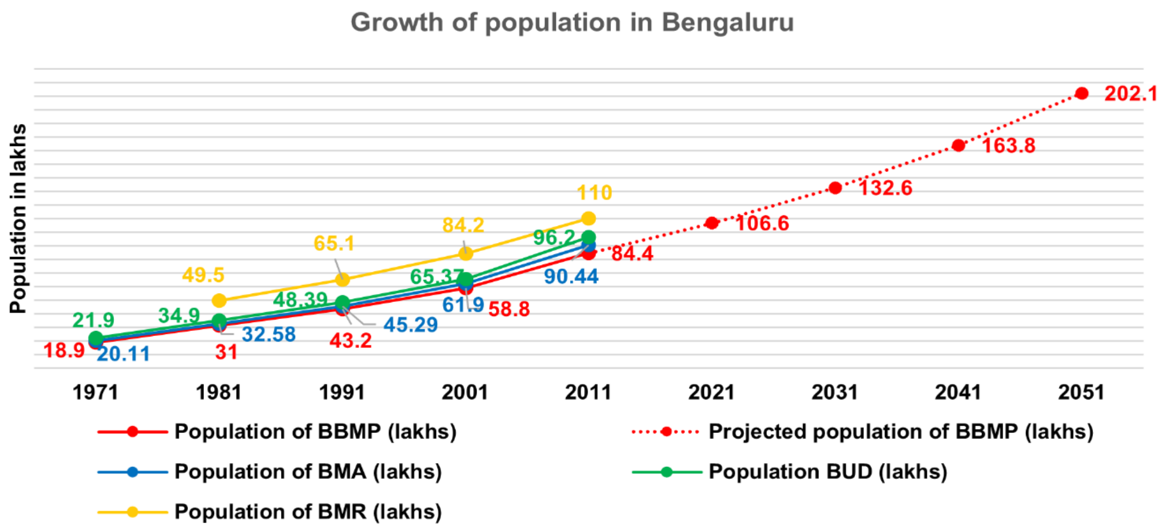
Bengaluru Mysore Infrastructure Corridor Area Planning Authority (BMICAPA). BMA includes BBMP and 251 villages and approximately had a population of 90 lakh in 2011.

Bangalore Urban district (BUD) came into being in 1986, with the partition of the erstwhile Bangalore district into Bangalore Urban and Bangalore Rural districts. Bangalore Urban has five taluks: Hebbal (Bangalore North), Kengeri (Bangalore South), Krishnarajapura (Bangalore East), Yelahanka (Bangalore North Additional) and Anekal.

Table 39: Planning jurisdictions and population densities

Jurisdiction	Area (sq.km)	Population (2011)	Population density (person per sq. km)
Bruhat Bengaluru Mahanagara Palike (BBMP)	713	84,43,675	11842
Bengaluru Metropolitan Area (BMA)	1294	85,20,435	6519
Bengaluru Urban District (BUD)	2196	96,21,551	4381
Bengaluru Metropolitan Region (BMR)	8005	1,16,58,906	1456

Figure 84: Growth of population in Bengaluru



Source: (Census 2011), RSP 2031-BMRDA and BBMP; WRI India Analysis, BBMP Restructuring Committee Report, 2017, (BBMP and India 2015)

Table 40: Population and growth rate of the BBMP area for the past three decades

Year	Area (sq.km)	Population (Millions)	Population density (Person per sq. km)	Growth Rate (%)
1991	225	4.32	19200	39.33
2001	225	5.89	26178	36.28
2011	713	8.44	11842	43.41

Source: Census

The population growth rate during the period of amalgamation (2001-2011) is about 43.41%. Specifically, due to a couple of reasons:

a. The erstwhile Bengaluru Mahanagara Palike (BMP) expanded over 225 sq. km. and was amalgamated with 7 City Municipal Councils, 1 Town Municipal Council and 110 villages to form BBMP in 2007 with an area of 713 sq. km.

b. The IT boom in Bengaluru city and the population rise has seen more migrants moving into the city from different parts of the country. The city witnessed an increase in population due to urbanisation and employment opportunities.

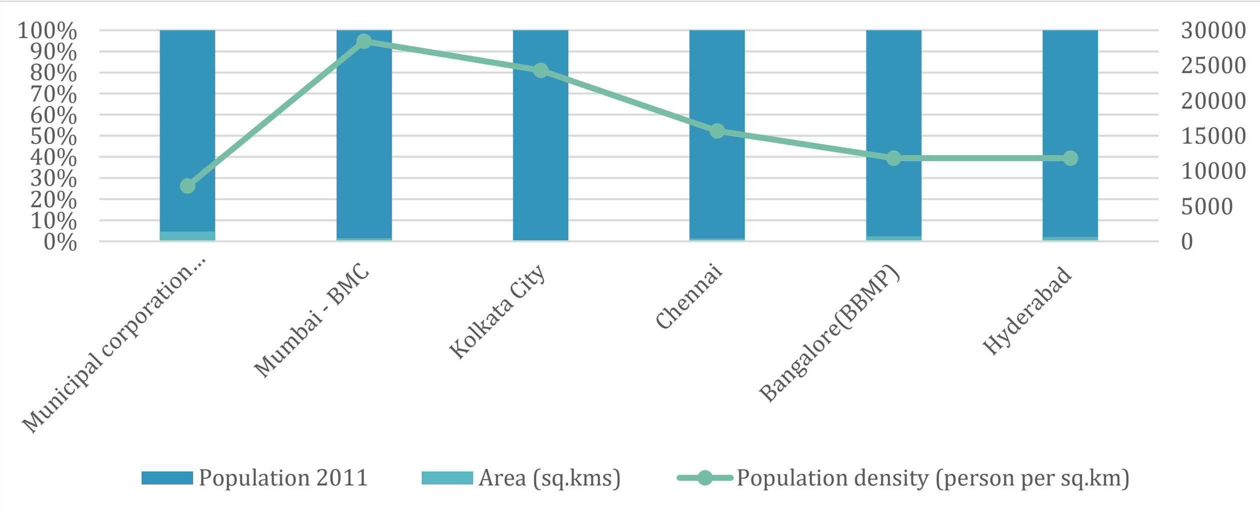
Due to increased area, the population density has seen a dip with a much larger spread of population base moving across the city.

Population densities of other metropolitan cities and Bengaluru

Table 41:Understanding area and population density in the past decade in other metropolitan cities

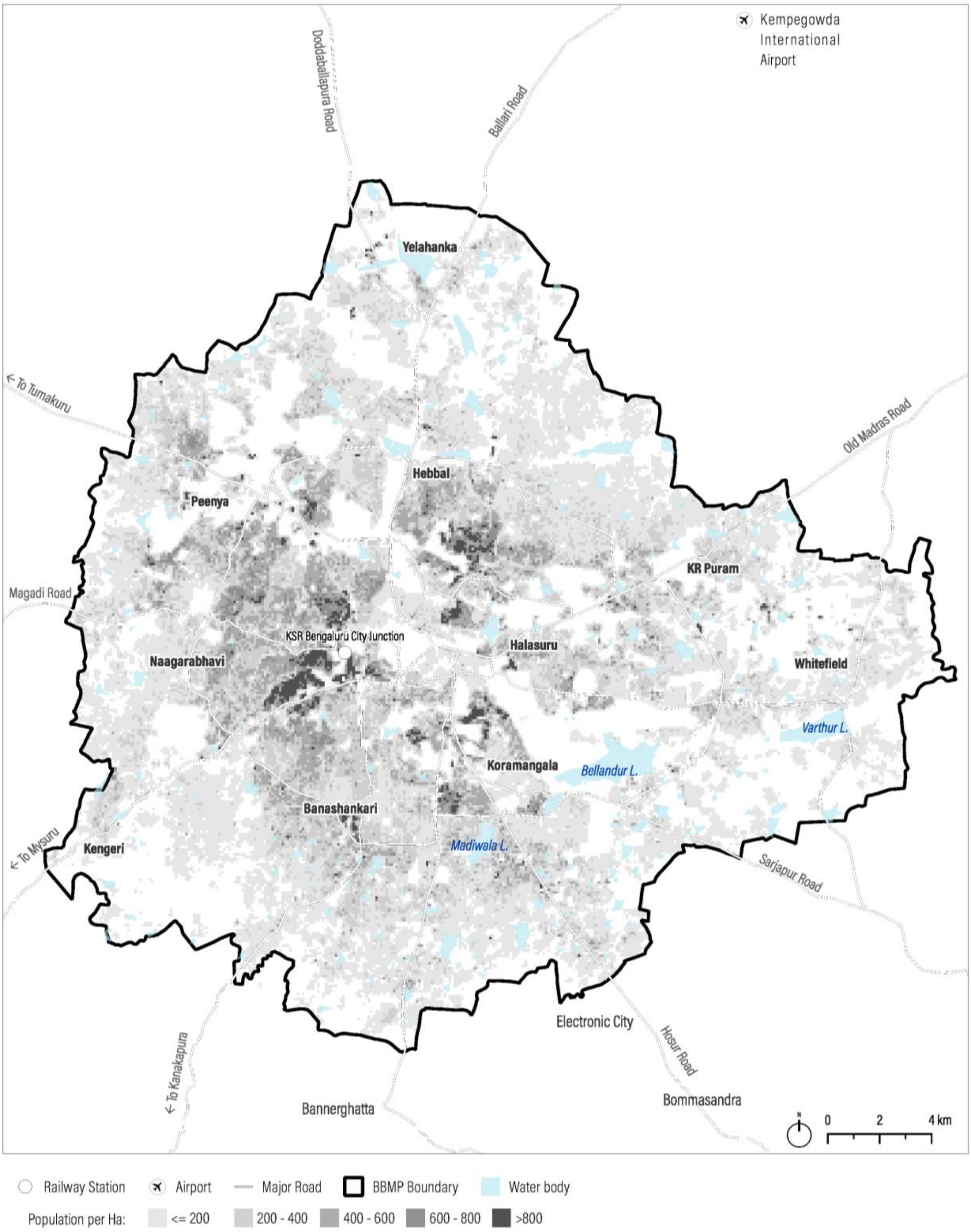
City (Municipal corporations)	Area (sq.km)	2011 Population density (person per sq. km)	Source
Municipal corporation of Delhi	1,397	7,880	B-PAC report
Mumbai - BMC	437.71	28,426	MCAP Report and Pathways data collection sheet
Kolkata City	185	24,306	(Census 2011)
Chennai	426	15,676	(TNPCB 2021)
Bangalore (BBMP)	713	11,842	(Census 2011)
Hyderabad	650	11,806	(Census 2011)

Figure 85:Different municipal corporations and population densities, 2011



Due to larger public transport infrastructure and vast employment opportunities, cities such as Mumbai, Kolkata and Chennai accommodate higher population density within the municipal corporation area, making them extremely compact cities, whereas cities such as Bengaluru and Hyderabad, the so-called IT hubs that have the migrant population moving in from other cities, are widespread over a larger area, specifically at the periphery where the IT industries are located. Figure.3 provides an understanding of the population density of the city in 2011:

Figure 86: Bengaluru's estimated population density distribution



Source: WRI India analysis using buildings data from KSRSAC; Landuse from BBMP, and population density estimates from Census 2011.

BMA's core area with 8 ULBs had additional 110 villages included in the peripheral areas as BBMP administrative boundary which in the above figures depicts that the core city has a higher density with a gradual spread of population moving towards the peripheral areas due to the IT industry set up in the periphery. Hence, a rational approach towards understanding the growth rate of the core and 110 villages in the periphery would provide a reasonable understanding of both the population growth of the city with regard to the density and may also provide an assumption on how the growth would be based on the need for infrastructural development of the city.

Existing population projections for Bengaluru city

Several studies on population projection were carried out for Bengaluru by various organisations in connection with infrastructure development for the city.

Table 42: Assumptions/conditions applied by different sources

SOURCE	ASSUMPTIONS/CONSIDERATIONS	Source
Bengaluru Development Authority (BDA)	"Master Plan 2015" was prepared by Bangalore Development Authority between 2003 and 2005 and the final plan was completed in 2007. The base year used for population projections is 2001. The annual growth rate for the BMP area (100 wards) is assumed to be 0.78%.	**https://openjicareport.jica.go.jp/pdf/12300356_01.pdf**
Bengaluru Water and Sewerage Supply Board (BWSSB)	An increase in growth rate is worked out at 4% per annum for 2012 to 2031, 3% per annum for 2032-2041 and 2% per annum from 2042 to 2051.	BWSSB
Revised Master Plan (RMP) for Bengaluru 2031	- Water availability based on population carrying capacity - Proportional distribution of population between the state and the region, conforming to the past trends - Share of the population between the core (BMA) and the rest of BMR. - Redistribution of projected population in core and peripheral areas as 80:20 - Projections were only till 2031 with annual growth rates for 2021 and 2031 at 2.2, 7.38.	RMP 2031
Bengaluru Water Supply and Sewerage Project (Phase-3), JICA report, 2017	- Referred to 10 different data sources for population projections such as - BDA, BMRDA, BWSSB, Ch2M, etc. - Also referred to the past decadal population trends of different cities - Looked into the population increase from 1941 to 2011 - An increasing growth rate is assumed due to the focus on 8 ULBs and 110 villages' infrastructural development. - Assuming a ceiling density to be 300persons/ha, Core and ULB see a lesser growth rate compared to 110 villages. - With the above-saturated growth rate consideration, the assumption of standard annual growth rate for the core is assumed at 0.78% (As per BDA, Master plan) and is applied till 2051. - For 8 ULBs and 110 villages different annual growth rates were assumed in consultation with BDA, BBMP and BWSSB) **High growth rates were authorised by BDA, BWSSB, BBMP and DHV.**	**https://openjicareport.jica.go.jp/pdf/12300356_01.pdf**

Table 43: Population growth for the next three decades from different sources:

Source	Jurisdictional boundaries	Population 2021 (millions)	2021 CAGR	Population 2031 (millions)	2031 CAGR	Population 2041 (millions)	2041 CAGR	Population 2051 (millions)	2051 CAGR
BWSSB	BUD	14.2	3.05%	21.1	2.2%	28.3	1.80 %	34.5	1.87%
RMP	BMA	9.96	2.2%	20.3	7.38 %	-		-	
Revised Structure Plan (RSP)	BBMP	11.24	2.83%	14.1	2.51 %	-		-	
JICA report (High growth)	**BBMP**	**10.66**	**2.36 %**	**13.2**	**2.21 %**	**16.38**	**2.13 %**	**20.2**	**2.12%**
JICA report (Medium growth)	BBMP	10.65	2.29%	12.7	1.77%	15.1	1.81%	18.1	1.82%
JICA report (Low growth)	BBMP	10.65	2.29%	12.3	1.47 %	14.28	1.48 %	16.5	1.49%

Source: (JICA 2017)

Based on the development pattern, JICA population projection was done for the BBMP area in three portions: Core area, 8 ULBs and 110 villages. The growth rate mentioned in the above table is the average of all the 3 portions together.

