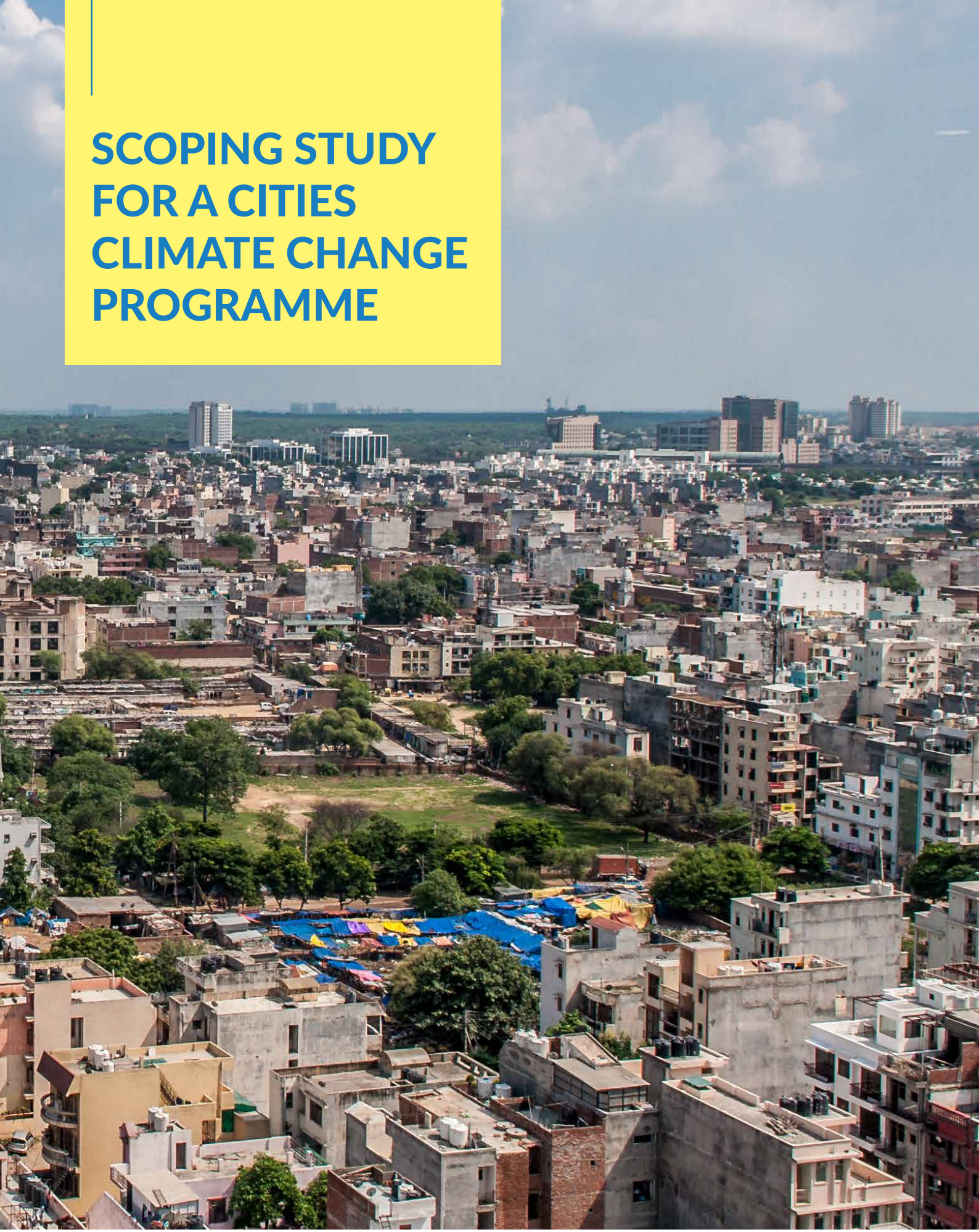
SCOPING STUDY FOR A CITIES CLIMATE CHANGE PROGRAMME



SHAKTI SUSTAINABLE ENERGY FOUNDATION

Oxford Policy Management

SCOPING STUDY FOR A CITIES CLIMATE CHANGE PROGRAMME

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Shakti Sustainable Energy Foundation is an enabler for clean energy and climate solutions. We work with policy makers, civil society, industry, think tanks, and academia to identify and scale energy system interventions that will reduce GHG emissions and tackle climate change.

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AC	Air conditioner
ACCCRN	Asian Cities Climate Change Resilience Network
ACT	Action on Climate Today
AFLOU	Agriculture, Forestry and Land Use
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BEE	Bureau of Energy Efficiency
BMC	Brihanmumbai Municipal Corporation
BMTC	Bangalore Metropolitan Transport Corporation
CCAP	City Climate Action Plan
CNG	Compressed Natural Gas
CSO	Civil Society Organisation
ECBC	Energy Conservation Building Code
EESL	Energy Efficiency Services Limited
FAME	Faster Adoption and Manufacturing of Hybrid & Electric Vehicles
GCF	Green Climate Fund
GCoM	Global Covenant of Mayors
GHG	Greenhouse Gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
GRIHA	Green Rating for Integrated Habitat Assessment
HRIDAY	National Heritage Development and Augmentation Yojana
ICE	Internal Combustion Engine
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
MCDA	Multiple Criteria Decision Analysis
MoEFCC	Ministry of Environment, Forest and Climate Change
MRV	Monitoring Reporting and Verification
NCAP	National Clean Air Programme
NIMS	National Inventory Management System
NIP	National Infrastructure Pipeline
NIUA	National Institute of Urban Affairs
NOX	Nitrogen Oxides
PM	Particulate Matter
PMAY	Pradhan Mantri Awas Yojana
PPP	Public-Private Partnerships
SAPCC	State Action Plan on Climate Change
SMC	Surat Municipal Corporation
SO2	Sulfur Dioxide
SPV	Special Purpose Vehicle
TV	Television
ULB	Urban Local Body
WBTC	West Bengal Transport Corporation
WTE	Waste to Energy

Preface

Our reflections on the state of climate action made it evident that urgent and decisive actions are required to combat the growing threat of climate change. While the challenges we face are immense, it is also an opportunity for transformative change. This was particularly true of Indian cities, and therefore we decided to delve deeper into cities as a venue for climate action. I am pleased to present this report, which meticulously scoped the need for climate action in Indian cities, and the role it could play in India meeting its global climate commitments.

Indian cities find themselves in the middle of the climate challenge. India has a rapidly growing urban population, and numerous urban centres that are expected house close to 50% of its population by mid-century. These cities are the engines of India's economic growth, and therefore are major source of GHG emission, and environmental degradation. The impact of climate change is already felt in our cities, with frequent flooding, heat and poor air quality days, that pose a risk to health, productivity and liveability. To ensure continued growth and prosperity of our cities, urban climate action is a necessity.

Cities are aggregators of demand, for goods, services and infrastructure. Therefore cities becomes an important site for the implementation of climate policies of the centre and state, and where ground-level implementation gaps are realised. Cities can become catalysts for enabling environmentally friendly behaviours if equipped to unlock these implementation gaps. Visionary leadership, robust planning, and community/business engagement, can foster low-carbon economies, promote renewable energy and emission free transport, enhances energy efficiency, reduces waste emissions, and help adopt other forms of sustainability.

This report serves as a comprehensive assessment of the current scenario of climate action in Indian cities. It emphasises the benefits of undertaking climate action in cities, the specific challenges, and its utility within the larger climate actions ecosystem. I commend the authors for their meticulous research, and willingness to engage with a challenging and wicked problem. It is my hope that the report will inform civil society and other urban stakeholders on the challenges and therefore the innovation required to enable bold steps towards a sustainable urban future.

Vivek Chandran

Director, Shakti Sustainable Energy Foundation

Executive summary

In his speech at COP 26 Prime Minister Narendra Modi announced that India will achieve the target of Net Zero emissions by 2070. To achieve the same, India will require a shift in how natural resources are utilised, technology is deployed, and land is managed as laid out in India's Long Term Low Carbon Development Strategy. The exact distribution of effort across sectors and states is still unknown, as is the combination of solutions to deliver the emission cuts required. It is therefore important to consider where and how to best support the transition to Net Zero. A question for the Shakti Sustainable Energy Foundation, and also relevant for other organisations, is the relative value of focusing on urban mitigation strategies. This report presents the evidence on the share of GHG emissions cuts required to achieve net-zero emissions that will take place within cities. It also explores the role that cities play in achieving ambitious climate action, and the challenges that exist in realising the mitigation potential, particularly related to urban governance constraints in India.

Cities in India offer large opportunities for emission reductions, as well as for building resilience. In India, about 400 million additional people are projected to live in urban areas by 2050 and around two-thirds of the built environment is expected to be constructed by 2030 (Khosla and Bhardwaj, 2019). Urbanisation pathways adopted now, particularly urban energy systems, will lock-in India's energy demand and GHG emissions for decades. With high population densities and many residents lacking basic housing, water and sanitation services, cities are also highly vulnerable to climate hazards like heatwaves, flooding, cyclones and water scarcity.

Buildings, transport and waste systems are the biggest sources of urban GHG emissions, and mitigation actions in these sectors will play an important role in achieving economy-wide net-zero emissions. Across a sample of city GHG emissions inventories, stationary energy contributes the majority of city emissions (>50 per cent), within which residential buildings as consumers of electricity has the largest share, while transport is the next highest contributor (United Nations Industrial Development Organization, 2017). Some examples of their mitigation potential include:

- ***Urban transport:*** The transport sector as a whole is responsible for 10-13.5 per cent of India's energy-related CO2 emissions, of which road transport accounts for the vast majority (Chaturvedi, Koti and Chordia, 2018; CAT, 2020; MoEFCC, 2021). Increased demand for transport, particularly in cities, is expected to result in CO2 emissions from the sector increasing 4-6 per cent per year (Chaturvedi, Koti and Chordia, 2018). As such, the transport sector will have to contribute around 15 per cent of the required reductions in urban emissions by 2050, to have a 50 per cent chance of limiting global warming to no more than 1.75°C (CUTS, 2021b). For example, to achieve net-zero emissions by 2070 in India, electric car sales must be 84 per cent of total car sales (Chaturvedi, 2021).
- ***Urban buildings:*** Buildings as a whole contributed to 25 per cent of overall energy use in India in 2019 (IEA, 2020). This is expected to dramatically increase: 70 per cent of the building stock that will exist in urban India in 2050 is yet to be built (National Institute of Urban Affairs, 2021), and energy demand from buildings could increase by 700 per cent by 2050, compared to 2005 levels (Chaturvedi, 2021; GBPN, 2014). The total electricity consumption by the residential sector is projected to increase from 280 TWh (2017-18) to 595 TWh (2027-28) under a business-as-usual scenario, a 66 per cent jump (Kachhawa, Kumar and Singh, 2019). To achieve net zero emissions by 2070, the intensity of electricity use within the building sector in total should decline by 45 per cent

by 2050 (Chaturvedi, 2021).

- ***Urban waste:*** The waste sector as a whole contributed 2.7 per cent of India's total GHG emissions in 2016 (MoEFCC, 2021). Urban solid waste is expected to increase to 1.1 million tonnes per day by 2050 (from 0.1 in 2017). Despite offering a comparatively smaller mitigation potential, through scientific management of waste practices there is huge scope for emissions savings.

However, the most important element in achieving urban mitigation is decarbonising the power supply, although the generation of power is often not within city domains. A global study of 84 cities shows that decarbonising the supply of energy to cities (mainly to buildings) has the highest emissions savings share at nearly half of the total urban mitigation potential, while reducing demand for electricity in buildings also offers nearly a quarter of the savings potential (C40/ Arup, 2016).

There are a range of well-known mitigation strategies available to deliver these emissions savings. While some are technological solutions to reduce a particular source of GHG emissions down to zero (e.g., electric vehicles), others just reduce emissions down to a certain point (e.g., fuel efficiency of ICE vehicles). Many are still dependent on the decarbonisation of the electricity supply (e.g., electric vehicles), while for others the exact mitigation potential will depend on how the solution is designed and implemented (e.g., green buildings). Equally important are those mitigation solutions which reduce the demand for energy, and therefore ease the pressure on the massive upscaling of clean technology solutions required, such as renewable energy and electric vehicles.

To achieve net-zero emissions in India, all of the urban mitigation strategies will be needed but those with the most potential mitigation impact include in the transport sector (reducing the number of per-capita motorised private vehicle journeys, electrification of motorised vehicles, increasing non-motorised and public forms of transport and increasing fuel efficiency of private vehicles) and in the buildings sector ('green' – meaning carbon neutral - building design and construction materials, and rooftop solar electricity generation). In the waste sector definite numbers on emissions savings for different strategies were not available, although reducing the volume of waste produced and increasing the proportion of waste being reused appears to have high mitigation impact potential.

The urban mitigation strategies can also provide significant co-benefits for reducing air pollution and building resilience to climate change, but a potential socio-economic challenge. For example, there will be public health co-benefits from reduced vehicular emissions and waste burning. Creating synergies between adaptation and mitigation increases the cost-effectiveness of the actions and can make them more attractive to stakeholders (CUTS, 2021b; Knittel, 2016). The mitigation strategies should be carefully designed to manage the impacts on vulnerable groups and ensure the socio-economic benefits are fairly distributed. The low carbon transition will produce winners and losers, and often vulnerable groups in society will bear the cost. This is also a political economy consideration, as the distribution of costs and benefits may influence political support positively or negatively.

The biggest challenge is how to get these proven mitigation strategies universally adopted and effectively implemented across all cities in India. Unlike decarbonising the power sector, achieving the necessary cuts in urban emissions and energy use, involves a massive number of public and private sector actors to take a range of coordinated actions, including incentivising behaviour change by the 480 million urban residents. There are different routes by which this change can happen, all of which involve all three tiers of government.

The role of cities in designing and delivering urban mitigation action can be expressed in the form of four key routes, all of which involve all three tiers of government. The first involves the state government and city authority – the Urban Local Body (ULB) - delivering and enforcing national level programmes and schemes, although this is obviously dependent on the central government. The other three routes involve the state and ULB taking pro-active leadership to design and deliver ambitious

mitigation solutions within their boundaries. This includes putting in place net-zero economic strategies, incentivising and mobilising demand for low-carbon technologies, and using their own resources to pilot and demonstrate the benefit of innovative new approaches and technologies. While in these cases the state and ULB are taking the initiative independently of the central government, they are likely to still be influenced by central financing, rules and regulations.

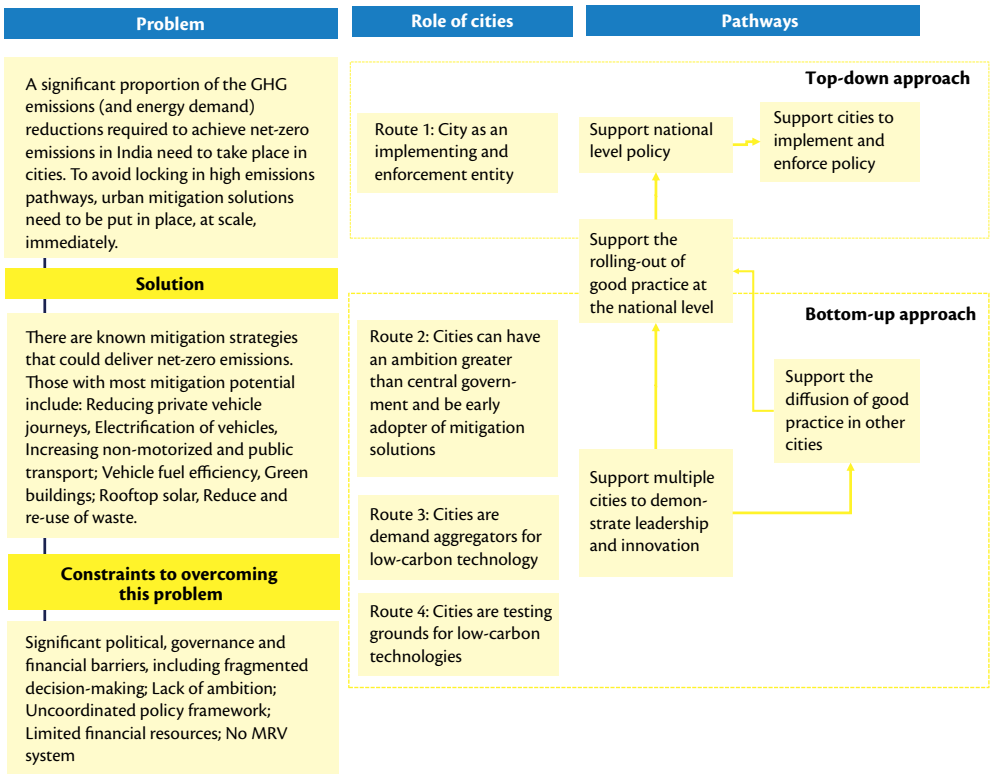
However, there are serious constraints and challenges that need to be overcome to put in place urban mitigation strategies. There are deep-rooted, systemic reasons why cities in India have so far not shown much leadership on ambitious climate action the way cities in the U.S, Europe and elsewhere have, including:

- ***Lack of ambition on urban climate action:*** To date, there has been limited city leadership on climate change, which is not surprising given their limited policy-making authority. However, there is a small but growing number of cities preparing City Action Plans on Climate Change (CCAP), most significantly Mumbai's detailed net-zero roadmap, which could be used to motivate others.
- ***Very limited institutional capacity for climate planning and delivery, particularly within ULBs:*** There are significant capacity constraints within state government and ULBs to plan, design, implement or enforce projects and polices on climate change. Issues range from the number of officials, technical skills as well as the softer aspect of partnership building, creative thinking and negotiating through complex problems. ICLEI and C40 offer lessons, such as embedding experts within state and city departments so that expertise gets institutionalised beyond the project lifetime.
- ***Lack of available financial resources and limited financial autonomy of ULBs:*** Cities in India face a shortage of funds to deliver even basic essential infrastructure and services, let alone meet any additional costs of climate measures. Of the 18 constitutional functions to be performed by ULBs less than half have a corresponding financing source. Financial autonomy has also worsened: For 37 ULBs the proportion of their own revenue generated in the city to their total revenue dropped from 67 per cent to 52 per cent between 2012 and 2018. ULBs also have limited authority to access alternative finances, such as international climate finance and development banks.
- ***Fragmented decision-making authority on urban issues, including limited decentralisation of powers to ULBs:*** Multiple government entities at different levels often need to be involved in the process of delivering climate action, and there is limited effective coordination. There is some experience of coordinating climate policy at the state level, and across levels of government for managing disasters. There are also opportunities for make greater use of the policy levers they have available to them, such as procurement, property tax incentives etc.
- ***Lack of a coordinated policy framework for urban climate actions:*** There are a large number of sectoral national and state policies and programmes which are relevant to urban climate action and can be leveraged, for example the Smart Cities Mission and its provisions for low-carbon technologies. CCAPs could be an opportunity to build policy coherence on urban climate action. However, lessons from the State Action Plans on Climate Change (SAPCCs) exercise need to be applied to ensure the plans are backed with sufficient political authority, finance and accountability mechanisms.
- ***No Monitoring, Reporting and Verification (MRV) system for urban climate actions:*** While most central schemes being implemented in cities require some reporting, none require measuring GHG emissions directly (URBAN-LEDS, 2020). However, there are some signs that MRV systems might improve: A few cities have begun collecting data on emissions on their own, using various global programmes and platforms; and India is also developing a National Inventory Management System (NIMS) for reporting to the UNFCCC which will require data from ULBs.

The final chapter of the report explores whether and how a new cities climate programme can make a substantial contribution to delivering the GHG emissions savings required in cities in India,

given the size of the challenge and the barriers to change which exist. Supporting state governments and ULBs to effectively implement and enforce the current set of policy priorities would by itself have an impact. However, the goal should be to support them to manage the much more ambitious, and quicker, transformative changes that will be required to reach net-zero emissions. Using learning from other programmes, the report puts forward policy-induced transformational change pathways that a programme could pursue (see figure below). This includes supporting top-down policy action, including the often-ignored issue of effective implementation and enforcement of national and state urban mitigation strategies. In addition, a programme can mobilise bottom-up policy action and work with a number of states and cities to demonstrate ambitious and viable mitigation action which then gets scaled up via the central government or through diffusion by other states. A cities programme should pursue multiple of these pathways to maximise the likelihood of impact.

Figure 1: Summary of change pathways



1. Introduction

This study presents the available evidence on the likelihood that a new cities climate change programme will make a significant contribution to India's net-zero emission trajectory. It is intended to inform the Shakti Sustainable Energy Foundation's decision-making process on whether to establish such a programme, and its potential scope.

There is growing global attention on the role of cities in achieving the necessary GHG emission cuts that will limit global warming to 1.5°C. Cities are centres of huge economic growth and consumption and consequently huge contributors to climate change. They account for 75 per cent carbon emissions globally (WRI, 2021). As the pace of urbanisation increases, so will carbon emissions from urban areas. As of 2018, 55 per cent of the world's population lived in urban areas, which is projected to rise to 68 per cent by 2050 (UNDESA, 2018). Globally, urbanisation and the corresponding economic and infrastructure development could account for an additional 226 GtCO2 by 2050 (UNEP, 2020).

In India, about 400 million additional people are projected to live in urban areas by 2050, double the number from 2014 (Khosla and Bhardwaj, 2019; Kumar et al., 2010; UN DESA, 2014). Urban India currently houses 34 per cent of the country's population, and by 2030 is projected to contribute 75 per cent of total GDP (CUTS 2019). An estimated two-thirds of India's built environment will be constructed between 2010 and 2030 (Khosla and Bhardwaj, 2019). As such, urbanisation pathways over the next decades, specifically that of urban energy systems, will be crucial in shaping India's future energy demand and GHG emissions.

54 per cent of India's urban abatement potential up to 2050 lies in cities with populations of less than a million, while only a quarter is in cities with over 5 million population (CUTS, 2021b). A large portion (approximately 70 per cent of buildings) of India's urban infrastructure is yet to be built (National Institute of Urban Affairs, 2021). This presents opportunities to incorporate resilience into infrastructure planning, investments and building standards, which will prevent locking into high carbon, climate vulnerable physical structures or risk investing public funds into future stranded assets.

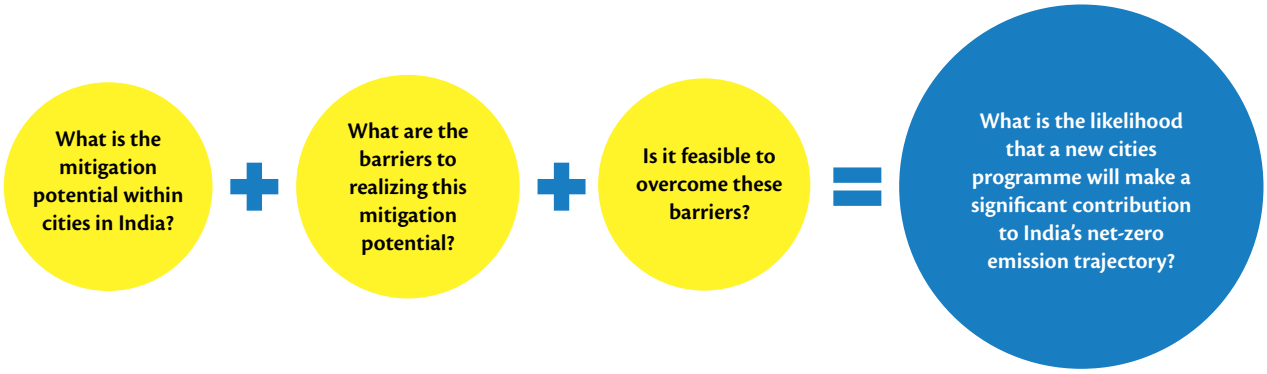
With high population densities and a large number of residents without basic water and sanitation services - 35 per cent urban citizens lived in slums as of 2018 (World Bank, 2018) - cities are also highly vulnerability to climate change impacts. These include heatwaves, flooding, cyclones and water scarcity, which have been experienced across Indian cities in recent years. Economic losses from the Chennai floods in 2015 were estimated to be USD 2.2 billion (The Hindu, 2018).

It is therefore well established that cities offer opportunities for both decarbonisation and resilience building, but the scale of the potential urban GHG emission savings that are actually feasible is less clear, given the significant governance, political and other barriers (as explored in section 4).

This study aims to unpack both the theoretical potential of ambitious urban climate action in India, as well as the reality of what is likely and manageable. It therefore explores the mitigation impact a new cities programme in India could have in reducing urban emissions in line with 1.5°C global warming targets, presenting analysis on the key urban emitting sectors, governance and institutional challenges, and learning from other urban climate programmes on how to overcome these challenges. It aims to provide the analysis required to consider the relative contribution that a cities programme could make to India's overall low-carbon growth trajectory, compared to investment in alternative approaches, such as deepening investment in decarbonising the power sector. The key

research questions that will be explored in this study are illustrated in Figure 2 below.

Figure 2: Key study research questions



The study is pertinent in light of India's commitment to a net zero by 2070 goal at COP26 in Glasgow This study does not offer an opinion on these questions but outlines the opportunities that could come from focusing on ambitious urban climate action, as well as the challenges of mobilising action in cities in India.

The findings are based on information obtained from a literature and document review and key informant interviews with state government and city officials, and civil society organisations active in urban climate initiatives in India (Interview list in Annex G). It has also been informed by the authors own climate planning experience and a stakeholder workshop convened by Shakti Sustainable Energy Foundation (SSEF) in October 2021.

A few methodological notes. Firstly, the definition of a 'city' is a geographical unit and not a unit bound by administrative or municipal boundaries, although in some places attention is given to the functions of the Urban Local Body (ULB). It should also be noted that the terms 'city-based', 'city-focused', 'city-level' are intended to mean geographical sites and not the urban local bodies. Secondly, given the mandate of the SSEF, the report focuses on mitigation of climate change in cities, but touches on co-benefits for adaptation and resilience building that can come from mitigation strategies. Lastly, the findings are limited by the availability of analysis, particularly in terms of mitigation scenarios, and it has not been possible to make definitive conclusions on some questions, such as the relative mitigation potential of different urban mitigation strategies. For the mitigation potential data, a neat split of the total national current and future projected emissions across urban and non-urban segments across sectors was not available from secondary sources. Therefore, data from multiple credible studies and sources that seemed relevant and reliable was used, even though not directly comparable as each have different methods, assumptions and definitions. There is a clear need to undertake further research on the role of cities to deliver India's net-zero emissions commitment.

