26th AIM International Workshop

Theme: GHG Mitigation in Asia

Low Carbon Development Trends in India



Prof. Amit Garg

September 3-4, 2020

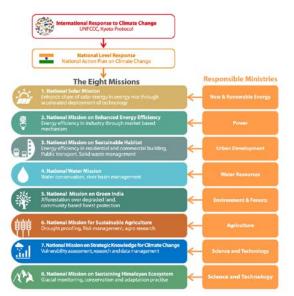
Development and Climate Change: SDG and NDC

India has been setting ambitious targets to achieved its development and Paris Agreement commitment by 2030 MDG (2000 – 2015) SDG (2015 - 2030)



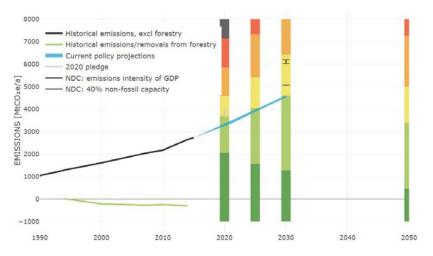


Source: UN MDG 2000





Source: UN SDG 2015

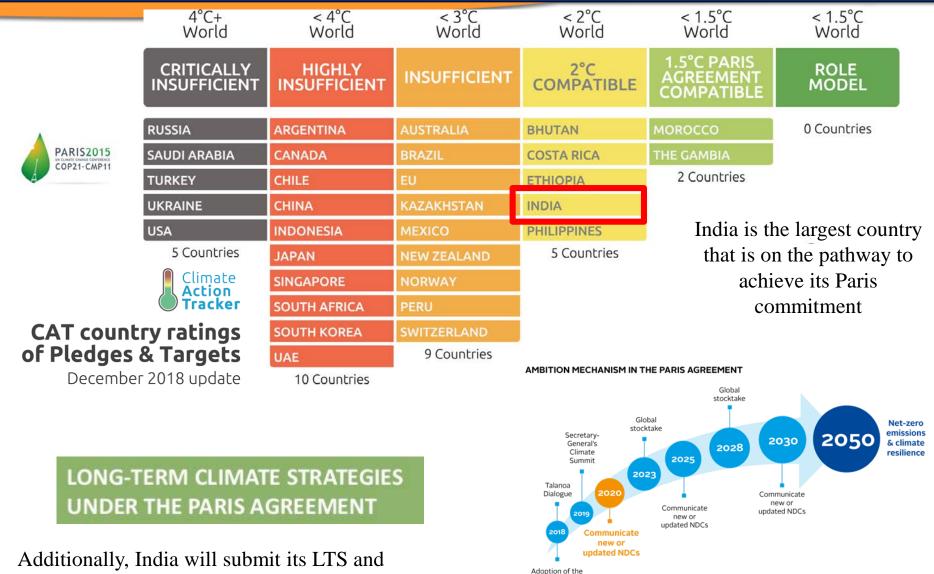


Source: https://climateactiontracker.org/countries/india/, 2020

Climate Change

Source: NAPCC 2008

Development and Climate Change: Future NDCs and LTS



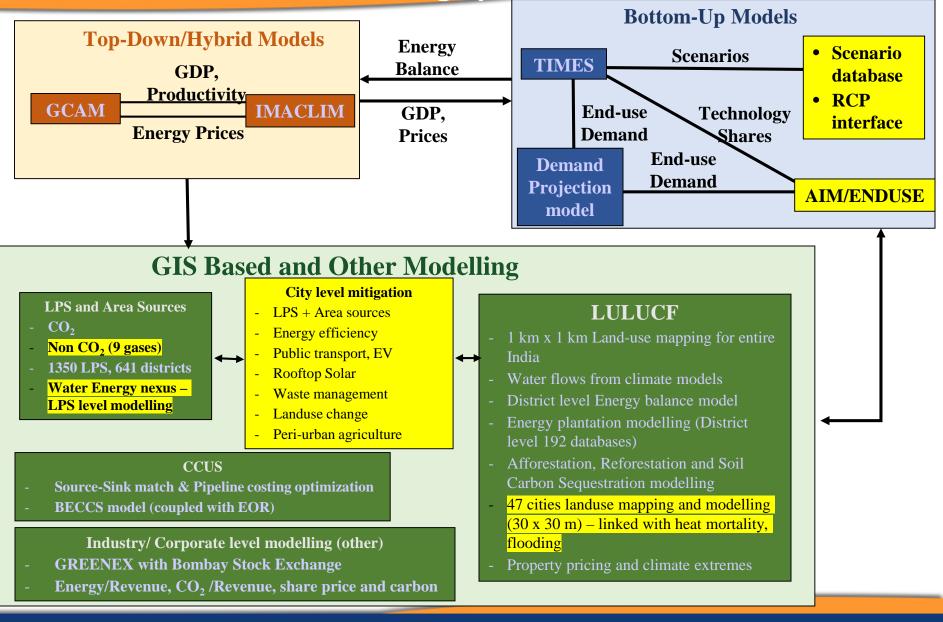
updated NDC in near future

Source: wri.org/publication/NDC-enchancement-by-20

Paris Rulebook

Soft Linked Top-down, Bottom-up, Hybrid and

GIS modeling System for India



Indian CO₂ Emissions

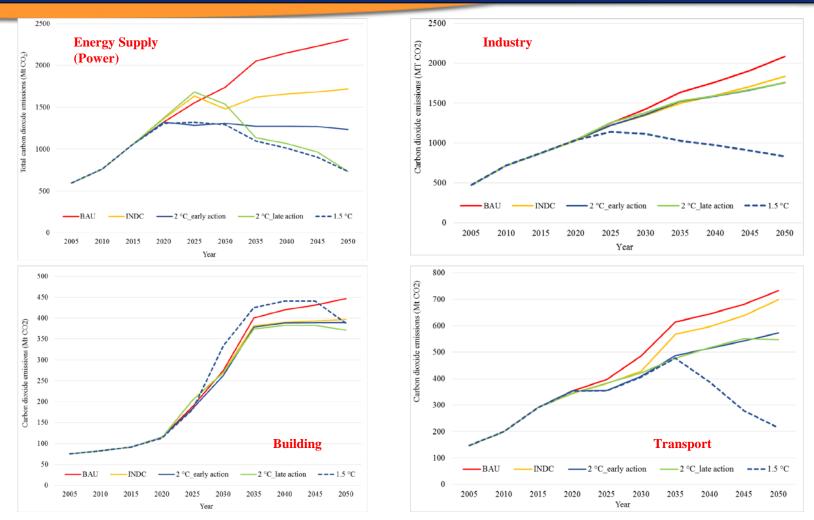
6000	Cumulative (CO2 mitigation 2011-2	0 <mark>50:</mark>		Scenario	Budget	CO2/capita (2050)