Challenges of projecting population for BBMP

1. In 2007, with the formation of the BBMP area with an additional 100 wards into the administrative boundary making the area increase from 225 sq. km. to 713 sq. km., a historic reference point is absent after BBMP was created.
   - The historical growth before 2007 may not imply a linear growth trend due to the drastic population growth hike at the time of Census 2011 due to the IT boom, this creates a gap in understanding the historical growth trend and its implication in future projections.
2. The recent census in hand is 2011 and there is a decade gap in understanding the population growth of a city over the years.
3. Bengaluru, with its multiple planning jurisdiction boundaries and various studies/department's population projections, cater to different boundaries creating a lack of reference points to deal with.
   - Also, there are multiple population projections derived at different years with different horizon estimates, making it difficult to interpret the growth trajectory.

Reasons for considering the JICA report high growth projections

BBMP area has experienced rapid population growth in the past decades, however, in the JICA report the tendencies of population densities in the areas are characterised as follows:

1. Core area: Population is saturated with a ceiling density. The growth rate shall be fixed through the future with a lower rate under the saturated conditions at present. The annual growth rate is assumed at 0.78 by BDA "Master Plan 2015" for the decade 2011-2021. The rate is assumed to be applied until the year 2051 in this report as well.
2. 110 Villages: Population is continuously growing with different growth rates by sub-area. The population for the next three decades were authorised through a tripartite meeting by BDA, BBMP and BWSSB. The overall average annual growth rate for future decades are: 4.38% for 2011-2021, 3.75% for 2021-2031, 3.25% for 2031-2041 and 3.0% for 2041-2051.
3. ULBs: There are three references on the projection of annual growth rate for ULBs as shown below.
    a. *Low growth rate*: 4.38% growth rate in 2021 and later from 2031 w.r.t the DPR for 110 Villages Water Supply and Sewerage Project, 1.3% is assumed to continue until 2051.
    b. *Medium growth rate*: 4.38% growth rate at 2021 and later from 2031 w.r.t the NMT report on the improvement of water supply, 2.36% growth rate is assumed to continue until 2051.
    c. *High growth rate*: The annual growth rates from 2021 are 4.38%, 2031 is 3.75%, 2041 is 3.25% and 2051 is 3%

The formula adopted in the JICA report is: **A = A0 (1+ r) n**, where A = population after n years, A0 = population in the base year, r = growth rate and n = years. The population by area are projected using annual growth rates assumed in the above item 1) to item 3) by area. The range of the population (maximum to minimum figures) is caused by the application of different population growth rates for ULBs.

For the CAP, currently, we have considered the high-growth scenario population projections of the JICA report.

G. Minutes of meeting

Stakeholder department briefing on sector wise draft goals, targets and actions under Bengaluru Climate Action and Resilience Plan (BCAP)

08.03.23 from 4:00 PM to 5:30 PM IST

at Bruhat Bengaluru Mahanagara Palike Head Office

Background: As a C40 City, Bengaluru is committed to developing its Bengaluru Climate Action and Resilience Plan that details the targets and actions of how the city will achieve its fair-share reduction of emissions in line with the most ambitious goals of the Paris Agreement. The Bengaluru Climate Action and Resilience Plan will also include actions that will help Bengaluru increase resilience to climate risks and reduce carbon emissions. In this regard, BBMP has been working with WRI India as a knowledge partner and C40 Cities as a technical partner in the preparation of the Bengaluru Climate Action and Resilience Plan.

The Bengaluru Climate Action and Resilience Plan preparation commenced in August 2021 through an official kick-off meeting facilitated by Ms. Vandita Sharma, IAS, CS, GoK. Currently a GPC-compliant GHG inventory has been completed for 2019, along with pathways modelling for various decarbonisation scenarios with an objective of achieving net zero by 2050. Also, a Climate Change Risk and Vulnerability Assessment has been completed for Bengaluru. Currently the project is in the stage of preparation of the final report along with finalisation of the targets and actions across sectors such as Stationary energy and buildings, transport, solid waste, water, wastewater, stormwater management, air quality, urban planning, greening and biodiversity, and disaster management.

Date: 08-03-2023

Venue: Meeting hall-1, BBMP Head office, Bengaluru

Time: 4-5:30 PM

Meeting agenda:

- Presentation on key findings and proposed sector-wise goals, targets, actions under Bengaluru Climate Action Plan
- Discussion with nodal officers/ representatives from stakeholder departments on goals, targets and actions

Members from BBMP:
- Sri. Parashuram Shinnalkar, Joint commissioner, SWM, BBMP
- Sri. Vishwanath, CE, BBMP
- Sri. Nagesh H, Nodal officer, SWM, BBMP

Members from WRI India:
- Ms. Jaya Dhindaw, Program Director- Integrated Urban Development, Planning and Resilience, Sustainable Cities & Transport Program, WRI India
- Ms. Shrimoyee Bhattacharya, Program Lead, Urban Development, Sustainable Cities and Transport, WRI India

- Ms. Radha Chanchani, Manager, Sustainable Cities & Transport Program, WRI India
- Ms. Nanduri Prashanti, Senior Program Research Associate - Sustainable Cities and Transport, WRI India
- Ms. Praseeda Mukundan, Senior Program Research Associate, Urban Development, Sustainable Cities and Transport, WRI India
- Mr. Chetan Venkataramana Naika, Senior Program Associate - Sustainable Cities and Transport, WRI India
- Dr. Sruthi Subbanna, Senior Program Research Associate - Sustainable Cities and Transport, WRI India

Members from C40:

- Mr. Benjamin John, City Advisor for Bengaluru, C40 Cities

List of Attendees of all other stakeholder departments: A copy of the attendance is attached below.

Meeting Proceedings:

- Sri Parashuram Shinnalkar, Joint Commissioner (SWM), BBMP welcomed the attendees and started the meeting.
- Ms. Shrimoyee Bhattacharya, Program Lead, Urban Development, WRI India and Mr Benjamin John, City Advisor, C40 gave a brief overview of Bengaluru's engagement in the C40 cities network and the key components of the Climate Action Plan.
- Ms Shrimoyee then presented the BCAP progress update, she covered the preparation process, stakeholder engagement undertaken during plan preparation process along with the key outputs (GHG inventory, CCRA, Pathways modelling, Targets and Action identification) of the BCAP work.
- Dr. Jaganmohan Sharma, Director General EMPRI stressed on the need for a climate action plan for Bengaluru and the need for leveraging initiatives announced at the national level such as the green credit programme.
- The attendees were then divided into sector-wise break-out groups to have focussed discussions on sector-wise goals, targets and actions.
- Key discussion points from each group discussion is summarised below.

a) Energy and Building

The representatives from KREDL, KPTCL, BESCOM, and Department of Industries and Commerce were present. Below are the key discussion points that were recorded during the sectoral group discussions.

- KREDL representative suggested to provide more details on the specific roles that secondary agencies take up. To this WRI India, responded that the suggestion will be considered upon the internal discussion on how to include the general roles in the form of a footnote of the action track tables.
- KREDL representative suggested to mandate the auditing rather than to assess energy efficiency in existing public buildings and conduct a feasibility study to understand the potential shift to maximise energy-efficient buildings. To this WRI India, responded that changes will be made accordingly.
- KREDL representative suggested to include an action or revise the existing 2.4 action to "Revise the BBMP building bye-laws to mandate the implementation of ENS codes for all residential buildings in the city". To this WRI India, responded that changes will be made accordingly.

- KREDL representative suggested to replace the 2.10 action with "Develop energy auditing guidelines for the electrical retrofitting of buildings to energy-efficient fixture, appliances, conduits etc.
- KPTCL and BESCOM representatives jointly suggested to remove the action 3.2 as BESCOM's or state's RE grid is dominated by private players and the RE generation is mostly from Independent Power Producers (IPPs).
- KPTCL representative asked the reason for grid electricity to be included in the action plan, when the generation of the power is happening outside the boundary which is beyond the jurisdiction of BBMP. To this WRI India, responded by firstly talking about the GPC protocol and the different scopes (1, 2, and 3) of emissions involved in the calculation of GHG emission inventory of a defined boundary and how Bengaluru is indirectly responsible for the GHG emissions as part of scope 2 emissions.

b) Transport

The representatives from the Transport department, DULT, Traffic police, Police, KRIDE, BMTC, KSRTC, and BMRCL were present. Below are the key discussion points that were recorded during the sectoral group discussions.

Below are the key discussion points that were recorded during this sector group discussion:

- Ms. Praseeda from the WRI team initiated the transport sector break-out group discussion by listing the key goals and targets identified for the sector. She highlighted that these were arrived at based on detailed analysis, modelling exercise and multiple rounds of consultations with all the concerned departments throughout the CAP process. Hard copy of the key goals and the action recommendations were shared with the participants. She then requested the participants to share their comments of the goals/targets/action recommendations.
- Mr. Gnanendrakumar from the Transport Department mentioned that multi-modal integration (MMI) related activities should be under the responsibility of the recently approved BMLTA. He added that providing infrastructure (e.g. Bus stops) for last-mile connectivity through public transport/inter mediate-public transport services should be the responsibility of BBMP, supported by the public transport agencies.
- Mr. Gnanendrakumar also suggested that public transport agencies should subsidise their ticket fares and if possible, make public transport free of cost. This could increase the ridership and mode share of these modes. He emphasised that this loss born by the public transport operators should be compensated by other means. To this point, Ms. Praseeda mentioned the 'Designing a *Green Credit Scheme'* has been and action proposed under CAP to promote the adoption of public transport and NMT. She added that, the scope of this scheme could be broadened to include the above-mentioned point on arriving at a mechanism to compensate the public transport operators.
- Mr. Manjunath from KRIDE pointed out that the organisation is planning to provide subsidies on ticket fares to women and children. Smart cards are also being planned.
- Mr. Yashwanth from BMTC highlighted various initiatives that BMTC has taken up to electrify its fleet in the near future.
- Mr. Gnanendrakumar also mentioned different initiatives taken up by the Transport Department on providing safer public transport services (e.g. Planning for installation of Location tracking and panic buttons in buses), on improving fuel efficiency (e.g. No tax and no permit requirement for EVs <25 Km/hr) and vehicle efficiency (e.g. Implementing the Scrappage Policy, not allowing government vehicles >15yrs to function).
- He also suggested to the WRI India team to include points on *Global Warming Potential* in the PPT for the upcoming meeting.

- Mr. Mohamed from DULT listed out various projects/ initiatives taken up by DULT on NMT, pilot testing of electrification SWM vehicles, etc. He also mentioned the status of the recently approved BMLTA.
- Mr. Satish from KSRTC mentioned various initiatives that the corporation was taking up to shift the cleaner fuels.
- Ms. Shreya from KRIDE asked if there could be any provision to give incentives to agencies like KRIDE who are including green building guidelines in their construction and related activities. To this the WRI team member suggested that the scope of the 'Green Credit Scheme' could be widened to include all such aspects. This however could be detailed out when the Scheme is being designed.
- Ms. Snehalatha from BMRCL highlighted that pushing for public transport shouldn't be the only strategy and the city should actively look out for ways to improve the first and last mile connectivity along with curbing private vehicles.
- Ms. Shashikala from BTP, pointed out that the city lacks basic infrastructure for NMT such as safe footpaths, streetlights, cycle tracks, etc. She also mentioned that to reduce congestion, the goods vehicles are not allowed to enter the city during the peak hours (7:30am-11am).
- Mr. Pragadeesh from KRIDE mentioned the need for having a multimodal freight management system.
- To the above point Mr. Mohamed added that DULT is in discussion with BMRCL to find out the possibilities of using the metro for fleet movement (esp. in the airport line)
- While discussing about electric vehicles Mr. Yashwanth highlighted that disposing the EV cells will be a huge problem in the future and a viable solution for it is yet to be suggested. He also highlighted that the lack of adherence of freight vehicles (trucks) to emission standards is a major issue.
- Ms. Snehalatha emphasised that all the public transport agencies shouldn't try to compete with each other instead complement and collaborate to have an efficient transport system in the city.
- To the various comments and concerned raised by all the participants, Ms. Praseeda highlighted the corresponding actions/provisions recommended under the CAP.
- Ms. Praseeda summarised the discussion by listing out the key goals and targets again. The participants in-principle agreed to those. She also requested all the participants to give further inputs/comments and suggestions on the Action recommendation and Goals (if any) via email.

c) Air Quality

The representatives from KSPCB and Department of Health & Family Welfare were present. Below are the key discussion points that were recorded during the sectoral group discussions.

- Department of Health & Family Welfare suggested to have an action on data collection of influenza-like illness (ILI) and severe acute respiratory infections (SARI) cases and related admission data on daily basis from the hospital to monitor the respiratory illness due to poor air quality.
- Department of Health & Family Welfare suggested to deploy AQI display monitors in the hotspot areas.
- KSPCB suggested to remove the action on usage of low-cost sensors for air quality monitoring.

d) Water and Wastewater

The representatives from BWSSB were present. Below are the key discussion points that were recorded during the sectoral group discussions.