2. Potential of Indian cities to deliver mitigation of GHG emissions in line with a 1.5°C global warming pathway

This section presents available evidence from literature on the extent to which cities can, in theory, contribute to India's overall low-carbon growth trajectory to net-zero emissions. It is important to first define the scope of 'urban emissions' and this study focuses on three sectors which are clearly within the geographic domain of a city - buildings, transport and waste – and are significant sources of GHG emissions, including as large consumers of electricity.

Within these sectors, there are a range of possible mitigation strategies, and growing evidence on the GHG emission savings they could deliver. These range from 570 MtCO2e from the electrification of the vehicle fleet, to up to 116 MtCO2eq from energy efficient appliances (ACs, fridges, TVs, fans), to up to 3MtC02eq per year for expansion of Waste to Energy plants (CAT 2020; Parikh and Parikh, 2016; GHG Platform India, n.d). However, many of these emissions savings are dependent on the decarbonisation of the electricity sector, which is largely outside the control of cities.

These strategies also deliver important co-benefits, particularly to social development and inclusion, air pollution and adaptation to climate impacts, but also potential negative effects that need to be managed. For example, electric vehicles will lead to both new jobs being created, but also job losses in traditional vehicle manufacturing sectors. It will also lead to some immediate air pollution benefits (through reduced NOX emissions) but could increase SO2 emissions from increased demand for electricity (which will have to at least in the near term be met through thermal power).

To achieve net-zero emissions, all of the urban mitigation strategies will be needed, but due to limited capacity and resources, cities may need to prioritise amongst them, at least for immediate implementation. An example of a prioritisation framework which can be used when designing its programme is presented, based on the idea of Multiple Criteria Decision Analysis (MCDA).

2.1 The contribution of cities to achieving net-zero emissions in India

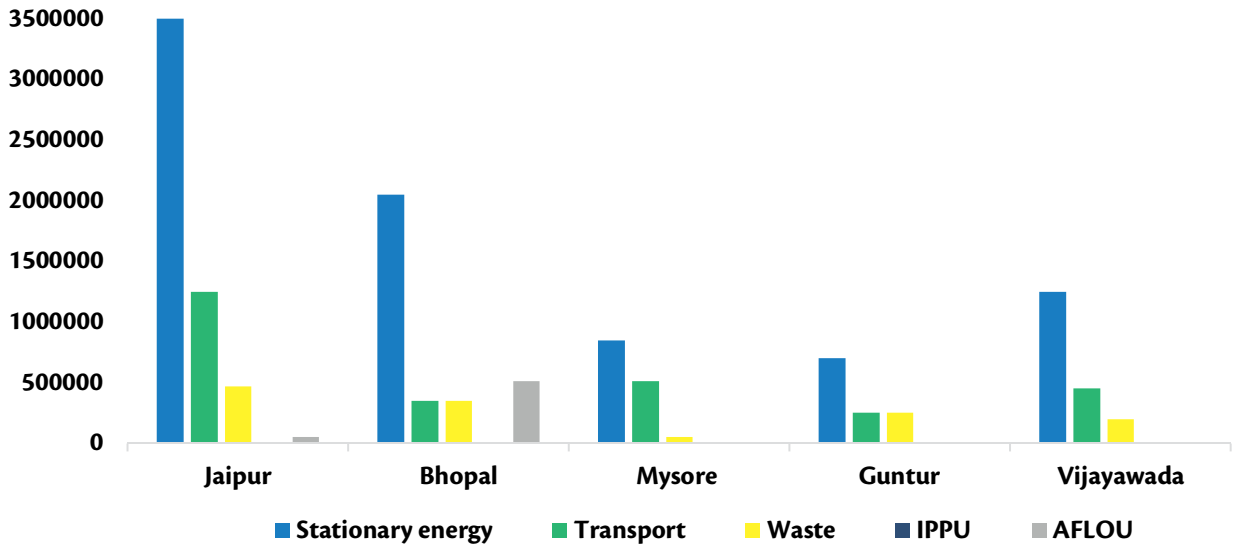
There is clear evidence that cities in India are a major source of India's GHG emissions, primarily as large consumers of energy, as well as direct emitters, and the biggest share comes from buildings, transport and waste sectors (NIUA, 2021; CAT, 2020; CUTS, 2021b). However, there is limited detailed bottom-up analysis available on current and projected future GHG emissions from India's cities specifically, and which sectors have major emissions abatement potential. Post India's COP26 pledges, new modelling and analysis is expected to emerge which should provide greater clarity and certainty on the exact contribution of different sectors and regions.

There are various methodological challenges to calculating the urban contribution of India's total GHG emissions, including how to define 'urban' and the need to downscale nationally reported emissions. See Annex A for more detail on the definition of a city. Sethi and Mohapatra (2013) estimated that

that two-thirds of India's emissions are being generated in urban areas, but this includes many thermal power plants within a broader definition of an urban areas. This was supported by spatial analysis that concluded that 60 per cent of GHG emissions from India's thermal power plants fall within urban boundaries (Sethi, 2015). The National Institute of Urban Affairs (2021) have reported from an unpublished study that an estimated 44 per cent of the country's carbon emissions originate in urban areas, from transport, industry, buildings, and waste. All these studies differ from global estimates that 8.6 – 13 per cent of emissions are from cities, because it situates power stations as outside cities (Satterthwaite, 2008).

For greater clarity, it is useful to look at a breakdown of emissions sources from cities in India. Analysis of GHG inventories for five Indian cities (Figure 3) developed as per the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) shows that stationary energy[1] contributes the majority of city emissions (>50 per cent), within which residential buildings as consumers of electricity is the largest contributor. Transport is the next highest contributor, followed by waste sector with a much smaller share. Industrial processes (IPPU) and agriculture, forestry and land use (AFLOU) constitute even smaller shares (United Nations Industrial Development Organization, 2017). Therefore, as a proxy to understand cities overall contribution to India's low-carbon growth trajectory, it is possible to instead study the contribution of buildings, and the transport and waste sectors.

Figure 3. GHG emissions by sector in five Indian cities (MT CO2 eq)



Source: UNIDO (2017)

If current trends continue, while electricity generation and industrial sectors will continue to be the major contributors to India's GHG emissions, cities will play a significant role, particularly as consumers of energy. Table 1 consolidates available information on the three major sources of emissions in cities in India – buildings, transport and waste – on current and projected future emissions if current trends continue.

1 Consists of 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 transportation of coal, Fugitive emissions from oil and natural gas systems (GPC Protocol, WRI 2020).

Table 1: Summary of analysis available on current and future emissions

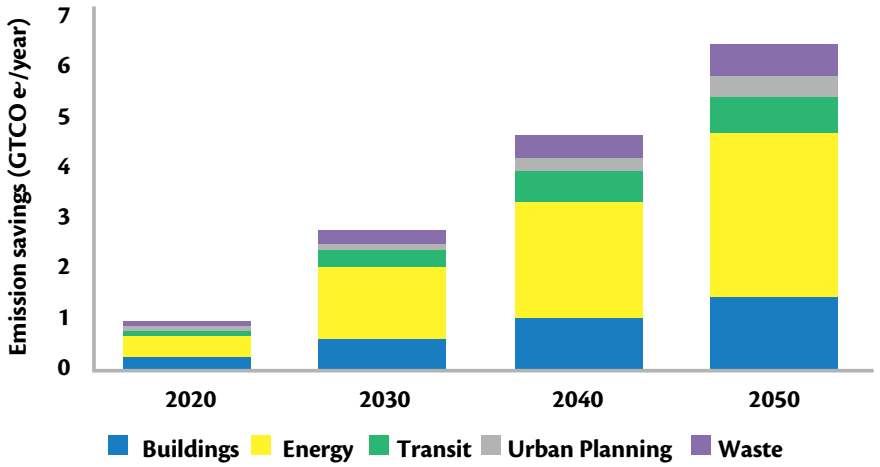
Sector	Current emissions	Business as Usual projections
Urban transport	Transport sector as a whole is responsible for 10-13.5 per cent of India's energy-related CO2 emissions (274,434 Gg CO2e), of which road transport accounts for the vast majority (Chaturvedi, Koti and Chordia, 2018; CAT, 2020; MoEFCC, 2021).	CO2 emissions from transport sector will continue to grow 4.1-6.1 per cent per year, leading to seven-fold increase by 2050 (from 2010 levels) (Chaturvedi, Koti and Chordia, 2018) and account for 22 per cent share of India's final energy use by 2050 (Chaturvedi, 2021). Increased demand for urban transport contributing to relatively fast growth in emissions in the sector (together with increased freight truck emissions), with 70 per cent of India's passenger journeys expected to be in urban areas in 2050 (compared to 50 per cent today) (CAT, 2020).
Urban residential and commercial buildings	Building sector as a whole accounted for 25 per cent of overall energy use in 2019. Of the fuels used in buildings, 19 per cent was electricity and 55 per cent was biomass (IEA, 2020).	Indian building energy demand could increase by as much as 700 per cent by 2050 compared with 2005 levels (GBPN, 2014). This will be driven by increased demand for lighting and cooling, which will reach nearly 50 per cent of total energy consumed by buildings, followed by appliances (India Energy Policy Simulator, 2021). This is a result of rising household incomes, urban populations and temperatures (Ahluwalia and Patel, 2021). However, the building sector's share of India's final energy use by 2050 is projected to decrease, to 19 per cent (Chaturvedi, 2021). It is also estimated that if current energy efficiency policies are fully implemented, then 101 MtC02eq of emission savings from residential buildings are possible by 2031, and 34 MtC02eq from commercial buildings (BEE, 2021).
Urban waste	The waste sector as a whole contributed 2.7 per cent of India's total GHG emissions in 2016 (75,232 GgCO2e) of which 79 per cent was from wastewater treatment and discharge and 21 per cent from solid waste disposal (MoEFCC, 2021). In 2017, 0.1 million tonnes of urban solid waste was generated each day, creating 11.67 MtCO2eq (GHG Platform India, n.d.).	Urban solid waste is expected to increase to more than 400 million tonnes a year (1.1 million tonnes a day) by 2050 (TERI and Shell, 2021).

It is clear that decarbonising the supply of electricity, together with electrification of energy services, is the most important factor for achieving net-zero emissions in India. India will need to deploy cleaner energy technologies on a massive scale, to replace the current dependence on coal, and the speed at which this transition happens will determine the date at which net-zero emissions are achieved (TERI and Shell, 2021; Chaturvedi, 2021). To reach net-zero emissions by 2070, India needs to reduce coal-based generation by an estimated 99 per cent between 2040 and 2060 (assuming no carbon capture and storage), and solar power capacity should increase from 48GW in 2021, to 5,630 GW by 2070 (Chaturvedi, 2021; Ministry of Power, 2021). If net-zero emissions are achieved by 2050, then an estimated 90 per cent of the generation mix will need to come from renewables by 2050 (TERI and Shell, 2021). The development of alternative fuels, particularly hydrogen and biofuels, will also be important for reducing emissions in the industrial and transport sectors when electrification is not feasible (TERI and Shell, 2021; Chaturvedi, 2021).

While cities are not expected to significantly contribute to the massive expansion of renewable energy required, they still play an important role in terms of reduced demand for energy and

electrification of the transport sector. India needs to not only shift to green electricity production, and electrify as many sectors as possible, but also increase energy efficiency to reduce the growth in total energy demand (Ahluwalia and Patel, 2021; TERI and Shell, 2021). A global study of 84 cities shows that decarbonising the *supply of energy to cities (and primarily to buildings) has the highest emissions savings share at nearly half of the total urban mitigation potential, but reducing demand for electricity in buildings also offers nearly a quarter of the savings potential (see Figure 4) (C40/ Arup, 2016). In a scenario of having a 50 per cent chance of limiting warming to no more than 1.75°C, as defined by the IEA, there is a potential for savings of up to 1,784 MtCO2-e from urban sectors relative to a reference scenario (see Figure* 5), but almost 50 per cent of the total mitigation potential hinges on decarbonisation of electricity (CUTS, 2021b).

Figure 4. Estimated emission savings per year versus BAU achieved by 84 C40 cities up to 2050, 1.5°C scenario



Source: C40, Arup (2016)

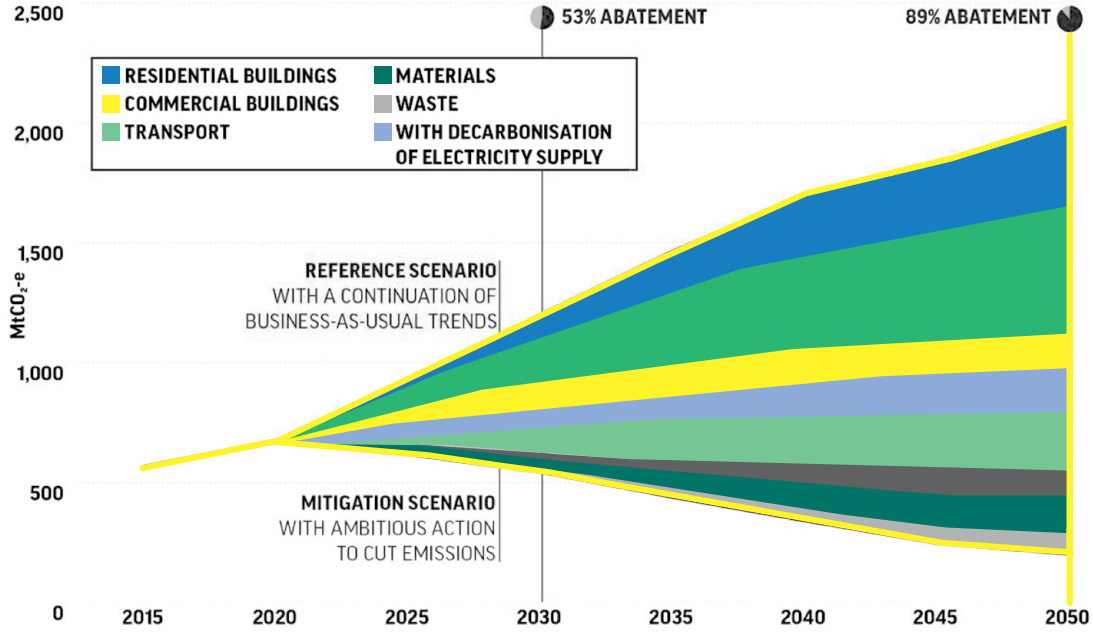
Given the high energy intensity of buildings, the urban building sector, particularly the residential segment, can contribute to achieving net zero emissions in India. It is projected that 70 per cent of the building stock that will exist in Indian cities in 2050 is yet to be built (National Institute of Urban Affairs, 2021), which provides a huge opportunity to leapfrog to more energy efficient designs, construction materials and appliances. The total electricity consumption by the residential sector is projected to increase from 280 TWh (2017-18) to 595 TWh (2027-28) under business-as-usual scenario, a 66 per cent jump (Kachhawa, Kumar and Singh, 2019). To achieve net zero emissions by 2070, the intensity of electricity use within the building sector, with respect to total GDP, should decline by 45 per cent by 2050 (Chaturvedi, 2021). To achieve it by 2050, a complete shift to efficient buildings, efficient electrical appliances and public infrastructure such as lighting, is required by the same year (TERI and Shell, 2021). Of the total GHG savings required from urban sectors by 2050, to have a 50 per cent chance of limiting warming to no more than 1.75°C, as defined by the IEA, it is estimated that 52 per cent of the savings will come from residential buildings and 20 per cent from commercial buildings (see Figure 5) (CUTS, 2021b).

Urban transport systems also offer significant potential for mitigation of GHG emissions as part of India's overall low-carbon trajectory. The transport sector will have to contribute an estimated 15 per cent of the reductions required in India's urban GHG emissions by 2050 to have a 50 per cent chance of limiting warning to no more than 1.75°C (see Figure 5) (CUTS, 2021b). This includes through the electrification of two/ three wheelers, passenger cars, light commercial vehicles and city buses which are traditionally powered by petrol or diesel (Ahluwalia and Patel, 2021). To achieve net-zero

emissions by 2070 in India, electric car sales must be 84 per cent of total car sales, electric trucks must constitute 79 per cent of freight trucks and remaining trucks running on hydrogen (Chaturvedi, 2021). If net-zero emissions are reached by 2050, it will require all 2- and 3-wheeler vehicles to be completely electric by 2030 (TERI and Shell, 2021).

The urban solid waste sector offers a much smaller GHG emissions reduction potential, but there is huge scope for better scientific management of waste practices which will deliver some emissions savings. Urban solid waste is expected to increase to more than 400 million tonnes a year by 2050, unless there is a significant strategy of reduction, reuse and recycling of waste (TERI and Shell, 2021). The composition of the waste generated, and the method of disposal, as well as how residue waste in landfill is dealt with, will determine the quantity of GHG emissions the sector will produce. For example, 0.5-3 MtC02eq per year could be saved if all urban solid waste was processed in Waste to Energy plants (GHG Platform India, n.d.).

Figure 5. GHG abatement potential in key urban sectors in India to 2050



Source: CUTS (2021b)

Box 1: Share of emissions directly controlled by ULBs

While cities can make a significant contribution to achieving net-zero emissions in India, as sites of much of the mitigation actions required, the Urban Local Bodies (ULBs) governing the cities are not direct in control of most of these emissions. See Section 4.4 for more details. The analysis in this report relates to emissions from activities located within the geographic unit of the city, rather than those just controlled by the ULB.

Analysis of urban emissions of 41 Indian cities finds that in most of the cities, the proportion of emissions under the direct control of the ULB is very low - below 10 per cent (except Lucknow and Thiruvananthapuram where it is 20-22 per cent) (ICLEI, 2009). This includes the emissions from all the ULB's operations and services such as corporation buildings and facilities, street lighting, water supply system and sewage systems and corporation run transportation, with water supply and sewage treatment contributing a higher proportion.

While the absolute volume of emission savings that ULB's could directly achieve is relatively modest, it can bring other benefits. ULBs incur significant costs to procure energy for providing local public services like street lighting and water supply. If current energy efficiency policies are implemented fully (e.g. Smart Cities, AMRUT, Street Lighting Programme etc), and just using existing technologies, 12 per cent of energy use could be saved through ULB's own operations, representing 7MtC02e, by 2031 (BEE, 2019). For example, efficiency measures in water systems could result in 25 per cent energy and monetary savings and retrofitting all urban conventional streetlights with LEDs could save 50 per cent of total energy (ibid). Beyond the climate mitigation benefits, this will also free up ULBs' budgets for other development initiatives.

2.2 Urban mitigation strategies with high impact potential

There is a range of potential mitigation strategies that could be used to deliver the emission reductions outlined in the previous sections, with some modelling available of the GHG emission savings that can be expected. The table below provides a sample of some of the 'solutions' that that have been identified as having high potential in recent studies of urban climate action for three key sectors of transport, buildings and waste. This list is not comprehensive, and there are certainly other mitigation actions available to ULBs (see Box 1), but these are the ones considered to have the most GHG emission reduction potential. Each of these solutions is described in Annex B. The table below summarises the evidence available on the extent to which each mitigation solution is currently being implemented, and the estimated potential GHG emission reduction if it is scaled up.

Table 2: Summary of evidence on mitigation strategies

Mitigation Strategy/ Solution	Policy actions that will support the solution	Current situation	GHG emission reduction potential
		TRANSPORT	
Reduce number of per-capita motorised private vehicle journeys	• Improve public transport infrastructure • Incentivise car sharing • Incentivise modal shift • Sustainable and innovative urban planning	Passenger demand per capita is projected to increase under current scenario four-fold by 2050 (CAT, 2020).	Passenger demand per capita needs to decrease by 22 per cent by 2050 to achieve 'Paris-aligned' emissions. The average occupancy rate of private vehicles also needs to increase to 3.2 pkm/vkm[2] by 2050 (compared to current rate of 2.6 pkm/vkm). Innovative urban planning to reduce passenger demand could contribute to a 17.5 per cent reduction in emissions (205Mt C02e/year) (ibid.).
Electrification of motorised vehicles	• Incentivise shift to electric mobility • Sustainable and innovative urban planning	By December 2021, 7,96,000 Electric Vehicles were registered on the e-amrit portal in India, representing just 1.32 per cent of total sales. 1,800 public charging stations had been installed (ET Energy World, 2021).	Assuming there is no major trend away from private vehicles, then to reach net zero, need to achieve, 570 MtCO2eq savings from electrification of vehicle fleet. (CAT, 2020). For net-zero emissions by 2050, 100 per cent of 2- and 3- wheeler vehicles will need to be electric (TERI and Shell, 2021), and for net-zero by 2070, electric car sales must be 84 per cent of total car sales (Chaturvedi, 2021).
Increase non-motorised and public forms of transport	• Improve public transport infrastructure • Incentivise modal shift • Sustainable and innovative urban planning	Out of around 8,000 cities in India, only 65 have some kind of formalised public transport (CSTEP et al, 2019).	Such transport modes could viability reach up to 90 per cent by 2050 (CSTEP et al, 2019). A 77 per cent shift of passenger urban transport activity to public forms of transport could deliver 155 MtCO2e/year by 2050 (CAT, 2020).

2 Passenger-kilometres/ vehicle-kilometres

Increase fuel efficiency of private vehicles	• Incentivise shift to electric mobility • Sustainable and innovative urban planning • Tighten emission standards	Indian norms for fuel consumption in passenger vehicles led to 1.2 Mtoe fuel savings and 3.7 MtCO2eq in 2017-20 (BEE, 2021)	Assuming there is no major trend away from private vehicles, then to reach net zero, need to achieve 145 MtCO2eq from improved efficiency of private vehicles by 2050 (CAT, 2020).

	BUILDINGS		
Green building design and construction materials	• Building codes/ bye laws • Certification/ labelling schemes • Net zero building construction • Financial incentives • Consumer awareness	Green buildings market in India is still nascent, and focused in large metros, with only an estimated 5 per cent of all buildings classified as 'green' in 2018 (IFC, 2018). There are a number of different green building certification programmes. For example, in 2018, 5.27 billion sq.ft. of buildings were registered with the Indian Green Building Council (India Green Building Council, 2018).	The green building certification schemes have different estimates of their emission saving potential. Compliance with GRIHA norms for commercial buildings results in an estimated 38 per cent GHG emission reduction (GRIHA, 2022). LEED buildings offer 50 per cent GHG emission savings due to reduced water consumption and 48 per cent emissions savings due to solid waste management (Mozingo and Arens, 2014) Buildings that adhere to the Energy Conservation Building Code of are expected to have energy savings of 40-60 per cent (BEE, 2011).
Solar water heating	• Building codes/ bye laws • Net zero building construction • Financial incentives • Consumer awareness	In 2017, India had 7.7GWth of solar thermal capacity (compared with 350GWth in China) (Weiss and Spork-Dur, 2018).	Assuming the replacement of coal as the fuel used, the GHG-emission reduction potential of solar water heating ranges from 13.4 tCO2 to 22.4 tCO2 (Singh Rawat et.al., 2020)
Rooftop solar powered electricity generation	• Building codes/ bye laws • Net zero building construction • Financial incentives • Consumer awareness	In 2021, cumulative rooftop solar installations reached 6.1 GW, 83 per cent of which was in ten states (MERCOM, 2021)	The government's plans for 40GW of rooftop solar capacity has the potential to mitigate 58 MtC02eq, an estimated 2.36 per cent of India's current total GHG emissions (Hirwe and Guru, 2021)
Energy efficient appliances	• Certification/ labelling schemes • Consumer awareness	The Standards and Labelling Scheme led to energy savings of 69 BU, monetary savings of Rs. 39,000 crores and emission savings of 53 MtCO2eq during 2019-20 (BEE, 2021).	Estimated savings in households' electricity consumption from ACs, refrigerators, TVs, and ceiling fans, could reduce by 10–27% in 2030, saving 42-116 MtCO2eq. With additional finance and bulk procurement, could increase to 128 MtCO2eq (Parikh and Parikh, 2016).
Cool roofs	• Building codes/ bye laws • Net zero building construction • Financial incentives • Consumer awareness	More than 60 per cent of roofs in India are made from metal, asbestos, and concrete – trapping heat inside buildings (NRDC, 2019).	Scaling up cool roofs across the country will save 700GWh of energy use, 0.60-0.65 MtCO2eq, and five billion rupees over 10 years (ibid).

	WASTE		
Reduce and reuse of waste	• Segregation of waste • Consumer awareness • National programme on bioremediation	As of 2017, 154,034 tonnes of urban solid waste generated each day, creating 11.67 MtCO2eq (GHG Platform India, n.d.)	In USA, kgCO2e saved per tonne of material recycled ranges from 88 (glass) to 4079 (aluminium), and an estimated 20-50 MtCO2e savings per year is possible if packaging is reduced by 25 per cent. (Ahluwalia and Patel, 2018).
Waste to energy (WTE)	• Segregation of waste • Construction of waste processing/ treatment plants	In 2017, 259 MW of grid connected / captive power was generated by 7 functioning WTE plants, reducing GHG emissions by 0.67 MtCO2eq per year (but, only 1/3 of waste came from urban areas). 48 WTE plants in planning/ construction expected to avoid 0.39-1.96 MtC02eq per year, depending on technology adopted (GHG Platform India, n.d.)	Taking into account functioning and planned WTE in 2017, an additional 0.51-2.99 MtC02eq per year could be saved if remaining urban solid waste was processed in WTE plants (ibid).
Compositing organic waste	• Segregation of waste • Consumer awareness • Construction of waste processing/ treatment plants	Organic matter makes up more than 65 per cent of urban solid waste in India. Production of urban compost plants in India in 2009 was 0.15Mt per year, compared to a potential of 0.71Mt (Mandpe et.al., 2020).	Compositing organic matter of urban solid waste could reduce 50 per cent load in landfills (with CO2 sequestration in soil, and improved soil quality) (Mandpe et.al., 2020). For every tonne of waste that is composted, saves up to 79 kg of CO2eq and fertiliser displacement saves up to 82kg of CO2eq of GHG emissions (Boldrin, et.al., 2009).
Bioremediation of landfill sites	• National programme on bioremediation	As of 2019, there were 3,159 landfills in India (CPCB, 2019). Only 21% of total urban solid waste in India was processed in 2017 (which was reported to have risen to 56% in 2019) with the remaining dumped or in landfill (GHG Platform India, n.d.) In Mumbai, in 2016, 80% of all solid waste (8,600 tonnes) dumped every day in landfill which emitted 2,523 MtCO2eq every day – equivalent to 196,000 passenger vehicles each year (Ahluwalia and Patel, 2018)	Bioremediation, or 'biomining' (the recovery of soil and recyclable material) is only possible for landfill sites having a higher organic content. It achieves permanent near-zero emissions of GHG emissions. It is not yet clear how many of the 3,159 landfills have the potential for it.