(² 0) 5000	DALLAS LOW O	C is 18 bt-CO ₂ carbon futures ranges 2	-57 bt-CO ₂		BAU (NPi)	165	3.2
ns (Mt C					INDC	147	2.7
Total carbon dioxide emissions (Mt CO ₂) 3000 5000 7000 7000					2 ° C_early action (NPi2020_high)	<mark>136</mark>	2.3
ix 3000)				2 °C_late action (INDC2030_low)	128	1.9
Total ca)				1.5 °C (NPi2020_verylow)	108	1.2
1000)				Notes:		
(BAU INDC 2 °C_early action 2 °C_late action 1.5 °C			Carbon budget 2011-2050 in billion ton-CO ₂ (scenario name) denote CDLINKS name			
	2005 2010	2015 2020 2025 Ye		045 2050			
	Scenarios	Bt-CO ₂ (% reduction)	Energy Efficiency (bt-CO ₂)	Renewable (bt-CO ₂)	es Demand Reduction (bt-CO ₂)		CCS (bt-CO ₂)

Scenarios	Bt-CO ₂ (% reduction)	(bt-CO ₂)	(bt-CO ₂)	(bt-CO ₂)	(bt-CO ₂)
BAU to INDC	18 (11%)	10	7	1	0
INDC to 2 °C	11-19 (8-13%)	1-2	3-5	3-4	4-8
INDC to 1.5 °C	39 (27%)	4	6	6	23

Cumulative CO₂ budget: India needs room for development, results within higher range of global models.