- BWSSB officials addressed the point on 35% of treated wastewater reuse for non-potable purposes across the city. They suggested a slight modification across the city to the properties that have dual pipeline systems.
- BWSSB officials commented for point 1.1 that currently BWSSB is providing 100% piped water supply to all the households within the core and 8ULB areas and 110 villages, with the support of BBMP the borewell water is being pumped and supplied to the households.
- For point 1.2, BWSSB officials stated that the department already has the actual water consumption data of the city, and this point could be modified to make the data available in open access platform.
- For point 2.1, BWSSB officials stated that a pilot was conducted to an area of 135 sq. km. and to achieve this action across the city, the department would require additional funding from the government.
- For point 2.5, BWSSB officials have stated that the tariff has been modified to a volumetric tariff structure and is submitted to the Government and awaiting approval.
- BWSSB officials stated that currently, the department is yet to investigate the matters of water and energy-efficient appliances awareness.
- To point 2.14, BWSSB officials suggested modification that the TG Halli Reservoir is ready to operate which could provide an additional 110MLD of water, but this is subjected to 1.2TMC allocation that they are awaiting.
- BWSSB officials said that property-level RWH is being extensively implemented and promoted but there are no actions yet on community-level RWH.
- BWSSB officials stated that all the existing STPs will be upgraded to biological treatment systems by 2027, hence, point 4.2 can be modified accordingly.
- BWSSB officials stated that the department has no role in the construction of public toilets, stormwater management and groundwater, hence these actions were not discussed.

e) *Urban Planning, Greening and Biodiversity*

The representatives from Forest department, BDA, and KBB were present. Below are the key discussion points that were recorded during the sectoral group discussions.

Below are the key discussion points that were recorded during this sector group discussion: Ms. Radha from the WRI team initiated the discussion by highlighting the key goals/targets suggested for the sector. Goal/target wise comments/inputs from all the participants are listed below.

A major point is that for quantitative goals, knowing current baselines is crucial.

- Prepare and adopt the RMP 2041 and set up the Master Plan Coordination Committee, by 2025
  - Representative from BDA informed that the tender for preparation of Revised Master Plan (RMP 2041) has been cancelled as the Terms of Reference and Scope of Work has changed. Provisions of the approved Bengaluru TOD Policy are to be included. Spatial mapping of existing development has been done through remote sensing and drone surveys, with help from KSRSAC. While timelines for preparation and approval of the RMP are not clear, the current RMP can be amended to incorporate notified TOD Zone Plans and Regulations.
- Around 90% of the new households in the city (from 2019) should be accommodated in TOD Zones by 2050
  - Representative from BDA felt this was possible, however its likely this goal was not well understood and may be worded differently.
- All spatial plans and DCRs to adopt climate action as a lens by 2030
  - Representative from BDA felt this can be done. Even without the proposed amendment to KTCPA (mandating land suitability, carrying capacity and impact

analysis), RMP preparation does consider most of these aspects. Climate action can be included/embedded within the strategies and proposals of key stakeholder and implementing agencies (like BBMP) and other sectoral agencies; which are typically incorporated into the RMP.

- Conserve and restore all blue-green networks in the city. All urban infrastructure schemes/projects should adhere to disaster resilient standards.
  - Representatives from all agencies agreed with this goal, though some clarity is needed on disaster resilient standards. Representatives from the Forest Department (district level) clarified that some lakes were under their jurisdiction, so they should be included accordingly in other sectors such as Water, too.
- Increase the city's tree cover (canopy) from the baseline by 10% by 2030 and 20% by 2040.
  - Representative from BBMP (Forest Department) confirmed that the Tree Census exercise is ongoing. There was some discussion on what the baseline number of trees (about 14 lakh) and tree cover (about 15%) in the city. Rep from Forest Department (District Level) suggested that the goal should be clear about whether one is looking at trees per capita or area under tree cover. He felt that if it the latter, then given the baseline the goal/targets seem achievable. He also pointed out that it may be easier to increase tree cover in the urban district beyond BBMP, compared to within it (as it is already highly developed). Others in the group also agreed that this goal would require identifying public and private spaces to plant more trees as well as along roads, and that the BBMP Engineering (Roads/Lakes) Department also had a significant role to play here. They should be included as a secondary responsible agency.
- Increase the city's vegetation cover and permeable surface to 40% of the city surface area by 2040 to tackle flood and heat related disaster risk reduction.
  - Again, there was some discussion on the baseline – some studies suggest this is about 8% and others 30%. The group felt that this has to be clear. If it is the latter (30%) then the goal of 40% seems achievable – through NBS and regulations in the RMP mandating the creation of more open and permeable spaces. The rep from BDA noted that the RMP already mandates 15% reservation for open spaces.
- Convert 75% of the city's footpaths to permeable surface material by 2050
  - Representatives in the group could not comment on this goal as it was a question primarily for the BBMP Engineering Department.
- Operationalise the (recently re-constituted) Biodiversity Management Committee (BMC) by 2023 and prepare the People's Biodiversity Register (PBR) by 2025.
  - Reps from the State Biodiversity Board agreed to this goal as this is a mandate by the Act and Rules. The year for preparation of the PBR needs more clarity. They expressed that the above goals (restoration of blue-green networks, increasing trees and open spaces etc) would also support biodiversity. The need for recognising water bodies as habitats and planting native species trees/vegetation was emphasised.
- Provide safe and affordable housing for 100% urban poor and vulnerable groups in locations having access to public transport stops/stations within 5-minute walkable distance by 2050
  - Reps from BDA felt this was possible (being a longer-term goal) through appropriate provisions in the RMP and several government affordable housing schemes/projects that have been announced or are underway.
- Increase the city's publicly accessible per capita open space from the existing 2.2 sq. m. to 6 sq. m. by 2050
  - The group felt this goal was possible if various strategies could be adopted - such as leveraging buffer spaces around water bodies, institutional open spaces and RMP regulations pertaining to creation of public open spaces. The challenge of mandated open spaces (within large private layouts/developments) not have public access (despite being public assets as per RMP regulations) was discussed. The rep from BDA

clarified that the Draft RMP 2031 (now withdrawn) had tried to address this issue by mandating public access roads.

f) Disaster Management

The representatives from KSNDMC were present. Below are the key discussion points that were recorded during the sectoral group discussions.

Some of the key comments that were recorded during the discussion included:

- Few action points that addressed expanding the existing information dissemination system to an even more elaborate and inclusive system was discussed at greater length. KSNDMC official mentioned about the more recent initiatives by the organisation like the Common Alerting Protocol (CAP) dashboard portal and CAP SACHET platform initiated by the National Disaster Management Authority. This provides a converged platform for dissemination of targeted alerts to people in vernacular languages.
- In addition Integration of DEWS (Disaster Early warning system) of KSNDMC with CAP SACHET platform for effective dissemination of messages
- Further, the Emergency Response Support System which is a single pan India emergency number is being extended for Natural Calamities
- The Early Warning Dissemination System (EWDS) has also been initiated by KSNDMC.
- KSNDMC is also providing technical expertise in preparing a city level Disaster Management Plan with BBMP
- Overall KSNDMC was happy to support BBMP for the suggested actions to achieve the goals and targets for enhancing city’s resilience.

Key Decisions and Next Steps:

- Departments will apprise their respective HoDs on BCAP goals, targets, actions pertaining to their sectors and share further feedbacks and suggestions with WRI India
- BBMP will convene another follow up meeting with heads of sector agencies/ senior officials on BCAP goals, targets, actions
- WRI India will review, evaluate and incorporate suggestions received from stakeholder departments in the final draft of BCAP.

Attendance sheet

①

CLIMATE ACTION & RESILIENCE PLAN – BENGALURU CITY
Briefing nodal officers on
sector-wise draft goals, targets, and action under BCAP

Time: 4 pm to 5.30 pm
Date: 08/03/23
Location: BBMP HQ, Annex Building 1, Meeting Room 1

ATTENDANCE

#	Name	Organization	Designation	Contact Number	Email	Signature
3	K N Poramesha	PWD	CE	[illegible]	[illegible]@gmail.com	[illegible]
4	Rahul Priyadarshi	BWSSB	ACE	998011188[illegible]	rahulone@hotmail.com	[illegible]
5)	T Jahesh.J.R	Forest	RFO	9480685539		[illegible] 8/3/23
6	Saritha Baga	EMPRI	Sr. Consultant		dcc-empri@karnataka.gov.in	G.A.B
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11	Gayatri Kulkarni	KPTCL	EE KPTCL	82778 95891	eepss1kptcl@gmail.com	[illegible]
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17	Mohamed Fazil	DULT	JD.	9880403788	dultbangalore@gmail.com	[illegible]
18	M.J. Govardhan Singh	Bio diversity Board	DCF	7022548991	mjgsingh18@gmail.com	[illegible]

CLIMATE ACTION & RESILIENCE PLAN – BENGALURU CITY

Briefing nodal officers on
sector-wise draft goals, targets, and action under BCAP

Time: 4 pm to 5.30 pm

Date: 08/03/23

Location: BBMP HQ, Annex Building 1, Meeting Room 1

ATTENDANCE

#	Name	Organization	Designation	Contact Number	Email	Signature
19	Sahana. C.B	KREDL	PE	9741147766	kredl09@gmail.com	
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22.	J. Gnanendrakumar	Transport Dept.	ACT (E+E)			

(2)

CLIMATE ACTION & RESILIENCE PLAN – BENGALURU CITY

Briefing nodal officers on
sector-wise draft goals, targets, and action under BCAP

Time: 4 pm to 5.30 pm

Date: 08/03/23

Location: BBMP HQ, Annex Building 1, Meeting Room 1

ATTENDANCE

#	Name	Organization	Designation	Contact Number	Email	Signature
1	Dr. Nagaraj. A.S.	Health & Family welfare Dept	R.O. NVBDCP	9448335091	nagarajas460@gmail.com	
2	Dr md shariff	Dept of Health & Family welfare GOK	Deputy Director	8553322999	ranvbdcp@gmail.com	8/3/2023
3	Indira. J	Assistant General Manager	BESCOM	9449844898	cgm.op.works@gmail.com	
4	M.D. Karthik	BESCOM	DGM (OP)	9448097747	—	08/03/23
5	Jayaprakash B	K.S.P.C.B	A.S.O	9986015104	agmc@kspcb.gov.in	
6	Fathimathul Sabna	KBB	UNDP-NBA Intern	9400913701	fathimathulsabna6@gmail.com	
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CLIMATE ACTION & RESILIENCE PLAN – BENGALURU CITY
Briefing nodal officers on
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ATTENDANCE

#	Name	Organization	Designation	Contact Number	Email	Signature
8	VIJAY.H	APCfree	ACP, COP, Bengaluru	9480801031	vijayhadagali08@gmail.com	
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10	Manjunath C T	KREDL	Executive Engineer	9372228729	~~kredl09ec~~ kredl09ec@gmail.com	

(3)

CLIMATE ACTION & RESILIENCE PLAN – BENGALURU CITY
Briefing nodal officers on
sector-wise draft goals, targets, and action under BCAP

Time: 4 pm to 5.30 pm
Date: 08/03/23
Location: BBMP HQ, Annex Building 1, Meeting Room 1

ATTENDANCE

#	Name	Organization	Designation	Contact Number	Email	Signature
1)	Sri. Parashuram Shinnalkar, KAS	BBMP	JC(SWM)	9108626626	jcswmbbmp2@gmail.com	
2)	Sri. Vishwanath	—do—	CE(I/c)			08.03.2023
3)	Nagesh. H.	—do—	Nodal officer (SWM)	9731291617	nodalofficerswm@gmail.com	08/03/2023

CLIMATE ACTION & RESILIENCE PLAN – BENGALURU CITY
Briefing nodal officers on
sector-wise draft goals, targets, and action under BCAP

(4)

Time: 4 pm to 5.30 pm
Date: 08/03/23
Location: BBMP HQ, Annex Building 1, Meeting Room 1

ATTENDANCE

#	Name	Organization	Designation	Contact Number	Email	Signature
1.	PRAGADEESH	K-RIDE	Dy. Mgr	8778699291	pragadeesh.kride@ka.gov.in	
2.	YASHWANTH KUMAR	BMTC	Dy C.M.E	7760991124	dycme@mybmtc.com	
3.	SHREYA D.P	K-RIDE	A.C Engineer	9901425165	(1) krideplanning@gmail.com (2) purvi.shreya@yahoo.in	
4.	Jaganmohan Sharma	EMPRI	DG	94498 63506	dgempri@karnataka.gov.in	

Head of the stakeholder department briefing on sector-wise draft goals, targets and actions under the Bengaluru Climate Action and Resilience Plan (BCAP)

13.03.23 from 4:00 PM to 5:30 PM IST

at Vikasa Soudha, Bengaluru

Background: As a C40 City, Bengaluru is committed to developing its Bengaluru Climate Action and Resilience Plan that details the targets and actions of how the city will achieve its fair-share reduction of emissions in line with the most ambitious goals of the Paris Agreement. The Bengaluru Climate Action and Resilience Plan will also include actions that will help Bengaluru increase resilience to climate risks and reduce carbon emissions. In this regard, BBMP has been working with WRI India as a knowledge partner and C40 Cities as a technical partner in the preparation of the Bengaluru Climate Action and Resilience Plan.

The Bengaluru Climate Action and Resilience Plan preparation commenced in August 2021 through an official kick-off meeting facilitated by Ms. Vandita Sharma, IAS, CS, GoK. Currently, a GPC-compliant GHG inventory has been completed for the year 2019 along with pathways modelling for various decarbonisation scenarios to achieve net zero by 2050. Also, a Climate Change Risk and Vulnerability Assessment has been completed for Bengaluru. Currently, the project is in the stage of preparation of the final report along with the finalisation of the targets and actions across sectors such as Stationary energy and buildings, transport, solid waste, water, wastewater, stormwater management, air quality, urban planning, greening and biodiversity, and disaster management.

