Urbanization, urban infrastructure and low carbon cities

Shobhakar Dhakal
Associate Professor, Energy Field of Study
Asian Institute of Technology (AIT), Thailand
shobhakar@ait.ac.th, shobhakar.dhakal@gmail.com

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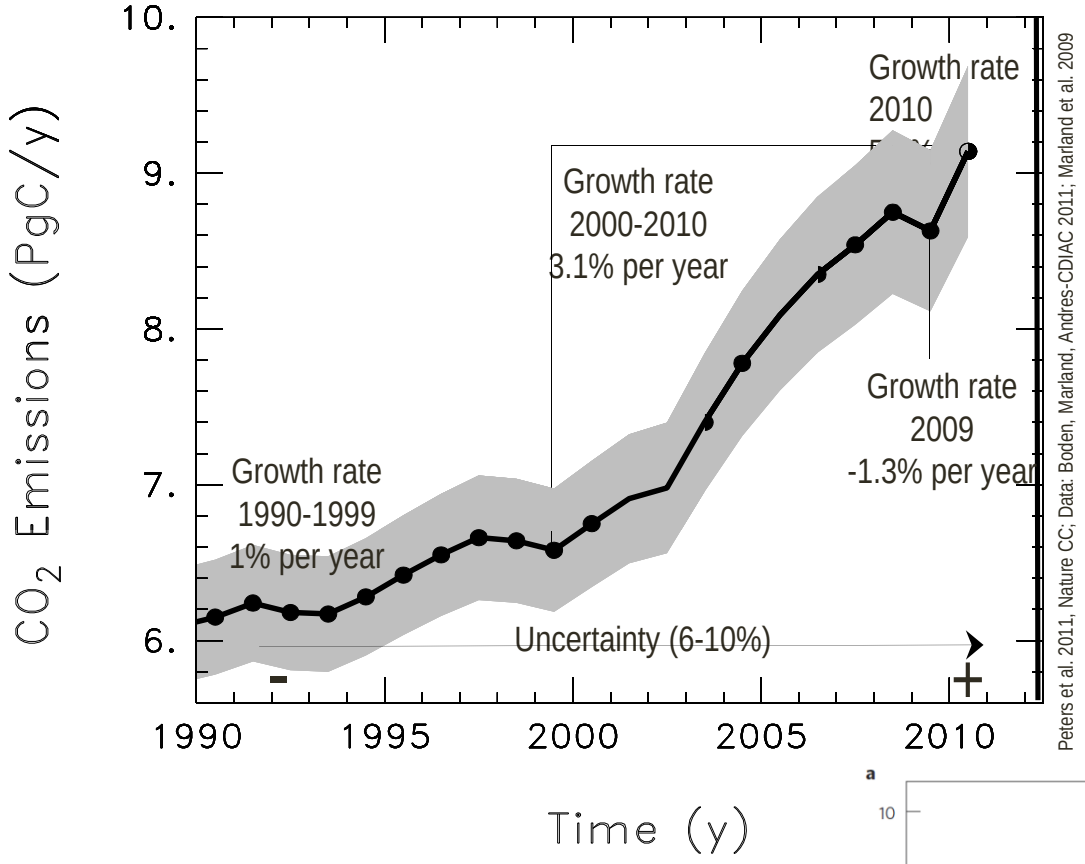
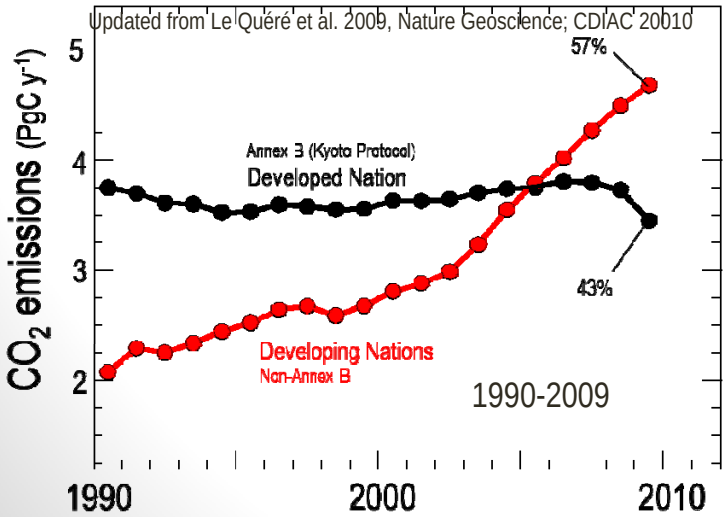
- Global CO2 and urbanization trends
- Role of urbanization and urban areas in carbon emissions
- CO2 emissions in cities, what they tell us?
- Key messages

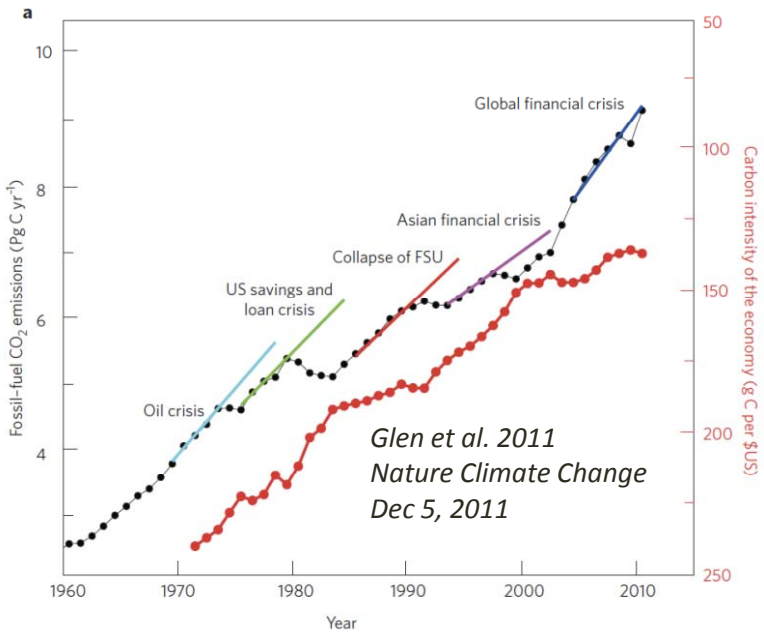
Fossil Fuel & Cement CO_2 Emissions



Peters et al. 2011, Nature CC; Data: Boden, Marland, Andres-CDIAC 2011; Marland et al. 2009

2010
9.1 GtC
(or 33.4 GtCO2)