Source: Vishwanathan, S.S., Tiwari, V., Garg, A. and Shukla, P.R. (2018)

Sectoral Emissions



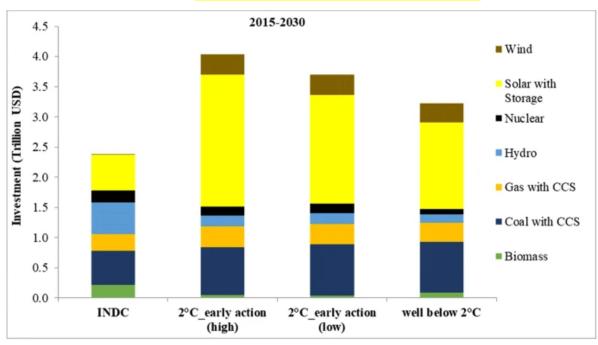
Power, Industry and Transport mainly responsible for reduction in emissions in low carbons scenarios

Source: Vishwanathan, S.S., Tiwari, V., Garg, A. and Shukla, P.R. (2018)

Energy Transformation: Investments

These transformations will likely need investments of **US\$ 6–8 trillion** between 2015 and

2030 across various scenarios





(high) (low) 39-52% shared by $\swarrow \ \textcircled{\ } \end{array}{\ } \textcircled{\ } \r{\ } \r{\$

13–17% shared by transport sector



19–25% shared by industry sector



11–14% shared by building sector

Source: Vishwanathan and Garg (2020)

Sustainable Development : Macroeconomic Assessment

Low carbon pathways and sustainable development can co-exist with policy alignments

ELSEVIER	Contents lists avail World De	e 122 (2019) 104623 able at ScienceDirect velopment Isevier.com/locate/worlddev	E BERNER	RESE Mac
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Achieving sustainabl Macroeconomic asse	•	lia along low carbon pathways:	Creek for access	"Publi des Po
Dipti Gupta ^{3,*} , Frédéric G	hersi ^b . Saritha S. Vishwana	athan ^c , Amit Garg ^d		AB
^b CNRS, CIRED, 45 bis, avenue de la Belle Ga ^c Faculty Room 12, Indian Institute of Manag	Amagement, Ahmedabad, Gajarut 380015, It brielle, 91736 Nagent sur Marne CEDEX, Fra gement, Ahmedabad, Cajarut 380015, India titute of Management, Ahmedabad, Gajarut 3	NCP		Alt mi 20 un pa su
ARTICLE INFO	ABSTRACT			su
Article history:		e economic growth concurrently with greenhouse gases (GHG ag implications for the Indian economy, predominantly fuelles		er
Keywords:		ne inequality with the bottom 50% of its population owning elopmental challenges include 304 million people living in p		an
India	lion without access to elect	ricity, 92 million without access to safe drinking water, and a	round 2 million	ce
Energy-economy modelling Low carbon pathways		llenges, India has committed to reduce the GHG emission inte		
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Taylor & Francis -7. 779-799 aylor & Francis Group 1080/14693062.2019.1648235 OPEN ACCESS Check for upstates RTICLE onomic assessment of India's development and mitigation S ¹, Frederic Ghersi^b, Saritha S. Vishwanathan^a and Amit Garg^a Group, Indian Institute of Management, Ahmedabad, India; ^bCIRED, AgroParisTech, CIRAD, CNRS, EHESS, Ecole Tech, Univ Paris-Saclay, Nogent-sur-Marne, France **ARTICLE HISTORY** rapidly growing economy, India faces many challenges, including in Received 31 December 2018 e Sustainable Development Goals of the United Nations. Moreover, post-Accepted 23 July 2019 te actions outlined in India's Nationally Determined Contribution (NDC) KEYWORDS Paris Agreement envision development along low-carbon emission India; energy-economy With coal providing almost three-quarters of Indian electricity, achieving model; sustainable ts will have wide-ranging implications for economic activity. Assessing development: 2°C: 1.5°C: cations is the focus of our research. To do so, we use a hybrid modelling dimate policy that combines the strengths of the AIM/Enduse bottom-up model of tems and the IMACLIM top-down economy-wide model. This hybrid e rests upon an original dataset that brings together national accounting, ance and energy price data. We analyse four scenarios ranging to midisiness-as-usual (BAU), 2°C, sustainable 2°C and 1.5°C. Our 2°C pathway npatible with economic growth close to the 6% yearly rate of BAU from 50, at the cost of reduced household consumption but with significant npact on foreign debt accumulation. The latter impact stems from ent of the trade balance, whose current large deficit is the primary cause ssil fuel imports. Further mitigation effort backing our 1.5°C scenario htly higher annual GDP growth, thereby revealing potential synergies deep environmental performance and economic growth. Structural sumptions common to our scenarios significantly transform the activity ectors. The envisioned transition will require appropriate policies, notably the conflicting interests of entrenched players in traditional sectors like , and the emerging players of the low-carbon economy. insights rbon pathways are compatible with Indian growth despite their high ent costs away from fossil fuel-based energy systems would result in foreign e savings to the tune of \$1 trillion from 2012 to 2050 for oil imports. ng deep decarbonization in India requires higher mobilized capital in les and energy efficiency enhancements. out fossil fuels would, however, require careful balancing of interests conventional and emerging sector players through just transitions. Gupta 🖾 dipti.gupta@iiml.ac.in 🖸 Indian Institute of Management Lucknow, Chintan faculty room no. 235, IIM Road, adesh 226013, India een republished with minor changes. These changes do not impact the academic content of the article (s). Published by Informa UK Limited, trading as Taylor & Francis Group ess article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (http://creativecommons.org/ 0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not or built upon in any way.