Date: 13-03-2023

Venue: Hall No-317, Vikasa Soudha, Bengaluru

Time: 4-5:30 PM

Meeting agenda:

- Presentation on key findings and proposed sector-wise goals, targets, and actions under Bengaluru Climate Action Plan.
- In-principle consensus on mitigation and adaptation goals and targets proposed under BCAP
- Discussion on BCAP Monitoring, evaluation, reporting and governance arrangements

Members from BBMP and UDD:

- Sri Rakesh Singh, Additional Chief Secretary, Urban Development Department, Govt of Karnataka
- Sri. Parashuram Shinnalkar, Joint commissioner, SWM, BBMP
- Sri. Basavraj Kabade, Chief Engineer, SWD, BBMP
- Sri. Nagesh. H, Nodal officer, SWM, BBMP

Members from WRI India:

- Ms. Shrimoyee Bhattacharya, Program Lead, Urban Development, Sustainable Cities and Transport, WRI India
- Ms. Radha Chanchani, Manager, Sustainable Cities & Transport Program, WRI India
- Ms. Priya Narayanan, Senior Program Manager, Urban Development, Sustainable Cities and Transport, WRI India
- Ms. Nanduri Prashanti, Senior Program Research Associate - Sustainable Cities and Transport, WRI India
- Ms. Praseeda Mukundan, Senior Program Research Associate, Urban Development, Sustainable Cities and Transport, WRI India
- Mr. Chetan Venkataramana Naika, Senior Program Associate - Sustainable Cities and Transport, WRI India

- Dr. Sruthi Subbanna, Senior Program Research Associate - Sustainable Cities and Transport, WRI India

Members from C40:

- Mr. Benjamin John, City Advisor for Bangalore, C40 Cities

List of Attendees of all other stakeholder departments: A copy of the attendance is attached below.

Meeting Proceedings:

- Sri Basavraj Kabade, Chief Engineer, SWD, BBMP welcomed the attendees and started the meeting.
- Ms. Shrimoyee Bhattacharya, Program Lead, Urban Development, WRI India and Mr Benjamin John, City Advisor, C40 gave a brief overview of Bengaluru's engagement in the C40 cities network and the key components of the Climate Action Plan.
- Ms Shrimoyee then presented the BCAP progress update, she covered the preparation process, stakeholder engagement undertaken during the plan preparation process along with the key outputs (GHG inventory, CCRA, Pathways modelling, Targets and Action identification, Goals/Targets and broad actions of each sector, Governance and monitoring) of the BCAP work. She suggested the following points:

  Monitoring, evaluation and reporting
    - GHG inventory could be updated every 2 years
    - Annual assessment of loss and damage due to climate-related disasters
    - Climate change risks and vulnerability assessment can be conducted every 3-5 years

  Governance
    - Bengaluru climate action cell can be formed and housed in BBMP (Coordinate with other dept., monitoring etc.) where the technical wing is at EMPRI (Update GHG inventory, Conduct ~~CCRAVA~~CCRA-VA and anchor capacity building and training). This cell could also work as a project preparation facility to help raise funds, support departments and forge partnerships.
- Sri. Rakesh Singh, ACS-UDD advised WRI India to follow up with all agencies to provide the actions/goals of each department through BCAP that can be taken up by the departments respectively. He informed WRI India to update the progress and provide a copy of the BCAP actions/goals/targets over an email for his comments. He instructed the officials present from the stakeholder departments to provide their feedback on the proposed goals, targets and actions within 7 days.
- KREDL suggested being included in the actions about PAT schemes. Since KREDL is the state-designated agency for PAT they will work with the assigned agency like the Department of Industries and Commerce as long as the tasks with the respective agencies are made clear.
- Forest department suggested being included in the actions about lakes rejuvenation (as 5 lakes within BBMP are under their jurisdiction). They also requested the WRI India team to visit their office to discuss action points that were towards urban planning, greening and biodiversity.
- Sri. Basavraj Kabade from BBMP requested WRI India to reach out to him on Friday to discuss the actions on solid waste and stormwater management.

Key decisions and next steps

- Representatives of stakeholder departments in-principle agreed on the sector-wise goals and targets set under BCAP
- Departments will provide their inputs on proposed actions within seven working days from 13.03.23
- WRI India will review, evaluate, and incorporate suggestions received from stakeholder departments in the final draft of BCAP.

Attendance sheet

CLIMATE ACTION & RESILIENCE PLAN – BENGALURU CITY
Briefing nodal officers on
sector-wise draft goals, targets, and action under BCAP

Time: 4 pm to 5.30 pm
Date: ~~08~~ 13/03/23
Location: ~~BBMP HQ, Annex Building 1~~, Meeting Room 317, VIKASA SOUDHA

ATTENDANCE

#	Name	Organization	Designation	Contact Number	Email	Signature
1)	B. Maruthi	B.d.a.	Adtp	99455-86729	——	13/3
2)	M.J. Govardhan Singh	Bio diversity Board	DCF	7022948991		
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12.	Basavaraj R. Kabade	CE, SWD BBMP	Chief Engineer	9739625025	basavarajkabade@hotmail.com	
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CLIMATE ACTION & RESILIENCE PLAN – BENGALURU CITY

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Time: 4 pm to 5.30 pm

Date: ~~08~~ 13/03/23

Location: ~~BBMP HQ, Annex Building 1,~~ Meeting Room 317, VIKASA SOUDHA

ATTENDANCE

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11	Dr. Rohini Balasubramanian	RITES Ltd.	Sustainability & Climate Change	9880688788	rohini.b@rites.com	Rohini B

H. Technical specifications and summary of Pathways-AQ rapid scoping tool by C40 cities

Pathways-AQ builds on an earlier 'Pathways' tool which models greenhouse gas emissions over time and allows users to input climate actions to estimate how they would impact the city's emissions by 2050. In addition to modelling emissions of CO2e, Pathways-AQ models emissions of fine air pollutants (PM2.5), along with four pollutants that combine in the atmosphere to produce PM2.5 – nitrous oxides (NOx), sulphur dioxide (SO2), ammonia (NH3) and volatile organic compounds (VOC).

It then uses spatial analysis from an external simplified air quality model, the Intervention Model for Air Pollution (InMAP-Global), to convert emissions of PM2.5 and other precursor pollutants into an annual average PM2.5 concentration within the city's boundary. Finally, Pathways-AQ uses data from the Global Burden of Disease study to estimate city-wide mortality from six air pollution-linked diseases, to assess how climate policies may impact public health(Climate Leadership Group 2022).

InMAP-Global: Intervention Model for Air Pollution is a reduced-complexity model originally developed for the United States, to simulate annual-average primary and secondary PM2.5 concentrations across a global-through-urban spatial domain: "Global InMAP". Global InMAP uses a variable resolution grid, with horizontal grid cell widths ranging from 500 km in remote locations to 4km in urban locations. We evaluate Global InMAP performance against both measurements and a state-of-the-science chemical transport model, GEOS-Chem. Against measurements, InMAP predicts total PM2.5 concentrations with a normalised mean error of 62%, compared to 41% for GEOS-Chem. For the emission scenarios considered, Global InMAP reproduced GEOS-Chem pollutant concentrations with a normalised mean bias of 59%–121%, which is sufficient for initial policy assessment and scoping. Global InMAP can be run on a desktop computer; simulations here took 2.6–8.4 hours(Thakrar et al. InMAP).

GEOS-Chem: GEOS-Chem enables simulations of atmospheric composition on local to global scales. It can be used off-line as a 3-D chemical transport model driven by assimilated meteorological observations from the Goddard Earth Observing System (GEOS) of the NASA Global Modeling Assimilation Office (GMAO). It can also be used on-line as a chemical module coupled to weather and climate models("Overview" 2017).

Bengaluru CAP-AQ Summary:

Bengaluru experiences the negative effects of air pollution, with ambient fine particulate matter ($PM_{2.5}$) level in the city 8 times the level recommended by the World Health Organization (i.e., 5 ug/m^3). Many sources of air pollution are also sources of climate pollutants, so reducing these sources can have the dual benefits of improving air quality and mitigating climate change. By implementing its CAP, Bengaluru has the opportunity to improve air quality, while contributing to global climate change mitigation and ensuring the well-being of its citizens.

Bengaluru's CAP actions and scenarios were analysed using Pathways-AQ, a rapid, accessible scoping tool created to understand the air quality and health implications of city climate policies. Pathways-AQ is a combined GHG and air quality scoping tool. It creates an air quality emissions inventory by applying air pollutant emission factors to "activity" (fuel use) data. In addition to modelling emissions of carbon dioxide equivalent (CO_2e), it models direct emissions of PM2.5 along with four pollutants that combine in the atmosphere to produce PM2.5: nitrous oxides (NO_x), sulphur dioxide (SO_2), ammonia (NH_3), and volatile organic compounds (VOC).

To calculate emissions, Pathways-AQ uses a bottom-up approach to model activity within the city for the residential, commercial, industrial, transport and waste sectors, then multiplies each activity by an emission factor (emissions per unit of activity) to estimate the mass of pollutants generated.[74] Pathways-AQ then uses spatial analysis from an external tool, the InMAP (Intervention Model for Air Pollution) model (Muller et al. 2017), to convert emissions of PM2.5 and other precursor pollutants into an annual average $PM_{2.5}$ concentration within the area of the city's boundary. Finally, Pathways-AQ uses baseline population health data from the Global Burden of Disease 2019 Study, coupled with relative risk curves, to estimate city-wide mortality from six diseases that are linked to air pollution (PM2.5).

Currently, the two largest contributors to annual average PM2.5 concentrations in Bengaluru are 1) on-road transport, including high-emitting cars and buses; 2) manufacturing and industrial emissions.

Bengaluru can have a positive impact on its air quality by fully implementing its climate action planning scenarios, averting hundreds of premature deaths each year through climate actions that benefit air quality as well, though the improvement is not enough to lower $PM_{2.5}$ concentrations to meet the World Health Organization (WHO) ambient air quality guidance (i.e., 5 ug/m^3). The estimated changes in air pollution and premature mortality presented in Table 1 provides an indication of the reductions in $PM_{2.5}$ concentrations and the associated premature deaths over the modelled time horizons, under the Existing and Planned (E&P), Ambitious and Extended scenarios, respectively. Table 44 provides the estimates.

Table 44: Estimated changes in air pollution and premature mortality associated with the implementation of Bengaluru's Climate Action Plan scenarios

	Change in air pollution **(Annual average reduction in $PM_{2.5}$ concentration)**	**Change in premature mortality (Deaths avoided per year)**
Existing and Planned Scenario		

[74] Note, importantly, that only emission sources included in the GHG inventory are reflected in this analysis. Pathways-AQ generates mass emission estimates for GHGs as well as PM2.5 and precursor pollutants. This analysis does not include all emission sources within the city.

	Change in air pollution (Annual average reduction in $PM_{2.5}$ concentration)	Change in premature mortality (Deaths avoided per year)
2030	3.0 µg/m3	560
2040	4.6 µg/m3	1,368
2050	6.5 µg/m3	2,913
Ambitious Scenario		
2030	4.1 µg/m3	790
2040	7.2 µg/m3	2,230
2050	11.4 µg/m3	5,495
Extended Scenario		
2030	5.1 µg/m3	989
2040	8.8 µg/m3	2,796
2050	13.0 µg/m3	6,383

Source: C40 cities analysis

Under the E&P scenario, climate mitigation strategies in the manufacturing industrial sector — such as promoting energy efficiency — yield high potential to mitigate GHG emissions and reduce air pollution. Other strategies with potential to markedly reduce both air pollution and GHG emissions include: reducing the number of trips using on-road vehicles, shifting away from high-emitting on-road vehicles to walking and cycling; switching to cleaner on-road transport fuels; improving cooking appliances and using cleaner fuels in new commercial buildings.

Bengaluru can reduce its annual average population-weighted $PM_{2.5}$ by 15% to 36.9 µg/m3 in 2050 in the E&P scenario (for $PM_{2.5}$ attributable to sectors included in Pathways, the climate action planning modelling tool) (Figure 87), preventing 2,913 early deaths in 2050 (Figure 88). The actions that will be particularly helpful in improving air quality under this scenario are related to improving vehicle emission standards, and shifting away from motorcycles in the transport sector.

Figure 87: Air quality implications of climate actions in the E&P scenario

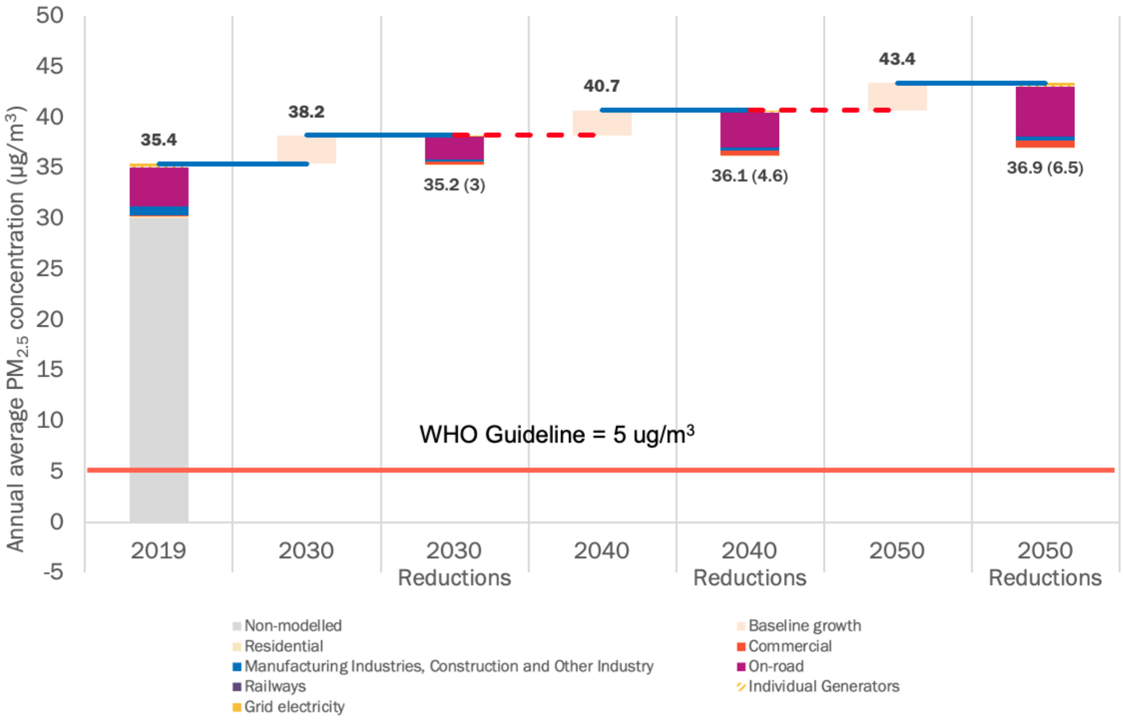


Figure 87 *Air quality implications of climate actions in the E&P scenario. The top numbers show the projected baseline PM2.5 concentrations in a given year. The lower numbers represent the PM2.5 concentration expected after implementation of the E&P scenario. The difference between the top and lower numbers equates to the reduced PM2.5 concentration in a given year and is represented in brackets next to each lower number.*