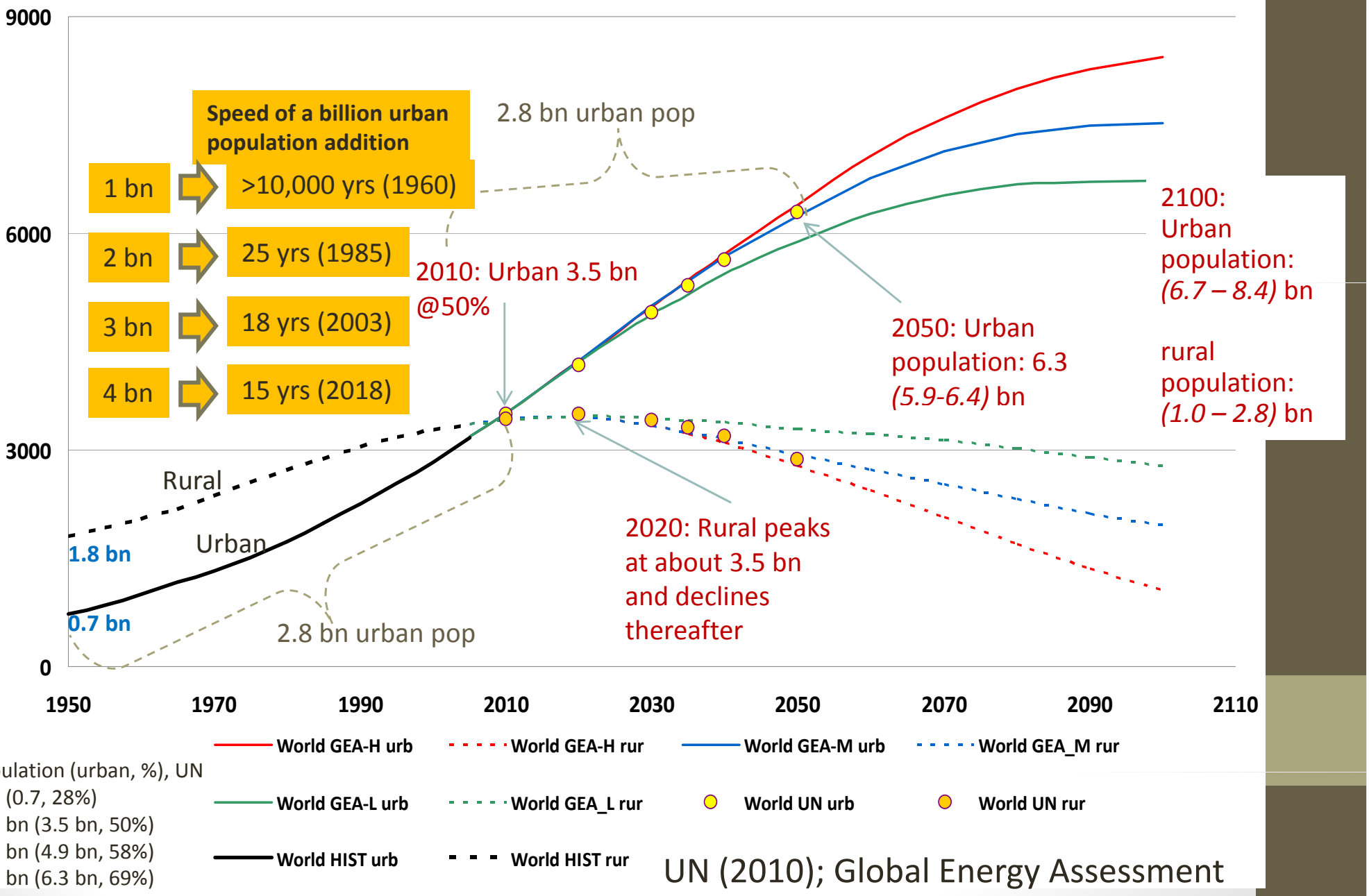




Glen et al. 2011
Nature Climate Change
Dec 5, 2011

Urban and Rural Population (Millions)

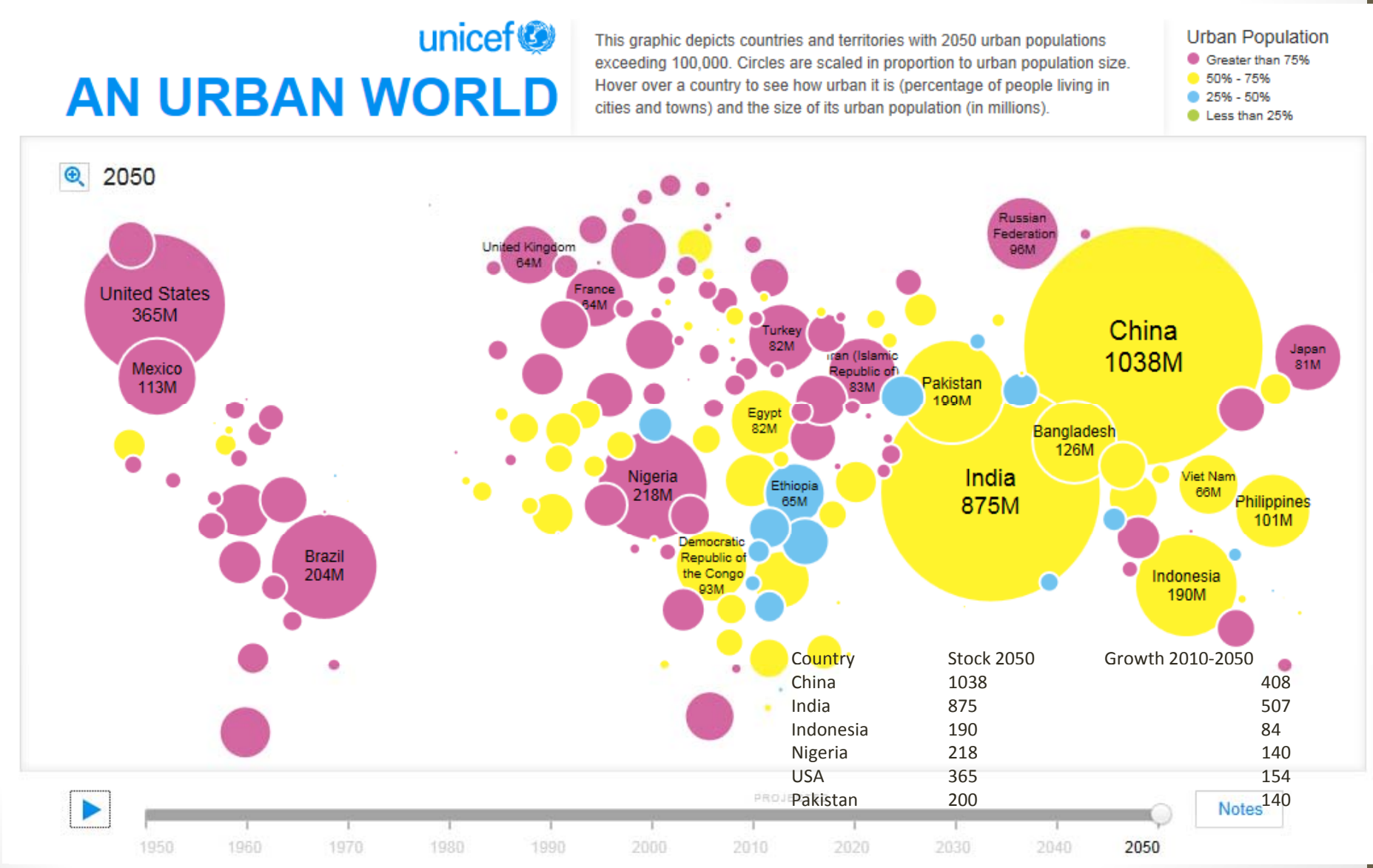
(GEA-H, GEA-M, GEA-L and UN WUP, 2010)