Source: Gupta et. al 2019; Gupta et. al 2019

Low-Carbon Developments in Indian Transport Sector

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Sustainable development and carbon neutrality: Integrated assessment of transport transitions in India



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ARTICLE INFO

ABSTRACT

Keyword: Modal transitions Deep decarbonization Development Carbon neutrality Modal shift Energy-economy modelling Dependence on crude oil imports, high correlation with economic growth, and contribution to air pollution cause the transformations in transport sector in India to have significant ramifications. Moreover, these transitions are to be steered through the global and domestic sustainable development and carbon neutrality goals. In this paper, we determine the energy environmenteconomy implications of transport sector dynamics by undertaking an integrated analysis using a novel methodological approach involving two main arpects soft-coupling the UMACIAM-IND and AIM/Enduse models; and back-causing approach with long-term benchmarks. We examine four accurators business-as-usual (DAM), development first (DEVI), carbon neutrality (CNT) and synchronous (SYNCH). Our synchronous scenario pathway reduces the crude cal and natural gas imports by 68% for the year 2050 compared to 2012 in the BAD scenario, leading to forsign exclusions strategic policies which provide equitable access of transportation to all.

1. Introduction

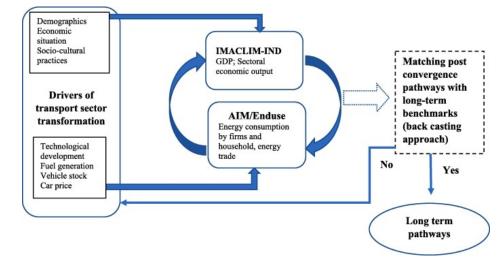
Transport sector plays a pivotal role in improving regional connectivity and facilitating movement of individuals, and trade of goods across the country. Rapid economic growth and urbanization, since the end of the nineteenth century, have led to an unprecedented increase in the demand for mobility services (NTI Aayog and Rocky Mountain Institute, 2018). With the share of manufacturing sector in GDP poised to grow up to 25% by the year 2022 from 17% in 2018 (MoCI, 2018), freight transport demand is expected to rise quickly. On the one hand, the large scale growth in passenger traffic (from around 3000 BPMK in the year 1995 to over 10,000 BPK in 2017) led to rise in the private vehicle ownership rather than public transport system, and on the other, growth in freight traffic (from around 1000 BTKM in 1995 to over 2500 BTKM in 2017) was accompanied by the dominance of road transport in total traffic share compared to rail (Fig. 1). These transformations and future possibilities along with government-led reform measures can have certain co-benefits and trade-offs for energy systems, environment, and domestic economy, which we set out to investigate in this paper.