Figure 88: Health implications of climate actions in the E&P scenario

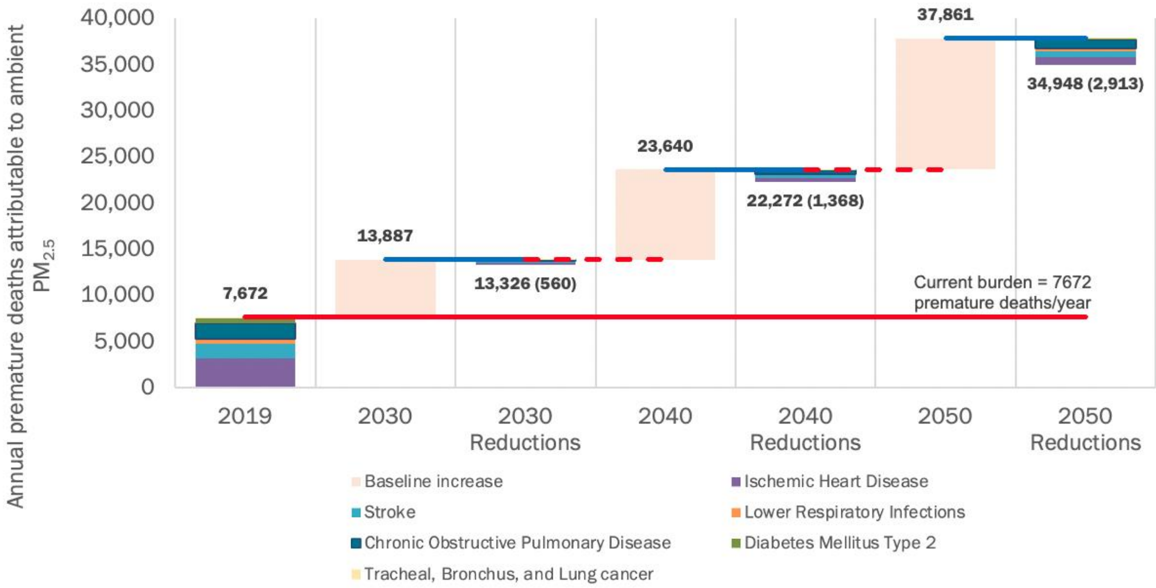


Figure 88 *Health implications of climate actions in the E&P scenario. The top numbers show the projected baseline premature mortality due to ambient PM2.5 exposure in a given year. The lower numbers represent the number of premature deaths expected after implementation of the E&P scenario. The difference between the top and lower numbers equates to the premature deaths avoided in a given year, and is represented in brackets next to each lower number.*

Under the Ambitious scenario, on-road transport sector climate mitigation strategies—such as fuel switching in buses from unclean energy sources (diesel) to electricity—have high potential to mitigate GHG emissions and reduce air pollution.

Implementing the Ambitious scenario is projected to reduce annual average population-weighted PM2.5 by 11.4 µg/m³ in 2050 (Figure 89); which would prevent 4,856 early deaths in 2050 (Figure 90). The sectors that have the highest potential to reduce PM2.5 and majority of health benefits accrued in that year are establishing vehicle emission standards and fuel switching measures in diesel buses, as well as industrial fuel switching measures.

Figure 89: Air quality implications of climate actions in the Ambitious scenario

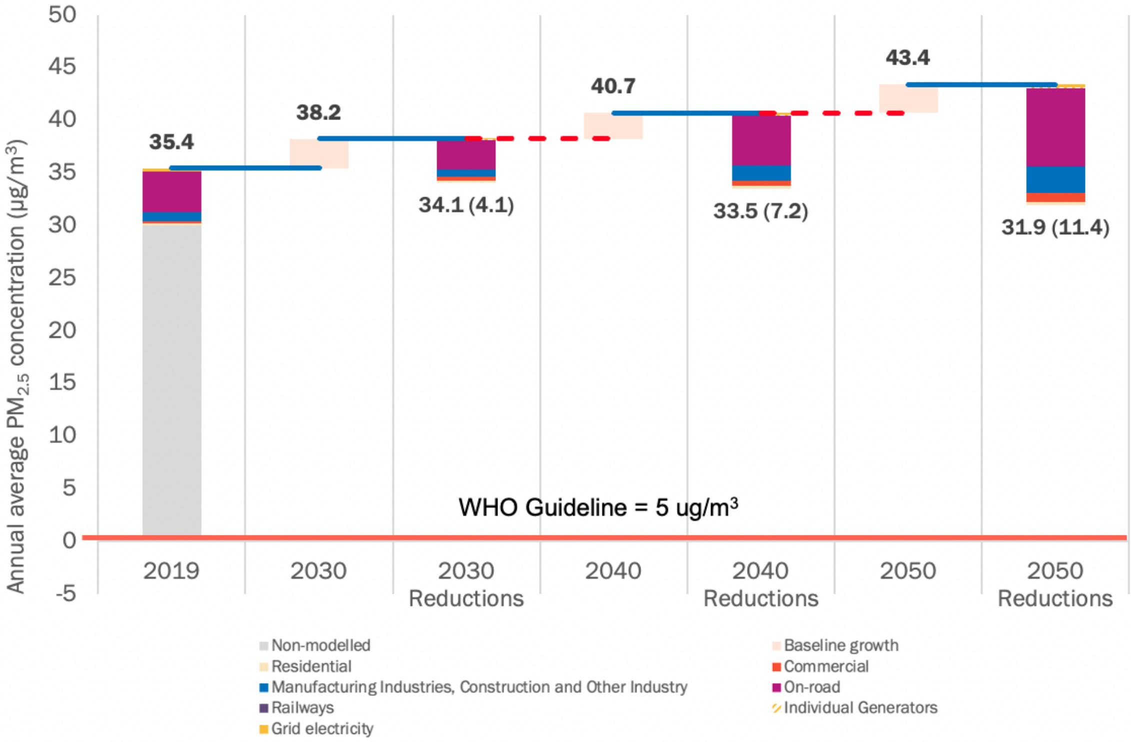


Figure 89. *Air quality implications of climate actions in the Ambitious scenario. The top numbers show the projected baseline PM2.5 concentrations in a given year. The lower numbers represent the PM2.5 concentration expected after implementation of the Ambitious scenario. The difference between the top and lower numbers equates to the reduced $PM_{2.5}$ concertation in a given year and is represented in brackets next to each lower number.*

Figure 90: Health implications of climate actions in the Ambitious scenario

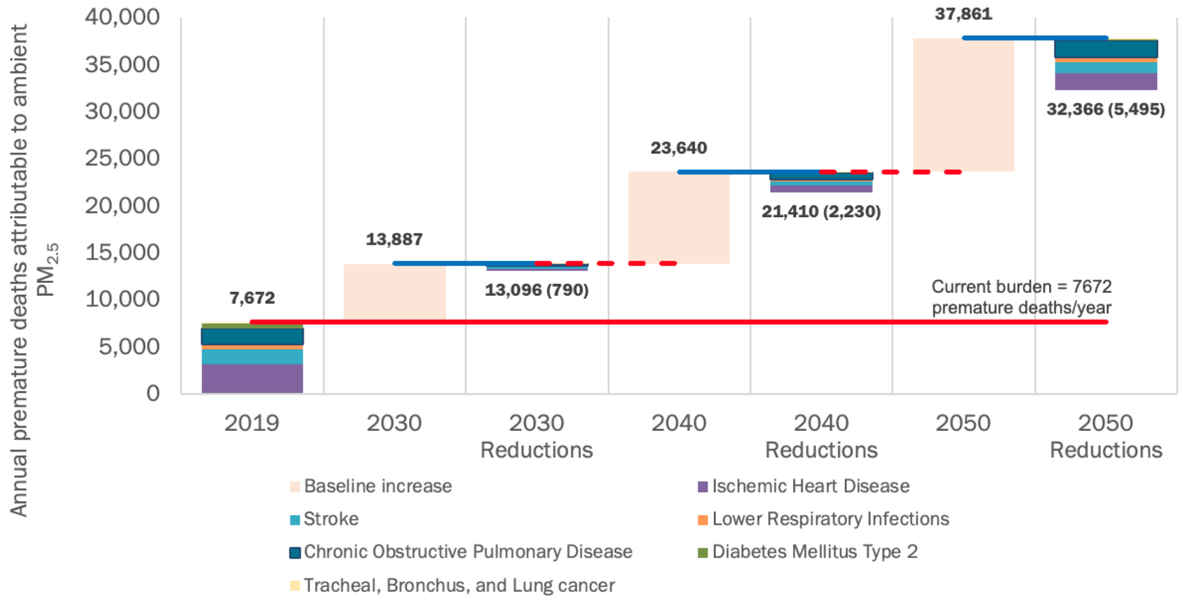


Figure 90 *Health implications of climate actions in the Ambitious scenario. The top numbers show the projected baseline premature mortality due to ambient PM2.5 exposure in a given year. The lower numbers represent the number of premature deaths expected after implementation of the Ambitious scenario. The difference between the top and lower numbers equates to the premature deaths avoided in a given year, and is represented in brackets next to each lower number.*

Figure 91: Air quality implications of climate actions in the Extended scenario

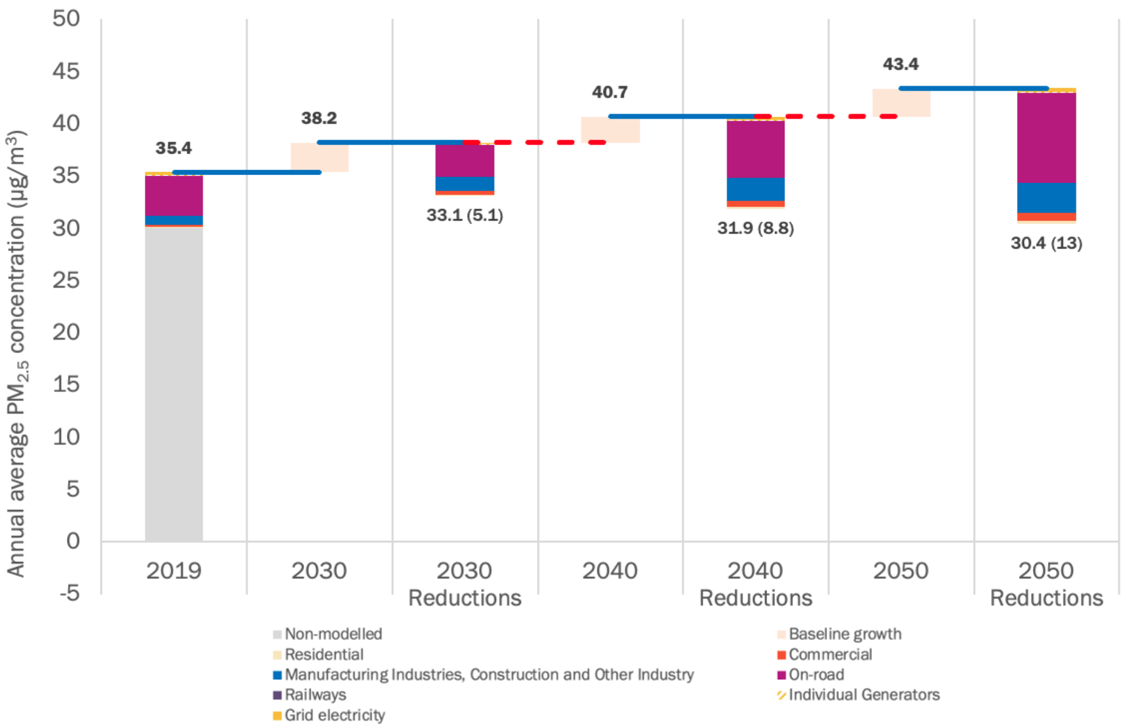


Figure 91 *Air quality implications of climate actions in the Extended scenario. The top numbers show the projected baseline PM2.5 concentrations in a given year. The lower numbers represent the PM2.5 concentration expected after implementation of the Ambitious scenario. The difference between the top and lower numbers equates to the reduced PM2.5 concertation in a given year and is represented in brackets next to each lower number.*

Figure 92: Health implications of climate actions in the Extended scenario

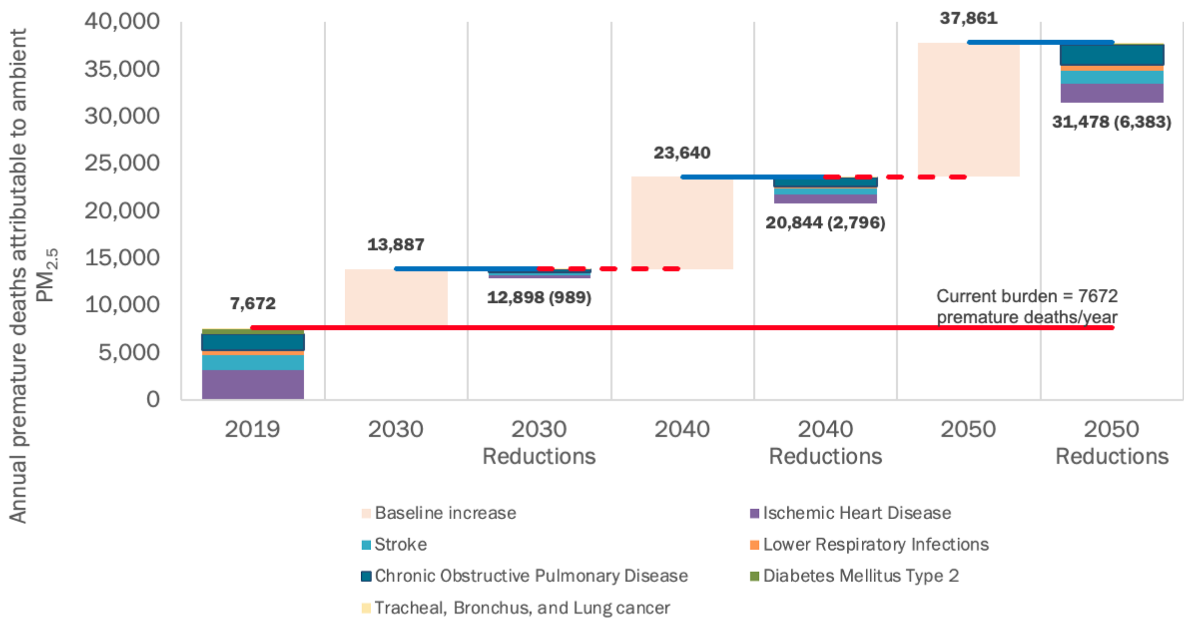


Figure 92 *Health implications of climate actions in the Extended scenario. The top numbers show the projected baseline premature mortality due to ambient PM2.5 exposure in a given year. The lower numbers represent the number of premature deaths expected after implementation of the Ambitious scenario. The difference between the top and lower numbers equates to the premature deaths avoided in a given year, and is represented in brackets next to each lower number.*

An Extended scenario was developed to identify mitigation actions that could potentially close the gap between Ambitious Scenario and Deadline 2020 emission reduction targets. Under the Extended scenario, climate mitigation strategies such as fuel switching in buses from unclean energy sources (diesel) to electricity, promoting energy efficiency and fuel switching in industries have high potential to mitigate GHG emissions and reduce air pollution.