Total population (urban, %), UN
1950: 2.5 (0.7, 28%)
2010: 6.9 bn (3.5 bn, 50%)
2030: 8.3 bn (4.9 bn, 58%)
2050: 9.1 bn (6.3 bn, 69%)

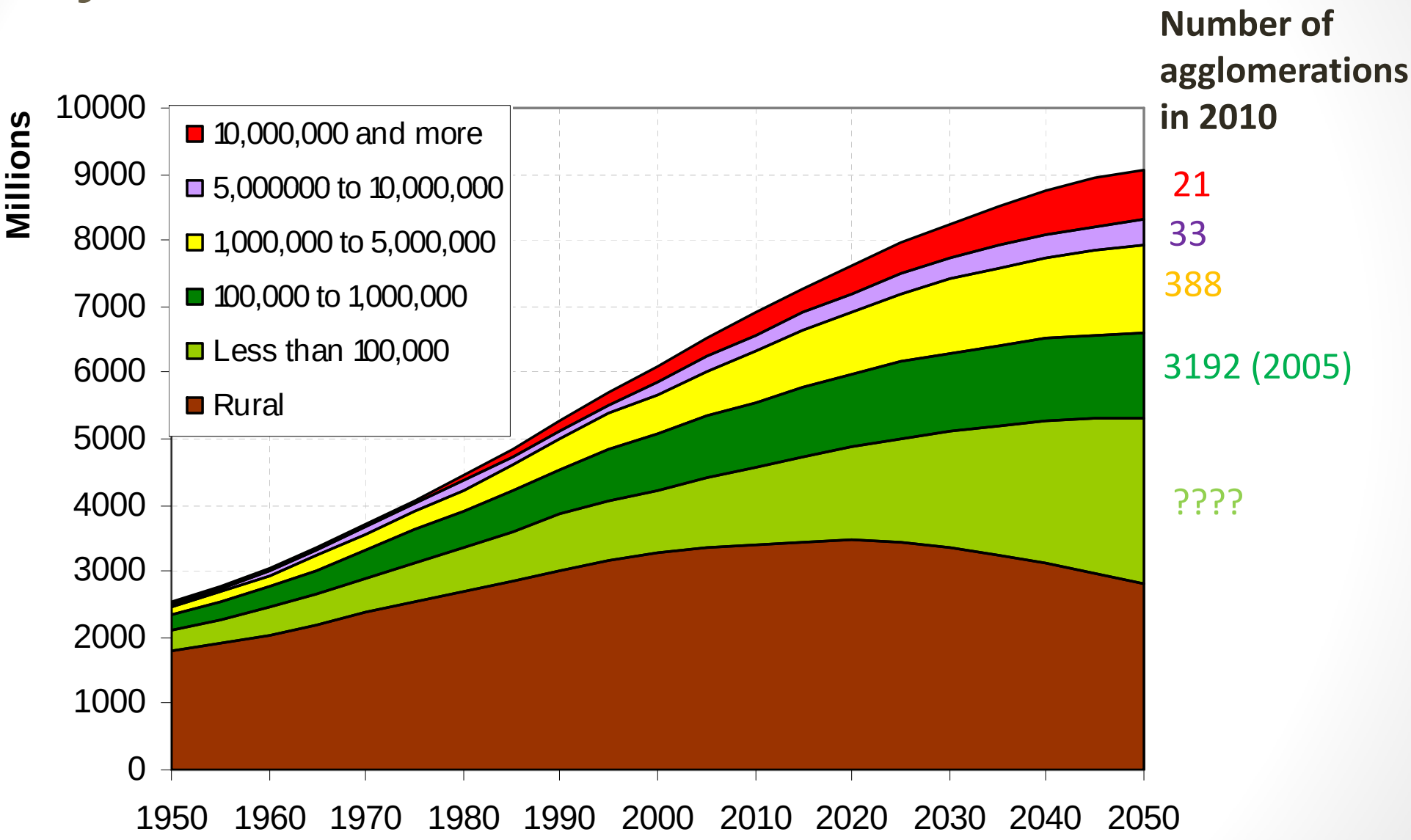
UN (2010); Global Energy Assessment

Rapidly urbanizing world



©http://www.unicef.org/sowc2012/urbanmap/

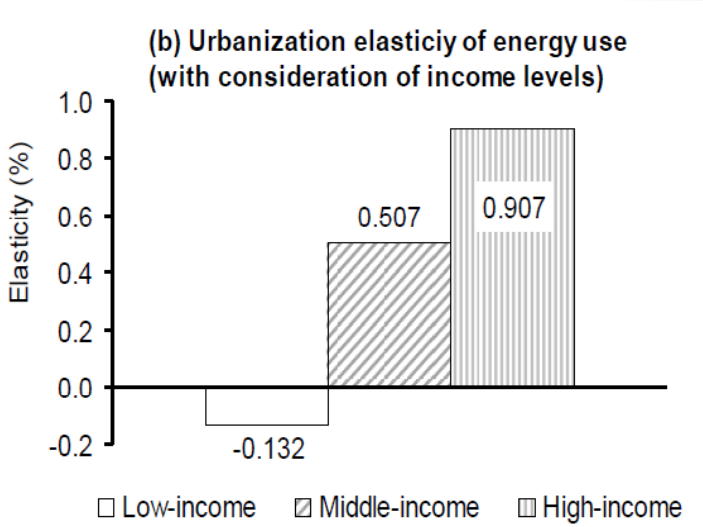
World urban population growth dominated by small & medium-size cities!