To achieve net-zero emissions, all the urban mitigation strategies discussed in this section will be required but will contribute in different ways. While the exact scale of their contribution will be determined by the specific design of the technology or practice, there are some which clearly hold more potential for GHG emissions savings than others. The following describes each of the strategies which the available evidence suggests will have the greatest impact on GHG emission savings, including some of the policy actions required to enable them.

Reduce the number of per-capita motorised private vehicle journeys *(GHG emission reduction potential of 205 Mt C02e/year by 2050* (CAT, 2020))***: Reducing demand for transport journeys can occur from making urban areas more compact with better public transport infrastructure and encouraging neighbourhoods to provide a full range of services within easy access. This type of urban development – often referred to as 'Transit-Oriented Development' requires new types of integrated city planning systems. Behavioural and employment practices can also reduce transport journeys, which can be encouraged through incentives and schemes for carpooling and work from home norms (CAT, 2020). Reducing demand for private journeys needs to be combined with the electrification of vehicles***

(powered through clean energy) to be carbon neutral.

Electrification of motorised vehicles *(GHG emission reduction potential of 570* Mt *C02e/year by 2050 (CAT, 2020)): Electric forms of road transport vehicles are a viable alternative to internal combustion engine (ICE) vehicles for two- and three-wheelers, public transport vehicles, light duty vehicles and heavy-duty vehicles. They are currently the most efficient technology compared to ICEs and other carbon neutral alternatives (e.g., synthetic fuels). However, they require an extensive deployment of renewable energy to be carbon neutral. The Government of India has already put in a place a vision and strategy for rolling out the electrification of motorised vehicles, with incentives and supportive policy measures for both the manufacture and adoption of electric vehicles, including the installation of charging infrastructure. The challenge is to roll out and expand these schemes at the pace required.*

Increase non-motorised and public forms of transport *(GHG emission reduction potential of 155* Mt *C02e/year by 2050 (CAT, 2020)): A modal shift to environmentally friendly transport modes such as walking and cycling, will reduce transport passenger demand and be space and cost-efficient for cities. Urban planning therefore needs to ensure citizens have access to safe cycling and walking routes. Public transport vehicles such as buses and light-trains also have much higher occupancy rates than light duty vehicles, so more passengers can be pooled in one vehicle, which in turn reduces per capita emissions from mobility as well as congestion, urban space requirements, and noise (CAT, 2020). This requires an investment in public transport infrastructure systems, and to achieve net-zero emissions, it also needs to be electrified and run on a clean energy source. An improvement in the quality of public transport infrastructure may not be sufficient to encourage a modal shift away from private vehicles, and additional incentives will be required.*

Increase fuel efficiency of private vehicles *(GHG emission reduction potential of 145* Mt *C02e/year by 2050 (CAT, 2020))***:** Increasing the efficiency of vehicles – in terms of the level of fuel consumption and GHG emissions – is particularly important for ICE vehicles. Fuel efficiency is affected by several variables, including weight, design and engineering of vehicle, tyres, use of air conditioning, and driving habits. The Government of India has fuel consumption standards for different types of vehicles. For passenger vehicles these are corporate standards Corporate Average Fuel Economy (café)), meaning that they relate to the Corporate Average Fuel Consumption (in litres/100 km) to the Corporate Average Curb Weight of all the cars sold by a manufacturer in a fiscal year (BEE, 2022). These can be progressively tightened to require manufacturers to find new ways to increase efficiency.

Green building design and construction materials *(38 per cent GHG emission reduction potential (GRIHA, 2022)): There is no universal definition of a green building, but in general it means a building which for which the planning, design, construction and operations prioritised considerations around its impact on natural resources, related to its energy and water consumption, indoor air quality, source of materials and effects on its local environment. There are various different codes, standards and certification schemes for green buildings in India although none of them are yet promoting carbon neutral building practices (and therefore also require a clean energy supply). These are described in detail in Annex B, and summarised below:*

- LEED is an internationally recognised green building certification system covering a wide range of metrics, such as resource utilisation, reduced CO2 emissions, improved indoor environmental quality.
- GRIHA is Government of India's national rating system for green buildings which includes 11 criteria, including sustainable site planning, construction management, energy efficiency, occupant comfort, water and waste management etc.
- BEE has a voluntary certification to incentivise energy efficiency in commercial buildings. It is based on the actual energy consumption of the building relative to its size.
- The ECBC established minimum standards for energy efficiency standards for commercial and large

residential buildings, which also includes higher efficiency voluntary standards. It sets minimum building envelope performance standards to limit heat gains (for cooling dominated climates) and to limit heat loss (for heating dominated climate) as well as for ensuring adequate natural ventilation and day lighting.

There are a range of policy actions required to ensure a complete shift to net-zero construction practices for new buildings, and the retrofitting of existing stock. This includes using building codes and bye-laws to mandate various or all of the elements of a green building, an expansion and tightening of the certification and labelling schemes and fiscal and other incentives for both the private sector and consumers.

Rooftop solar powered electricity generation *(GHG emission reduction potential of 58* MtC02eq for 40GW) (Hirwe and Guru, 2021): A rooftop solar power system, or rooftop PV system, is a photovoltaic (PV) system that has electricity generating solar panels mounted on the rooftop of a residential or commercial building. As of June 2021, there was 7,701 MW of installed capacity of rooftop solar in India, of which 2,507 was installed on commercial buildings, 3,902 on industrial buildings, and 1,292 on residential buildings (Bridge to India, 2021). There are a range of policy measures already in place to meet the national target of 40GW of rooftop solar power installed, which can be expanded and scaled up. This includes using building codes and bye-laws and finding financial and other incentives to encourage the adoption in new and existing buildings.

Reduce and reuse of waste *(Exact emission reduction potential unknown in India)*: Reduce means to cut back the amount of waste generated, while reuse means to find new ways to use things that otherwise would have been thrown out. This is crucial to avoid waste going to landfill and the resulting emissions and saves emissions from the manufacture of goods. It relies entirely on changing the behaviour of individuals and private actors and their consumption patterns. This can be facilitated by raising awareness on the environmental impact of waste, but also disincentivising waste creation. In addition, urban waste management systems can facilitate reuse of waste at the central level and encourage new markets for waste products.

However, within this group of high potential impact strategies, their exact contribution to transition pathways to a net-zero economy differ, and can be roughly categorised as the following:

- *Reducing a particular source of GHG emissions down to zero*, and therefore being a carbon neutral technology or practice that is relevant in a net-zero future (e.g. Increase non-motorised forms of transport, reduce and reuse of waste);
- *Reducing a particular source of GHG emissions down, but not necessarily to zero,* and therefore are important stepping-stones in the transition to a net-zero future. (e.g. increased fuel efficiency for ICE vehicles, green buildings – depending on exact definition);
- *Reducing a particular source of GHG emissions down to zero, but only if the supply of energy is decarbonised,* and therefore their impact is strongly dependent on the complete switch to renewable energy sources (e.g. electrification of vehicles, green buildings)
- *Reducing demand for energy supply*, and therefore the amount of renewable energy capacity addition required to decarbonise the electricity system (e.g. reducing per-capita motorised private vehicles, increasing public transport, energy efficient appliances, cool roofs, solar water heating, rooftop solar);

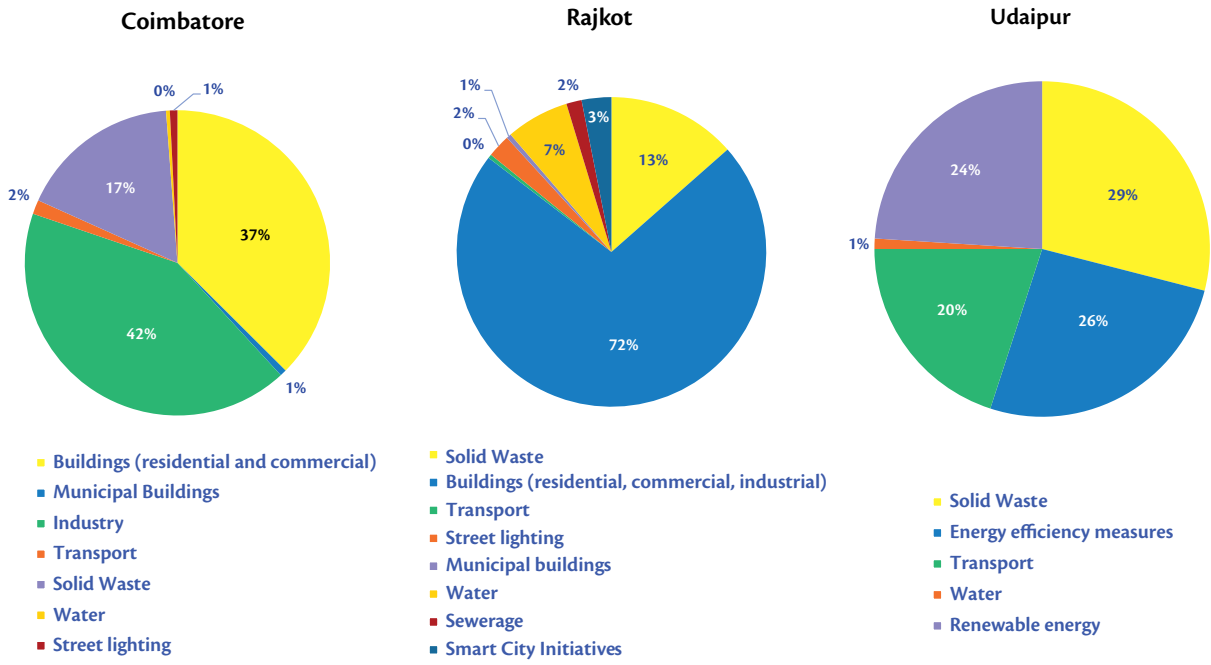
A number of these also provide an additional mitigation benefit of supplying renewable energy to the grid, which includes grid-connected rooftop solar systems and waste to energy plants.

The sequencing of the actions is also important in determining when emissions will peak and net-zero emissions are achieved. Global urban emissions pathways give a strong indication that nearly all

(97 per cent) of actions needed up to 2050 should begin by 2030, and the ensuing two decades should be for scaling up implementation and funding (C40/ Arup, 2016). The strategies also cannot be looked at in isolation, as there are synergies which come from different combination of actions, most obviously the need to decarbonise the electricity supply in parallel to electrifying transport services.

Despite the need to maximise all mitigation opportunities, it will likely be necessary to prioritise urban mitigation strategies, at least for immediate investment. The best combination of strategies for the city will depend on a variety of factors, for example, the current rate of electrification of public transport, projections of growth in personal vehicles, and whether the building stock has viable potential for rooftop solar. A number of cities are already undertaking this prioritisation exercise as part of a city climate action planning process (see Section 4.5). Figure 6 illustrates the diversity in the mitigation strategies prioritised by three City Climate Action Plans (CCAPs).

Figure 6: Examples of prioritised mitigation strategies in three CCAPs



Source: Compiled from CCAPs

A prioritisation framework for urban mitigation strategies could therefore be useful. This should ideally be based on a Multi-Criteria Decision Analysis (MCDA) approach (Bhardwaj et al, 2019a). There are multiple criteria that could potentially be used to prioritise urban mitigation strategies, including expected potential mitigation impact, and likelihood of success (given barriers which exist in the enabling environment – including policy, institutional, finance, behavioural and political barriers). The potential co-benefits from each mitigation strategy could also be considered. Weights can be used to reflect the importance a city or partner gives to the different criteria. Table 3 below is a simplified example, using just two criteria – 'potential mitigation impact' and 'likelihood of success' – with each being weighted equally [3]. The estimated ratings are provided as High (dark yellow); Medium (light yellow); and Low (light green). This is informed by the IPCC's feasibility assessment of "1.5°C

3 The score for 'potential mitigation impact' is based on available evidence on GHG emission reduction potential by 2050 (see Table 2). The score for the 'likelihood of success' is a summary of scores for the significance of five barriers: Policy barriers (is there any policy incentive or push for this strategy?); Institutional barriers (are there multiple tiers of institutional coordination needed to achieve it?), Financial barriers (what is the scale of finance required relative to other actions?); Behavioural barriers (are citizens likely to adopt the behaviours required?) and Political barriers (is there enough political will for it?). These are based on a subjective assessment by the authors informed by the expert interviews and literature review conducted for this study.

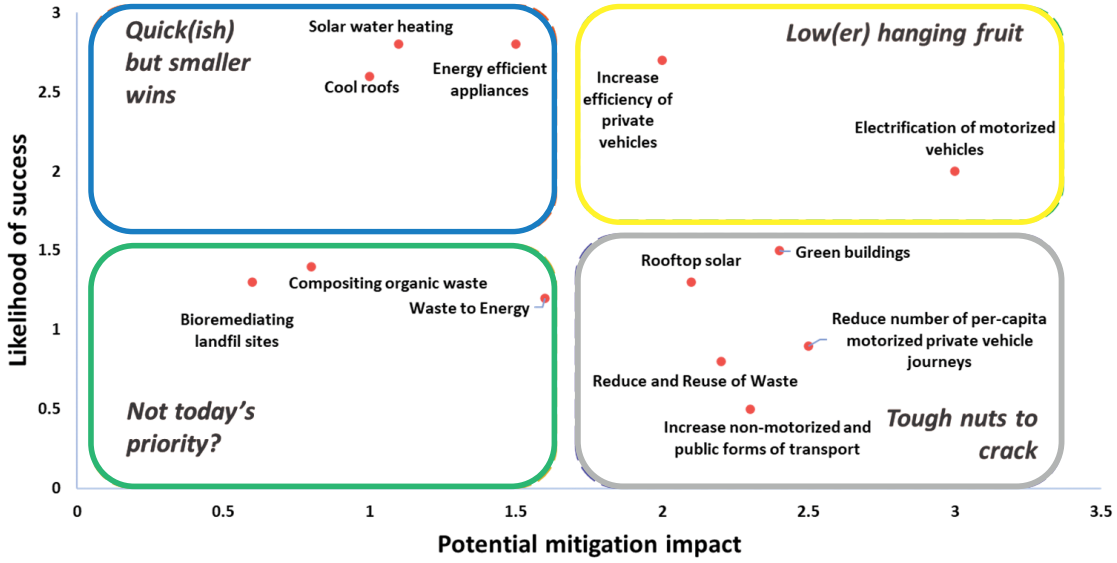
relevant mitigation options", which considers the economic, technological, institutional, socio-cultural, environmental and geophysical potentially blocking barriers (IPCC, 2019).

Table 3: Example of prioritisation method for mitigation strategies

	Potential mitigation impact	Rating of Barriers					Likeli-hood of success
		Policy	Institutions	Finance	Behavioural	Political	
Reduce number of per-capita motorized private vehicle journeys		Med	Med	High	High	Med	
Electrification of motorized vehicles		Low	High	High	Low	Low	
Increase non-motorized and public forms of transport		Med	Med	High	High	High	
Increase efficiency of private vehicles		High	High	Low	Low	Med	
Green buildings		High	High	Med	Med	Med	
Solar water heating		Low	Low	Med	Med	Low	
Cool roofs		Med	Low	Med	Med	Low	
Energy efficient appliances		Med	Low	Med	Med	Low	
Rooftop solar		Med	Med	High	High	Med	
Reduce and Reuse of Waste		High	HIgh	Med	High	Med	
Waste to Energy		High	High	High	Med	Med	
Compositing organic waste		High	High	High	Med	Low	
Bioremediating landfil sites		High	High	High	Med	Med	

From this prioritisation assessment, the strategies can be plotted on a graph (see below) and roughly categorised in terms of whether they are a priority.

Figure 7. Graphical representation of prioritisation method for mitigation strategies



2.3 Co-benefits to urban mitigation strategies

Cities in India need to be at the forefront of not just efforts to achieve net-zero emissions, but also to build a resilient, clean, healthy and equal society. It is therefore important to consider the co-benefits, but also the potential costs, that any mitigation strategy can have for at least socio-economic development and social inclusion, air pollution, and adaptation to climate change. Building and sustaining human and ecological adaptive capacities to recover from climate induced impacts greatly depends on meeting mitigation targets. Without mitigation, adaptation efforts would involve very high social and economic costs, while for some natural systems it would be nearly impossible.

Socio-economic development and social inclusion: There is growing recognition that the transition to a low-carbon economy will have winners and losers, and that in many cases, it is those that are already the most vulnerable and marginalised in society who will have to bear the costs (TERI and Shell, 2021; Khosla and Bhardwaj, 2019). There is a lot of evidence that urban mitigation actions can produce social development benefits, for example, creating an estimated 8.2 million new jobs in India (mostly through energy efficiency measures in the building sector) (CUTS, 2021). However, it is not clear how accessible 'green jobs' - such as building retrofits, rooftop solar installation and in compositing facilities - are to local communities and those without advanced skills. The creation of new jobs also needs to be balanced against the jobs that will be lost from fossil fuel dependent sectors, such as in coal mining, production. For example, the informal sector in India is currently a major provider of waste collection and recycling activities (it is reported that 50-80 per cent and nearly 100 per cent of plastic and glass bottles are recycled due to the informal sector) but they are an extremely vulnerable group of workers (CSE, 2021). Therefore, a switch to scientific and formal management waste management systems needs to integrate and protect the rights on these workers.

Finding effective ways to reduce the social and economic inequities that will occur as a result of implementing mitigation strategies is also important for securing political support. For example, the global shift to electric vehicles has worried automobile workers given they require less parts, and use more automated processes, than Internal Combustion Engine (ICE) vehicles, leading to worker protests and industry lobbying against electric vehicles (Eisenstein, 2019). It has been estimated that while a 30 per cent shift to electric vehicles in India will create an estimated 120,000 direct manufacturing jobs, om the flipside it will also cause 160,000 job losses in oil production and ICE vehicle manufacturing (Soman et. al., 2020). It is also likely that the individuals losing jobs would not have access to the new industry jobs even if re-skilling programs were implemented, as their qualifications, experience and age factor may work against them. There may also be regional imbalances to the social costs – whether it is job losses, increased prices, or financial or other barriers to accessing low-carbon technology – which may affect patterns of migration to, or away from, cities.

Beyond the potential employment benefits and costs, there is a public health dimension to many mitigation strategies. This includes those associated with co-benefits to reduced air pollution (see below) as well as a range of others. For example, a shift to non-motorised forms of mobility increases daily exercise, while improved public transport infrastructure can reduce road accidents and cool roofs can reduce the health impacts of heat waves.

The Just Transition agenda calls on decision-makers and practitioners to incorporate socio-economic considerations into the design and delivery of mitigation strategies. Some examples of the specific actions that can be taken include:

- Carry out active dialogue with communities that are likely to be affected by the mitigation solutions to build consensus around a plan to manage the likely impacts.

- Establish 'green skill' development programmes targeted at re-skilling those in fossil fuel dependent industries to allow for alternative employment in the new 'green' sectors.
- Enable small and micro industries, and the informal sector, to participate in and benefit from mitigation solutions, such as incorporating 'waste pickers' within waste management systems.
- Ensure the benefits of clean technology, such as reduced energy and fuel bills, are available to all, which may require subsidising the cost of electric vehicles, home insulation and other technologies for low-income households;
- Carry out all legal, thorough due diligence and process when repurposing public utility land, which was being used by local communities for livelihood and other purposes, for mitigation solutions.

Table 4 gives some examples from across the three urban sectors of how inclusion has been explicitly considered for mitigation strategies in India and other countries.

Table 4: Examples of enhancing socio-economic benefits of mitigation strategies

Sector	Examples
Transport	• The City of Los Angeles is moving rapidly towards electrified transportation. To include people and communities often left out of these transformations, Los Angeles entered a unique public-private-partnership to launch an electric car sharing program in low-income neighbourhoods of the city (Tinoco, 2018) • In the Khayelitsha area of Cape Town, South Africa, a street improvement project was undertaken to increase walking, but also reduce violence against women. Tree planting, overhead lighting and easy-to-maintain materials led to a 30 per cent increase in pedestrian activity and transformed the high-crime area into a sustainable and multifunctional public area (Welle et.al., 2015). • In London, the city provides grants to particular groups of people (including disabled people, low income households, small businesses) for scrapping their older, more polluting vehicles, to help them avoid paying the ultra-low emission zone charge (TfL, 2022).
Buildings	• In Cape Town, under the national subsidised housing rules, the city previously built homes for its low-income communities without insulated ceilings, making it difficult to control internal temperatures. In 2010 they started installing insulated ceilings and proper exterior plastering resulting in significant reductions in household energy costs, and improved health indicators (C40 and Burohappold, 2015) • In Kenya, 'Solvatten' combines a solar water heating system and water treatment and is targeted at residents of urban slums. More than 450,000 people around the world are using the low-cost technology, resulting in reduced emissions from the burning of firewood and increasing public health indicators (Solvatten, 2022). • As part of their Heat Action Plan, Ahmedabad Municipal Corporation has demonstrated the benefits of cool roofs by working with volunteers to apply locally available white lime paint to the roofs of an initial 3,000 low-income households. Local real estate developers are expanding it further and pamphlets, hoardings and adverts are increasing community awareness (NRDC, 2019). • 'Weatherisation Assistance Programmes' in the US reduce energy costs for low-income households by funding energy efficiency improvements. While traditionally this has focused on insulation and building improvements, some, such as the 'Energy Savings Assistance' Programme run by California utilities also include lighting, refrigerators, and air conditioning (Cluett et.al., 2016). • Demand-driven sectors like solar rooftops create many more jobs than utility scale solar and wind energy due to their decentralised nature. Over 38,600 workers were employed in India for just 3.8 GW of installed rooftop solar, as compared to around 37,900 workers for 26.2 GW of utility scale solar and over 23,300 workers for 35.6 GW of wind energy (CEF, 2019).

Waste	• The city of São Paulo has been working since 2002 with the informal waste sector - waste-picker cooperatives – to integrate them into the city's waste management system. They are providing basic equipment, such as personal protective equipment, to workers in sorting centres. In 2009, the city set up a municipally funded training programme for waste-picker associations to gain qualifications in basic resource salvage, the management of cooperatives and solidarity economy enterprises. All profits from the sale of recyclables goes directly to the cooperatives (C40, 2020). • In Pune, SwaCH is a pro-poor public private partnership wholly owned by self-employed waste workers, which collects and separates waste door-to-door on behalf of the Municipal Corporation (Harhare, 2021). • In Oaxaca, Mexico, 25 tons of waste have been composted, and 1 million tonnes of GHG prevented, over four years by marginalised people living in a slum. A 'worm power' programme has distributed worm compositing kits to households, and 3,500 people have benefited from the sale of the compost and/or cultivating vegetables (UNFCCC, 2022).

Air pollution benefits: The extent to which a mitigation strategy also reduces local air pollution should be an important consideration. As per the Global Burden of Disease study, 1,670,000 people died due to air pollution in 2019 in India, half of which were in just five states (Uttar Pradesh, Maharashtra, Bihar, West Bengal and Rajasthan). The economic cost was US$ 36,803 million, which is equivalent to 1.36 per cent of India's GDP. (Health Effects Institute, 2020). The emission sources of air pollution and carbon emissions overlap in many cases – such as vehicular emissions, burning of waste, and diesel generators - allowing for many dual benefit strategies (Kaur and Pandey, 2021).

Energy-related fuel combustion is the major contributor to air pollution (through NOx, SO2, and PM emissions) and climate change (through CO2 emissions) and should therefore be at the heart of a strategy to deal with both crises in India (IEA, 2021). However, explicitly considering the volume of air pollution benefits from any mitigation strategy can yield greater synergies. For example, while decarbonising the power sector is central to both reducing air pollution and tackling climate change, it needs to particularly target Captive Power Plants which provided nearly 19 per cent of India's electricity supply in 2019 (although this likely under-estimates the number of diesel generators <1MW) and which are more likely than grid-connected plants to be run on fossil fuels, and are major sources of localised air pollution (IEA, 2021). In addition, a rapid roll-out of electric vehicles will reduce NOX immediately, but will likely increase SO2 as in the short-term coal fired power plants will have to meet the increased demand for electricity until the expansion of renewables gets to sufficient scale. Tighter environmental regulations in thermal power plants could help mitigate this negative side-effect for air pollution (IEA, 2021).

Adaptation and resilience benefits: Cities in India are already facing a range of climate impacts, including coastal surges and cyclones, heat waves, water shortages and floods (Khosla and Bhardwaj, 2019; Sridhar, 2016; Sahay, 2017). In fact, India is home to 43 of the world's 100 most at-risk cities from environmental risks including natural disasters and air pollution, with New Delhi being second highest risk city globally, followed by Chennai (3rd), Agra (6th) and Kanpur (10th) (Verisk -Maplecroft, 2021). This is causing significant financial and human losses. For example, it was reported that between 2005-15, recurrent floods in Mumbai resulted in 3,000 deaths and Rs 14,000 crore of losses (Jha and Desai, 2021). Cities therefore need to design strategies for building their resilience to these increasing impacts.

Adaptation and mitigation both consist of technological, institutional and behavioural measures, and require research to consider costs and benefits, and economic and policy mechanisms to encourage their adoption. When thinking of costs and benefits of adaptation and mitigation options, it is important to remember that spatial and temporal benefits of each are felt at different scales, which leads to different levels of decision-making initiative. Adaptation benefits usually tend to be local/ regional and often near-term, whereas mitigation benefits will be felt after decades and at a diffused, global scale. As a

result, international or national policies tend to drive mitigation action, whereas it is mostly local actors and communities taking adaptation measures. The benefits of adaptation also tend to be valued or measured differently depending on the social, political and economic local context (Klein et al, 2018).