Implementing the Extended scenario is projected to reduce annual average population-weighted $PM_{2.5}$ by 13 μg/m³ in 2050 (Figure 90), which would prevent 6,383 early deaths in 2050 (Figure 90). The sectors that have the highest potential to reduce $PM_{2.5}$ and majority of health benefits accrued in that year are establishing vehicle emission standards and fuel switching measures in diesel buses, as well as industrial fuel switching and energy efficiency measures.

Summary

Mainstreaming air quality work across all relevant city departments will encourage better coordination and effective use of resources to accomplish the city's stated air quality management and climate change-related goals. Although air pollution may seem like a future issue, the reality is that it is creating health effects and causing early death now. As Bengaluru grows, air pollution need not to get worse. Taking action now will prevent early deaths every year.

I. Sector-wise Institutional Mapping

A representation of roles and responsibilities of all the departments and agencies involved in the activities of each of the sectors are given below.

<u>Legend:</u>

Agencies/departments who plays a Primary Role
Agencies/departments who plays a Secondary Role (Supporting role)
Agencies/department who plays multiple roles

Energy and Buildings

Figure 93 Overview of the key activities and responsibilities in the energy sector (electricity)

Generation

- KPCL
- Hydroelectric power plants, Thermal plants, Diesel, Gas, Wind and Solar

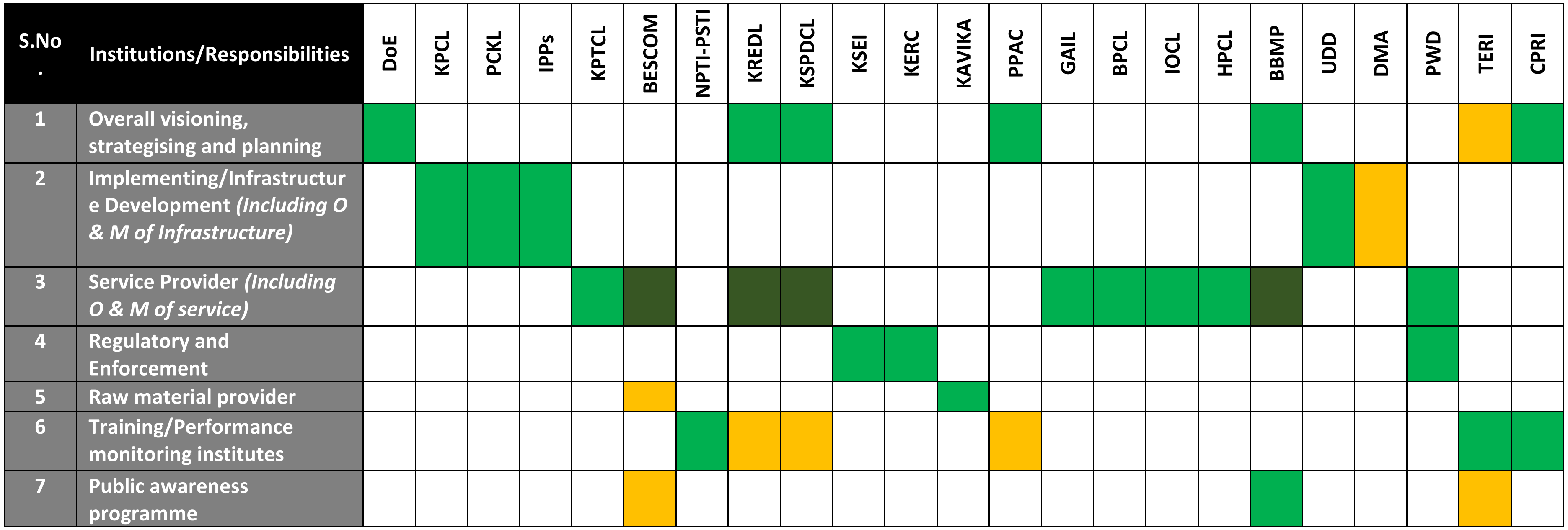
Transmission (trading)

- PCKL- Trading of electricity from generation sources and supply to KPTCL
- IPPs such as GMR, Jindal, Lanco etc.
- KPTCL- Purchase electricity from KPCL & IPPs

Distribution (Supply)

- BESCOM - Purchase electricity from KPTCL and supplies to Bengaluru city consumers

Figure 94 Institutional Mapping of the Energy and Buildings sector



List of Abbreviations			
KPCL	Karnataka Power Corporation Limited	KSEI	Karnataka State Electrical Inspectorate (GoK owned)
PCKL	Power Company of Karnataka Limited	KERC	Karnataka Electricity Regulatory Commission
KPTCL	Karnataka Power Transmission Corporation Limited	KAVIKA	Karnataka Vidyuth Kharkhana Limited (Government undertaking)
BESCOM	Bengaluru Electricity Supply Company Limited	BBMP	Bruhat Bengaluru Mahanagara Palike
NPTI	National power training institute (Central Government owned)	UDD	Urban Development Department
GAIL	GAIL Gas Limited (PSU - Central Government)	DMA	Directorate of Municipal Administration
BPCL	Bharat Petroleum Corporation Limited (Central Government owned)	KSBDB	Karnataka state biofuel development board
IOCL	Indian Oil Corporation Limited (GoI owned)	TERI	The Energy and Resources Institute
HPCL	Hindustan Petroleum Corporation Limited (Central Government owned)	CPRI	Central Power Research Institute
KREDL	Karnataka Renewable Energy Development Limited (Nodal agency-GoK)	DoE	Department of Energy - GoK
KSPDCL	Karnataka Solar Power Development Corporation Limited (Venture from KREDL)	IPP	Independent Power Producers

Transportation

Figure 95 Institutional Mapping of the Transportation sector

No.	Institutions/ Responsibilities	BBMP	Transport Department (GoK)	UDD	Police and Traffic	DULT/BMLTA	BDA	BMRDA	DTCP	PWD	NHAI	KRDCL	Smartcity -SPV	BMRCL	K-RIDE	Railways	BMTC	KSTDC	BESCOM	Fuel Suppliers (e.g. BPCL,HPCL,IOCL, GAIL)	KUIDFC	KRDCL
1	**Overall visioning, strategising and planning**																					
2	**Implementing/Infrastructure Development** *(Including O & M of Infrastructure)*																					
3	**Service Provider** *(Including O & M of service)*																					
4	**Fuel Suppliers**																					
5	**Regulatory and Enforcement**																					
6	**Giving Technical support/assistance to other agencies**																					
7	**Financing** *(other projects)-* **Fund Channelisation**																					

List of Abbreviations			
UDD	Urban Development Department	BMRCL	Bengaluru Metro Rail Corporation Limited
DULT	Directorate of Urban Land Transport	K-RIDE	Karnataka- Rail Infrastructure Development Company Limited
BMLTA	Bangalore Metropolitan Land Transport Authority	KSTDC	Karnataka State Tourism Development Corporation
BDA	Bangalore Development Authority	BMTC	Bangalore Metropolitan Transport Corporation
BMRDA	Bangalore Metropolitan Region Development Authority	KRDCL	Karnataka Road Development Corporation (KRDCL)

DTCP	Department of Town and Country Planning (Directorate of Town & Country Planning)	BWSSB	Bangalore water supply and sewerage board
BBMP	Bruhat Bengaluru Mahanagara Palike	BESCOM	Bangalore Electricity Supply Company Limited
KUIDFC	Karnataka Urban Infrastructure Development and Finance Corporation	KRDCL	Karnataka Road Development Corporation

Solid Waste Management

Figure 96 Institutional Mapping of the Solid Waste Management sector

S.No.	Institutions/Responsibilities	UDD	BBMP	KSPCB	CPCB	DMA	KUIDFC
1	Overall visioning, strategising, planning, governing and monitoring						
2	Implementing/Infrastructure Development *(Including O & M of Infrastructure, along with rejuvenation and management)*						
3	Service Provider *(Including O & M of service)*						
4	Regulatory and Enforcement						
5	Consulting/Advisor/technical/knowledge/Funding guidance/support to implement policies and programmes etc.						
6	Training, Performance/Quality monitoring						

List of Abbreviations			
BBMP	Bruhat Bengaluru Mahanagara Palike	DMA	Directorate of Municipal Administration
UDD	Urban Development Directorate (Urban Development Department)	KUIDFC	Karnataka Urban Infrastructure Dev & Finance Corporation
KSPCB	Karnataka State Pollution Control Board	CPCB	Central Pollution Control Board

Air Quality

Figure 97 Institutional Mapping of the Air Quality sector

No.	Institutions/ Responsibilities	KSPCB	CPCB	IMD	BBMP	BDA	BESCOM	DULT/ Transport Dept.	BMTC	BTP	Food & Civil Supplies Dept.	KIADB	KUIDFC	KPCL	KREDL	GAIL	IOCL	Health Care Facilities
Air Quality Monitoring Network																		
1	Overall visioning, strategising and planning																	
2	Implementing/Infrastructure Development *(Including O & M)*																	
3	Regulatory and Enforcement																	
4	Inspection and Quality Control																	
5	Data Repository																	
Mitigation																		
6	Overall visioning, strategising and planning																	
7	Implementing/Infrastructure Development *(Including O & M of Infrastructure)*																	
8	Service Provider *(Including O & M of service)*																	
9	Policy review & enhancements																	
Adaption																		
10	Overall visioning, strategising and planning																	
11	Implementing/Infrastructure Development *(Including O & M of Infrastructure)*																	
12	Public Awareness campaigns																	

List of Abbreviations			
O&M	Operations and Maintenance	BMTC	Bangalore Metropolitan Transport Corporation
KSPCB	Karnataka State Pollution Control Board	BTP	Bengaluru Traffic Police
CPCB	Central Pollution Control Board	KIADB	Karnataka Industrial Areas Development Board
IMD	Indian Meteorological Department	KUIDFC	Karnataka Urban Infrastructure Development and Finance Corporation
BBMP	Bruhat Bengaluru Mahanagara Palike	KPCL	Karnataka Power Corporation Limited
BDA	Bangalore Development Authority	KREDL	Karnataka Renewable Energy Development
BESCOM	Bangalore Electricity Supply Company Limited	GAIL	Gas Authority of India Limited
DULT	Directorate of Urban Land Transport	IOCL	Indian Oil Corporation Limited

Water. Wastewater and Stormwater Management

Figure 98 Institutional Mapping of the Water, Wastewater and Stormwater Management sector

S.No	Institutions/Responsibilities	UDD	BWSSB	CGWB	GWD - KGA	BBMP	KSPCB	KTCDA	LDA	EMPRI	BDA	KSNDMC	KSRSAC	KIADB	KUIDFC	Forest Dept.
1	Overall visioning, strategising, planning, governing and monitoring															
2	Implementing/Infrastructure Development *(Including O & M of Infrastructure, along with rejuvenation and management)*															
3	Service Provider *(Including O & M of service)*															
4	Regulatory and Enforcement															
5	Consulting/Advisor/technical/knowledge etc.															
6	Quality monitoring, Training and performance monitoring, research, technical support															

7	Data repository															
8	Funding support															

List of Abbreviations	
BWSSB	Bangalore water supply and sewerage board
GWD-KGA	Ground water directorate, Karnataka Groundwater authority
KTCDA	Karnataka Tank Conservation, and Development Authority
UDD	Urban Development Directorate (Urban Development Department)
LDA	Lake Development Authority
KSPCB	Karnataka State Pollution Control Board
EMPRI	Environmental Management Policy & Research Institute
BDA	Bangalore Development Authority
KSNDMC	Karnataka State Natural Disaster Monitoring Centre
KSRSAC	Karnataka State Remote Sensing Applications Centre
KIADB	Karnataka Industrial Areas Development Board
KUIDFC	Karnataka Urban Infrastructure Development and Finance Corporation

Urban Planning, Greening and Biodiversity

Figure 99 Institutional Mapping of the Urban Planning, Greening and Biodiversity sector

		Administration			Planning and Development							Housing		Utilities and Service Providers							Data Repository	Disaster Monitoring & Management		Environment & Biodiversity			
No.	Institutions/ Responsibilities	BBMP	UDD	MPC	DTCP	Karnataka State Town	KIADB	BDA	BMRDA	DULT/ BMLTA	KUIDFC	Karnataka Housing Board	Karnataka Slum Development Board	BWSSB	BESCOM	PWD	Fire Services Dept.	KRDCL, NHAI	Transport Providers - BMRCL, BMTC, KSRTC	KGWA	KSRSAC	KSNDMC	KSDMA	Forest Dept.	KSPCB	KBB	EMPRI
1	Overall visioning, strategising, planning and coordinating																										
2	Implementing/Infrastructure Development *(Including O & M of Infrastructure)*																										
3	Service Provider *(Including O & M of service)*																										
4	Regulatory and Enforcement																										
5	Giving Technical support/assistance to other agencies																										