Source: Global Energy Assessment/KM18, prepared from UN 2009 update data

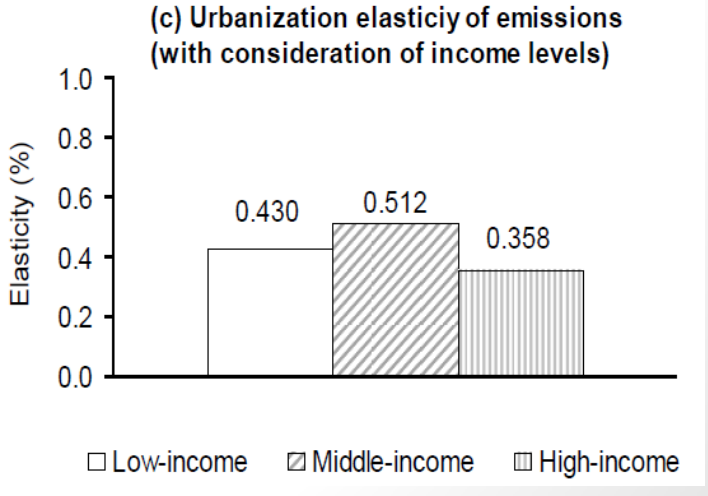
Urbanization and global CO2

- Urbanization led to increase global CO2 emissions in the past
- Urbanization could “lead to an increase in projected future emissions by more than 25 per cent in the future particularly in developing country regions, mainly through effects on labor supply” (O’Neill et al. 2010 PNAS)

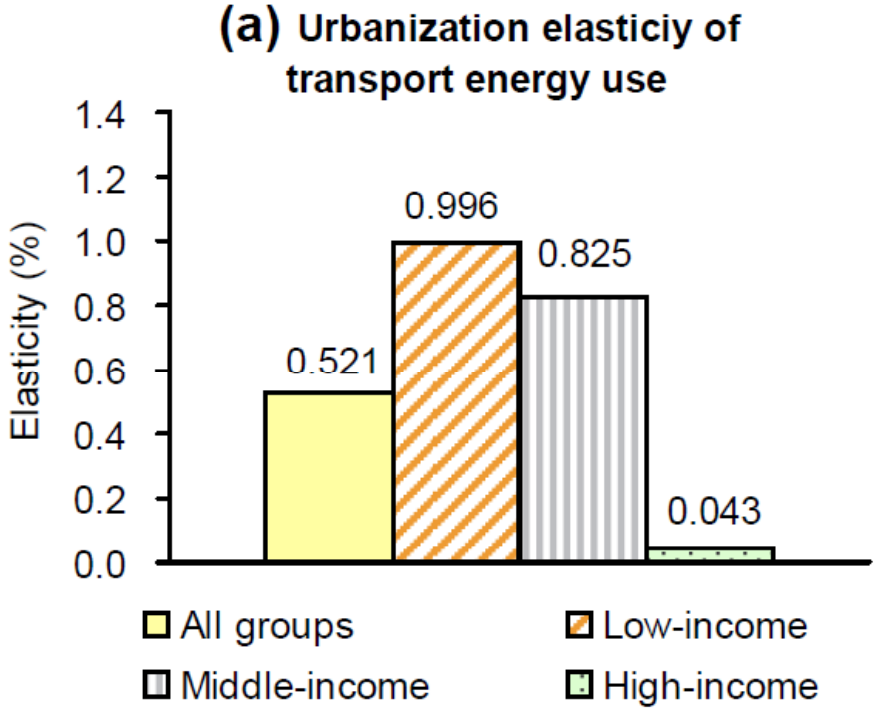


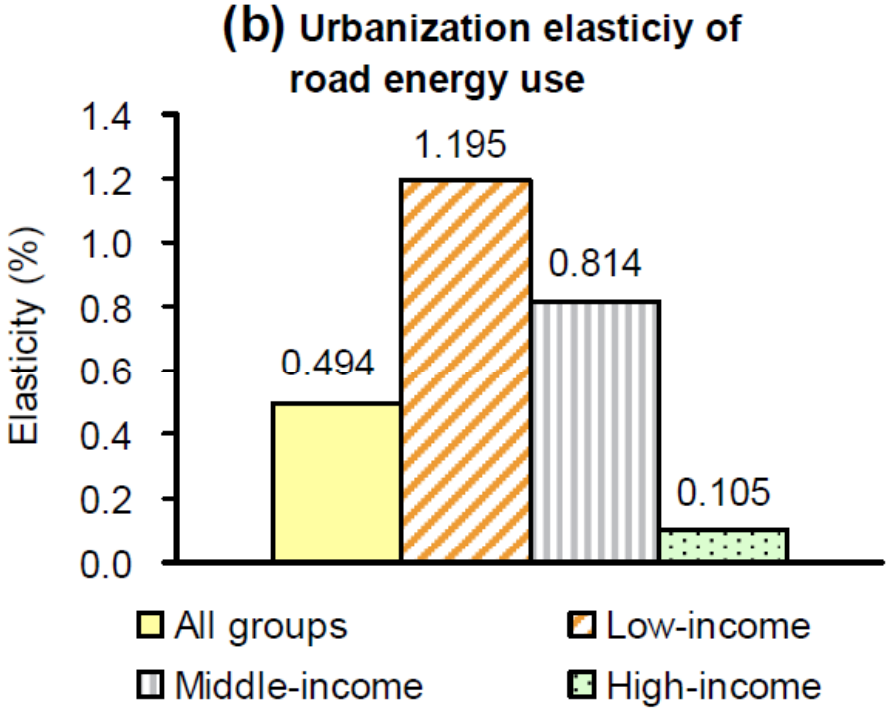
Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model and a sample of 88 countries for the period 1975–2005

Poumanyvong and Kaneko, 2010, Ecological Economics.