Creating positive synergies between adaptation and mitigation is urgently needed and can also increase the cost-effectiveness of actions and potentially make them more attractive to stakeholders (CUTS, 2021b; Knittel, 2016). The IPCC Sixth Assessment Report finds that of various adaptation options for urban systems, green infrastructure and ecosystem services were found to have the highest feasibility, and synergy with mitigation (IPCC, 2022). However, there are some potential trade-offs that need to be managed. For example, air conditioning is used to manage extreme heat impacts, but it results in increased energy consumption, the source of which will still likely be fossil fuels. A number of urban mitigation solutions, such as Waste-to-Energy plants, can also be relatively water intensive (although this often depends on the specific technology and design used), which can add to local water stress.

Table 5: Examples of priority urban adaptation strategiesTable 5 gives example of global good practices for urban adaptation strategies. For example, more than 100 cities and districts in India have prepared Heat Action Plans, which establish early warning systems, public cooling centres, shaded spaces, cool roofs and new green infrastructure. The city of Ahmedabad's Heat Action Plan (2013) has served as an example for other cities and has saved an estimated 1,200 lives annually from extreme heat (CUTS, 2021b).

There are many co-benefits to both adaptation and mitigation that come from nature-based solutions. For example, conserving green spaces in a city can play a critical role in mitigation and adaptation aspects by decreasing local temperature, protecting from floods and helping recharge groundwater, as well as providing carbon sequestration benefits (IIED, 2016). Urban heat islands occur when cities replace green cover with pavements and buildings, which increases energy costs and heat-related illness. Studies show that Mumbai's green cover decreased by 40 per cent between 1991 and 2018, leading to a 2 degrees Celsius average temperature rise (The Hindu, 2021). In another example, the reduction of waste from Bangalore would deliver GHG emissions savings, but also return the common lands to the citizens of Mundur on the outskirts of the city who for years have been making room for landfill sites. This would also support biodiversity conservation, provide "green lungs" for Bangalore, and reduce the metropolitan's carbon footprint (Damodaran, 2012).

Table 5: Examples of priority urban adaptation strategies

Urban adaptation strategies		
Type of action	**Adaptation action/ Hazard**	**Examples**
Systemic resilience actions - Actions that increase the adaptive capacity of a city, regardless of the hazard exposure(s) the city might face	Increasing awareness	Hazard maps, impact assessments, spatial analysis; information campaigns to citizens
	Incorporating risk	Incorporate climate risk into urban planning; rating resilience of infrastructure; limit construction in risk prone areas
	Optimising response	Early warning systems; emergency protocols
	Enhancing financing programmes	Climate insurance

Hazard specific actions - Actions that reduce the impact of a specific hazard or enhance a city's ability to recover from that hazard	Extreme heat	Tree plantation; cool roofs; reflective pavements
	Inland flooding	Nature based sustainable urban drainage systems (reduced paved spaces, rain gardens, bioswales); river catchment management
	Coastal flooding and storm surges	Flood and storm resilient buildings (dry-proofing/ wet-proofing, elevated buildings); Coastal artificial barriers (seawalls, groynes); mangrove restoration
	Drought	Water conservation practices; water efficient building practices; smart technology for water supply systems
	Wildfires	Ignition-resistant building codes; Fuel breaks; Prescribed and controlled burns.

Source: C40/ McKinsey (2021).

Each potential mitigation strategy has a combination of co-benefits that need to be evaluated. For example, the Delhi Metro has been relatively well evaluated for the different benefits it has provided (Doll and Balaban, 2013; Puppim de Oliveira and Doll, 2016). This includes shifting approximately 230,000 vehicles off the road by 2015 and the associated GHG emissions savings this represents, however the total number of vehicles in the city continued to increase due to economic growth (Panwar et.al., 2018). 30 per cent of commuters also reported to having an extra 30 minutes of physical exercise, suggesting some health benefits, and there were reported to be 591 less road accidents (ToI, 2017). However, there were some equity trade-offs, as poorer people could not afford the metro ticket price (Doll et al. (2013).

Table 6 attempts to summarise the different types of negative and positive impacts of the urban mitigation strategies discussed in this section. However, in reality how a mitigation strategy is designed and implemented - for example the exact choice of technology, and whether rules are enforced - will determine the exact distribution of costs and benefits. For example, Waste to Energy (WTE) continues to be a controversial policy option in India, with many communities nearby to WTE plants protesting against the toxic fumes and reported dumping of toxic waste (Singh Sambyal, et.al., 2019). However, in Surat, a WTE plant was shown to have reduced carbon emissions and water pollution, accruing local health benefits (Kapshe et al., 2013; Puppim de Oliveira and Doll, 2016).

Table 6: Mapping of potential co-benefits and costs of mitigation strategies

	Other potential positive and negative impacts					
	Socio-economic		Air pollution		Adaptation and resilience	
	Negative impacts	Positive impacts	Negative impacts	Positive impacts	Negative impacts	Positive impacts
Reduce number of per-capita motorized private vehicle journeys	Reducing journeys/ car sharing not possible for all	Car pooling can increase social connections	None	Reduction of vehicular emissions, a main cause of air pollution	Extreme weather conditions may make walking/ cycling more difficult	Public transport potentially better able to adapt to extreme weather conditions (floods, heat waves)
Electrifi-cation of motorized vehicles	High costs of EVs inaccessible to lower income households	Health benefits of reduced air pollution	None (assuming decarbonized supply of electricity)	Reduction of vehicular emissions, a main cause of air pollution	Electricity supply at risk from extreme weather events, and can be water intensive	Reduced depence on oil imports which are subject to disruption from extreme weather

Increase non-motorized and public forms of transport	Less convenient/ accessible for some individuals	Health benefits, and more accesible transport for all	None (assuming public transport is low-emission)	Reduction of vehicular emissions, a main cause of air pollution	Extreme weather conditions may make walking/ cycling more difficult	Public transport potentially better able to adapt to extreme weather conditions (floods, heat waves)
Increase efficiency of private vehicles	Potential increased fuel costs and need to replace cars affecting lower income households in particular	Health benefits of reduced air pollution	No evidence	Reduction of vehicular emissions, a main cause of air pollution	No evidence	Reduced depence on oil imports which are subject to disruption from extreme weather
Green buildings	Current high costs of green buildings inaccessible to lower income households	Health benefits from better insultation and ventilation	None	Reduced emissions from construction material, dust and reduced indoor air pollution sources	None	Better able to withstand extreme weather events; and more water efficient
Solar water heating	Costs of installation is high and inaccessible to lower income households	Once installed, reduces household energy bill	None	Reduced indoor air pollution if replacing use of solid fuels	Electricity supply at risk from extreme weather events, and can be water intensive; Could increase water consumption	Reduced depence on oil imports which are subject to disruption from extreme weather
Cool roofs	Costs of installation can be inaccessible to lower income households	Once installed, reduces household energy bill; Health benefits from reduced indoor temperatures	No evidence	By reducing air temperatures, can reduce the rate of smog formation	None	Protects from extreme heat by reducing air temperature
Energy efficient appliances	Higher price can be inaccessible for lower income households	Once purchaseed, reduces household energy bills	No evidence	No evidence (beyond reducing emissons from power generation)	No evidence	None (unless also water efficient)
Rooftop solar	Costs of installation can be inaccessible to lower income households; Not all homes suitable for the technology	Once installed, reduces household energy bill	No evidence	No evidence (beyond reducing emissons from power generation)	No evidence	Avoids disruptions from the impact of extreme weather on electricity grid

Reduce and Reuse of Waste	None (assuming informal sector is integrated into new schemes)	Reduced health impacts from waste dumping and pollution of natural resources	No evidence	Reduced air pollution from biomass burning and other practices	None	Reduces amount of waste blocking drainage systems and causing floods
Waste to Energy	Exisitng WTE plants reported to have created local health impacts due to pollution of natural resources	No evidence	Existing WTE plants a major source of air pollution	No evidence (unless new technology adopted)	Existing WTE plants consume relatively large amounts of water	No evidence
Composit-ing organic waste	None	Food grown with compost requires no/less pesticides, and has associated health benefits	No evidence	None (beyond reducing emissions from other waste disposal practices)	None	Increases soil health and replenishes ground water
Bioremedi-ating landfill sites	None	Reduced health impacts from landfill polluting local natural resources	No evidence	Reduced air pollution from landfills	No evidence	No evidence (beyond less water pollution by landfill)
	KEY					
	On balance, appears to offer greater positive impacts					
	Offers mix of negative and positive impacts					
	On balance, appears to offer greater negative impacts					
	Does not appear to offer any significant immediate negative or positive impacts					

Source: Authors' analysis, based on a variety of sources

3. Cities' current role in delivering urban mitigation strategies

This section explores the different levels and parts of government which need to work together to achieve the urban mitigation potential outlined in the previous chapter. Unlike most Western countries, governance of urban issues is not decentralised to the city authority, the Urban Local Body (ULB). Rather, decision-making and financial resources are concentrated at the state level, with the central government retaining some significant powers and influence. This could indicate that a top-down approach, through national or state level incentives or policy direction, is the most effective way to mobilise urban action on climate change. However, all three levels of government – centre, state and ULB – actually need to be engaged.

This includes ULBs, who despite having limited decision-making powers and financial resources, are a crucial actor in achieving urban mitigation potential in India. This includes their role in delivering state and national mitigation programmes within the city, as well as through their own policy levers. Most ULBs have struggled to perform these roles effectively – the next section explains why – which has affected the performance of a number of a national urban missions and schemes. Therefore, to deliver the much needed GHG emission cuts required in cities in India, every level of government needs to be engaged, including a bottom-up approach of working with ULBs.

3.1 Constitutional roles and responsibilities for urban mitigation strategies

As per the Constitution of India, managing urban affairs is largely the responsibility of state governments. It bestows power on states to frame policies and enact legislation for matters related to land, housing, urban development and provision of civic infrastructure (see Table 12 in Annex A for details on the division of constitutional powers). The central government formally plays an 'advisory' role in these functions, providing technical and crucially financial support (NITI Aayog, 2021). However, in reality, historical circumstances have led to an empowered central government that influences the shape of state policy in nearly all spheres of governance (Pillai and Dubash, 2021).

Institutional roles and responsibilities for managing climate change have emerged from how the environment has been historically governed. The constitution grants the central government power to legislate on subjects related to international treaties, regardless of whether it is exclusively under state jurisdiction. This allowed the Environmental Protection Act 1986 to give sweeping powers to the central government to take all measures necessary to protect the environment. The central government can also shape and influence subjects under state control, such as agriculture and water governance, through channelling finance through national programmes and providing 'model legislation' for states to adopt (Pillai and Dubash, 2021).

However, states are the crucial link in climate planning within India's federalist system, particularly in terms of managing the local political environment (Pillai and Dubash, 2021). State governments translate national priorities to align with their own local priorities and realities, which are reflected in

state policies such as State Action Plans on Climate Change (SAPCC), electric vehicle plans, afforestation programmes and energy conservation building codes. Even for subjects for which the policy framework and resources are coming from the central government, state governments are responsible for implementation, or ensuring this happens by ULBs or state-managed urban parastatals. State governments are also crucially responsible for land-use planning, and long-term urban development planning, although this responsibility has been devolved to ULBs in many states.

The distribution of powers is reflected in the three critical urban sectors for mitigation:

Transport: The Constitution of India includes urban transport, under the category of urban development, as under the responsibilities of the state, with the 74th Constitutional Amendment allocating transport as a mandatory function of ULBs. Certain aspects of urban transport also fall under the union list (see Table 7), most significantly suburban rail transport systems. A number of central government acts, including the Motor Vehicle Act, Road Transport Corporation Act and Indian Tramways Act, have extended responsibilities to State Governments. However, states are unable to further devolve powers to ULBs for some subjects, as they overlap with union laws, including on urban planning and roads and bridges (Ministry of Housing and Urban Affairs, 2016) The central government also sets rules that impact urban transport to meet their responsibilities for environmental affairs and international treaties, for example, emission standards and transport safety rules. In addition, the central government shapes urban transport policy and practice through funding and guidelines (e.g. Smart Cities Mission, National E-Mobility Programme).

Buildings: The 74th Constitutional Amendment bestowed powers to ULBs for urban planning, including through the formulation of a city Development Plan or Master Plan which outlines the zoning regulations and building by-laws governing all construction. However, the central government has a significant role in shaping these provisions, such as through the National Building Code and the Urban and Regional Development Plans Formulation and Implementation Guidelines which are not formally mandatory but are followed in most states. The central and state government also finances building related schemes, including construction of social housing and subsidies for rooftop solar energy systems.

Waste: As per the Constitution, solid waste management is a state subject and state governments are responsible for ensuring that all ULBs introduce and follow appropriate waste management policies and practices. The 74th Constitutional Amendment made it more explicit that ULBs have this responsibility for their jurisdiction. The central government primarily provides guidelines and technical assistance to support states. However, using powers drawn from other subjects the central government can also set rules and regulations. For example, excising powers conferred by the Environmental Protection Act 1986, the centre notified the Municipal Solid Waste (Management and Handling) Rules, which were updated in 2016 to mandate the source segregation of waste and other rules.

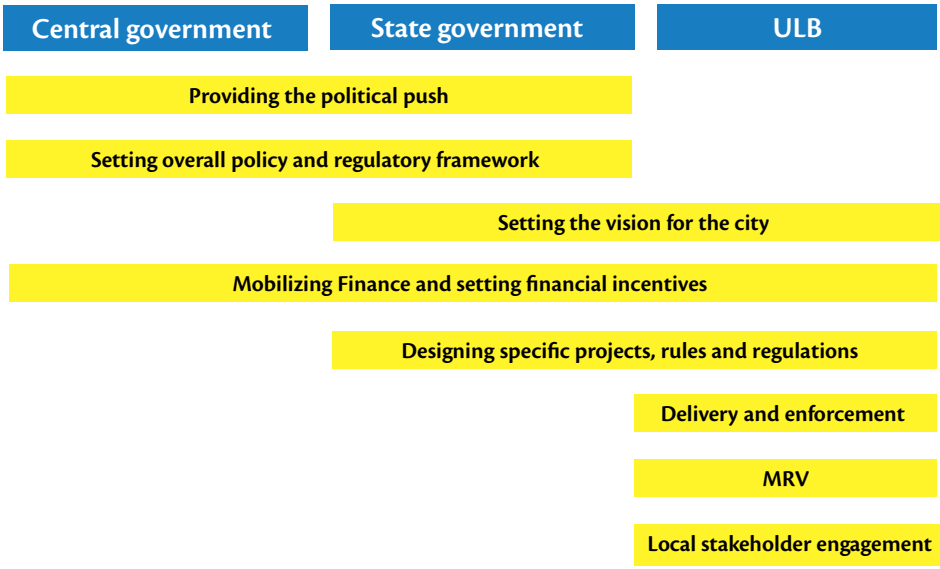
3.2 The role of the city in delivering urban mitigation strategies

The state government and ULB play a crucial role in urban climate governance, despite the power, resources and influence of the centre. In fact, many central government policy priorities and programmes have failed to have the expected impact because lower levels of government lack the capacity or political will to implement them effectively. For example, the Energy Conservation and Building Code (ECBC) was first launched by the central Bureau of Energy Efficiency (BEE) in 2007 but required state governments to adopt the code, and ULBs to enforce it. By 2017 only 11 states had notified ECBC and only two had notified at Municipality level, and the slow pace of implementation was due to capacity and governance constraints at the state and city levels and the need to engage many

private sector actors (AEEE, 2017; ICLEI, 2019). In addition, states and ULBs can proactively put in place policy measures in advance of any central government directive using the various policy and financial powers at their disposal.

Figure 8 below gives an illustration of how many of the roles and responsibilities for urban climate action in India are shared across multiple levels of government.

Figure 8: Shared roles and responsibilities for urban climate governance in India



It is possible to distil four routes that cities can pursue to deliver net-zero emissions, which combine various roles and responsibilities outlined in the previous diagram.

Route 1: Cities effectively deliver and enforce top-down policy measures: ULBs, or the mostly state-owned parastatals are at the front-line of implementing national urban mitigation strategies, such as segregation of waste and enforcement of rules and regulations, such as compliance checks of the ECBC. They also have responsibility for Monitoring, Reporting and Verification (MRV) for a wide range of central and state programmes relevant for urban mitigation. This is currently a wide range of monitoring mechanisms, performance indicators and reporting systems. In some states and for some schemes there are also third-party performance audits of ULBs.

This route is most appropriate for those mitigation strategies and policy actions which the central government has formal power to regulate, for example for suburban rail transport and vehicle emission standards. In addition, cities play a primary 'delivery' function for central government schemes (e.g. Smart Cities Mission) although to different degrees there is still the option for states and ULBs to define the exact shape and scope of delivery.

Route 2: Cities pro-actively adopt a more ambitious vision and strategy for climate change: State governments can put in place an approach and set of policy measures on net-zero economic growth that go beyond the ambition of the national government. A ULB has a constitutional mandate for urban planning, which has mostly been limited to spatial analysis (See Box 3). Climate change should be mainstreamed within urban planning and development processes, such as Master Plans, infrastructure development plans and municipal budgets (C40/ Arup, 2016). In addition, some states and cities have taken the initiative to prepare more holistic socio-economic development strategies and plans. Box 4 discusses the potential of City Climate Change Action Plans (CCAPs) for bringing together and

prioritising the sectoral and cross-sectoral actions required for tackling climate change, as well as for providing a monitoring framework for implementation. To deliver this strategy, states and ULBs can use various policy levers available to them (see Routes 3 and 4).

This route is most appropriate for giving a clear signal to the market and stakeholders about the intentions of the city to put in place policy measures and incentives that go beyond the ambition of the central government. For example, cities can develop integrated low-carbon transit-oriented plans which bring together various existing central government schemes and policies, but also include additional policy and financial levers available to the state and ULB. This type of planning and strategy making allows the city to cover a wide spectrum of mitigation solutions and should ideally be cross-sectoral in nature to allow synergies and trade-offs to be identified and managed.

Route 3: Cities can use policy and financial incentives to build demand for low-carbon technology: States and ULBs have scope to design their own urban development projects and regulations within their jurisdiction which gives them the opportunity to be more ambitious than national policy. They can use this to act as demand aggregators for low-carbon technology and create an ecosystem of service and infrastructure providers.

Table 7 maps the key policy actions identified in literature and by experts consulted that are required to deliver the key urban mitigation strategies. For each of these, it provides examples of specific policy levers that each level of government (centre, state and ULB or urban parastatal) has authority to initiate. In addition, Annex D provides details of the broad responsibilities and powers of the ULBs governing two different cities in India – Surat Municipal Corporation (SMC) in Surat and Brihanmumbai Municipal Corporation (BMC) in Mumbai – and examples of the types of policy initiatives on climate change they have the authority to initiate.

This highlights that while a few are truly top-down actions, such as national certification and labelling schemes, and fuel standards, most involve the state government and/or ULB. The state and ULB specifically have a significant number of policy options available to it, which can allow them to pursue ambitious action irrespective of the national level of ambition. This includes financial levers that states and ULBs can utilise, such as setting parking fees which generate resources and can disincentivise private vehicles and adjusting property tax to encourage the adoption of low-carbon building practices. For example, since 2000, Thane Municipal Corporation has provided a 10 per cent rebate in property tax for solar water heating installation (PACE-D, 2018).

This route is most appropriate for building consumer demand for low-carbon technology and incentivising new low-carbon service providers. For example, in the waste sector, states and ULBs can build a market for recycling and compositing of waste, which could include financial incentives for segregation of waste and building markets for compositing. This could include facilitating new companies and cooperatives that can manage these processes, ideally including the informal waste sector, as well as consumer awareness campaigns on the benefits of scientific waste management.

Route 4: Cities can innovate and experiment to kick-start wider adoption of low-carbon technology: States and ULBs have sufficient resources and power to demonstrate the benefits and feasibility of new low-carbon technologies, to encourage others to invest at a greater scale. This demonstration effect is important for increasing investor confidence as well as raising awareness of businesses and service providers of the commercial viability of some of these technologies.

There is space for cities to innovative across a whole wide range of mitigation solutions, including for any type of urban infrastructure that is state- or ULB-funded (e.g. roads, street lighting, walking and cycling infrastructure), as well as by forming public-private-partnerships (e.g. waste to energy plants). ULBs also

deliver a range of municipal services (see Annex D) which provide important opportunities to pilot new technologies, for example, the introduction of electric buses, installation of solar energy-based water pumps for the supply of water to the city and retrofitting schools and ULB offices with carbon neutral building practices.

This route is most appropriate for mitigation solutions that can be fully or partially public sector funded but will ultimately be scaled up by private sector actors. For example, the ULB can demonstrate the viability and commercial benefits of rooftop solar on their office buildings to encourage commercial offices to also adopt the technology. These public-sector funded technologies will also support and strengthen local service providers and de-risk their investments.

Table 7: Examples of policy levers available to each level of government

Policy action	Mitigation strategies the policy support				Specific policy levers available to different levels of government		
TRANSPORT							
	Reduce number of per-capita motorized private vehicle journeys	Electrification of motorized vehicles	Increase non-motorized and public forms of transport	Increase efficiency of private vehicles	Centre	State	ULB/ Parastatal
Improve public transport infrastructure	▲		▲		Incentivize transport oriented development in public infrastructure projects		Establish monthly transport passes
					Fund new infrastructure projects		Online platform for bookings/ timings for all transport modes
							Reform land registry systems and construction permits
Incentivize car sharing	▲				Clear and harmonized operation and data protection rules	Fiscal incentive for shared service, rather than ownership	priority access to certain services
Incentivize shift to electric mobility		▲		▲		Purchase subsidies and/or tax exemptions	ensuring adequting charging infrastructure
Incentivize modal shift	▲		▲			Subsidise cost to ensure affordability	Low emission zone charges; congestion charges;

Sustainable and innovative urban planning	▲	▲	▲	▲			City level plans for walking infrastructure	
							Coordinating agency for intermodal transport services	
Tighten emission standards				▲	Strengthen existing emission standards			
WASTE								
	Waste to Energy	Reduce and reuse waste	Com-positing organic waste	Bioreme-diating landfil sites	Centre	State	ULB/ Parastatal	
Segregation of waste	▲	▲	▲				Fiscal incentives (waste collection fee etc)	
							Uniform colour code for household segregation	
							Inclusion of informal sector	
							Strengthen the market for segregated waste	
Consumer awareness programmes on waste management practices		▲	▲		Creation of Indian standard for compost	Subsidies for compost production	Information, Education and Communication Campaigns;	
							Marketing of city compost	
National programme on bioremedi-ation		▲		▲	Updated guidance/ rules	Fund bioremediation projects		
Construction of waste processing and treatment plants	▲		▲		Fund new WTE processing plants and compositing facilities			
BUILDINGS								
	Energy efficient appliances	Green build-ings	Solar water heating	Cool roofs	Rooftop solar	Centre	State	ULB/ Parastatal
Building codes/ bye-laws		▲	▲	▲	▲			Incor-porate net-zeron construc-tion prac-tices in bye-laws

Certification/ labelling schemes						Expansion of appliance standard and labelling scheme		
	▲	▲				Expansion/ consolidation of green building certification schemes		
Construction of net-zero buildings		▲	▲	▲	▲	Integration in home building schemes		Construc-tion of net-zero municipal buildings
Financial incentives		▲	▲	▲	▲		Subsidies on electricity bills	Property tax incentives
							Economic incentives for DISCOMs	Fast-track approvals
Consumer awareness	▲	▲	▲	▲	▲		Access to finance for building owners	
							net/ gross metering	

Source: Authors' analysis, based on a variety of sources.

3.3 Comparison of urban climate governance in India and other countries

India's particular model of urban governance makes it difficult to compare with how city climate planning has evolved in other countries. In particular, ULBs have significantly less power, authority and financial autonomy than their counterparts in Europe, North America and elsewhere.

Indian cities have not experienced the same level of devolution of decision-making and financial authority that many other cities around the world have seen in recent decades. Despite the intention of the 74th Amendment, Indian cities' governance is still controlled by upper levels of government. In contrast, directly elected Mayors have increased markedly around the world, including in Columbia in 1986, Mexico City in 1997 and all cities in Germany, Italy and Poland, although many successful cities, including Copenhagen, Melbourne and Prague, still do not one (Hambleton, 2013).

Table 8 highlights some of the differences in the division of powers between levels of government across cities in India (using Surat as an example) and elsewhere (using New York City and London as examples). It uses examples of some of the policy actions identified previously (see Table 7) to roughly indicate which level of government is responsible for making these policies, financing them, and implementing and enforcing them[4]. Annex C gives a more complete description of the responsible agency at each level

4 The levels of government are not directly comparable. The 'city' governance is labelled as the ULB in Surat and in London includes also the Local Councils which are within the city. In London there is no 'state' government comparable to India and the USA. The 'centre' refers to the federal government for New York's case.

of government for each city, across the entire set of policy actions. This highlights a few key differences in India's model of urban climate governance (while recognising the small sample size):

- ULBs in India have significantly less involvement in the policy-making process and for the financing of the policy actions, compared with the city government in London and New York, but a similar level of involvement in the implementation and enforcement process. This suggests that India should focus on replicable learning around implementation models and enforcement mechanisms.
- For some policy actions, responsibility has been retained at the central level across all three cities, particularly in terms of setting fuel efficiency standards and regulations around waste construction plants. This is logical for those issues where national or at least state level consistent rules are required. This makes it clear where top-down, versus bottom-up, policy advice should be focused.
- This mapping of constitutional roles and responsibilities does not sufficiently capture the differences in capacity and resources and the wider political economy context between cities in India and beyond. These are explained in detail in Section 4.

In general, it is clear that India needs to evolve its own unique model of leading, designing and delivering urban climate action in India. The experiences of other countries may provide inspiration and learning but cannot be automatically replicated in India.