6	Disaster Resilient Planning, Management and Preparedness																										
7	Data repository																										
8	Quality Monitoring																										

List of Abbreviations			
O&M	Operations and Maintenance	KSNDMC	Karnataka State Natural Disaster Monitoring Centre
BDA	Bangalore Development Authority	KSDMA	Karnataka State Disaster Management Authority
UDD	Urban Development Directorate (Urban Development Department)	KBB	Karnataka Biodiversity Board
DTCP	Department of Town and Country Planning (Directorate of Town & Country Planning)	EMPRI	Environmental Management & Policy Research Institute
KIADB	Karnataka Industrial Areas Development Board	BMRDA	Bangalore Metropolitan Region Development Authority
KUIDFC	Karnataka Urban Infrastructure Development and Finance Corporation Limited	BBMP	Bruhat Bengaluru Mahanagara Palike
PWD	Public Works Department	KRDCL	Karnataka Road Development Corporation
KSRSAC	Karnataka State Remote Sensing Applications Centre	KGWA	Karnataka Ground Water Authority

Disaster Management

Figure 100 Institutional Mapping of the agencies involved in overall Disaster Management

S. No.	Key Responsibilities	Admin		Public Works		Urban Planning			Health		Housing		Service Providers						Data Centres			Forestry		Pollution	
		DMC, BBMP	KSDMA	SWD, BBMP	SWM, BBMP	Road Infra, BBMP	Town Planning, BBMP	BDA	PHC	Govt Hosp	KHB	KSDB	BWSSB	BESCOM	Fire Services Dept.	KGWA	KRDCL	Transport: BMRCL,BMTC	KSNDMC	IT Cell, BBMP	KSRSAC	Forest Cell	KFD	KSPCB	CPCB
1	Data Repository																								
2	Prediction and initial information centre																								
3	Prime contact/nodal centre																								
4	Support departments: Floods																								
5	Support departments: Drought																								
6	Support departments: Heat																								
7	Support departments: Storms																								
8	Support departments: Air Pollution																								
9	O & M during disaster																								

Figure 101 Institutional Mapping of the agencies involved in Urban flooding Management

S. No.	Key Responsibilities	Admin	Public Works		Urban Planning			Health		Housing		Service Providers					Data Centres			Forestry		Pollution	
		DMC, BBMP	SWD, BBMP	SWM, BBMP	Road Infra, BBMP	Town Planning, BBMP	BDA	PHC	Govt Hosp	KHB	KSDB	BWSSB	BESCOM	Fire Services Dept.	KRDC	Transport: BMRCL,BMTC	KSNDMC	IT Cell, BBMP	KSRSAC	Forest Cell	KFD	KSPCB	CPCB
1	Data Repository																						
2	Prediction and initial information centre																						
3	Prime contact/nodal centre																						
4	Support departments: Floods																						
5	Support departments: Storms																						
6	O & M during disaster																						

List of Abbreviations			
DMC	Disaster Management Cell, BBMP	BESCOM	Bangalore Electricity Supply Company Limited
BBMP	Bruhat Bengaluru Mahanagara Palike	KGWA	Karnataka Ground Water Authority
SWD	Storm Water Management Cell, BBMP	KRDCL	Karnataka Road Development Corporation
SWM	Solid Waste Management Cell, BBMP	KSRSAC	Karnataka State Remote Sensing Applications Centre
BDA	Bangalore Development Authority	KSNDMC	Karnataka State Natural Disaster Monitoring Centre
PHC	Public Health Centre	KFD	Karnataka Forest Department
KHB	Karnataka Housing Board	KSPCB	Karnataka State Pollution Control Board
KSDB	Karnataka Slum Development Board	CPCB	Central Pollution Control Board
BWSSB	Bangalore water supply and sewerage board	KSDMA	Karnataka State Disaster Management Authority

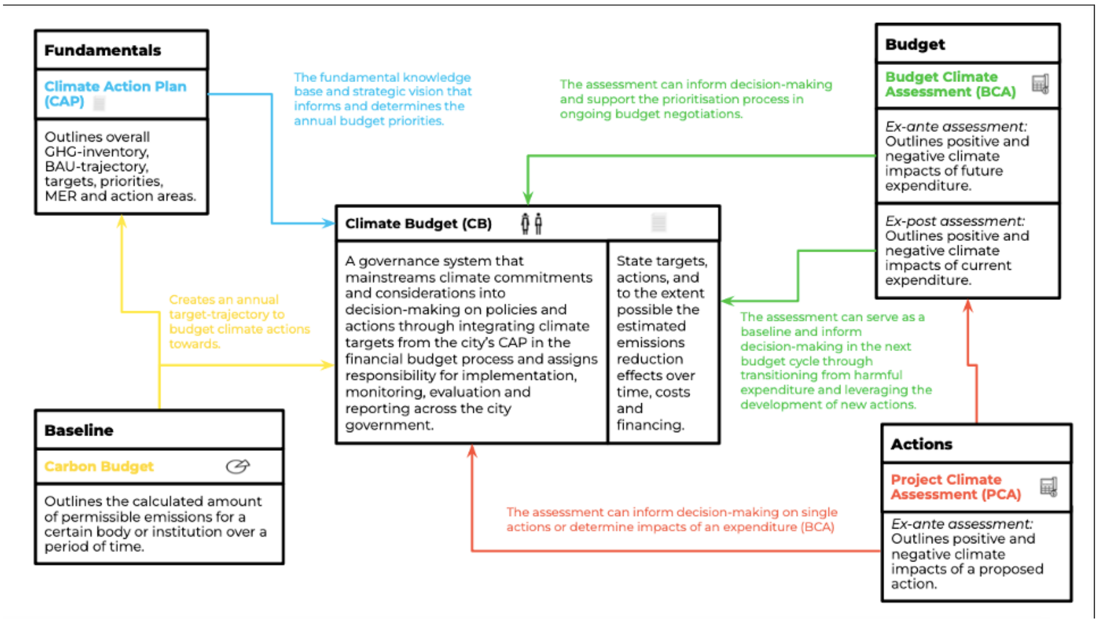
J. Climate budget

J.1. C40 climate budget pilot programme

Cities around the world are adopting climate budgeting as a governance system to turn climate commitments into funded and measurable actions across city government. Here are some key points on why your city should consider climate budgeting:(Knowledge hub 21AD)

- Mainstreaming action and accountability: Climate budgets embed climate considerations into decision-making across all city departments, ensuring that climate action becomes mainstream in every government agency. Science-based emissions reduction targets and caps on emissions are integrated into the city's main budgeting process, holding all parts of government accountable for their climate impact.
- Ownership by the finance department: Climate budgets place responsibility for delivering climate action with the city's chief financial officers (CFOs). The finance department collaborates closely with the team leading the city's climate change response, ensuring that spending plans are realistic in reducing greenhouse gas emissions.
- Concrete actions and financing: Climate budgeting turns long-term climate targets into annual delivery plans, prioritising and financing the most effective actions. It sets year-by-year emission caps aligned with long-term targets, specifying policies, costs, responsible entities, and expected emission reductions. This approach provides transparency, accountability, and a way to monitor the impact of climate actions.
- Different from carbon budgeting: While related, climate budgeting is not the same as carbon budgeting. A carbon budget defines the cumulative amount of CO_2 emissions permitted within a specified timeframe, while climate budgeting integrates the long-term emission reduction target into a city's operations and policies.
- Visibility of climate leadership: Climate budgets make climate action transparent and systematic, stimulating public awareness, discussion, and support for climate policies. They elevate climate issues on the political agenda and demonstrate leadership, giving cities leverage in discussions with national and regional governments, businesses, academia, and other stakeholders.
- By adopting climate budgeting, cities can integrate climate considerations into their decision-making processes, prioritise actions, and demonstrate their commitment to climate leadership.

The C40 Cities Climate Budget Pilot is an initiative undertaken by the C40 Cities network, a global network of cities committed to addressing climate change. The pilot programme aims to assess the alignment of city budgets with climate action goals. It focuses on evaluating the extent to which city budgets support and promote climate-friendly policies and initiatives.



Source: C40 Climate Budget Pilot

There are several key components and assessment methods used in the C40 Cities Climate Budget Pilot:

- **Ex-ante assessment**: This assessment is conducted before the implementation of city budgets. It involves analysing the proposed budgets and identifying how they align with climate action objectives. This assessment helps identify potential gaps and areas where climate considerations can be integrated into budgetary decisions.
- **Ex-post assessment:** This assessment takes place after the implementation of city budgets. It evaluates the actual outcomes and impacts of the budgetary decisions on climate action. It provides insights into the effectiveness of the allocated funds, identifies success stories, and highlights areas that require improvement for future budget cycles.
- **Project Climate Assessment:** This component focuses on evaluating specific projects and initiatives funded through city budgets. It assesses the greenhouse gas emissions reduction potential, climate resilience, and sustainability aspects of these projects. This assessment ensures that the projects align with climate targets and contribute to overall climate action efforts.
- **Carbon budget:** A carbon budget refers to the total amount of greenhouse gases that can be emitted within a specific timeframe to limit global warming to a certain level. The C40 Cities Climate Budget Pilot considers carbon budgets as a framework for evaluating the alignment of city budgets with climate action. By comparing the actual emissions associated with budgetary decisions against the defined carbon budgets, the initiative can determine if the budgets are in line with the emissions reduction goals.

Through these assessments and considerations, the C40 Cities Climate Budget Pilot provides cities with valuable insights into how their budgetary decisions impact climate action. It helps city officials identify areas for improvement, make informed decisions, allocate resources effectively, and promote sustainable and climate-friendly development. The pilot programme ultimately aims to enhance the integration of climate considerations into budgetary processes, enabling cities to take more effective action against climate change.

J.2. Mumbai – Draft Climate budget template

Table 45 Climate Budget Template

A	B	C	D	E	F	G	H	I	J
Fund Code	G.L. Code	Cost Centre Code	Name of Work	Work executed by	Estimated cost of the work	Revised Estimates 2022-2023 (In thousands)	Budget Estimates 2023-2024 (In thousands)	*Alignment with MCAP Action Track	# Description of intended work

All work items have to be described in as much detail as possible under column J. Please add a quantitative description of the work/activity mentioned in terms of potentially what can be achieved within the next financial year: for example, length of footpath to be built, kWh of solar capacity to be installed, number of electric vehicles to be purchased, area of green open space to be created, number of composting pits to be setup, number of public toilets to be built etc. Additionally, please also describe some qualitative features of the work mentioned: for example integration of road safety in street infrastructure, integration of nature-based solutions while creating open green spaces, using passive design strategies like cool roofs in buildings, integration of flood mitigation measures in road work activities, using permeable paver blocks for footpaths/public spaces/parks etc.

Glossary

Term	Definition
1.5° C warming scenario	The Intergovernmental Panel on Climate Change (IPCC) defines the 1.5° C warming scenario as the limit to which the average global temperature should be allowed to increase above pre-industrial levels. This scenario is believed to be a threshold beyond which there will be significant negative impacts on the environment, human health, and socio-economic systems.
5AR	The IPCC 5th Assessment Report (AR5) is a comprehensive report on climate change. The report provides the most up-to-date assessment of the scientific, technical, and socio-economic aspects of climate change, including its impacts, future projections, and mitigation options. The report was written by hundreds of leading scientists from around the world and is widely regarded as the most authoritative source of scientific information on climate change.
Activity data	Greenhouse Gas Protocol Corporate Accounting and Reporting Standard (GHG-GPC) defines activity data as the quantitative information on the activities or processes that result in greenhouse gas emissions or removals. This includes data on fuel consumption, energy use, production volumes, and other relevant parameters that are used to calculate emission factors and estimate greenhouse gas emissions from various sources and sectors.
Adaptation	As per IPCC, adaptation is a process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to the expected climate and its effects.
Adaptive capacity	The ability of an individual or a system or the local governing body to adapt themselves to the needs of the region and the people during hazard occurrence and to respond in a timely efficient manner thereby reducing loss and damage.
Aerobic processes	As per the United States Environmental Protection Agency (US EPA), aerobic processes are typically associated with wastewater treatment, where aerobic bacteria are used to break down organic matter and other contaminants. These aerobic processes involve the use of oxygen to support the metabolism of bacteria, which in turn help to reduce the level of pollutants and make the wastewater safe to discharge or recycle. Examples of aerobic processes used in wastewater treatment include activated sludge, trickling filters, and rotating biological contactors.
Ambitious scenario	GHG-GPC defines an ambitious scenario as a hypothetical scenario that assumes a company or sector will implement transformational actions, such as adopting new technologies or business models, to achieve a significant reduction in emissions beyond what is required by existing regulations or market expectations. This scenario is used to assess the potential for achieving deep decarbonisation and contributing to long-term climate goals.
Anaerobic processes	As per the US EPA, anaerobic processes are biological processes occurring in the absence of oxygen that convert organic matter into methane and other gases, volatile fatty acids, and end products such as carbon dioxide, ammonia, and hydrogen sulphide. These processes include anaerobic digestion, fermentation, and methanogenesis, and are used to treat organic waste, producing biogas as a renewable energy source. Anaerobic processes

	can also occur in natural environments, for example, in the gut of animals and in wetlands.
Biogenic carbon dioxide	As per IPCC, biogenic carbon dioxide refers to the carbon dioxide emissions that are released during the burning of biomass (organic matter derived from plants, animals, and microorganisms). Biogenic carbon dioxide is therefore distinct from fossil fuel emissions, which are derived from carbon that was stored in the Earth's crust over millions of years.
Biological nutrient removal	As per the US EPA, Biological nutrient removal (BNR) is a wastewater treatment process that incorporates biological mechanisms to remove nitrogen and phosphorus from wastewater. The process utilises microorganisms that convert the nitrogen and phosphorus compounds in the wastewater into gas or solid forms that can be removed from the water.
Blue-green infrastructure	According to the European Commission, blue-green infrastructure is “an interconnected network of natural and semi-natural areas, which can provide multiple benefits for society and the environment, such as water retention, biodiversity conservation, recreation and aesthetic value, as well as opportunities for economic development and job creation”
Bulk waste generators	As per the Solid Waste Management Rules, 2016, bulk waste generators are defined as any person or establishment that generates more than 100 kg of waste per day. This includes commercial establishments such as hotels, restaurants, hospitals, educational institutions, offices, markets, and residential complexes with more than 20 units.
Business as usual scenario	As per GHG-GPC, a business-as-usual scenario refers to a projection of a company's greenhouse gas (GHG) emissions that assumes no change in business practices or adoption of new emission reduction measures. It is a baseline against which a company can measure the effectiveness of its emission reduction efforts.
Capacity building	According to the United Nations Development Programme (UNDP), capacity building “is the process through which individuals, organisations, and societies obtain, strengthen, and maintain the capabilities to set and achieve their own development objectives over time”
Carbon dioxide equivalent (CO2e)	The IPCC defines CO2e as “the amount of CO2 that would have the same global warming potential (GWP) as a given amount of another GHG, taking into account the difference in their radiative properties and atmospheric lifetimes”
Carbon sequestration	The process of capturing, removing and storing Carbon dioxide (CO2) from the earth’s atmosphere.
Circular economy	The United Nations (UN) defines a circular economy as “an industrial system that is restorative and regenerative by intention and design” (UN, 2020). It is an economic model that aims to minimise waste and maximise the use of resources by keeping products, components, and materials at their highest value for as long as possible.