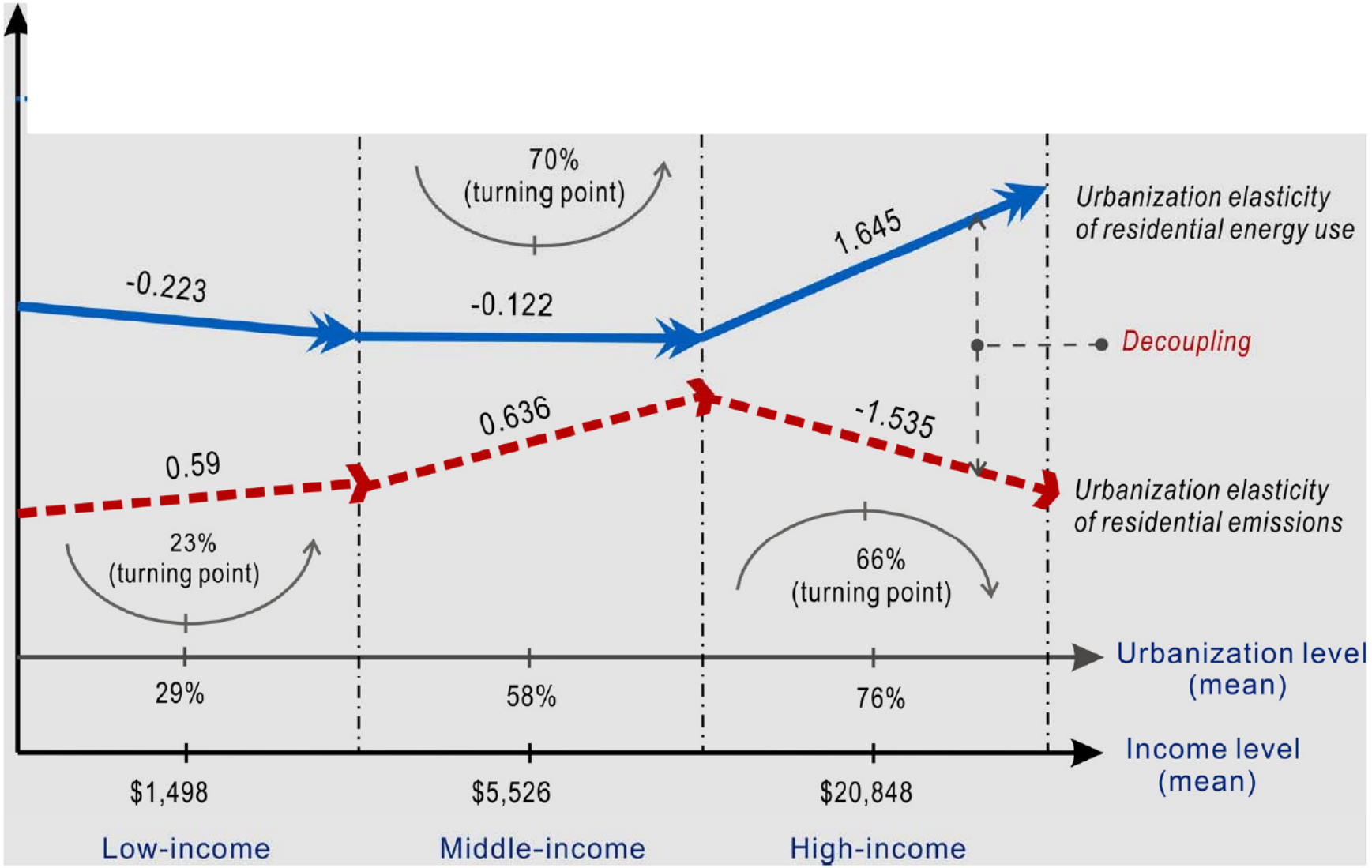
Urbanization elasticity of transport and road energy use





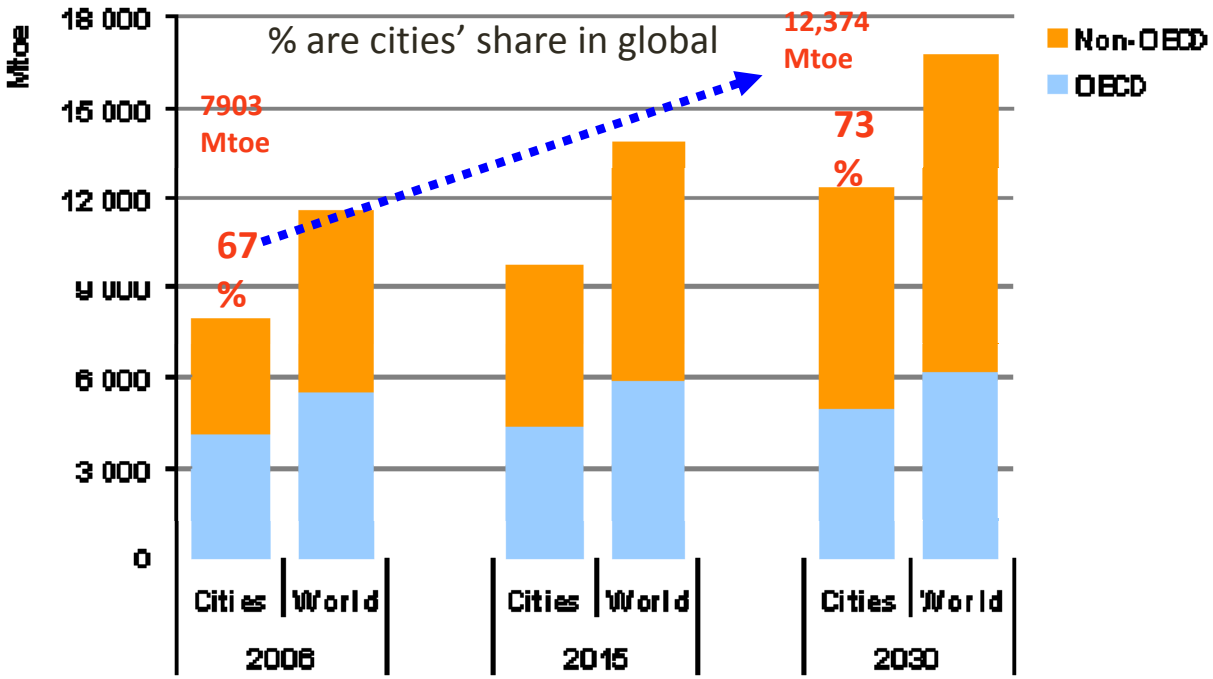
Poumanyvang, Kaneko, and Dhakal, 2012, Energy Policy

Impact of urbanization on national residential energy use and emissions



Under publication, do not quote…Phetkeo Poumanyvang, Shinji Kaneko, Shobhakar Dhakal

Urban contribution to global primary energy demand and CO2 emissions

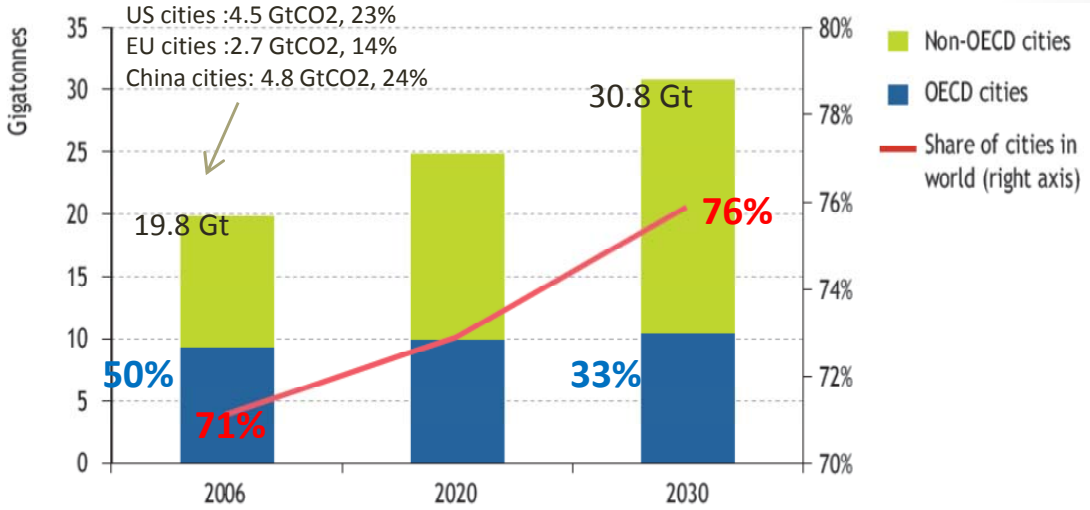


81% cumulative increase in 2006-2030 come from non-OECD countries

Source: WEO, 2008

Out of 12.6 GtCO2 global CO2 addition in next 25 years, cities contribute 11 Gt or 87%