Table 8: Approximate mapping of institutional responsibilities for select policy actions[5]

	Responsible levels of government								
	Makes policies			Finances policies			Implements/ enforce policies		
	Surat	London	NYC	Surat	London	NYC	Surat	London	NYC
Public Transport Infrastructure	Centre/ State/ ULB	City (and Local Council)	City	Centre/ State	City	Centre/ State/ City	Centre/ State/ ULB	City	City
Promotion of Electric Vehicles	Centre/ State	City	City	Centre/ State	City	Centre/ State/ City	State/ ULB	City	State/ City
Fuel efficiency	Centre/ State	Centre/ City	Centre/ State	N/A			State	City	Centre/ State
Building bye-laws/ codes	Centre/ State/ ULB	Centre	City	N/A			State/ ULB	Local Council	City
Green social housing	Centre/ State	City	City	Centre/ State	City	City	State/ ULB	City	City
Segregation of waste	Centre/ State	Centre/ City (and Local Council)	State/ City	Centre/ State/ ULB	City (and Local Council)	City	ULB	City (and Local Council)	City
Waste treatment plants	Centre/ State	Centre	State	Centre/ State	City (and Local Council)	City	ULB	Centre/ Local Council	City

Source: Author's own analysis.

5 Dark green corresponds to central government, medium green corresponds to state government, light green indicates city/ ULB and mix of shades indicates responsibility is spread across multiple levels.

4. Overcoming barriers to realising India's urban mitigation potential

This section examines the critical barriers to cities in India contributing to net-zero economic growth in India, and how these can be managed or overcome. There are deep-rooted and systemic reasons why cities in India have not so far shown leadership on climate change in the same way that cities in the US, China and elsewhere have done so. Cities in India have much more limited decision-making authority and financial autonomy and there are significant political economy constraints to ambitious urban climate action. However, there are opportunities to address, or at least help manage, the barriers to ambitious urban climate action. These are cross-sectoral and aim to enhance the overall enabling environment for urban climate action. They therefore sit above, and support, the specific sectoral mitigation strategies listed in Section 2.2. The evidence therefore suggests that it is still possible to mobilise mitigation action in cities in India, despite these barriers, but it requires a careful and considered approach.

While every city in India faces its own particular set of governance constraints – which are not unique to just action on climate change - this section focuses on the most critical and common barriers to ambitious urban climate action:

- Lack of ambition on urban climate action, and political-economy constraints to cities and states being proactive on climate planning;
- Very limited institutional capacity for climate planning and delivery, particularly within ULBs;
- Lack of available financial resources and limited financial autonomy of ULBs;
- Fragmented decision-making authority on urban issues, including limited decentralisation of powers to ULBs;
- Lack of a coordinated policy framework for urban climate actions, a cause and effect of the challenge of coordinating across the multiple relevant institutions;
- No Monitoring, Reporting and Verification (MRV) system for urban climate actions.

After discussing each barrier and the opportunities to overcome them in turn, the chapter also highlights learning from other cities programmes in India on the practical realities of supporting transformative change, at scale, across India.

4.1 Overcoming a lack of ambition on urban climate action

There has been very limited leadership shown by cities in India on climate change as a cross-cutting issue, with some notable exceptions. In general, cities in India are not driving the agenda on climate change nor pushing the central and state governments to be more ambitious in their climate strategy. There are likely political economy factors, such as vested interests, within the city which limit the level of ambition of the city. For instance, in Indore, a Pradhan (councillor) attempted to disrupt a planned project to install water harvesting systems as it allegedly challenged an entrenched system of patronage through which he exchanged tankers of water in the summer for political allegiance in local

elections (Bahadur and Tanner, 2014). There is also very limited evidence of citizens demanding city officials and elected representatives to take action on climate change. As one expert stated, the public are not demanding action on air pollution which has a very direct impact on their health and lives, so it looks unlikely that they will make demands for action on climate. But concerns like air pollution could drive cities to initiate some of the discussed sectoral policy actions earlier than the other actions, thereby laying the foundations for gradual ambition-raising on climate. For instance, the now mainstream air pollution-health impacts conversation is leading to a slow rollout of policies, mostly driven by the National Clean Air Programme, to target pollution sources such as disincentivising private car use, which brings emission reductions too. The policy actions gradient could start with actions on public welfare issues showcasing win-win benefits and making the case for considering the next level of policy measures.

The central and state governments have also not pushed, nor even encouraged, cities to be ambitious on climate change. There has been no directive from the centre to state governments requiring the preparation of city-level climate action plans, and no state government has unilaterally taken the decision to require all ULBs to prepare such plans. There is no central policy framework outlining how cities are expected to contribute to India's overall vision and targets on climate change. State Action Plans on Climate Change (SAPCC) often include a chapter on actions to be taken in urban areas, but the plans themselves put little attention on mitigation (Jogesh and Dubash, 2014; Gogoi, 2019).

In general, city leadership is not likely given India's governance system. Most mayors are endowed with limited executive responsibilities, except for in Madhya Pradesh and West Bengal, and their term ranges from one to five years (NITI Aayog, 2021). For all cities in India, the mayoral system remains weak, and the mayors are titular heads with less power than the state-appointed Municipal Commissioner (Jha, 2018). Cities are also not given sufficient attention in state and central level policymaking because the distribution of power in the Indian political system is such that the urban population is underrepresented in both national and state legislatures (Ahluwalia, 2019; Burdett et.al., 2014; Mohanty, 2016; Rao and Bird, 2014). As a result, governments have focused on rural concerns, and there is a lack of vision and strategy on how cities in India will grow and develop (Ahluwalia, 2019). For example, in the energy sector, cities are seen as a reliable source of revenue and where infrastructure upgrades are relatively straightforward to implement but are not centre stage in deliberations on policy and strategy (Sivaramakrishnan, 2014; Sreekumar and Josey, 2012).

There are pockets of leadership among cities in India which suggests there is an opportunity to work with the most proactive cities to drive bottom-up change on urban decarbonisation across India as a whole. For example, Rajkot has won global awards for its efforts on tackling climate change and the 43 cities in Maharashtra have committed to take rigorous and immediate action to halve global emissions by 2030 (TCG, 2021; Times of India,). There is a much longer list of cities that are being proactive on specific mitigation strategies, such as Kolkata's expanding fleet of electric buses and Delhi's metro which is running on 60 per cent renewable energy (Euronews, 2021). Working with the more proactive cities will be needed initially to showcase quick wins and workable solutions for drawing the attention of other cities, the state or the Centre in order to scale and meet national goals.

However, it has tended to not be climate change which has motivated cities to act, but local concerns and priorities, driven by regulatory and market forces, which have delivered a co-benefit of GHG emission savings (Boyd and Ghosh, 2013). For example, Mumbai's 2021 decision to conserve 330 hectares of Aarey forest land by declaring it as a reserved forest was likely motivated by a range of local environmental and social issues, but also resulted in preserving a major carbon sink for the city (Indian Express, 2021). In some cases, a concern for adapting to the impacts of climate change has also resulted

in mitigation action. In addition, in New York, the introduction of cool roofs, to manage the increasing frequency of heat waves, has also reduced energy usage, and every 2,500 square feet of roof that is coated can reduce the city's carbon footprint by 1 ton of CO_2 (NYC, 2021).

Donor funded urban climate change programmes have traditionally also focused on advocating 'win-win' solutions that deliver both the cities' immediate priorities, but also climate change co-benefits (Fisher, 2014). While some experts reported that they are increasingly able to put climate change more central to the narrative when engaging with government officials, they still try to make strong connections with local policy priorities. One opportunity is the growing public concern on air pollution across many cities in India. Until recently the policy and scientific debates around air pollution and climate change tended to take place them separately. However, it is increasingly understood that the sectors that contribute to GHG emissions are also sources of air pollution and there could be an opportunity to put political pressure on cities to take action on both, through an emphasis on the health benefits (see section 2.3).

There is also learning from other urban climate programmes on how to motivate and inspire government officials to show leadership on urban climate change. This includes:

- Identify and nurture particular individuals, including government officials but also volunteers and community leaders, who can act as 'policy entrepreneurs' to support city wide action. Those supporting Gorakhpur and Indore, under ACCCRN, highlighted the role of Municipal Commissioner of Gorakhpur who undertook certain policy measures to embed the resilience discourse in city governance, as well as informal champions, such as a local doctor who used his social standing in the Maheva settlement to introduce the project team to the local residents (Bahadur and Tanner, 2014).
- Recognise the efforts of cities through international awards and accolades which further motivates them to position themselves as global leaders on urban climate change. For example, Delhi efforts in water stewardship was recognised at the C40 World Mayors' Summit in 2019, including for their rejuvenation of water bodies and efforts for eradicating water tankers. Kolkata also won an award for their electric bus programme at the 2019 World Mayors' Summit which inspired them to further expand their electric bus roll out.
- Mobilise coalitions of organisations with often varied interests to join forces to drive for change (Beermann et. al., 2016). For example, in the 1980-1990s, Delhi's severe air pollution gained the attention of the media, a private litigator, and civil society organisations who together put pressure on the Supreme Court to mandate the use of CNG in public transportation vehicles and instructed the Delhi government to take further action. In Mumbai a partnership has emerged between the Koli fisherman and national CSOs to campaign around protecting the city's mangroves since the floods in 2005, as well as to physically plant trees to buffer storm surges (Boyd and Ghosh, 2013).
- Motivate city officials through exposure to a global network of cities leading action on climate change. For ICLEI providing opportunities for officials to travel to another city is not just about the incentive factor of an overseas visit but has also helped them feel part of something bigger and connected to a wider movement of change. This is particularly relevant given the fragmented nature of institutions in India (Fisher, 2014).
- Be honest about the costs and benefits of climate action, and the potential loses and losses. For example, those who will not be able to afford to buy an electric vehicle will potentially be penalised through higher fuel prices, or workers in fossil fuel-based industries who may lose their jobs. The growing narrative around a 'Just Transition' provides a useful framework to discuss and plan for these issues with cities (see section 2.3).

Box 2: Leadership of cities on mitigation planning and reporting on GHG emissions

In 2020, 16 cities and two states in India voluntarily disclosed their GHG emissions via CDP's platform, primarily due to their commitments to climate leadership programmes like C40 Cities Climate Leadership Group (C40), the Global Covenant of Mayors for Climate and Energy (GCoM). Over half of the cities also reported to have either included sustainability targets in their city master plans or the action was in progress. 43 per cent cities had a published plan for adaptation. Towards low carbon planning, around half the cities revealed they had identified opportunities in the process of addressing climate change, while a third had a GHG emission reduction target in place.

Source: CDP (2021)

4.2 Overcoming very limited institutional capacity for climate action planning and delivery

There are significant capacity constraints within ULBs to plan for, design and implement or enforce projects and polices on climate change. This is not unique for climate change: ULBs are increasingly given additional functions and responsibilities, such as preparation of a city development plan, city mobility plan, city sanitation plan, e-governance, and meeting the numerous benchmarks set by the Government of India for service delivery. However, this has not been accompanied by any increase in capacity, or resources (Ahluwalia, 2019). Municipal officials in most cases are employees of the state governments and are posted by the state government to individual cities. The experience of the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) demonstrated that lack of capacity within ULBs is a major constraint in planning and implementing the projects for urban development (Ahluwalia, 2019). The capacity constraints range from the number of officials available, their technical skills as well as the softer side of building partnerships, creative thinking and negotiating through problems. There are not even accurate and usable maps of many of the major cities in India available with their functionaries or in the public domain (NITI Aayog, 2021).

There are also capacity gaps at the state level to address urban climate issues. NITI Aayog (2021) has estimated that only 4,000 of the 12,000 posts required for town planners in state town planning departments have been sanctioned. Technical expertise on climate issues within state governments tends to be concentrated in a few departments only, and not in those managing the key emitting sectors within cities (Kumar, 2018). There are data constraints that limit states and cities' ability to plan for climate change, as the information available on climate risks and emission reduction potential is not disaggregated down to local levels. Lastly, there is a lack of creative thinking and interest in testing new innovative practices. For example, decision-making on energy systems in cities remains driven by existing practices of technological fixes, central directives, and contracting out services (Bhardwaj et.al. 2019a).

Developing institutional capacity is a pre-requisite to successfully leveraging the other opportunities listed in this section. Other donor funded urban climate programmes in India reported the challenge of building momentum and progress around the commitment and interest of a small number of progressive officials, and when they move on, the programme struggles to continue. An assessment of ICLEI's work in five cities found that while there were individual champions there was little evidence of a wider network of supportive organisations or stakeholders (Fisher, 2014).

Programmes with a capacity development objective often focus only on building the technical knowledge and skills of individual officials, but the actual scope should be much broader. The starting point is to understand the functions that ULBs need to design and deliver ambitious climate action, and the competencies required to do this (Nastase, 2018). For climate change, these competencies include being able to understand and interpret climate data, identify co-benefits with development priorities,

build collaborative networks for decision-making, and make the case for the allocation of resources, and many more (Shakya et.al., 2018). There is some learning from donor-funded programmes on how to effectively develop these capabilities in India, and beyond:

- Climate change experts embedded within key state departments and municipal corporations are often effective in raising the performance of the organisation. BEE has created cells of engineers and architects within state departments to embed the Energy Conservation and Building Code (ECBC) within the building plans. The four Indian cities that were competitively selected to be part of the 100 Resilience Cities (RC) have been provided a 'Chief Resilience Officer' who reports directly to the Municipal Commissioner and convenes departments and stakeholders to develop a resilience strategy, and generally be a technical resource for the city (Berkowitz, 2014)
- The challenge with the embedded expert model is to ensure this expertise gets institutionalised beyond the lifetime of the programme, and that the experts do not get diverted into supporting the routine work of the city (Tanner, 2018). The Action on Climate Today (ACT) programme succeeded in making the case and building political support in Assam, Kerala and Maharashtra for increasing the number of officials within climate change cells (Shakya, 2018).
- Avoiding one-off and ad-hoc training sessions and instead mainstreaming climate change within the government's own training institutions. For example, the ACT programme developed a climate change module within the core civil service training programme of the Kerala Institute for Local Administration (Shakya, 2018). Training should also go beyond technical skills to also 'coach' officials on the soft skills of leadership and influencing.

Technical assistance programmes should be designed with a core integrated objective of building long-term individual and institutional capacity. This should influence how the assistance is provided. For example, supporting research institutes located in the city to prepare technical analysis will build their capacity and provide the ULB with a technical resource they are more likely to consult in the future. In addition, rather than creating an ad-hoc cross-department working group just for the purpose of delivering the programme efficiently, a permanent group or committee on climate change could be institutionalised (Shakya, 2018).

4.3 Overcoming a lack of available financial resources and financial autonomy

Cities in India face a shortage of funds to deliver even basic infrastructure and service needs, let alone meet the additional cost of climate proofing the city. Annex E maps the financing options for urban climate action. The resources available to cities in India are in general inadequate to meet the current requirements to their populations and are unprepared for the rapid future urban population growth which is expected (Rao and Bird, 2014). Out of the 18 functions to be performed by municipal bodies under the 74th Constitutional Amendment Act, less than half have a corresponding financing source (Sahsranaman and Prasad, 2014). Between 1999 to 2004 average actual spending in 30 large municipal corporations was only about 24 per cent of the (inflation-adjusted) requirements set out by the 1963 Zakaria Committee (Mohanty et al. 2007). Table 16 shows that for 37 Municipal Corporations (having a population above one million) total municipal revenue has declined as a percent of GDP from 0.49 per cent in 2012-13 to 0.45 per cent in 2017-18 (Ahluwalia. et.al., 2019). The Covid-19 pandemic has further put pressure on municipalities' resources, with lost local revenue and extra expenditure required.

There is therefore a critical gap in finance available to fund the transformation required in India's cities to achieve a net-zero emission trajectory. There are no detailed estimates available across cities in India on

the exact climate finance gap which exists. The IFC studied a sample of cities' climate-related targets and action plans in emerging markets and identified USD 29.4 trillion in climate related investments required in six sectors, which included USD 4bn of investment opportunities in Rajkot (IFC, 2018). The National Infrastructure Pipeline (NIP) estimates that INR 15 trillion (USD 215 billion) was invested in urban India between 2013 to 2019 and projects an expenditure of INR 19 trillion (USD 271 billion) to 2025 (DEA, 2020). It is likely that costs will increase if climate considerations are integrated.

ULBs face barriers in accessing even the funds which are potentially available for ambitious climate action and have limited decision-making power over how some funds are utilised within the city. While there are differences between cities in India, in general, there is a lack of financial autonomy both in mobilising resources and in setting user charges to cover costs (Ahluwalia, 2019; Panagariya, 2014). There has been a deterioration in almost all of the major financial indicators of empowerment for cities in India from their already very low levels (Mohanty, 2016). For a sample of 37 Municipal Corporations, the proportion of own revenue (tax and non-tax revenue generated in the city) to their total municipal revenue dropped from 67 per cent in 2012-13 to 51.6 per cent in 2017-18, while for Municipal Councils and Nagar Panchayats dropped from 25.1 per cent to 23.4 per cent (Ahluwalia et al., 2019). Some states have even abolished important sources of own revenue for ULBs without providing adequate substitutes, such as when Rajasthan and Haryana abolished the property tax without consulting the cities (Sahsranaman and Prasad, 2014). However, one contributing factor is also the low collection efficiency for property tax, which ranges from 47-74 per cent (Mehta and Mehta, 2020).

In what appears to be a promising move, the 15th Finance Commission in its 2021-2026 report, allocated INR 1.5 lakh crore in grants to ULBs over the next five years. This marks a 78 per cent rise over the last allocation. Further, in an attempt to increase investor confidence in future municipal fund raising, it imposes conditions for timely publishing of annual municipal accounts and service level benchmarks (Ramnani, 2021).

Cities also have very limited capabilities to access alternative sources of finance. External funds, such as bank loans, bonds or capital market instrument are available only to cities with a stable and significant source of internal revenue and sufficient credit worthiness (Sahsranaman and Prasad, 2014). Cities also require state government, and sometimes also the national government, approval for formally joining external programmes or partnerships and the approval procedure is often associated with considerable time delays and budget constraints (Beermann, 2014). For example, any funding proposal to the Green Climate Fund (GCF) needs to be approved and submitted by the Ministry of Environment, Forest and Climate Change (MoEFCC).

There are opportunities to access alternative sources of financing for ambitious climate actions, beyond municipal resources and inter-governmental transfers. This is particularly relevant for the large investments required in low-carbon infrastructure. Some opportunities include:

- Municipal bonds are attractive to cities, particularly for sectors where the expected revenues can be predicted with a reasonable level of certainty, such as water supply and sewerage projects (URBAN-LEDS, 2020). However, there has been limited success in using bonds among cities in India.
- International climate finance, including the Green Climate Fund, has so far not reached cities in India to a significant extent, but it is available for urban climate action. It requires cities to develop a funding proposal, and together with the state government, get it approved and submitted by the central government.
- Development banks are eager to provide loans for viable infrastructure projects but requires cities and states to demonstrate a viable revenue stream to ensure repayments. ICLEI has started facilitating global platforms for cities to showcase their project ideas to international finance

institutions, although there has not been much success yet for Indian cities, partly as the money needs to be routed via upper levels of government.

- Market based instruments have largely dropped from the policy radar after the Clean Development Mechanism and Joint Implementation (CDM/ JI) became unviable, but under the Paris Agreement global carbon markets are likely to receive a new boost. Cities in India have some limited experience with these schemes. For example, Indore earned Rs. 50 lakh of revenue by selling carbon credits on the voluntary carbon market for processing waste in bio-methanation and compost plants (Bhattacharjee, 2020). Some cities have experimented with other types of market mechanisms, most notably Surat which established the world's first Particulate Trading System expected to reduce particulate emissions by 29 per cent from current levels from 158 industrial plants (Greenstone et.al., 2019).

The private sector is an important source of climate finance which could be further directed to particular urban mitigation strategies. Between 2016 – 2018, there was on average USD 19 billion per year of tracked green finance flows in India, of which 39 per cent came from commercial banks, 12 per cent from public sector undertakings and 5 per cent from project developers and corporates (Sinha et al, 2020). However, this private finance is heavily skewed towards the renewable energy sector, and to a much lesser extent sustainable transport, although there is limited data available across other sectors (Muralidharan et.al, 2021; Sinha et al., 2020; Varma et.al., 2015)). There are different entry-points to mobilise increased private investment in other areas of low-carbon urban growth, including:

- The use of voluntary codes and certification schemes is now well established for energy efficiency but uptake among the private sector remains limited. This includes GRIHA (Green Rating for Integrated Habitat Assessment), Indian Green Building Council (IGBC) rating program, and the Leadership in Energy and Environmental Design (LEED) rating scheme.
- Corporations can be advocates for ambitious city action on climate change. For example, various large corporations have set voluntary targets for achieving net-zero emissions, including Reliance Industries Ltd. by 2035, HDFC Bank Ltd. by 2031-32, Tata Consultancy Services Ltd. by 2030 (Usmani, 2021).
- Public-Private Partnerships (PPP) can be an effective means of delivering ambitious climate actions. For instance, a public streetlighting project in Bengaluru expects to raise about $70 million of private sector investment to replace 465,000 fluorescent and metal vapor fixtures with energy efficient LED versions (Eco-Cities, 2021).

However, to mobilise finance from these alternative sources, significant capacity must be developed across state and ULB departments. They require enhanced capacity for developing bankable project proposals, based on a rigorous feasibility assessment. In addition, new partnerships and enhanced communication are required between the public sector, financing institutions and the private sector. As one expert reported, providing technical support for cities is easier, but while mobilising finance for investment is much harder, it will have a much greater impact.

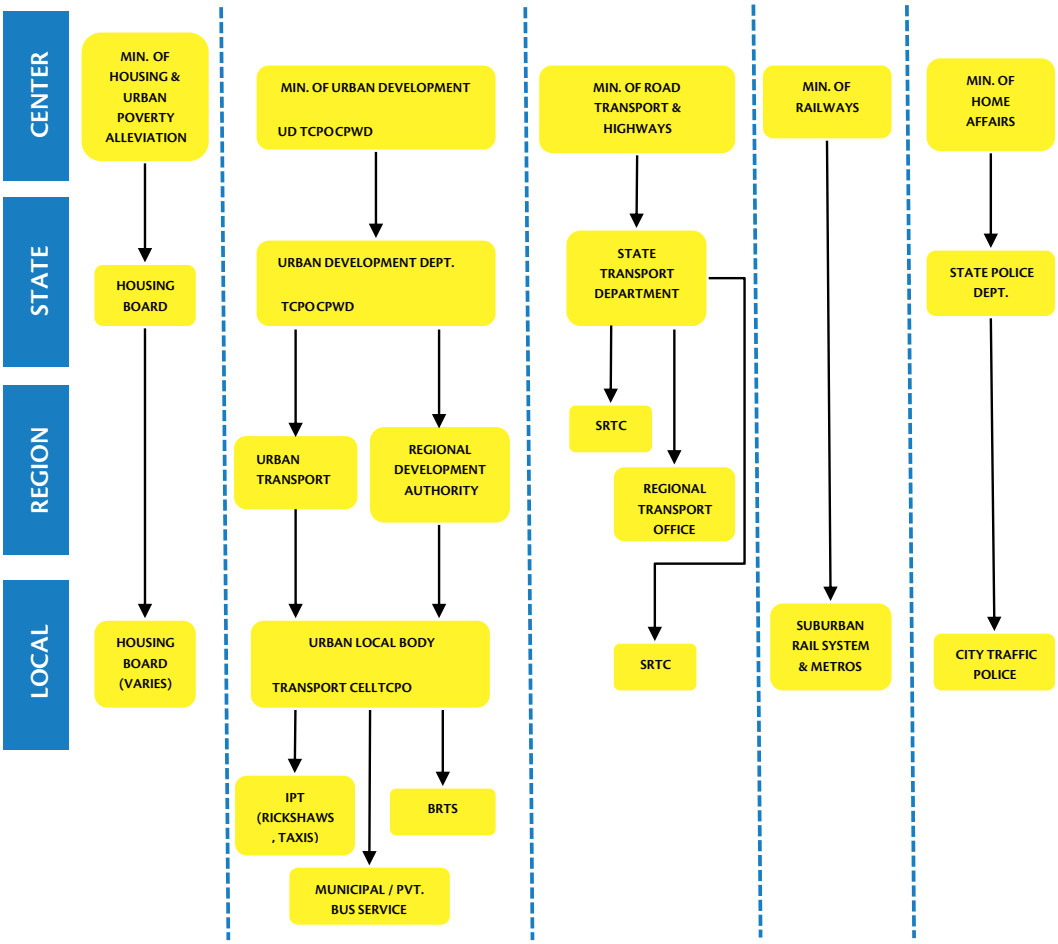
4.4 Overcoming fragmented decision-making authority on urban issues

Decision-making authority on climate related issues is split across the central government, state governments and ULBs, although it differs significantly across states and cities. Section 3 highlighted that power to set policy and regulations on the sectors most critical for decarbonisation in cities is concentrated with state governments, with ULBs playing an important delivery function (C40/ Arup, 2016; CUTS, 2021).

Despite the 74th Constitutional Amendment in 1993 which expanded the list of functions under cities' jurisdictions, a significant decentralisation of power and governance has not occurred (NITI Aayog, 2021; Beermann et al., 2016). For example, even if a city aims for 100 per cent share of electric vehicles, the State Government controls the electricity generation mix and the relative share of renewable energy, and so there is no guarantee of the actual impact on GHG emissions. In addition, only a few ULBs have full control over the city's transportation system. Road transport, including bus fleets, is a state function. For example, West Bengal Transport Corporation (WBTC) manages bus operations, ferries as well as trams in the city of Kolkata and Bangalore Metropolitan Transport Corporation (BMTC), a special purpose vehicle, manages bus operations in the city. State governments have created parastatals to overcome capacity constraints in ULBs, including development authorities, water supply and sewerage boards, public work departments, slum housing and development boards etc. These are performing functions that should be vested with the ULB as per the 74th Constitutional Amendment (NITI Aayog, 2021).

Figure 9 gives an example of all the varied institutions involved in managing land use and transport systems in Indian cities.

Figure 9. Institutions managing land use and transport in Indian cities



Source: IIHS (2015).