Climate	The Intergovernmental Panel on Climate Change (IPCC) defines climate as "the average weather conditions in a place over a long period of time, usually 30 years or more"
Climate change	The IPCC defines climate change as a long-term change in the average state of the climate, or in its variability, that persists for decades or longer. This includes changes in temperature, precipitation, sea level, and other climate variables, resulting from natural and human causes, that have significant impacts on natural and human systems.
Climate change risk	The IPCC defines climate change risk as the potential for adverse effects, such as damage or harm, resulting from climate change impacts and their interactions with vulnerabilities and exposure of human and natural systems. Climate change risk is assessed by considering the likelihood, magnitude, and timing of impacts, and can be mitigated through adaptation and mitigation actions.
Co-Benefits	The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors. Co-benefits are also referred to as ancillary benefits.
Decarbonised electricity grid	The International Energy Agency (IEA) defines decarbonisation as "the process of reducing greenhouse gas emissions, particularly carbon dioxide (CO_2), from the energy system, by shifting from fossil fuels to low-carbon energy sources and improving energy efficiency."
Direct emissions	The IPCC defines direct emissions as emissions from sources that are owned or controlled by the reporting entity. Direct emissions include emissions from combustion of fossil fuels, from industrial processes, and from biological sources such as enteric fermentation or manure management.
Disaster	Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery
Drought	A drought is a long, dry period that causes a water imbalance. Different types of drought affect crop production or water supplies. A megadrought is an abnormally long drought, lasting a decade or more.
Emission factor	The IPCC defines emission factor as a representative value that relates the quantity of a pollutant released into the atmosphere to an activity associated with the release of that pollutant. Emission factors are used to estimate greenhouse gas emissions from various sectors and activities, such as energy production, transportation, and industrial processes.

Emission scenario	As per the IPCC, predicting future emissions of substances (e.g., greenhouse gases, aerosols) based on factors such as economic development, technological advancement, and land use. These predictions are then used to create climate projections through modelling.
Exposure	The presence of people in a region that could potentially host hazards. It also refers to the adaptive capacity of an individual in the occurrence of the hazard.
Fossil fuel	The IPCC defines fossil fuels as "fuels derived from geological sources, including coal, oil, and natural gas, formed from the remains of dead plants and animals that have been transformed by geological processes."
GHG	The IPCC defines greenhouse gases (GHGs) as "gases that absorb and emit radiation within the thermal infrared range, leading to a warming effect on the climate system." The main greenhouse gases of concern in the context of climate change are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (such as hydrofluorocarbons and sulphur hexafluoride). These gases are emitted through various human activities, including the burning of fossil fuels, deforestation, and agriculture.
GHG emissions inventory	An estimate of emissions from the sources and sinks within a defined spatial and temporal dimension
GHG-GPC	GHG-GPC is a widely used and internationally recognised framework for measuring, managing, and reporting greenhouse gas emissions and removals from business activities. The GHG-GPC provides standardised methodologies and reporting requirements for companies and organisations to track and report their emissions, and to set emissions reduction targets and strategies.
Global warming	Global warming is the long-term heating of Earth's surface observed since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere.
Global Warming Potential	Greenhouse gases warm the earth by absorbing energy and decreasing the rate at which the energy escapes the atmosphere. These gases differ in their ability to absorb energy, that is, they have various radiative efficiencies. They also differ in their atmospheric residence times. Each gas has a specific global warming potential (GWP), which allows comparisons of the amount of energy the emissions of 1 ton of a gas will absorb over a given time period, usually a 100-year averaging time, compared with the emissions of 1 ton of CO_2.
GPC BASIC level	The GPC BASIC level is a simplified version of the Greenhouse Gas Protocol Corporate Accounting and Reporting Standard (GPC), designed for small and medium-sized enterprises (SMEs) and organisations with limited capacity for greenhouse gas accounting. The GPC BASIC level provides a standardised framework for calculating and reporting greenhouse gas emissions from a limited set of emission sources, such as energy use, business travel, and waste disposal.
Green buildings	According to the US EPA, a green building "is a structure that is environmentally responsible and resource-efficient throughout its life-cycle." This includes the design, construction, operation, maintenance, renovation, and demolition of the building.

Grid electricity	Grid electricity, as defined by the Greenhouse Gas Protocol Corporate Accounting and Reporting Standard (GHG-GPC), refers to electricity that is purchased and supplied from the power grid, which may be generated from various sources such as fossil fuels, nuclear, hydropower, wind, solar, and others.
GRIHA	GRIHA (Green Rating for Integrated Habitat Assessment) is a green building rating system developed by The Energy and Resources Institute (TERI) in India. The GRIHA rating system evaluates the environmental performance of buildings and their impact on occupants' health and well-being. The system provides a framework for the evaluation of the environmental performance of buildings across India.
Ground water recharge	The process by which external water is added to the zone of saturation of an aquifer, either directly into a geologic formation that traps the water or indirectly by way of another formation
Ground water replenishment	According to the United Nations, groundwater replenishment is “the process of increasing the amount of water that enters an aquifer, either naturally or artificially, to augment the available groundwater resources.”
Hazard	Hazard refers to the probability of occurrence of extreme weather events either due to natural causes or due to human interventions resulting in loss. The loss could be loss of life, injury, infrastructure damage, loss of natural resources, or loss of livelihood.
IGBC	The Indian Green Building Council (IGBC) is a non-profit organisation that promotes sustainable buildings and cities in India. As per the IGBC, green buildings are “energy-efficient, water-efficient, resource-efficient, and environment-friendly.” They incorporate features such as efficient lighting and appliances, renewable energy sources, water-efficient plumbing fixtures and irrigation systems, low-emitting materials, and sustainable landscaping. The IGBC offers a rating system for green buildings in India, known as the LEED India rating system.
Impact	Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, drought and sea level rise, are a subset called physical impacts.
Inclusivity	The term generally refers to the principle of ensuring that all individuals and communities have equal access and opportunities to participate in decision-making processes related to climate change mitigation and adaptation, and to benefit from the outcomes of these processes. Inclusivity also emphasises the importance of addressing the needs and perspectives of marginalised and vulnerable groups, such as low-income communities, indigenous peoples, women, and youth.

Indirect emissions	This term refers to emissions that are a consequence of the activities within well-defined boundaries of, for instance, a region, an economic sector, a company or a process, but which occur outside the specified boundaries. For example, emissions are described as indirect if they relate to the use of heat but physically arise outside the boundaries of the heat user, or to electricity production but physically arise outside of the boundaries of the power supply sector.
IPCC guidelines	The IPCC guidelines are a set of internationally recognised scientific and technical standards for assessing and reporting GHG emissions and removals, and for conducting climate change vulnerability and mitigation assessments. The guidelines are developed and periodically updated by the IPCC, with the participation of scientists, experts, and governments from around the world.
ISWM	The IPCC defines Integrated Solid Waste Management (ISWM) as a waste management approach that combines various waste management practices, such as waste reduction, segregation, collection, recycling, composting, and disposal, in a coordinated and systematic manner to minimise the environmental, social, and economic impacts of waste generation and management.
IUWM	The IPCC defines Integrated Urban Water Management (IUWM) as a planning and management process that seeks to reconcile the diverse and conflicting demands for water resources in urban areas by integrating water supply, wastewater management, stormwater management, and other water-related activities to ensure sustainable and efficient use of water resources.
Just Transition	Just Transition refers to a set of principles and practices aimed at ensuring that the transition to a low-carbon and sustainable economy is fair and inclusive, and that no individual or group is left behind. It emphasises the need to address the social and economic impacts of the transition, including job losses and economic dislocation, and to provide support and opportunities for workers and communities affected by the shift away from fossil fuels. Just Transition also seeks to address broader issues of social and environmental justice, including the disproportionate impacts of climate change on vulnerable and marginalised communities.
Land surface temperature	According to the UN, land surface temperature is “the radiative skin temperature of the Earth’s surface, measured at a specific time and under specific conditions, such as cloud cover, solar radiation, and soil moisture.”
LEED	LEED stands for Leadership in Energy and Environmental Design. It is a green building certification programme that was developed by the US Green Building Council (USGBC) to promote sustainable building practices and reduce the environmental impact of buildings.
Low carbon	IPCC defines low carbon as a term used to describe an energy system or technology that emits lower amounts of carbon dioxide (CO2) and other GHGs than conventional alternatives.

Mitigation	This term refers to a human intervention to reduce the sources or enhance the sinks of GHGs. This report assesses human interventions to reduce the sources of other substances which may contribute directly or indirectly to limiting climate change, including, for example, the reduction of particulate matter emissions that can directly alter the radiation balance (e.g., black carbon) or measures that control emissions of carbon monoxide, nitrogen oxides, volatile organic compounds and other pollutants that can alter the concentration of tropospheric ozone, which has an indirect effect on the climate.
Net zero	Net zero means achieving a balance between the amount of GHG emissions produced and the amount removed from the atmosphere, resulting in no further increase in the concentration of these gases in the atmosphere. This balance can be achieved through a combination of reducing emissions and increasing carbon removal efforts, such as afforestation, reforestation, and carbon capture and storage technologies.
Non-specified sources (NSS)	Non-specified sources are all the remaining emissions from facilities consuming electricity not specified elsewhere. A portion of Bengaluru's energy demand is being catered to by an open-access market, which allows customers to choose from a few competitive power companies, rather than being forced to buy power from the local utility monopoly. Due to limited/no information on the open access consumers and their suppliers, the grid electricity consumed through open access has been bucketed into the non-specified source.
Paris Agreement	The Paris Agreement is an international treaty aimed at addressing climate change. It was adopted at the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) in December 2015, and entered into force on November 4, 2016. The Paris Agreement has been signed by 196 countries and ratified by 191. Its goal is to limit global warming to well below 2 degrees Celsius above pre-industrial levels, while pursuing efforts to limit the temperature increase to 1.5 degrees Celsius. To achieve this, countries have agreed to set their own targets for reducing greenhouse gas (GHG) emissions, known as nationally determined contributions (NDCs).
Pathways model	Pathways is a model developed by C40 Cities that can be used to integrate emission reduction scenarios.
RCP	Representative Concentration Pathways (RCPs), make predictions for varied scenarios of how concentrations of greenhouse gases in the atmosphere will change in future as a result of human activities. RCPs try to capture the consequences of changes in greenhouse gas concentration on the earth systems, simulate the response of climate systems and provide a wide range of models. Scenarios include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0), and one scenario with very high GHG emissions (RCP8.5).

Refuse-derived fuel	Refuse-derived fuel (RDF) is a type of fuel derived from municipal solid waste (MSW) and other forms of waste. It is produced by processing MSW to remove non-combustible materials and creating a uniform fuel product that can be burned in facilities that generate energy through combustion. RDF is often used as a supplement to traditional fossil fuels, such as coal or oil, in industrial boilers and power plants. This reduces the amount of fossil fuel required for energy production and helps to divert waste from landfills.
Resilience	The ability of a system, its people and its economy to anticipate, absorb and accommodate or recover from a hazardous event in a timely and efficient manner.
Scientific waste management	As per the UNEP, scientific waste management involves "the collection, transportation, treatment, and disposal of waste, as well as efforts to minimise waste generation and promote recycling, reuse, and recovery of valuable resources." It also includes measures to reduce the environmental impact of waste disposal, such as using landfills that meet stringent safety and environmental standards, and implementing measures to prevent pollution and contamination of soil, water, and air.
Sink	Any process, activity or mechanism that removes a greenhouse gas (GHG), an aerosol or a precursor of a GHG or aerosol from the atmosphere
Social equity	The National League of Cities, a US-based advocacy organisation for cities and towns, defines social equity as "the fair, just and equitable management of all institutions serving the public directly or by contract; the fair, just and equitable distribution of public services and implementation of public policy; and the commitment to promote fairness, justice and equity in the formation of public policy."
Sustainable Development Goals	The Sustainable Development Goals (SDGs) are a set of 17 global goals established by the United Nations in 2015, as part of the 2030 Agenda for Sustainable Development. The SDGs are intended to be a universal call to action to end poverty, protect the planet, and ensure that all people can enjoy peace and prosperity by 2030.
Urban heat island	According to the US EPA, urban heat island refers to the "phenomenon in which metropolitan areas tend to be warmer than their surrounding rural areas, due to human activities and the built environment". This can result in a number of environmental and health impacts, including increased energy consumption, decreased air quality, and adverse health effects.
Vulnerability	The tendency of a region and/or an individual to be exposed to climate hazards and its impact. It would also encompass the extent of exposure of an individual to a particular hazard based on the extent of exposure.
Vulnerable hotspots	The IPCC defines vulnerable hotspots as geographic areas that are particularly susceptible to the impacts of climate change due to their high exposure to climate hazards and high levels of vulnerability. Vulnerable hotspots can include areas with high population density, poverty, weak governance, limited access to resources, and low levels of adaptive capacity.

Water security	The United Nations defines water security as “the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.”
Zero waste	Zero waste generally refers to the goal of minimising waste production and maximising recycling, reuse, and composting to reduce the amount of waste sent to landfills and incinerators.

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Bengaluru
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