89% of cumulative increase in 2006-2030 in urban CO2 comes from non-OECD countries



Urban contributions to regional/national CO2 emissions, 2006

Urban's national primary energy contribution

- USA : 80% (2006), 87% (2030)
- EU: 69% (2006) 75% (2030)
- China: 75%
- Australasian cities': 78% to 80%

Urban's national CO2 contribution

- China 85%
- USA 80%
- Europe 69%

Urban per capita CO2 < regional/national averages in developed world but far greater in China and developing countries as a whole

(WEO, 2008; Dhakal 2009; Parshall et al 2009)

Challenge/opportunities for managing urbanization

- Ensuring 'quality' of urbanization in **new developments-** avoiding a lock-in to the wrong path (urban form , urban infra, urban design)
  - Global urban land could expand by 1.5 mn sq km by 2030 from 2000 (France + Germany + Spain) Seto et al (2011). PLoS ONE 6(8): e23777. doi:10.1371/journal.pone.0023777
  - 2.8 billion additional urban population by 2050
- Reorienting investments in green urban infrastructure systems and other measures to enhance the efficiency in **existing cities**
  - Infra replacement cycles, enhancing urban energy system, Urban design and transportation infrastructure, buildings and energy efficiency, co-benefits

GHG emissions in cities and urban agglomerations

- Role of large-size cities are important (despite urban agglomeration less than 500,000 population size account for 48% of total urban population for the year 2005)
  - 50 largest cities is eqv to 3rd largest emitter after China and USA
  - China: 35 largest and key cities representing 18% population account 40% of energy-related CO2 (Dhakal, 2009)
  - United States: 20% of trans & res CO2 from 10 largest metro areas (Brown et al 2008)
  - Thailand: Bangkok City with 9% of country's population (5.7 mn) emit 26% of CO2 from energy use in 2005 (Aumnad and Dhakal, forthcoming)
- But the role and function of city matters
  - Tokyo with 10% of Japan's population emit 4% of nation's all GHG emissions

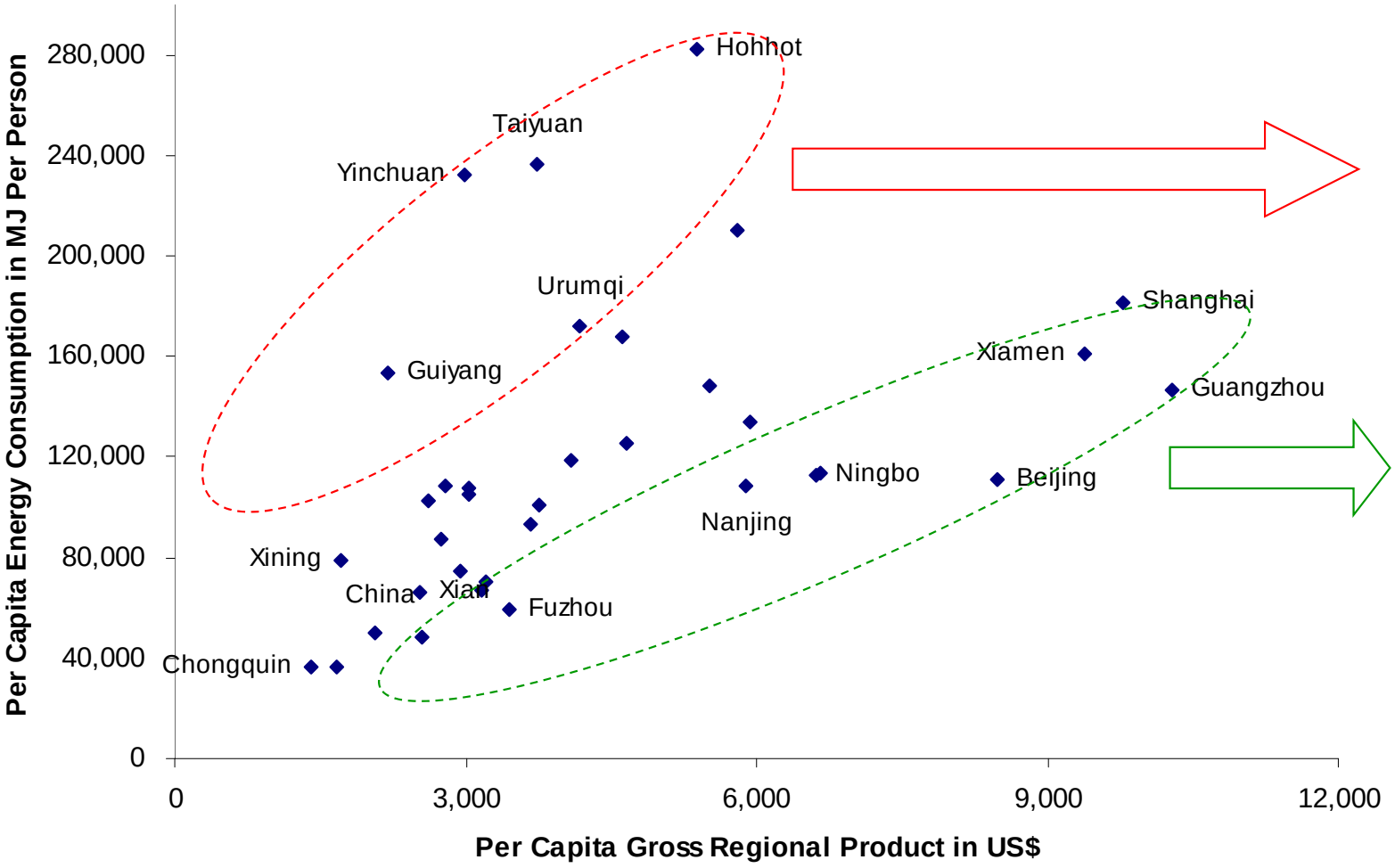
Dhakal (2010). Current Opinion in Environmental Sustainability, DOI:10.1016/j.cosust.2010.05.007

GHG emissions in cities and urban agglomerations- what we know?