The fragmented nature of decision-making power over urban climate actions means multiple government entities, at different levels, often need to be involved in the design and delivery of a particular climate action. In a typical Indian city, multiple public sector organisations or agencies – ULBs, ports, railways etc – own land under their jurisdiction (NITI Aayog, 2021). Coordination across these

levels of government, and organisations is usually limited, and there is often no intermediary body responsible for coordination (Sharma and Tomar, 2010). For example, there is very little coordination between the Ministry of Heavy Industries at the central level, and cities who are expected to implement state level and Central schemes (such as subsidies and charging infrastructure provisions under FAME-2) to make the radical shift to electric mobility. There is usually no department or organisation within the city with the specific mandate on electric mobility, and there is no coordinating body to support cities to translate the criteria of central policy and programmes to the local context and support the monitoring and reporting on progress on implementation. As cities continue to proliferate and expand, there is also a need to think of regional city systems, like the Delhi National Capital Region, 'city clusters' or 'satellite cities'.

There have been some efforts to strengthen coordination on climate change issues at the sub-national level, which could be scaled-up. Many states have mandated a department or agency with specific responsibilities on climate change (e.g., the Environment Protection Training and Research Institute in Telangana and the Environmental Planning & Coordination Organisation in Madhya Pradesh), but they have limited authority and capacity to also help cities coordinate with the state and centre on the breadth of issues related to climate change (URBAN-LEDS, 2020).

Many cities in India have proven to be effective at coordinating multiple agencies and sectors for a particular purpose, including health planning and responding to natural disasters but this has not extended to the more fragmented sphere of climate planning (Sharma and Tomar, 2010). Under the ACCCRN and 100 Resilient Cities programmes some cities attempted to break down policy-making silos, for example Surat created an urban resilience trust fund within the Municipal Corporation and South Gujarat Chamber of Commerce came together with the city to identify and plan actions. But these are ad-hoc examples which were dependent on the external support of the programmes (Chu, 2016).

Whilst decision-making over many of the largest sources of urban emissions rests with state governments, ULBs are still able to leverage some influence over GHG emissions in the city. This differs considerably across states and cities (see Annex D), but in general, some policy levers they could potentially use include:

- Incentives for energy efficiency and reduced energy consumption, for example, through the eco-friendly design of municipal corporation offices and properties.
- Adoption and enforcement of standards and regulations, to ensure private development is low-carbon and climate resilient. For example, in Philadelphia, USA, the city government provides an incentive to property owners to manage stormwater on-site, by lowering their monthly charges to the city government for stormwater if they have incorporated features such as open space, impervious area reduction and others, within their building (Negreiros et.al. 2021).
- Adopting green procurement standards is a growing trend in cities, such as in Cape Town and Santiago, that leverages ULB's purchasing power (Negreiros et.al., 2021). This could potentially follow the BEE and EESL's model for bulk procurement of energy efficient technology to reduce upfront costs and longer term operation and maintenance costs.
- City development plans (see Box 3) should have climate change mainstreamed throughout, but this will require a fundamental shift away from just addressing the most immediate and pressing needs of the city (Bahadur and Tanner, 2014). A study of 59 city plans found that only 10 per cent have climate-relevant strategies and 30 per cent reference climate issues in some form (Kumar and Geneletti, 2015).

In many cases, and particularly for smaller cities in India, the scope of these policy levers will be relatively small, and likely to produce a modest impact on GHG emissions. However, there are other benefits to

pursuing them, particularly in terms of building institutional capacity within ULBs which is also required to implement state- and centre-led policy initiatives.

Box 3: City development plans

City Master Plans or Development Plans are land-use plans prepared for a 10-year (e.g., Bengaluru) or 20-year (e.g., Delhi and Mumbai) time period. They determine the spatial allocation for open spaces, civic amenities, and usage of land for residential, commercial, industrial purposes along with defining the transportation networks. The most effective way of addressing emissions reduction in City Development Plans is through addressing land-use transportation interactions. For example, the Development Plan for Ahmedabad includes compact and multi-nucleated development through using land as a scares resource and protection of natural infrastructure of the city.

However, capacity and governance constraints have limited the effectiveness of these planning documents. In 2021 NITI Aayog published a report highlighting the challenges of urban planning in India. For example, around 52% of statutory towns and 76% of census towns do not have any Master Plans. There is also debate on the value of the plans themselves, given they are static and seldom broken down into implementable projects. Even those cities with plans still see land being illegally subdivided and unauthorised construction. NITI Aayog calls for a paradigm shift to urban planning, with a more inclusive and data-driven approach to spatial planning covering all the relevant sub-sectors of a city, including mobility, energy, natural environment etc, and looking beyond administrative boundaries to consider regional planning (NITI Aayog, 2021).

4.5 Overcoming the lack of a coordinated policy framework for urban climate action

There is a siloed and fragmented policy framework on climate change in cities, a cause and effect of the challenge of coordinating across institutions. There is no policy directive on cities to take cross-sectoral action on climate change, nor prepare a CCAP, and only limited mention of cities within SAPCCs (Revi, 2008; Sethi and Mohapatra, 2013). There are many national and state policies, missions and programmes which are relevant to urban climate action, but these are typically sectoral and are led by national ministries and departments and in turn involve various state level departments (CAT, 2020). As such the policy agenda for climate change, and its practical implementation, is spread across many different government entities.

Some efforts have been made by the Smart Cities Mission for the convergence of different urban schemes, including AMRUT, HRIDAY, PMAY, FAME and SBM Mission, through Special Purpose Vehicles (SPVs) established in the city. But these SPVs have not been tasked specifically to manage climate change issues in the city. One state government official interviewed felt that these schemes and planning initiatives such as the City Clean Air Plans remain ad-hoc entry points that will not be effective unless it forms part of an overall coordinated strategy on urban climate action.

City Climate Action Plans (CCAPs) offer a significant opportunity to build policy coherence on urban climate action. Cities have been taking mitigation action through sectoral actions and schemes (e.g., electric mobility planning, bioremediation of landfills etc) but some cities have progressed from these siloed sectoral actions to an institutionalised comprehensive process like CCAPs. Several cities have taken the initiative, with support from external programmes and organisations, in particular C40 and ICLEI, to prepare CCAPs. This has been shown to promote a cross-sectoral perspective, and avoids the pitfalls of focusing on ad-hoc, experimental pilot projects which aim to provide evidence of outcomes and benefits (Khosla and Bhardwaj, 2019; Boyd and Ghosh, 2013; Hackenbroch and Woiwode, 2016)

Table 17 in Annex F provides examples of different CCAPs and similar that have been prepared. The members of the C40 network - Delhi, Mumbai, Kolkata, Bengaluru and Chennai – are at different stages of preparing their GHG Inventory and preparing a Climate Action Plan. This includes setting a GHG emission commitment aligned to the global target of limiting global warming to 1.5°C, for example

Chennai and Bengaluru have pledged to become carbon neutral by 2050. In 2021 Mumbai published its CAP based on findings from the city's first GHG inventory and a detailed vulnerability assessment. The plan addresses climate resilience with both mitigation and adaptation strategies across six areas: Sustainable waste management, urban greening and biodiversity, urban flooding, and water resource management, building energy efficiency, air quality, and sustainable mobility. The plan targets a 30 per cent emissions reduction by 2030 and reaching net zero by 2050 (against base year of 2019), setting out detailed targets and actions. Notably, 90 per cent grid electricity will come from renewables, and 40 per cent residential buildings will have solar PV by 2050, and all buses will be electrified by 2030 and 96 per cent of 4 wheelers by 2050 (MSN, 2021; Mumbai Climate Action Plan 2022).

Other published plans and strategies have mitigation of climate change as a potential co-benefit, and the focus is either on building resilience to climate change (e.g. Surat), on blue-green infrastructure (e.g. Madurai) or on biodiversity conservation (e.g. Gangtok). Rajkot, Udaipur and Coimbatore published Climate Resilient City Action Plans, but the actual interventions are primarily mitigation, rather than adaptation focused. In addition, cities in India that do not meet the National Ambient Air Quality Standards are required to submit clean air plans under the National Clean Air Programme (NCAP). Box 4 below summarises learning on the benefits and challenges of CCAPs.

Box 4: The benefits and challenges of a CCAP

Indian cities have prepared CCAPs because of their involvement in an externally funded network or programme (with the exception of the city clean air plans which are required by the NCAP). As a result, the plans vary in scope and detail, and there has been no comprehensive monitoring and evaluation of implementation and effectiveness. However, anecdotally, there is limited evidence that the plans have resulted in new actions being taken by cities. Some of the reasons for this include:

- There is limited accountability on the city for implementation, as the plans sit outside any state or central government mission or programme.
- The plans run in parallel to the main statutory planning documents for urban development, and for sector specific planning

There is no coordinating agency with an overview across the different city and state departments who are engaged in climate relevant initiatives.

The other reasons are in line with the barriers presented in this section, including lack of finance and limited capacity. However, there are some positive developments, for example, cities across Maharashtra are preparing climate action plans as a result of pressure by the State Government (following the signing up of the 'Race to Zero' campaign). However, it remains to be seen whether this will momentum will be sustained.

The experience of CCAPs seems to align with emerging learning from the city clean air plans. In a review of 102 plans, only Delhi's had a legal mandate for implementation and 40 per cent of the actions listed fall under the purview of multiple agencies with no coordinating arrangements planned (Ganguly et.al., 2020)

Despite these challenges in implementation, there are reports that the process of developing a CCAP has provided institutional benefits, which resonates states' experiences of developing SAPCCs (Gogoi, 2019; Kumar, 2018). In particular:

It can strengthen the understanding of both city and state officials on climate risks within a city and opportunities for both mitigation and adaptation. It is therefore essential that the CCAP is based on a robust evidence base, particularly a GHG inventory and vulnerability assessment. This therefore also helps to build capacity for an eventual MRV system. For example, one expert reported that officials may know how much waste is being generated, but not how much water is being used for that process, or they may know how many rickshaws are registered but not what fuel is being used. This information would empower them to take action.

It helps the state government, ULB and implementing partner to understand the specific opportunities and barriers for that city. The pathway to reach net-zero emissions will be different for all cities, particularly between the larger cities with existing infrastructure that has 'locked-in' emissions and smaller cities which still need to build this infrastructure. The process of developing the CCAP can help build new partnerships and facilitate better institutional coordination. If done properly the plan should be developed by a cross-sectoral group of officials, perhaps involving both state and city level officials. It should also involve local experts and stakeholders. This could help establish a permanent mechanism for coordinating on climate change issues, including for monitoring implementation of the CCAP.

In summary, there should not be too much expectation placed on CCAPs directly leading to large scale action on climate change. They will not automatically resolve issues related to access to finance and implementation capacity. The risk is that it will be a one-off exercise and not be integrated into planning, finance and delivery systems. As such, they should be considered the starting point for engaging with a city, not the end point.

The many national and state schemes, programmes and missions which are directly or indirectly supporting mitigation actions in cities (see Annex E), can also be further leveraged to support and finance ambitious urban climate action. See section 3.2 for further details. In some cases, the opportunity is just for cities to be more effective in delivering these programmes, and this will likely result in GHG emission savings. For example, the National Clean Air Programme (NCAP) mandates the development and execution of Clean Air Plans for cities, targeting 20-30 per cent reduction in air pollution. It covers actions for various emitting sectors including transport and is useful for providing a framework where city relevant actions can be systemically monitored (MoEFCC, 2019). If these plans are effectively designed and delivered, this will likely deliver significant GHG emissions mitigation co-benefits. The India Cooling Action Plan that aims to provide access to low carbon cooling will also likely deliver significant energy saving benefits to cities in India if properly implemented.

Box 5: Smart Cities Mission

The Smart Cities Mission was one of the first urban focused programmes to also include a focus on the energy sector and allows cities to enhance basic energy infrastructure and deploy low-carbon technologies in their jurisdiction (Bhardwaj et.al., 2019b). The top sixty cities dedicated around 10 per cent of their planned budgets for energy projects (Taraporevala, 2018). The programme's focus on low-carbon growth remains relatively small and is limited to a set of technologies and policy guidelines as devised by central ministries, but provides ULBs with an opportunity, and source of finance, to experiment.

In other cases, the national or state policy or programme may be less obviously geared towards delivering climate actions, but provides sufficient flexibility to allow cities, or states, to pursue mitigation strategies, particularly with regards to sustainable transportation, urban energy efficiency and clean energy projects (CUTS, 2021b). For example, the Rajkot Municipal Corporation's primary objective was to address a growing demand for low-income housing built under the central government's Housing for All programme, but the city engineers incorporated climate-adaptive elements, such as rainwater harvesting and passive cooling and ventilation, on these sites, which led to additional climate mitigation benefits (Bhardwaj and Khosla, 2017).

There are also state and national policy entry-points which have the potential to deliver ambitious urban climate action, but which need some further consideration to realise this potential. For example, SAPCCs include chapters on urban climate actions, but do not yet provide the resources and capacity to cities to deliver them (Jogesh and Dubash, 2015; Kumar, 2018). The National Infrastructure Pipeline under the Department of Economic Affairs (DEA), Ministry of Finance, is expected to channel INR 19 trillion of public and private finance for building urban infrastructure, 17 per cent of the total INR 111 trillion, between FY20 and FY25. There is a significant opportunity to integrate climate risks and low carbon considerations into this investment.

Box 6: National Infrastructure Pipeline (NIP)

Managed by the Department of Economic Affairs and hosted by the India Investment Grid, the National Infrastructure Pipeline is a five-year plan of infrastructure development for India across sectors and states. The NIP objectives are to support India's economic ambitions by overcoming deficiencies in infrastructure and improving the quality of services provided in both urban and rural areas. It aims to showcase investment opportunities in India's infrastructure sector, improve project preparation and attract investments from abroad. Projects over INR 100 crore are featured. The major sectors by number of projects in the NIP include transport, water and sanitation, social infrastructure and energy. The NIP aims to bring in investments of INR 111 trillion (USD 1.5 trillion) between FY20 to FY 25. The Centre and state are expected to have almost equal share in implementation, with ~40 per cent share each, followed by the private sector at 21 per cent.

Sustainable and smart cities is one of the NIP's goals, through wastewater treatment, smart city infrastructure, transport, water supply, affordable energy. With the vast sectoral coverage, the NIP represents a huge potential to contribute to India's low carbon goals by integrating mitigation and resilience in India's infrastructure development especially in cities. In addition, the NIP aims to develop the enabling environment and undertake financial sector reforms including strengthening the municipal bond market.

4.6 Overcoming the lack of a monitoring, reporting and verification system

There is currently no Monitoring Reporting and Verification (MRV) system focused on urban climate action, and as such, limited transparency, and accountability. Some, but not all, national programmes have their own MRV arrangements, although most the schemes that are under the Ministry of Housing and Urban Affairs (e.g., the Smart Cities Mission or Atal Mission for Rejuvenation Urban Transformation), have no MRV mechanisms to measure GHG emissions directly, as that is not a central priority of these schemes (URBAN-LEDS, 2020). A small number of cities have taken the initiative to start collecting data on emissions: 8 cities have competed an inventory in line with the Global Protocol

for Community-Scale Greenhouse Gas Emission Inventories and 16 cities are voluntarily reporting their emissions annually under the CDP platform (ICLEI, 2021; CDP, 2021). This lack of measurement and reporting could mean that mitigation action in cities in India is being underestimated, as many programmes have addressing climate change as a side-benefit (URBAN-LEDS, 2020). A GHG Inventory, as well as ideally a climate change vulnerability assessment for the city, is also a necessary pre-requisite to developing any effective CCAP.

There are policy initiatives which could be built upon to develop a national MRV system for urban climate action. India is currently in the process of developing a National Inventory Management System (NIMS) for the preparation of National Communications and Biennial Update Reports to the UNFCCC on a continuous basis. This will require data to be submitted by ULBs. In addition, the Climate Smart Cities Assessment Framework (CSCAF) initiated under the Smart Cities Mission in 2019 and revised in 2020 establishes indicators and scoring criteria to strengthen transparency in the performance of the 100 smart cities in India. It evaluates cities' performance on tackling climate change in five key sectors (urban planning and green cover, mobility and air quality, energy and green buildings, water management and waste) with scores that are weighted based on their contribution to GHG emissions, and highlights gaps for action.

The performance of cities had improved under the 2020 framework with a higher number of cities improving their rating[6]. No city achieved 5 stars, the highest possible in the rating system, but nine received 4 stars - Surat, Indore, Ahmedabad, Pune, Vijayawada, Rajkot, Visakhapatnam – compared to four cities in 2019. Similarly, the number of cities with 3 and 2 stars increased, while the number with 1 star reduced. Sectoral scores give an indication of the magnitude of effort needed on climate action in sectors. Cities are making relatively more progress on energy, green buildings and waste - around 50 per cent cities scored either 3,4 or 5 stars in these sectors, compared to 10-25 per cent with the same rating in urban planning, mobility and air quality, and water management. Performance against numerous indicators for each sector give detailed insights into areas that need more support (National Institute of Urban Affairs, 2021).

Experts and CSOs felt that for the CSCAF to have sustained impact on the ground, it needs to be linked to financial incentives, perhaps via the Finance Commission or by directing multilateral finance and technical assistance to cities with improving scores. Unless this happens, it will not be taken seriously by the state or city. It should be noted that the CSCAF is dependent on self-reporting by cities, hence there are possibilities of over-estimation or under-estimation of results.

4.7 Summary of likelihood that the barriers to ambitious urban climate action can be overcome

The systemic barriers listed in this section, which have to date constrained the scale and ambition of urban climate change, are not insurmountable. There are opportunities, as described above, which a new cities climate change programme can pursue which either attempt to address and fix the constraint, or at least make it manageable. Table 9 summarises the barriers and their relative impact on efforts to promote leadership among cities on climate change and provides approximate ratings for the likelihood that a future SSEF programme can fix the barrier or at least be able to deliver change despite the barrier.

6 5 stars - Cities are able to showcase implementation / actions / impacts; 4 stars- Cities have allocated budgets/ started implementing climate actions; 3 stars- Committees are in place / plans in place / project proposals initiated; 2 stars – Cities collected data/formed committees/ hired technical agencies to plan climate action projects; 1 star - Cities are yet to consider or are in process of thinking about climate change. (National Institute of Urban Affairs (2021))

Table 9: Summary of likelihood that the barriers can be overcome

Barrier	Relative Impact	Likelihood that barrier can be fixed	Likelihood that change is likely despite the barrier
No political push on cities to take action on mitigation	**High**	Med – requires centre/ states to recognise the economic/ political benefits of cities taking initiative on climate change	High – some states/ cities already showing political leadership on climate change, so bottom-up political pressure might be possible.
Very limited institutional capacity in cities	**High**	Med – requires overhaul in bureaucratic structures and connected to issue of devolving decision-making and financial authority.	Med – can provide one-off boost to capacity for individual cities to ensure projects are designed/ delivered.
Lack of financial resources for cities and financial autonomy	**Med**	Low – requires large transfer of funds from industrialised countries to India, and from centre to cities.	High – finance is available (at centre/state/ DFIs/private sector) and can be used by cities with technical support.
Fragmented decision-making authority	**High**	Low – requires centre/ states to devolve decision-making to cities and give up control.	Med – requires building partnerships between city, state and centre for joined-up policy action (the likelihood of which depends on the city/state).
Lack of MRV	**Low**	Med – requires top-down directive for collection of data on emissions and actions.	High – data can be collected for individual cities without systemic change.

5. Conclusion: Design considerations for a cities climate programme

This study has explored the contribution that city level action on climate change can make to net-zero emissions in India, as well as the risk that it fails to realise this potential. This section draws from the previous analysis to present a set of key considerations while designing a future cities climate programme. These are the key issues which will determine whether a new programme is likely to make a significant contribution to India's net-zero emission trajectory.

The rationale for additional philanthropic support to cities to support the transition to net-zero emissions is obvious, given that a significant proportion of the emissions savings required will have to take place within cities in India. Reducing demand for energy from cities, and the electrification of the urban transport sector, are particularly important. The waste sector will also play a smaller but still important role in reducing direct emissions. However, compared to the critical role that decarbonising the power sector plays, the relative emissions savings potential of these 'urban sectors' is less (and much of this potential also relies on having a clean supply of energy). It is obvious that all mitigation strategies need to be pursued – both urban and non-urban – to achieve net-zero emissions. For example, reducing demand for energy is essential if the power sector is feasibly going to be able to bring on board the amount of renewable energy required to fully meet electricity demand with clean energy.

There are proven mitigation strategies that can deliver the emission savings required within cities to achieve net-zero emissions. However, these strategies will need to be universally adopted, across all cities in India, to achieve the necessary emission reductions. Unlike decarbonising the power sector, which involves a relatively limited number of government and private sector actors, urban mitigation strategies require the 480 million citizens living in Indian cities to adopt new behaviours and for an ecosystem of private sector actors to start providing the necessary net-zero products and services. Achieving universal adoption and effective delivery of the urban mitigation strategies is therefore a massive undertaking.

Cities themselves – meaning the state and ULB structures that govern them – play a crucial role in delivering the mitigation solutions required for net-zero emissions in India. Section 3 has outlined the different routes that states and ULBs can pursue and deliver net-zero economic growth. The first is delivering and enforcing national level programmes and schemes, although this is obviously dependent on the central government. The other three routes involve the state and ULB taking pro-active leadership to design and deliver ambitious mitigation solutions. This includes putting in place net-zero economic strategies, incentivising and mobilising demand for low-carbon technologies, and using their own resources to pilot and demonstrate the benefit of innovative new approaches and technologies. However, there are constraints, including critical political, institutional, finance and other barriers, outlined in Section 4, that make delivering any type of change in cities in India a large challenge.

The key question is therefore whether a new cities climate programme can make a substantial contribution to delivering the GHG emissions savings required in cities in India, given the size of the challenge and the barriers to change which exist. A cities programme will certainly have some impact in some cities, especially with regards to the strategies identified as 'low-hanging fruits', but it is not clear whether it can go beyond delivering incremental change, to contributing to transformational

change. India needs to put in place the policies, systems and practices required for net-zero economy now, and there is only a small window of opportunity to influence them. In addition, the impact of the programme cannot be incremental. A new cities programme therefore needs to focus on where and how it can support large-scale and catalytic GHG savings.

Transformational change could be a useful framework for the Theory of Change and for regularly evaluating the scale of change a programme is actually supporting. However, the term needs to be properly unpacked and defined to avoid it just being a 'buzzword'. Table 10 provides a suggested set of transformational change criteria, and how the design of a climate programme could meet them.

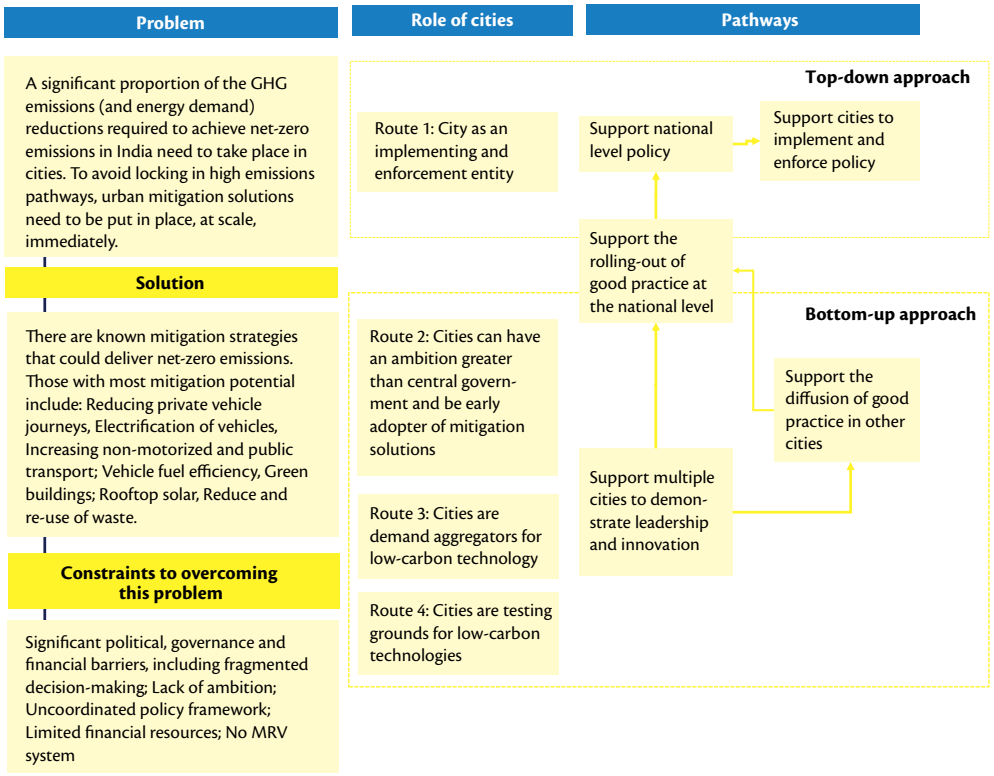
Table 10: Transformational Change considerations

Criteria	Implications for design of cities climate programme
Positive impact	The programme should not just focus on reducing GHG emissions, but also consider the impacts on different groups of people and ensure there is equity in the distribution of benefits. In addition, the programme should aim to maximise resilience and air pollution co-benefits. The impact of the programme should be carefully monitored through a results framework, and externally evaluated.
Large scale and radical impact	There are a range of mitigation strategies that need to be pursued at the urban level to reach net-zero emission. These are relatively well known, and most are already being pursued or at least discussed. A programme should focus on those with the highest mitigation potential but recognising that there are other considerations (for example, which are already being supported by other Programmes). This will require mobilising some political will and developing the policy framework at multiple levels. However, the real challenge is to deliver any of them at the scale and pace required. The constraints associated with India's multi-level urban governance system are already a barrier to the implementation and effectiveness of existing government priorities and schemes and will certainly limit a higher level of ambition. The programme should also be aiming to contribute to a significant proportion of India's overall GHG emissions required. It therefore needs to focus on delivering change across India, rather than being satisfied with success in a single city or small number of cities.
Long-term and sustained impact	The programme should also be aiming to contribute to a significant proportion of India's overall GHG emissions required. It therefore needs to focus on delivering change across India, rather than being satisfied with success in a single city or small number of cities.
Catalytic impact	The programme will be unable to directly deliver a transformation change in GHG emissions in Indian cities. Therefore, it needs to consider how to have an indirect influence at a larger scale. This include working with a wider set of partners to cover a greater number of cities or identifying entry-points for national level policy change. If the programme achieves the systems change described above, it will also likely result in unintended additional mitigation benefits.