Transport sector accounts for 9.4% share of domestic final energy consumption amounting to 52.3 Mice (CSO, 2019), and 47% of total refined petroleum products consumption which amounts to 82.5% of fuels consumed by transport services. Further, it accounts for 47% of the petroleum products' consumption in the country (IEA, 2015). Given the dependence on imports for meeting the crude oil demand (IPAC, 2019), it plays a critical role in the country's energy security dynamics. Further, it accounts for 13.3% of total energy CO₂ emissions with road transport dominating the mix with 90.1% share of total transport emissions followed by air (5.5%).

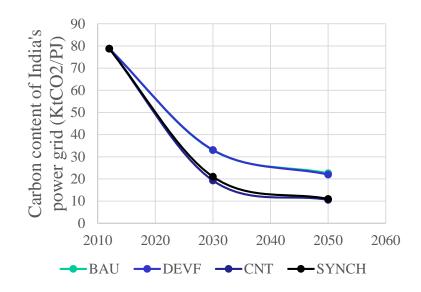
* Corresponding author at: Faculty room no. 235, Indian Institute of Management Lucknow, Lucknow, Uttar Pradesh 226013, India. E-mail addresse: dipti.gspta@iml.ac.in (D. Gupta), amitgarg@ima.ac.in (A. Garg).

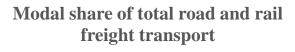
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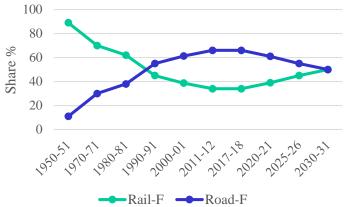
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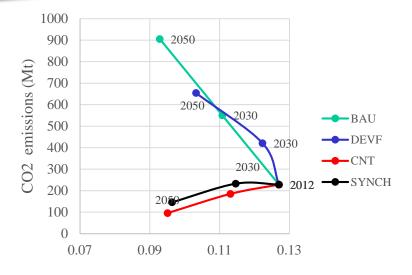


Integrating Transport & Power sector transitions









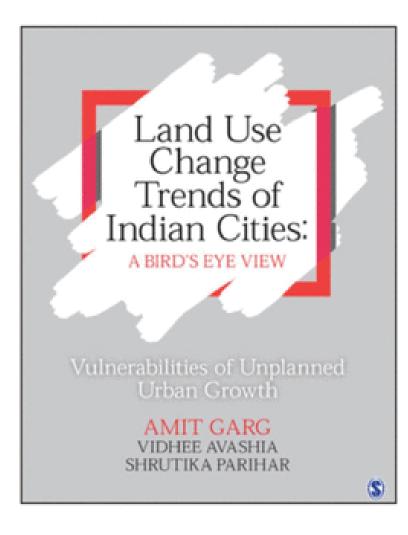
Cost per unit service (\$/rtkm)

Modal share of total road and rail passenger transport



Source: Gupta and Garg 2020

Development, Vulnerability, Adaptation : Indian Cities





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Urban commons service generation, delivery, and management: A conceptual framework

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Implications of land use transitions and climate change on local flooding in urban areas: An assessment of 42 Indian cities

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Journal of the Indian Society of Remote Sensing (June 2020) 48(6):877-908 https://doi.org/10.1007/s12524-020-01122-7

RESEARCH ARTICLE



Check for updates

Evaluation of Classification Techniques for Land Use Change Mapping of Indian Cities

Vidhee Avashia¹ · Shrutika Parihar² · Amit Garg¹

Received: 4 October 2019/Accepted: 30 May 2020/Published online: 20 June 2020 @ Indian Society of Remote Sensing 2020

Source: Garg et al. 2018; Shah and Garg 2017; Avashia and Garg 2020; Avashia et al. 2020