- Large variations in the scale of the total and the per capita emissions across cities
  - United States: for only transport and residential sectors, per capita highest in Lexington (3.5 tons) and lowest in Honolulu (1.4 tons) in 2005 within 100 metropolitan areas (Brown et al, 2009)
- Cities seem to evade the usual developing and developed country substantiation
  - Per capita CO2 emissions of Beijing, Shanghai, Tianjin and Bangkok are higher than Tokyo, New York City, and Greater London
- How to compare cities then?
- How to get perspective on urban development patterns and CO2 emissions relations from meta-analyses?

Dhakal (2010). Current Opinion in Environmental Sustainability, DOI:10.1016/j.cosust.2010.05.007

Varying energy-economy pathways within China's cities

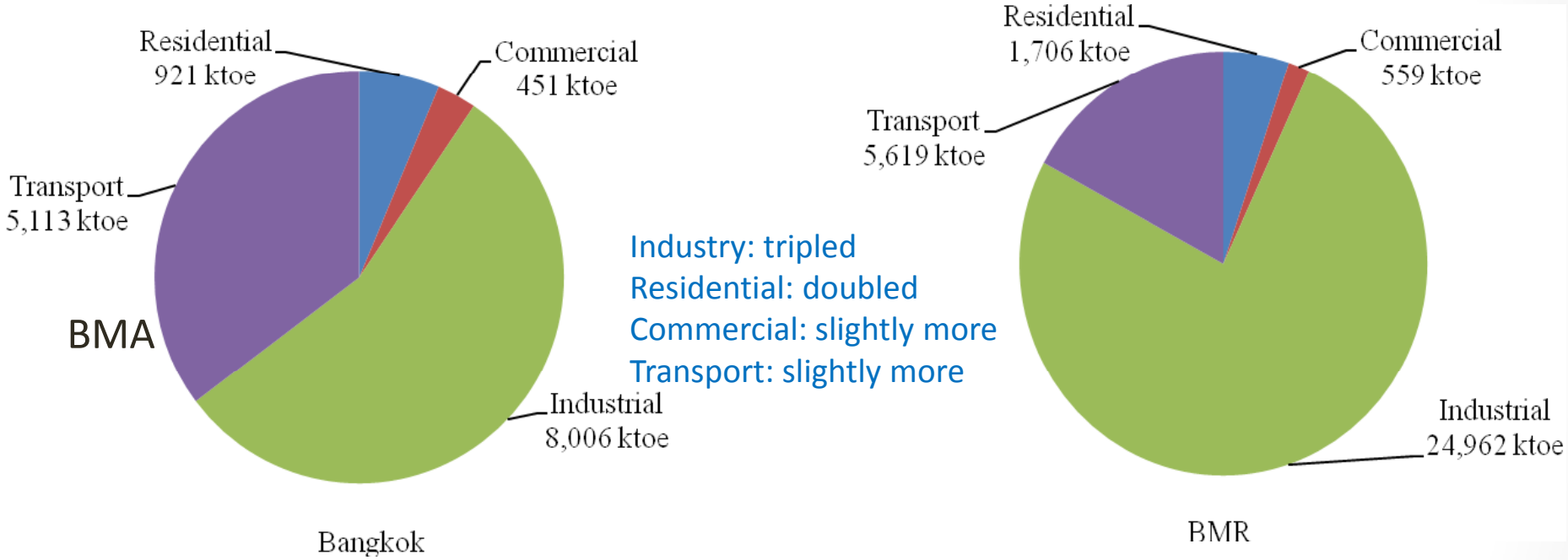


High energy intensive: with energy intensive industries and climatically cooler

Low energy intensive: Cities in eastern/southern part of the country with strong presence of service industries, close to coast and warmer climate

Dhakal (2009), Energy Policy, doi:10.1016/j.enpol.2009.05.020

Urban admin boundary vs agglomeration understanding



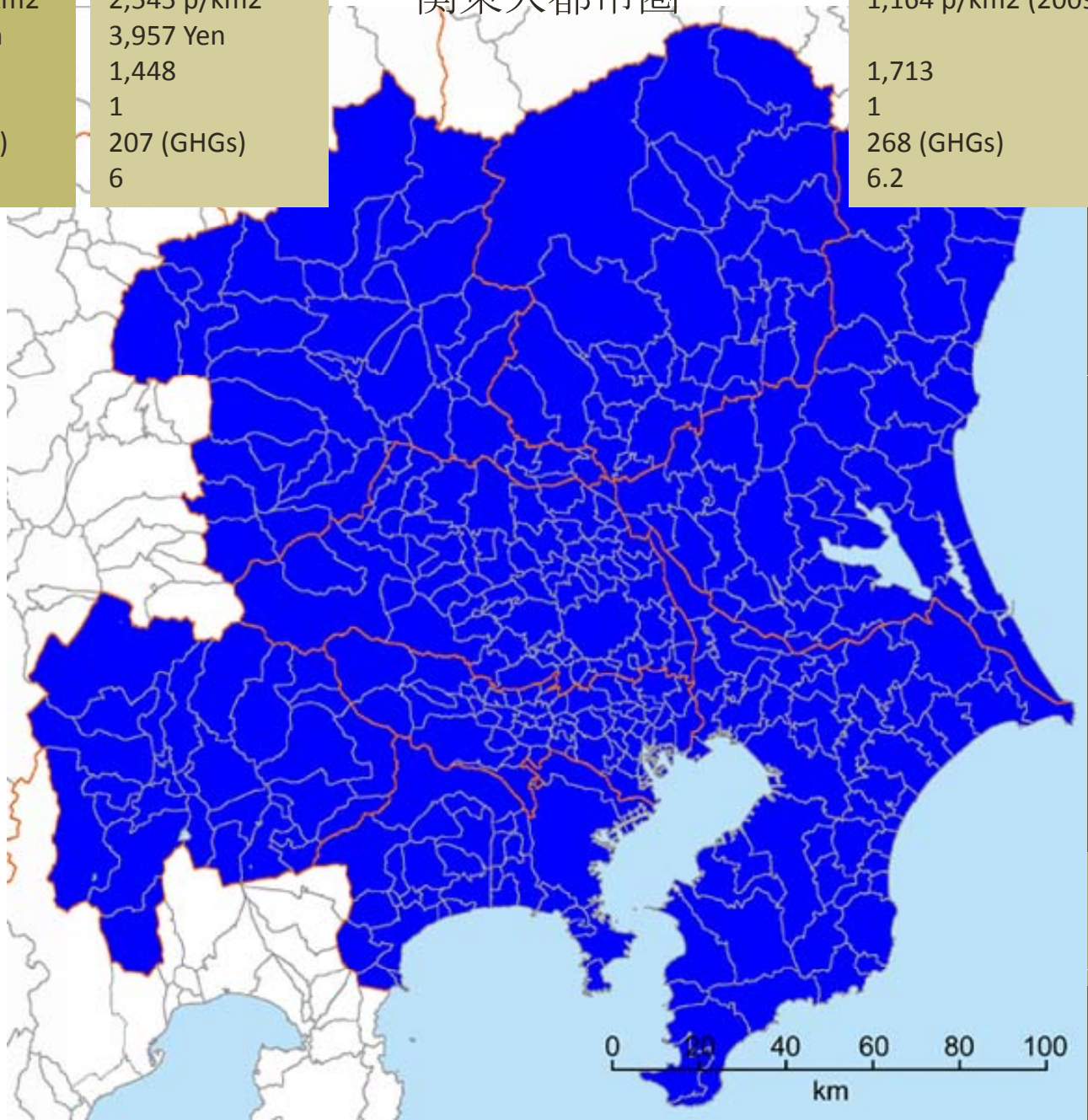
Energy demand in BMA and BMR, 2005- admin boundary based common perception can skew real picture

Bangkok Metropolitan Region (BMR) encompasses of Bangkok and five neighboring provinces, including Nonthaburi, Samut Prakan, Pathum Thani, Samut Sakhon and Nakhon Pathom.