To understand the likelihood that a new cities climate programme can contribute towards transformational change towards net-zero emissions in India, it is important to consider the policy-driven change pathways a programme can enable. This relates to how a city climate programme can mobilise city level mitigation action, at the level of ambition required to be in line with the net-zero growth trajectory, across the entire country. In particular, what are the pathways of change towards transformation, and how can a cities climate programme enable these. The focus is on policy-induced transformational change, however, this could be policy measures that enable market forces, for example, the standards and labelling schemes, and mass procurement schemes, that have shifted the supply and demand for appliances towards energy efficient models.

There are various top-down and/or bottom-up 'change pathways a cities programme can pursue to support the adoption of the required mitigation strategies by all cities in India, summarised in Figure 10 and described below.

Figure 10: Pathways to enable action across all cities in India



***Enabling top-down policy action*:** As Section 3 described, the constitutional responsibility for developing policy and regulation on urban climate issues is divided between the centre, state and ULB depending on the specific sector and mitigation strategy. However, even for those issues where policy-making authority rests solely with the state or ULB, for example municipal waste management, the centre still plays a key role in policymaking, for example, through funding, model regulations and setting national standards. Section 4 also outlined the many ways in which the central government can exert informal influence and pressure on sub-national governments. Therefore, for all the mitigation strategies identified in this report, top-down policy action is the most immediate way of getting a policy idea rolled out across the country.

This is the typical route that national research and civil society organisations use to enable policy action on urban issues, such as when advocating for an ambitious target on electric mobility and clarity in the approach through the national FAME programme, as well as by those supporting BEE to set mandatory and voluntary standards for energy efficiency of appliances found across all urban households. One expert argued that there is no substitute for the power of the central government to influence ambitious urban climate change, as the alternative is to just have pockets of good practice.

The second challenge for a cities climate programme is how to ensure effective delivery of the urban mitigation strategy. The 'implementation gap' often gets insufficient attention among donor funded programmes, and within civil society, because this is much more difficult to influence. Section 4 outlined many of the different reasons why urban mitigation strategies often fail to be delivered. A cities climate programme should focus significant attention on addressing these systemic issues, which lead to wider benefits across other development issues. However, this is very difficult to do across all cities in India, as it involves working directly with ULBs and states in most cases. Many of the governance and other constraints are also deeply embedded, and a new programme would need to have significant political capital to enable these political economy changes. It also seems like it would take a long time to address

these issues, which works against the urgency demanded by the climate emergency. However, there are some delivery challenges which a programme could conceivably enable.

One of the most critical delivery constraints is around institutional capacity at the city and state level (see Section 4.2), and this should be at the core of any new programme. Developing ULB and state capacity is critical for both effectively delivering a national or state urban programme and enforcing any rules and regulations, as well as developing their vision for net-zero growth and showing leadership across the country. The programme should have a clear strategy, integrated within the Theory of Change and Results Framework, for both individual and institutional capacity development. This will require a long-term commitment to support a particular city and/or state, and potentially new ways of delivering technical assistance. There is an important potential role of CCAPs in building institutional capacity (see Box 4). In addition, working with ULBs to design and implement mitigation actions within sectors they control (e.g., water supply and waste management) may have a relatively limited impact on actual emission savings, but the process will likely deliver significant capacity benefits.

In addition, unlocking and mobilising new climate finance for cities in India could be a useful entry-point for addressing the wider governance challenges. Access to finance is an obvious pre-requisite to any major investment in net-zero growth, particularly in terms of large infrastructure. Given there is a viable source of potential finance for ambitious urban climate action, for example from the private sector and international finance institutions, there is significant scope for a programme to support cities to access this funding. This requires not only technical support in project design, but also working with upper levels of government to advocate for cities to have more autonomy to access these and other sources of revenue. This may facilitate broader discussions, and potential action, on the need for more decentralised decision-making.

Box 7: Which city to work in?

City climate programmes need to carefully consider which cities to focus their direct efforts in, particularly for those aiming for bottom-up policy change. One expert cautioned that state officials or politicians will often suggest certain cities for their own interests, but it will be better to work in 2-3 cities in a state which are representative of the entire state and will give useful wider lessons. For one climate programme, it proved easier to mobilise action in smaller cities, partly as there is a more manageable number of stakeholders that need to be involved. Also, unlike the mega cities, they have tended to have not already invested in large infrastructure that will 'lock' them into a high-emission trajectory. While smaller cities are more representative of the majority of urban India and therefore potentially more relevant for replication, if a programme has a success in a larger city it is more likely to be visible and get promoted.

Informing bottom-up policy action: There are many examples of states and ULBs being more progressive and pro-active than the national average, which includes on climate issues. For example, Mumbai was the first city in South Asia to adopt a net-zero strategy for the city (see Section 4.5 for further examples). Across a range of mitigation strategies states and ULBs are also constitutionally empowered to unilaterally take action on urban climate change, irrespective of the national policy framework (see Section 3 for more details). Most urban climate change programmes in India have adopted a model of working with a small number of 'lighthouse' cities. Going 'deep' within a city is considered the best way of influencing change on the ground, as significant time is required to understand the local realities and build trust.

This involves working with the ULB and state to build political and bureaucratic interest in a policy action and supporting them to get it adopted. Given the serious capacity, finance, governance and other constraints facing ULBs (see Section 4) it can be assumed that a city programme will have to work with both the state and ULB to have a greater chance of influencing policy action within a city. Therefore, a 'cities programme' in the Indian context will look very different to an equivalent programme in Europe, the US and elsewhere which expect to mobilise action on climate change within cities by working

primarily with the city administration itself, to drive leadership and design and deliver mitigation strategies.

However, the obvious challenge with focusing on bottom-up policy change is how to get this scaled up to be in line with the 'scale' criteria of transformational change. Many urban programmes assume that their lighthouse cities will inspire and influence other cities to replicate their approach. However, there is little evidence that this is a viable pathway, with few examples available that a policy action taken by a single city, or small number of cities, was autonomously picked up by all or most other cities in India. An example is the Emissions Trading Scheme pilot for industrial emissions in Surat, launched by the Gujarat Pollution Control Board in collaboration with international partners, which Ludhiana learned from and adopted their own version of in 2021 (NCAP Tracker, 2021).

Another approach involves a good practice in a city or state getting the attention of the central government, who then learn from it and incorporate into national programmes or policy measures. For example, in 2013 Ahmedabad developed India's first Heat Action Plan in response to previous devastating heat waves, which the National Disaster Management Authority then used as a model to work with other cities to replicate (Padmanabhan, 2021). In general, the central government needs proof that any policy strategy is viable for the Indian context, and therefore having evidence of the practical costs and benefits will be of great interest to them. There are many examples of this type of bottom-up scaling strategy that are not specific to urban mitigation strategies, for example the National Rural Employment Guarantee Act is based on the experience of a similar scheme that was initiated previously in Maharashtra (Shah, Mehta, 2010).

For a city climate programme, this requires engaging both within individual cities and states, but also at the national level, to facilitate the adoption of ideas at both levels. To convince the central government that a policy action is viable, the programme should demonstrate scale across a state, and be aiming for state-wide adoption. This will require working with State Governments as the central partner of the programme, but also in multiple cities in the state to demonstrate the viability of different approaches. To facilitate nation-wide scaling, the programme should work with multiple states with different profiles to show viability across a range of contexts. The central government will also be more open to consider scaling-up a policy action if it is in line with one of their existing priorities.

Box 8: Learning on how to facilitate the diffusion of city level mitigation action

There is some practical learning from recent or ongoing climate programmes in India on how good practice and innovation from a particular city can be learned from and replicated by others. One expert cautioned against rushing into advocating for the replication of the project or intervention elsewhere, as it is important which elements are context dependent, and which are relevant to other locations. It was also suggested that if it is truly a 'good' practice, and is clearly solving a problem for the city, then it will naturally get the attention of other cities and they will want to learn about it. The first port of call for scaling-up for one programme is also the state government to suggest they roll it out across the state.

One model for promoting the scaling-up of best practices is through knowledge exchange platforms. The Government of India itself has adopted the diffusion by learning model of scaling-up best practices. India's Smart City Mission aims to develop a "replicable model for sustainable and inclusive cities", which "will act like a light house" and be adopted by other Indian cities (Beermann et al., 2016). India is also one of only a few countries to have introduced an Indian Peer Experience and Reflected Learning (PEARL) programme to actively support exchange and learning, mostly via the website[7], between 167 cities, especially in the area of urban infrastructure development (Campbell, 2012). The National Institute of Urban Affairs (NIUA) have been at the forefront of these and other initiatives to help scale-up best practices across cities in India.

Global platforms connecting cities from different countries appear to also lead to climate initiation and learning, the diffusion of policies and the formulation of joint GHG reduction targets (Beermann et al. 2016; Bukeley, 2010). Transnational actors, such as international NGOs, consultants and donors, also help transfer knowledge from other locations to cities in India (Stone, 2004; Fisher, 2014). There are also examples of individual cities in India partnering with another international city under a specific collaborative project. For example, Pune has collaborated with Bremen in Germany on many environmental projects, including biogas and waste management, since the 1970s (Beermann et al. 2016). However, there is no evidence that Indian cities specifically have benefited, and one expert reported that cities in India do not tend to learn from global experience as they consider the context in India to be too different. NITI Aayog (2021) has also cautioned against adopting international models of urban planning given differences in culture, demography, lifestyle etc. One expert advised a peer-peer learning system should be mindfully set up between cities that are similar in size and context, with multiple levels learning from each other's counterparts in the cities, whether political leaders, administrative officials, or engineers.

In summary, it looks likely that a new cities climate programme can make a serious and important contribution to India's overall mitigation targets. However, any cities climate programme will need to strike a balance between delivering results in the short-term, while also aiming for more systemic and fundamental change that is ultimately needed to achieve net-zero emissions. The programme should not just focus on mitigation strategies that are relatively straightforward to support and deliver, especially as this would not be fundamentally different from their current vertical programmes in different sectors. The added value of having a programme focused at a geographical unit is to strengthen cross-sectoral systems of planning and delivery. Therefore, a combination of these two approaches, and at the state level to be able to demonstrate sufficient scale, could be the best approach.

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Annex A: Background information on cities

Definition of a city in India: There are different methods to classify an Indian city, which has contributed to methodological challenges in attributing emissions to cities. The definition of an urban area (which for this study is used interchangeably with the term 'city') can be determined by administrative criteria, population size or density, or economic characteristics and urban infrastructure. This study adopts a flexible definition, which reflects the fact that cities in India are dynamic and rapidly expanding. This is also a practical necessity given the literature being reviewed itself uses different definitions.

This study broadly follows the definition of the Census of India, which includes all places that are considered 'Statutory Towns', including municipalities, corporations, cantonment boards and notified town area committees, but which have a population of at least 5,000. Other criteria include that at least 75 per cent of male main workers are engaged in non-agricultural pursuits, and there is a density of population of at least 400 per sq km (Census of India, 2011). Anything beyond this definition is considered a village, or rural.

Based on their population size, the Census of India broadly classifies all towns and cities into various class sizes

Table 11. Urban Agglomerations UA/Towns: Census of India 2011

Class	Population Size	Number (2001)	Number (2011) and per cent of Urban Popluation
Class I	1,00,000 above	394 (69 per cent)	468 (70 per cent)
Class I 'million plus metros'	More than 1 million	29 (17 per cent)	44 (20 per cent)
Class I 'mega cities/ metros'	More than 5 million	6 (21 per cent)	8 (22 per cent)
Class II - VI ('Towns')	Below 1,00,000	3,984 (31 per cent)	5,705 (30 per cent)
Total Urban Popultion (per cent of total population)		4,378	6,173

Source: NIUA (2016)

Constitutional distribution of powers: The table below summarises the distribution of powers relevant for action on climate change as per the Constitution of India, including the 74th Amendment.

Table 12: Examples of constitutional distribution of powers for subjects relevant to urban mitigation strategies

Central government	State government	Central – State shared	ULB
• International treaties and agreements with foreign governments • Railways • Highways • Industries (which parliament declares to be under union control) • Mines • Interstate rivers • Fishing • Taxes and excise duties • Residual powers in subjects not explicitly listed in the constitution.	• Land-rights in or over land and land tenure; • Land revenue; • Taxes on land and buildings; • Local government including ULBs • Public health and sanitation • Water infrastructure • Communication infrastructure • Industries (subject to provisions of Union list) • Taxes on vehicles, tolls, stamp duty rates	• Electricity • Shipping and inland waterways • Forests	• Urban planning • Regulation of land use and building construction • Social and economic development planning • Slum improvement and upgrading • Provision of urban facilities, such as parks and playgrounds • Public amenities such as street lighting, parking lots etc.

Annex B: Description of mitigation solutions

Each of the prioritisation mitigation strategies are described below, including an explanation of whether and how they can drive down emissions to net-zero.

Reduce number of per-capita motorised private vehicle journeys: Reducing demand for transport journeys can occur from making urban areas more compact with neighbourhoods providing a full range of services. Behavioural and employment practices can also reduce transport journeys, such as car pooling and work from home norms (CAT, 2020). Reducing demand for private journeys needs to be combined with the electrification of vehicles (powered through clean energy) to be carbon neutral.

Electrification of motorised vehicles: Electric forms of road transport vehicles are a viable alternative to internal combustion engine (ICE) vehicles for two- and three-wheelers, public transport vehicles, light duty vehicles and heavy duty vehicles. They are currently the most efficient technology compared to ICEs and other carbon neutral alternatives (e.g. synthetic fuels). However, they require an extensive deployment of renewable energy to be carbon neutral.

Increase non-motorised and public forms of transport: A modal shift to environmentally friendly transport modes such as walking and cycling, reduce transport passenger demand, and are also space and cost-efficient for cities. Public transport vehicles such as buses and light-trains have much higher occupancy rates than light duty vehicles, so more passengers can be pooled in one vehicle, which in turn reduces per capita emissions from mobility as well as congestion, urban space requirements, and noise (CAT, 2020).

Increase fuel efficiency of private vehicles: Increasing the efficiency of vehicles – in terms of the level of fuel consumption and GHG emissions - is particularly important for ICE vehicles. Fuel efficiency is affected by a number of variables, including weight, design and engineering of vehicle, tyres, use of air conditioning, and driving habits. The Government of India has fuel consumption standards for different types of vehicles. For passenger vehicles these are corporate standards (Corporate Average Fuel Economy (CAFE)), meaning that they relate to the Corporate Average Fuel Consumption (in liters/100 km) to the Corporate Average Curb Weight of all the cars sold by a manufacturer in a fiscal year (BEE, 2022).

Green building design and construction materials: There is no universal definition of a green building, but in general means a building which for which the planning, design, construction and operations prioritised considerations around its impact on natural resources, related to its energy and water consumption, indoor air quality, source of materials and effects on its local environment. There are various different codes, standards and certification schemes for green buildings in India, including:

- *Leadership in Energy and Environmental Design (LEED)/ Indian Green Building Council (IGBC) Green Ratings*: LEED is an internationally recognised green building certification system, providing third-party verification for a building using strategies intended to improve performance in metrics, such as resource utilisation, reduced CO2 emissions, improved indoor environmental quality. The green indicators of LEED have been adopted by as many as 57 countries and are considered benchmarks. In 2014, IGBC began managing the certification process for all LEED rating systems in India and customising the standards for the Indian context. For more information, see www.igbc.in
- *Green Rating for Integrated Habitats Assessment (GRIHA)*: GRIHA was developed by TERI and the Ministry of New and Renewable Energy (MNRE) and since 2007 has been the national rating

system for green buildings by the Government of India. It covers 11 criteria, including sustainable site planning, construction management, energy efficiency, occupant comfort, water and waste management etc. For more information, see www.grihaindia.org

- *BEE Star Programme for Commercial Buildings:* In 2009, BEE launched a voluntary certification to incentivise energy efficiency in commercial buildings. It is based on the actual energy consumption of the building relative to its size. It ratings buildings – including office buildings, hospitals, shopping malls etc – on a 1-5 scale, with 5 being the most efficient. For more information, see www.beeindia.gov.in/content/ecbc-commercial
- *Energy Conservation Building Code (ECBC):* The ECBC was launched by BEE in 2017 to establish minimum standards for energy efficiency standards for commercial buildings, which also includes higher efficiency voluntary standards. In 2018, 'Eco Niwas Samhita' was launched to extend the code for residential buildings larger than 500m2. It sets minimum building envelope performance standards to limit heat gains (for cooling dominated climates) and to limit heat loss (for heating dominated climate) as well as for ensuring adequate natural ventilation and day lighting. For more information, see www.beeindia.gov.in/content/buildings.

Solar water heating: Solar water heating systems absorbs solar radiation and transfers the heat energy to water flowing through it, which is stored in an insulated tank.

Rooftop solar powered electricity generation: A rooftop solar power system, or rooftop PV system, is a photovoltaic (PV) system that has electricity generating solar panels mounted on the rooftop of a residential or commercial building. As of June 2021, there was 7,701 MW of installed capacity of rooftop solar in India, of which 2,507 was installed on commercial buildings, 3,902 on industrial buildings, and 1,292 on residential buildings (Bridge to India, 2021).

Energy efficient appliances: There are various technological options for reducing the amount of energy household appliances consume. BEE has mandatory and voluntary labelling schemes, which prescribe the minimum levels of efficiency required, allows consumers to compare the energy consumption patterns of different products, and provides a 'certificate' to highlight that a product is highly efficient. The schemes cover a range of appliances including air conditioners, refrigerators, fans etc. For more information, see: https://beeindia.gov.in/content/star-labelled-appliances

Cool roofs: A cool roof reflects sunlight and absorb less heat, thereby reducing indoor temperatures. The technology can range from a simple lime-based paint, to more expensive reflective coatings or membranes.

Reduce and reuse of waste: Reduce means to cut back the amount of waste generated, while reuse means to find new ways to use things that otherwise would have been thrown out.

Waste to energy (WTE): WTE or energy from waste (EfW) is a process of recovering energy from waste. It burns non-recyclable, non-biodegradable, high-calorific-value waste to generate electricity and/or heat. It therefore requires waste to be segregated so that fuel generated is of high quality (Sambyal, 2019).

Compositing organic waste: Compositing is a natural process, carried out either aerobically or anaerobically, of decomposition and stabilisation of organic waste matter to produce compost manure. The resulting compost contains nutrients which are beneficial for plant growth. It can happen at various scales, including at the household level.

Bioremediation of landfill sites: Bioremediation or biomining of landfills/ dumpsites is a process in which soil and materials of economic interest (e.g., plastic, rubber and metal) is recovered along with recyclable materials. The waste is entirely cleared and the land is then able to be reclaimed for secondary usage (after 15 years) (CSE, 2020).

Annex C: Comparison of urban governance in India and elsewhere

The table below maps institutional responsibilities for policy design, delivery and financing across three sample cities.

Table 13: Mapping of institutional responsibilities for urban climate governance in Surat, London and New York City (NYC)

TRANSPORT									
Policy action	**Surat Municipal Corporation (SMC)**			**London**			**NYC**		
	Responsible govt institutions			**Responsible govt institutions**			**Responsible govt institutions**		
	Makes policies	**Finances policies**	**Implements/ enforce policies**	**Makes policies**	**Finances policies**	**Implements/ enforce policies**	**Makes policies**	**Finances policies**	**Implements/ enforce policies**
Improve public transport infrastructure	Centre: Central Railways (Local trains) Centre/ State: SPVs (Gujarat Metro Rail Corporation Ltd. (GMRCL)): ULB: Surat Urban Development Authority (SUDA) (transport planning); Surat BRTS (Sitilink) & Citi Bus Service (CBS) - Operated by Surat Sitilink Ltd., a wholly owned subsidiary of SMC.	Centre: e.g. DHI - FAME State:Transport Dept. (Gujarat State Road Transport Corporation (GSRTC))	Centre: Central Railways (Local trains) Centre/ State: SPVs (GMRCL)): ULB: SUDA (transport planning); Surat BRTS (Sitilink) & Citi Bus Service (CBS) - Operated by Surat Sitilink Ltd.	City: Transport for London (TfL) Local council: London borough councils	City: TfL (self-financing; GLA (grants)	City: TfL	City: NYC Council Mayor's Office; Depart.of Transportation	Centre: Federal Transport Administration (FTA) State/ City: Metropolitan Transportation Authority (MTA) corporate entity City: NYC Council Mayor's Office.	City: NYC Department of Transportation; MTA and subsidiaries (corporate entities)
Incentivize car sharing	ULB: SMC (parking policies).	State: State Finance Dept.	ULB: SMC; Traffic Police.	City: Transport for London (TfL) Local council: London borough councils	City: TfL	City: Transport for London (TfL) Local council: London borough councils	City: NYC Department of Transportation	City: Mayor's Office;	City: NYC Department of Transportation; New York City Housing Authority (NYCHA)
Incentivize shift to electric mobility	Centre: MoHUA State: Commissionerate of Transport (Electric Vehicles Policy for Gujarat)	Centre: MoHUA/ DHI/ MoRTH (various missions) State: State Finance Dept.	State: Commissionerate of Transport (vehicle registration, charging infratricture); State Energy Supply Corporations ULB: SMC (Charging infrastructure)	City: Transport for London (TfL)	City: TfL	City: TfL	City: Mayor's Office; NYC Department of Transportation	Federal: Internal revenue service (tax break) State: New York State Energy Research and Development Authority (tax rebates) City: Mayor's office;	State: New York State Energy Research and Development Authority City: NYC Department of Transportation

Incentivize modal shift	Centre: MoHUA; ULB: SMC: Sitilink/ CBS	Centre: MoHUA/ DHI/ MoRTH (various missions) State: State Finance Dept.	ULB: SMC: Sitilink/ CBS: Sitilink/ CBS	City: Transport for London (TfL)	City: TfL	City: TfL	City: NYC Department of Transportation	City: NYC Department of Transportation	City: NYC Department of Transportation; NYC Department of Citywide Administrative Services (DCAS)
Sustainable and innovative urban planning	Centre: MoHUA (Smart Cities) State: Urban Development & Urban Housing Department; Directorate of Town & Country Planning, GSRTC; ULB: SUDA; SMC	N/A	ULB: Smart City SPV; SMC	City: Transport for London (TfL) Local council: London borough councils	N/A	City: TfL	City: Mayor's office; NYC Council	N/A	City: NYC Department of Transportation; MTA and subsidiaries (corporate entities)
Tighten emission standards	Centre: MoRTH, BEE State: Commissionerate of Transport	N/A	State: Commissionerate of Transport; Gujarat Pollution Control Board (GPCB)	Centre: Department for Transport City: TfL	N/A	City: TfL	Centre: Federal Environmental Protection Agency (EPA); National Highway Traffic Safety Administration State: New York State Department of Environmental Conservation;	N/A	State: Department of Motor Vehicles; Department of Environmental Conservation
BUILDINGS									
Policy action	Surat Municipal Corporation (SMC)			London			NYC		
	Responsible govt institutions			Responsible govt institutions			Responsible govt institutions		
	Makes policies	Finances policies	Implements/ enforce policies	Makes policies	Finances policies	Implements/ enforce policies	Makes policies	Finances policies	Implements/ enforce policies
Building codes/ bye-laws	Centre- MoHUA (Model bye-laws); BEE (ECBC) State- Urban Development & Urban Housing Department/ State Designated Authority ULB: SMC.	State: State Finance Dept. (incentives)	State- Urban Development & Urban Housing Department/ State Designated Authority/ ULB: SMC.	Centre: Department for Levelling Up, Housing and Communities	Centre: Department for Levelling Up, Housing and Communities City: GLA (Retrofit Accelerator Programme); Mayor's Warmer Homes Scheme	Local council: Borough coucils planning departments	City: NYC Department of Buildings NYC City Council; Mayor's Office	City: Mayor's Office	City: NYC Department of Buildings; NYC Housing Authority (NYCHA); NYC Department of City Planning (DCP); NYC Department of Design and Construction

Certification/ labelling schemes	Centre- MoHUA; BEE (ECBC; appliances)	Centre- BEE (Energy Efficiency Financing Programme).	Centre: BEE	Centre: Department for Business, Energy and Industrial Strategy (BEIS)	Centre: BEIS (incentives)	Centre: BEIS	City: NYC Department of Buildings	City: NYC Department of Buildings	City: NYC Energy Efficiency Corporation; NYC Department of Housing Preservation and Development
Construction of green low-income houses	Centre: MoHUA (PMAY) State- Urban Development & Urban Housing Depart;	Centre: MoHUA (PMAY) State - Urban Development & Urban Housing Depart; State Finance Depart.	State: Urban Development & Urban Housing Dept. ULB: SMC (Slum Upgradation and Rehabilitation, Homeless shelters).	City: GLA (Homes and Community Agency)	City: GLA (Social Housing Decarbonisation Fund Mayor's Warmer Homes Scheme)	City: GLA	City: NYC Department of Housing Preservation & Development	City: NYC Housing Authority (NYCHA); NYC Department of Housing Preservation and Development (HPD)	City: NYC Housing Development Corporation;
Financial incentives	Centre- MoHUA; MNRE/ MOP (DISCOM) ULB (property tax rebates)	Centre: MoHUA (Smart Cities ; National Mission for Sustainable Habitats); BEE (Energy Efficiency Financing Programme) State: Finance Dept.	State: Finance Depart.; Urban Development & Urban Housing Depart. ULB: SMC	Centre: Department for Levelling Up, Housing and Communities	Centre: Department for Levelling Up, Housing and Communities	City: GLA Local council: Borough councils	State: Finance City: Mayor's Office; NYC Energy Efficiency Corporation;	State: NY State Energy Research and Development Authority City: NYC Department of Housing Preservation and Development; NYC Energy Efficiency Corporation; NYC Housing Authority (NYCHA);	State: NY State public utilities City: NY City schemes (NYC Retrofit Accelerator Program);
Consumer awareness	Centre- MoHUA; MOP/ MNRE (DISCOM)	Centre: MNRE (Grid Connected Rooftop Solar Programme; National Solar Mission); MoHUA (Smart Cities Mission).	State- State Energy Dept; ECBC Cells; DISCOMs	City: GLA (Homes and Community Agency)	City: GLA (Homes and Community Agency)	City: GLA (Homes and Community Agency)	State: NY State utilities; New York State Energy Research and Development Authority (NYSERDA) City: Mayor's Office;	State: NY State utilities City: NYC Department of Buildings;	State: NY State utilities New York State Energy Research and Development Authority (NYSERDA) City: Mayor's Office NYC Department of Buildings
WASTE									
Policy action	Surat Municipal Corporation (SMC)			London			NYC		
	Responsible govt institutions			Responsible govt institutions			Responsible govt institutions		
	Makes policies	Finances policies	Implements/ enforce policies	Makes policies	Finances policies	Implements/ enforce policies	Makes policies	Finances policies	Implements/ enforce policies

Segregation of waste	Centre: MoHUA State: Urban Development and Urban Housing Department, Gujarat Pollution Control Board (GPCB)	Centre: Swachh Bharat Mission State: Urban Development & Urban Housing Department, ULB: SMC	ULB: SMC	Centre: Dept. for Enviornment, Food and Rural Affairs (DEFRA) City/ Local Council: GLA and London Borough's partnership (London Waste and Recycling Board)	City/ Local Council: ReLondon (London Waste and Recycling Board)	Local Council: London borough councils; Sub-regional Waste Disposal Authorities	State: Department of Environmental Conservation City: NY City Council; Mayor's Office of Sustainability	City: Mayor's Office	City: NYC Department of Sanitation
Consumer awareness programmes on waste management practices	Centre: MoHUA State: Urban Development and Urban Housing Department ULB: SMC	Centre: Ministry of Jal Shakti (Swachh Bharat Mission) State: Urban Development & Urban Housing Department, ULB: SMC; Smart City SPV	ULB: SMC	Centre: DEFRA (Environment Agency) City/ Local Council ReLondon (London Waste and Recycling Board)	City/ Local Council: ReLondon (London Waste and Recycling Board)	City/ Local Council: ReLondon (London Waste and Recycling Board)	City: NYC Department of Sanitation	City: NYC Department of Sanitation	State: Depart. of Environmental Conservation; City: NYC Depart. of Sanitation
National programme on bioremediation	Centre- MoHUA, MoEFCC	Centre- Ministry of Jal Shakti (Swachh Bharat Mission)	ULB: SMC	Centre: DEFRA (Environment Agency)	Centre: DEFRA Local Council: Borough Council	Centre: DEFRA Local Council: Borough Council	Centre: USEPA State: Department of Environmental Conservation	State: Department of Environmental Conservation	City: Mayor's Office of Environmental Remediation
Construction of waste processing and treatment plants	State- Gujarat Pollution Control Board (GPCB)	Centre- Ministry of Jal Shakti (Swachh Bharat Mission); MoHUA (Amrut Cities) State: Finance Dept. ULB: SMC	ULB: SMC	Centre: DEFRA	Local Council: PPPs City/ Local Council: ReLondon (London Waste and Recycling Board)	Centre: DEFRA (Environment Agency) Local Council: Sub-regional Waste Disposal Authorities; London borough councils	State: Department of Environmental Conservation	City: Mayor's Office	City: NYC Depart. of Sanitation

Annex D: Capabilities of ULBs to introduce climate actions

The following table summarises the broad responsibilities of the main departments within two different ULBs. It also gives examples of climate actions they have the authority to potentially introduce. This has been compiled based on information available on the departments' websites.