Selected Recent Past and Ongoing Projects

INTERNATIONAL

- Exploring National and Global Actions to reduce Greenhouse gas Emissions (ENGAGE funded by H2020) (2019-2023)
- Deep Decarbonization Pathways Project (DDPP BIICS funded IKI and BMUB) (2018-2021)
- Linking Climate and Development Policies Levering International Networks and Knowledge Sharing (CD-LINKS) (2015-2019)
- Modelling and informing low-emission strategies (MILES) (2014-2017)
- Low climate impact scenarios and the implications of required tight emission control strategies (LIMITS) (2012-2014)
- Assessment of climate change mitigation pathways and evaluation of the robustness of mitigation cost estimates (AMPERE) (2011-2014)
- United States India Joint Center for Building Energy Research and Development: Grid responsive buildings (CBERD) (2012-2017)

NATIONAL

- Development of a prosumer driven integrated SMART grid (2018-2021)
- Risk and uncertainty assessment for Critical Railway Infrastructure due to impacts of Climate change (2018-2019)
- Estimating Energy Sector GHG Emissions from Unorganized sectors (2016-2018)
- Coordination of Energy Sector Inventory (2011-2018)

MITIGATION: SECTOR/TECHNOLOGY ASSESMENT

- Electric Vehicles: Indian Market Study (2017-2018)
- Energy plantations: Integrating land-use, water, energy and sustainable development at local level (2013-2015)
- Techno-economic Assessment of CO2 Capture and Storage Potential in India: A Policy Perspective (2013-2015)
- Study of Energy Balance of Rural India Using Geospatial Inputs (Energy and Mass Exchange in Vegetative Systems) (2013-2015)

STATE

• Revision of Gujarat's State Action Plan on Climate Change (SAPCC) (2019-2020)

CITY

- Can Peri-Urban Agriculture help to feed "hungry cities" (funded by GiZ) (2020-2021)
- Economic cost of impacts and adaptation to extreme rainfall event induced flooding for selected Indian cities (2016-2018)
- Linking GHG and local air pollution in Delhi (2018) video case study
- Solar rooftop in India: Sky is the limit (2020) video case study

Future Projects – Discussion for AIM Family

I. Modelling Non-CO₂ gases in all sectors (in Asian countries)

- > In most of the past and current literature, the focus has been on CO_2 emissions.
- Non-CO2 emission also contribute a significant amount to the warming.
- Presently, agriculture and livestock related emissions contribute above 65% of Indian CH₄ emissions and above 90% of N₂O emissions.
- ▶ We can work on proposal to model non-CO2 gases in Asia to contribute towards Global Stocktake 2023.

Selected references on the work published in past:

- Garg, A., Shukla, P.R. and Upadhyay, J. (2012). <u>N₂O Emissions of India: An Assessment of Temporal, Regional and Sector</u> <u>Trends.</u> *Climatic Change*, 110 (3), 755-782. doi: 10.1007/s10584-011-0094-9.
- Garg, A., Kankal, B., and Shukla, P.R. (2011). <u>Methane emissions in India: Sub-regional and sectoral trends</u>. *Atmospheric Environment*, 45, 4922-4929. doi: https://doi.org/10.1016/j.atmosenv.2011.06.004.
- Garg, A., Shukla, P. R., and Kapshe, M. (2006). The sectoral trends of multigas emissions inventory of India. *Atmospheric Environment*, 40, 4608-4620. doi: https://doi.org/10.1016/j.atmosenv.2006.03.045.
- Garg, A., Shukla, P. R., Kapshe, M., and Menon, D. (2004). Indian methane and nitrous oxide emissions and mitigation flexibility. *Atmospheric Environment*, 38 (13), 1965-1977.
- Garg, A., Shukla P. R., Bhattacharya S. and Dadhwal V.K. (2001). <u>Sub-region (District) and Sector Level SO₂ and NO_x Emissions for India: Assessment of Inventories and Mitigation Flexibility.</u> Atmospheric Environment 35(4), 703-713. doi: https://doi.org/10.1016/S1352-2310(00)00316-2.

II. Climate Change Mitigation: Mega-cities in Asia

- Cities produce 70 per cent of anthropogenic global carbon dioxide emissions.
- The 50 largest cities together emit greenhouse gases equivalent to 2,600 megatons of carbon dioxide per year. That is more than some countries. For instance, Russia emits about 2,200 MT and Japan about 1,400 MT per year.
- ▶ We can work on policy assessment towards mitigation in selected mega-cities in AIM partner Asian countries.



Thank you

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