Table 14: Mapping of capabilities of two ULBs

Brihanmumbai Municipal Corporation (BMC) The Municipal Commissioner, responsible for coordination across all departments, is appointed by the Chief Minister of the State, and is ultimately responsible to the state for city operations.	
Relevant Municipal Corporation departments and their broad responsibilities	**Examples of climate actions they have the authority to introduce**
BEST Electricity – Responsible for the distribution network i.e., energy reticulation services for the island city of Mumbai.	Efficient 24x7 supply through maintenance of transformers in the event of extreme climatic events to avoid usage of diesel back-up power. Incentives for roof-top solar installations.
BEST Transport – Procurement and operation of city buses.	Introduction of electric buses and charging stations.
Solid Waste Management Department – The SWM Department is headed by the Chief Engineer [SWM] Conservancy, Operation, Planning and Transport Sections of S.W.M. It is responsible for managing around 9000 tons of waste generated daily.	Ensuring that there is a circular waste economy in the city through implementing the reduce-reuse-recycle approach, and segregation at source.
Water Works Department – The pipe water supply is one of the earliest civic services provided by Hydraulic Engineer Department, one of the oldest departments. The main objective of Hydraulic Engineer department is to operate, maintain and provide water and related services to the citizens of Mumbai.	Usage of power efficient pumps/ solar energy-based pumps.
Road Maintenance Department – Responsible for city roads and footpaths – Construction, maintenance, and upkeep.	Provision of walking and cycling infrastructure.
Traffic Department – Regulation of city traffic.	Implementing congestion pricing, parking restrictions to disincentivise usage of private vehicles.
Environment Department – Responsible for water pollution control from industries, controlling noise and air pollution, control on polluting industries, measurement of emissions from air pollution sources. Sub - Dept.: Air Quality Monitoring & Research Laboratory sub department. Air Quality Monitoring and Research Laboratory (AQMRL) of Environment section in Solid Waste Management (SWM) department.	GHG inventory and air pollution interaction. Prepares the Environmental Status Report for Greater Mumbai in consultation with all other departments. Air Quality Monitoring in the city.

Garden & Trees Department – The Garden & Trees Department is an Administrative Department of MCGM that issues various Permits in consultation with and advice from other technical advisory departments like Fire Brigade, Maintenance, Engineering Department etc.	Maintenance of green cover and planting more trees to increase the carbon sink of the city.
Sewerage Operations Department – It operates and maintains the sewage collection, conveyance, pumping, treatment, and disposal system brought in place by the Sewerage Projects and Mumbai Sewage Disposal Projects departments.	Usage of power efficient pumps/ solar energy-based pumps, nature-based solutions.
Building and Factory Department – This department issues various Permits in consultation with and advice from other technical advisory departments like, Fire Brigade, Engineering, Estate, etc. In view of this it is necessary for any Establishment/Individual/Societies to obtain required Permit from Building & Factories department before starting any activities.	Mandatory usage of energy efficient appliances and roof-top solar installations in consultation with BEST Electricity.
Public Health Department – Responsible for civic hospitals and primary & secondary health care centres.	Health co-benefits assessment of reduced air and water pollution.
Education Department	Introduce syllabus on climate change in Municipal Corporation managed schools.
Development Plan Department – Responsibility of preparation of the City Development Plan and the related Development Control Regulations/ Code.	Ensure land-use transport integration through Transit Oriented Development, conservation of ecologically sensitive lands, promote compact development through control of FSI etc.
Disaster Management Department – Single-point source for all issues related to disaster management, Risk Assessment, Prevention & Preparedness, Mitigation, Response, Recovery & Reconstruction, Command & control agency between administration & field units, Provide early warning to citizens, Arrange for emergency supplies of water and food, Arrange for transfer of stranded & marooned persons, Arrange for emergency transport for the seriously injured, Coordinate for setting up temporary shelters, Coordinate with Non-Governmental Organisations.	Could initiate heat Island studies and preventive measures, AQ study, adaptation and mitigation interaction. (Disaster Management Plans for Mumbai are prepared for the two districts of Greater Mumbai i.e. District of Mumbai City and Mumbai Suburbs).
Assessment & Collection Department – Setting price and Collection of property taxes.	Offset certain tax components for energy efficiency certificate through implementation of ECBC regulations. Increase taxes for properties above a threshold that do not comply.

Surat Municipal Corporation (SMC)	
Relevant Municipal Corporation departments and their broad responsibilities	**Examples of climate actions they have the authority to introduce**
Engineering/ Street Light - The Streetlight Lighting is decentralised with all the zones and the Streetlight Department at the Head Quarters co-ordinates all activities.	Conversion of 100 per cent streetlights to LED thereby resulting in an overall energy saving.
Engineering/ BRTS cell - BRTS for Surat is a multifaceted project which integrates land use and transport, various forms of public transport services as well as other motorised and non-motorised modes through various physical, operational and policy interventions	Encourage mode shift from private to public transport through enforcing parking policy, efficient inter-modal transfers, penalties on private vehicles movement on BRT corridors and polluters pay principle on priority BRT routes.

Engineering/ The drainage department - provides the necessary infrastructure to carry the sewerage from domestic and industrial establishments of the city to the treatment plants, treating it and then disposing it appropriately.	Ensure tertiary treatment of sewage and industrial effluent and its usage in ground water recharge to improve ground water table thereby reducing ground water extraction energy usage.
Engineering/ Energy efficiency cell - conduct in house Energy Audit, conduct External Energy Audit, identify energy conservation projects and its feasibility, find sources for procuring power at lowest possible price, conduct feasibility study for own power generation from conventional & renewable energy sources, monitor the usages of electricity of entire corporation.	Use the lessons learnt from municipal energy efficiency in buildings and local production of renewables and inform future policy interventions for city wide efficiency through engaging with relevant state departments.
Engineering/ Environment cell – Mobile Ambient Air quality monitoring, execution and maintenance of bio-gas based power plant.	Expand the AQ monitoring to neighbourhood level through expanding monitoring equipment and work closely with the CAP cell.
SMC Development Services – Town Development – Development permissions for high rise, low rise, and commercial non-commercial buildings, and lay-outs, regularisation of high-rise and commercial buildings,	Ensure stringent adherence to GRIHA guidelines and ECBC requirement at the time of granting development permissions.
Engineering/ Town Planning – Preparation of Development Plan and Town Planning Schemes for the SMC jurisdiction, disposal of land and estate, Development control, Allotment of housing, shops and offices, Management of pay and use parking, plan approvals etc.	Ensure land-use transportation integration through incorporating Transit Oriented Development principles, ensure adherence to GRIHA and ECBC requirements.
Engineering/ Traffic Cell – Traffic and transportation surveys, operating city bus transportation on PPP basis, provide BRT mass transportation system etc.	Encourage the uptake of electric buses through convergence with state and national policies such as FAME for procurement of buses.
Engineering/ Water Supply – Long term planning, design and implementation & monitoring of water supply schemes, augmentation of new sources of water, increasing capacity of existing water treatment plants, procurement and laying of new pipelines etc.	Creation of reservoirs within the municipal jurisdiction to avoid long distance pumping costs, usage of solar pumps for water transmission, achieve efficiency in water supply through plugging NRW and industrial theft. Ensure 24x7 water supply to prevent usage of bore-well pumps.
Health/ Solid Waste Management – Storage of waste and segregation of recyclable waste at source, primary collection of waste, reduce quantity of waste going to landfill, derive income from waste processing,	Encourage segregation at source and creating a circular waste economy dove-tailing with the Swachh Bharat Mission.
Health/ Health Department - The Health and Sanitation department of Surat Municipal Corporation carries out a very broad spectrum of activities so as to improve the overall health of the citizens of Surat.	Commission co-benefits study of climate positive actions and their impacts on health of the citizens.
Air Quality Management Department/ Air Quality Management Cell - The cell looks into the implementation of NCAP which has a goal to achieve the specified annual average ambient air quality criteria in all parts of the country, including Surat, within a set period. The NCAP proposes a 20–30 per cent decrease in PM2.5 and PM10 concentrations at the national level by 2024, using 2017 as the baseline year for comparison.	Commission source apportionment studies and link to GHG inventory and strategise to reduce both through city Climate Action Plans and climate positive actions in coordination with Surat Smart City.

Annex E: Financing for urban climate action

This section provides a summary of the financing options for urban climate action in terms of the major sources of finance available and the current level of expenditure.

Finance flows to cities in India from or via the central government or state government and some is generated within the city itself. Table 15 breaks down the different sources of finance for cities. The exact volume and proportion of each of the sources depends on the size of the city and the extent to which finance is devolved within the state. Table 16 highlights significant differences between large and smaller cities in the portion of revenue generated with the city itself. To note, while a National Municipal Accounting Manual was introduced in the early 2000s there remains a wide variation in the way budget data is presented across states and municipalities, making it different to compare and come up with trends.

Table 15: Summary of finance sources of cities in India

Source	Examples	How cities can access them
Central government schemes ('plan grants')	Solar Cities Programme and Atal Jyoti Yojana; Smart Cities Mission; Faster Adoption and Manufacture of (Hybrid and) Electric Vehicles (FAME) programme; Municipal Energy Efficiency Programme, Street Lighting National Program (SLNP) and Unnat Jeevan by Affordable LED Efficiency; Atal Mission for Rejuvenation and Urban Transformation; Smart Cities Mission	Via the state governments or directly by the city, depending on the scheme
State level schemes ('plan grants')	Sikkim Ecological Fund (SEF); State Level Disaster Response Fund	Via the State Governments
Non-plant grants	To compensate against the loss of income and some specific transfers	Via central or state governments
Municipal budgets	Own non-tax revenue (e.g., lease amounts); Own tax revenue (e.g., property tax); Other receipts (e.g., sundry receipts); Assigned (shared) revenue (e.g., profession tax)[8].	Generated by the municipality itself. However, most local governments cannot set tax rates or change the bases of collection without the explicit concurrence of state governments
Debt financing	Life Insurance Corporation of India; State and Central Government; banks	Requires approval of State Government.
Multilaterals/ bilaterals/ climate funds	Green Climate Fund (GCF), Asian Development Bank (ADB), World Bank, KfW, JICA, International Climate Fund	Via Central Government. Also, finance is mostly channelled through accredited implementing entities, most of which are international agencies.
Private Sector	PPP, CSR	Depending on size and nature of project, may require state approval.
'New' financing instruments	Green bonds, land value capture, Market mechanisms (Gold Standard and Voluntary Carbon Standard)	Depending on size and nature of project, may require state approval.

8 Since the 14th Finance Commission, climate change has been a criterion to determine the intergovernmental fiscal transfers to the states.

Table 16: Municipal finance indicators: Revenue sources as a percentage in GDP

	37 Municipal Corporations		6 Largest Municipal Corporations		31 Other Municipal Corporations		Rest of the Municipal Corporations		Municipal Councils and Nagar Panchayats	
	2012-13	2017-18	2012-13	2017-18	2012-13	2017-18	2012-13	2017-18	2012-13	2017-18
Municipal Revenue	0.487	0.449	0.322	0.284	0.165	0.165	0.226	0.234	0.337	0.322
Own Revenue	0.328	0.231	0.237	0.165	0.090	0.066	0.116	0.122	0.085	0.075
Tax Revenue	0.196	0.123	0.139	0.080	0.058	0.043	0.083	0.085	0.045	0.043
Property Tax Revenue	0.086	0.084	0.067	0.064	0.020	0.020	0.032	0.046	0.020	0.019
Other Tax Revenue	0.110	0.038	0.072	0.016	0.038	0.022	0.051	0.039	0.025	0.024
Non-Tax Revenue	0.131	0.109	0.099	0.085	0.033	0.024	0.033	0.037	0.040	0.032
User Charges and Fees	NA	NA	0.067	0.063	NA	NA	NA	NA	NA	NA
Benefit charges and fees	0.057	0.046	0.045	0.041	0.012	0.006	NA	NA	NA	NA
Other sources of Non-Tax Revenue	NA	NA	0.032	0.022	NA	NA	NA	NA	NA	NA
State Transfers	0.103	0.155	0.052	0.088	0.051	0.067	0.066	0.022	0.168	0.148
Central Transfers	0.026	0.027	0.014	0.011	0.011	0.016	0.013	0.030	0.043	0.063
Market Borrowings	0.012	0.014	0.009	0.011	0.003	0.004	0.002	0.004	0.008	0.004
Municipal expenditure	0.444	0.367	0.293	0.234	0.152	0.133	0.162	0.171	0.228	0.240

Source: ICRIER (2019)

There is no budget analysis for any city in India tracking expenditure on low-carbon and climate resilient actions. There is limited disaggregated data at the city level, particularly for sectors where state grants are the primary source, and no harmonised framework for apportioning climate expenditure (Shreyanas, J. et.al. 2021). At a regional level, there was an estimated annual average investment of just USD 4 billion in urban climate finance in South Asia, compared to USD 208 billion of annual opportunities (Negreiros, 2021). In India, there is some tracking of budget allocations at the central level and in a number of states, for addressing climate change and some of this will flow down to cities. For example, Odisha's 2020/21 budget estimated the proportion of the key sector's budget allocations which were highly relevant to both mitigation and adaptation efforts, for example, 48 per cent of the Housing and Urban Development Department's budget, and 35 per cent of the Transport Department's (Government of Odisha, 2020). Between 2016-18 an estimated 56 per cent of all climate finance in India was from public sector, of which 37 per cent was disbursed by the central or state governments and 63 per cent by Public Sector Undertakings (PSUs). The bulk of public finance was directed towards the power generation sector (70 per cent) followed by energy efficiency and power transmission (20 per cent), and sustainable transportation (10 per cent) (Acharya, M. et.al., 2020).

Annex F: Mapping of city climate action plans in India

The table below provides details on a sample City Climate Action Plans (CCAPs) developed under various different climate programmes.

Table 17: Mapping of a sample of City Climate Action Plans in India

City	Programme	Targets	GHG Inventory developed?	Scope of interventions	GHG savings expected
Rajkot Climate Resilient City Action Plan (2019)	capaCITIES - ICLEI	No clear target set - Instead mentions mitigation potential based on existing and planned projects in different sectors.	Yes	Residential Building Sector (Energy efficient start rated buildings, replacement with LED bulbs and tube lights in households under UJALA, use of solar water heater, roof-top solar PV, green building design under SMART Ghar etc.); Commercial & Institutional Buildings/ facilities (Energy efficient star rated air-conditioners retrofits, replacement of CFL lights with LEDs, and existing fans with EE fans, roof-top solar PV installation); Manufacturing Industry & Construction i.e. Industrial Sector (Energy Efficient Star Rated appliance retrofits, Roof-top solar PV installation); Municipal Services – Water Supply (NRW reduction, Roof-top solar PV installation, re-use of water for gardening, EE implementation based on Energy Audits, rainwater harvesting, dual plumbing etc.), Sewerage (EE in pumping & SCADA implementation), roof-top solar PV installation for STPs and drainage pumping stations, 100 per cent sewerage network in the city, improved treatment quality of sewage etc.); Street Lighting (ESCo. Replacement of existing street lighting with LEDs); Transportation (Roof-top SPV for electric buses, replacement of 11 BRTS diesel buses with electric buses, replacement of diesel chakda with electric goods vehicles, public bike sharing scheme, NMT and pedestrian infrastructure etc); Solid Waste Management (segregation at source, scientific capping of solid waste dump sites, construction of leachate collection ponds, solid waste material recovery facility etc.), solar power for municipal buildings and buildings in smart city area, cool roofs.	A total of 310 Million kWh of electricity, 7,542 kilolitres of diesel will be saved by implementing proposed priority actions across different sectors, which will reduce 263,824tCO2e GHG emissions for the city. The total investment required for the proposed actions is INR 4,238 Million INR. Projected numbers show that GHG emission in year 2022-23 will be 2,728,390tCO2e after implementation of CRCAP as compared to 2,992,213tCO2e GHG emission as per business as usual scenario.

Udaipur Climate Resilient City Action Plan (2019)	CapaCITIES - ICLEI	No clear target set - Projections in terms of increase in emissions for medium term (2020-26) and long-term (2030, 2040 & 2050) have been made using HEAT+ . No mention of a mitigation potential.	Yes	Residential and commercial buildings (energy efficient appliances, solar water heating, rooftop solar etc), industrial sector (energy efficiency measures and solar power), water supply (solar pumps, reduced losses), sewerage (biogas electricity generation, solar powered treatment), LED street lighting, solar power for electric buses, solar power for smart city, energy efficiency and solar panels for municipal buildings, waste (compositing, waste to bio-methanation), electric buses and 3-wheelers	225,197 tCO2eq per year by 2023, representing 18 per cent of annual GHG emissions for 2016-17. An additional 225,197 tCO2eq from saving 104 Million kWh of electricity and 15,747 kilolitres of diesel
Coimbatore Climate Resilient City Action Plan (2018)	CapaCITIES - ICLEI	No clear target set - Projections in terms of increase in emissions for medium term (2020-26) and long-term (2030, 2040 & 2050) have been made using HEAT+ . No mention of a mitigation potential.	Yes	Residential Building Sector (Replacement of CFLs with LEDs, replacement of conventional air conditioners with EE air conditioners, electric geysers with heat pump geysers, energy efficient regenerative lifts, solar water heating systems, solar home lighting systems, SPV systems for bungalows etc.); Commercial and Institutional buildings/ facilities (EE in public worship places, LEDs in hotels, educational institutions, & hospitals, SPV systems for bus-stops, hospitals, colleges, educational institutions, vegetable markets, cinema theatres etc); Manufacturing Industry and Construction i.e. Industrial sector (Replacement with LED fittings, reducing transformer ratings, replacing machine motors with EE motors, EE in fabrication shops, microgrid solar PV plants in SEZs, SPV, solar water heating systems and solar steam generating systems for industrial units, EE cooling appliances etc.); Municipal Services (NRW reduction, Captive Solar PV plants for water pumping stations, Power factor correction panels at WTP and for sewage pumping); Street lighting (ESC0,. Replacement of existing street lights with LEDs– 21,000 & 41,292, SPV systems for lighting in parks); Transportation (6MW roof-top SPV for charging electric buses, replacement of 500 diesel buses with electric buses, public bicycle sharing system of 7,000 bikes); Municipal Corporation Buildings (Roof-top SPV, SPV system on dumping grounds); Solid Waste Management (Waste to energy bio-methanation plant, electricity generation from RDF).	A total of 1539.7 Million kWh of electricity will be saved by implementing proposed priority actions across different sectors, which will reduce 1,369,060 tCO2e GHG emissions for the city. The total investment required for the proposed actions is INR 49345.7 Million INR.

Mumbai City Climate Action Plan (2022)	C40	Reducing emissions by 30 per cent by 2030, 44 per cent by 2040 and 72 per cent4 by 2050. (Commitment by Ministry of CC & Environment + Brihan-Mumbai Municipal Corporation).	Yes	Sectoral actions in Energy and buildings, Integrated mobility, Sustainable waste management, Urban flooding and water resource management, Air quality, Urban greening and biodiversity; Energy and Buildings: decarbonising the city's electricity generation mix, transition to clean fuels and resource efficiency in buildings, Low carbon buildings, Passive design strategies to improve building resilience; Integrated mobility: public transport ridership improvement, access to non-motorised transport (NMT) and infrastructure, 100 per cent municipal and private ZEVs by 2050, zero emission freight; Sustainable Waste management: reduce landfill waste, decentralised waste management infrastructure, landfill remediation; Urban Greening & Biodiversity: Reduce urban heat island effect, Increase vegetation cover, restore and enhance biodiversity; Air Quality: reduce pollution concentration level by 20-30 per cent by 2030, increase monitoring data systems, community awareness; Urban Flooding & Water Resource Management: flood resilient infrastructure, Localised water conservation, reducing pollution and restoring aquatic, disaster risk and impact reduction	Mumbai's GHG emissions were 23.42 million tonnes of CO_2e, in base year 2019. In 2050, at 72 per cent reduced emissions, it is estimated to be around 6 million tonnes CO_2e.
Chennai City Climate Action Plan (upcoming)	C40	Carbon neutral by 2050 (Chennai Smart City Commitment)	Yes	At the time of conducting this research the plan was still under preparation. Hence scope unknown.	Scope unknown as still under preparation
Bengaluru City Climate Action Plan (upcoming)	C40	Carbon neutral by 2050 (BBMP Commitment)	Yes	At the time of conducting this research the plan was still under preparation. Hence scope unknown.	Scope unknown as still under preparation
Delhi City Climate Action Plan (upcoming)	C40	Reducing sectoral emissions by 50 per cent by 2030	Yes	At the time of conducting this research the plan was still under preparation. Hence scope unknown.	Scope unknown as still under preparation
Kolkata City Climate Action Plan (upcoming)	C40	Reducing sectoral emissions by 50 per cent by 2030	Yes	At the time of conducting this research the plan was still under preparation. Hence scope unknown.	Scope unknown as still under preparation
Surat Resilience Strategy (2017)	ACCRRN	No GHG emission target. Focus is on building resilience	No	Seven strategic pillars, 20 goals and 63 initiatives/ actions – Connectivity, Mobility services, and Regulation; Affordable housing; Water availability and quality; Employment and Economic Dependency; Environment and Ecosystems; Social cohesion; Public health.	No quantified GHG savings projected, although some relevant initiatives planned, including pollution audits on industrial plants and consumer awareness drives on renewable energy.

Madurai 'Future Proofing' Action Plan (2014)	Atkins 'Future Proofing Cities' programme	No GHG emission target. Focus is on 'blue green infrastructure'	No	14 projects based around six themes: Sanitation, including sewer system rehabilitation; Improved solid waste management; Rehabilitation of channels and tanks and green infrastructure improvements; Flood and surface water management; Water resources supply-demand management; Governance and future proofing.	No quantified GHG emissions savings projected.
Gangtok Biodiversity Strategy and Action Plan (2020)	ICLEI – INTERACT-Bio project	No GHG emission target. Goal is climate smart development and conservation	No	Five focus areas: Maintenance of forests and their eco-systems; Promotion of urban agriculture for urban food security; Maintenance and expansion of green spaces and avenue plantations; Conservation of water resources; Awareness raising and capacity building	No quantified GHG emissions savings projected.

Annex G: Interview list

CSOs	Government	Donors
TERI	Tamil Nadu Planning Department	Shakti Sustainable Energy Foundation*
WRI (x 3)	Pune Municipal Corporation	Multilateral (anonymous on request)
TCG	West Bengal Environment Department	
CEEW		
ICLEI		
Janaagraha		
Ex-C40 lead		

**interviewed for learnings from city level work in sector programmes*