Aumnad and Dhakal, manuscript under preparation

	Tokyo 23 wards	Tokyo Government "Tokyo or Tokyo City"	Greater Tokyo Area (Tokyo, Saitama, Chiba, Kanagawa)	Kanto Major Metropolitan Area (all municipalities with at least 1.5% of their population aged 15 and above commuting to Yokohama, Kawasaki, Sagamihara, Chiba, and Saitama or the 23 special wards)	National Capital Region (8 prefectures)
		東京圏			首都圏
Pop	8.49 mn	12.55 mn*	34.48 mn	34.6 mn (2000)	42.9 mn (2009)
Area	617 km2	1,779 km2*	13,547 km2	関東大都市圏	36,889 km2 (2009)
Density	13,770 p/km2	7,063 p/km2	2,545 p/km2		1,164 p/km2 (2009)
Av income hh (th)	4,600 Yen	4,225 Yen	3,957 Yen		
GRP (Bn US$, real)		815	1,448		1,713
Day/night pop	1.33	1.2	1		1
CO2 emissions MT CO2-e		63 (GHGs)	207 (GHGs)		268 (GHGs)
Per capita CO2, Tons		5	6		6.2

All data refers of 2005 unless otherwise indicated
*excluding islands



Picture and NCR data are from http://en.wikipedia.org/wiki/Greater_Tokyo_Area

Stylized hierarchy in urban energy-GHG drivers and policy leverages

Decreasing order of importance

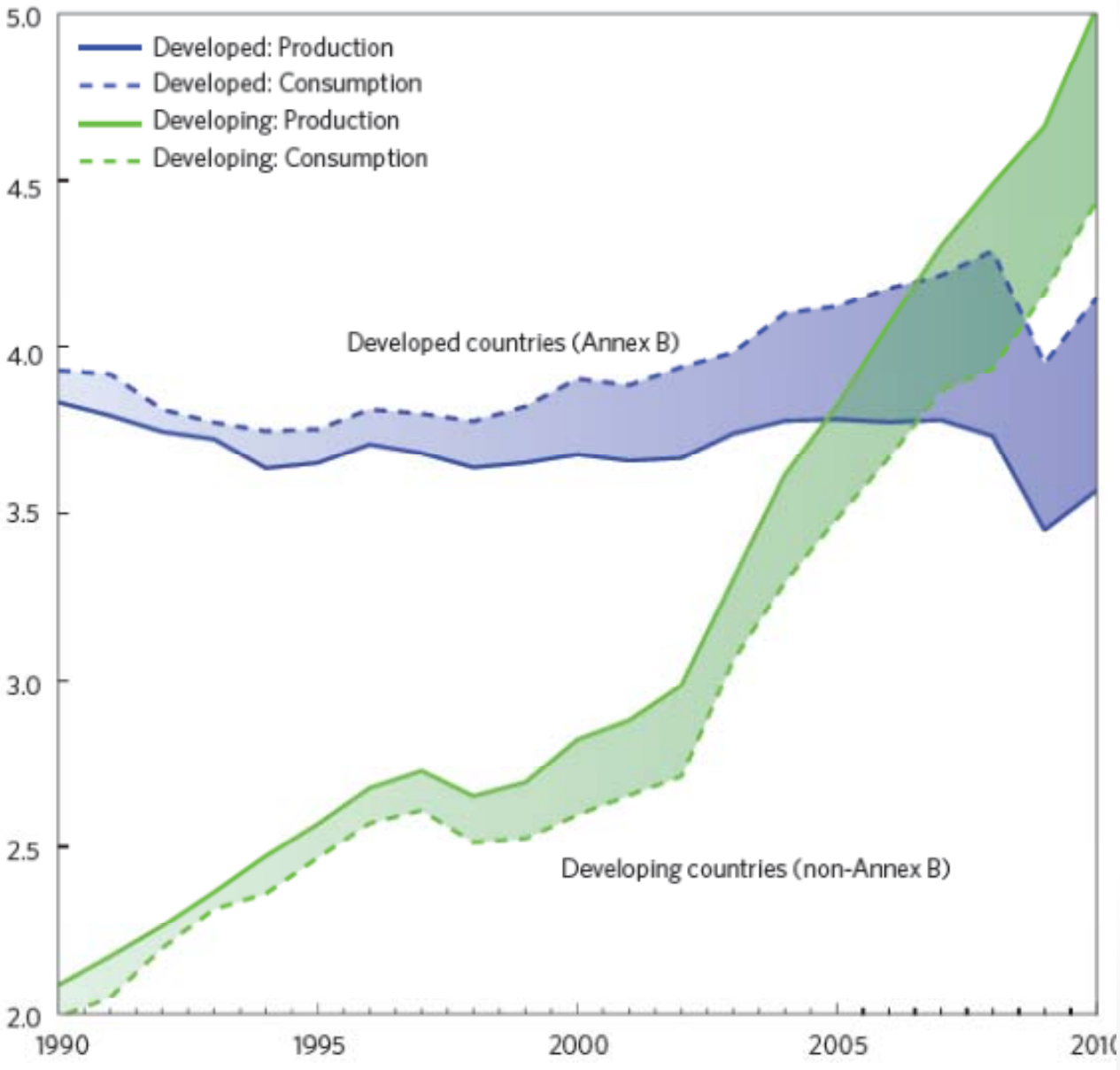
1. Spatial division of function (trade, industry structure)
2. Income (consumption)
3. Urban form (density↔public transport↔car ownership↔functional mix)
4. Efficiency of energy end-use (buildings, processes, vehicles, appliances)
5. Fuel substitution (imports)
6. Energy systems integration (co-generation, heat-cascading)
7. Urban renewables

Largest improvements come from systemic change

…but it requires overcoming policy fragmentation and dispersed, uncoordinated decision taking- needs to fix governance aspects

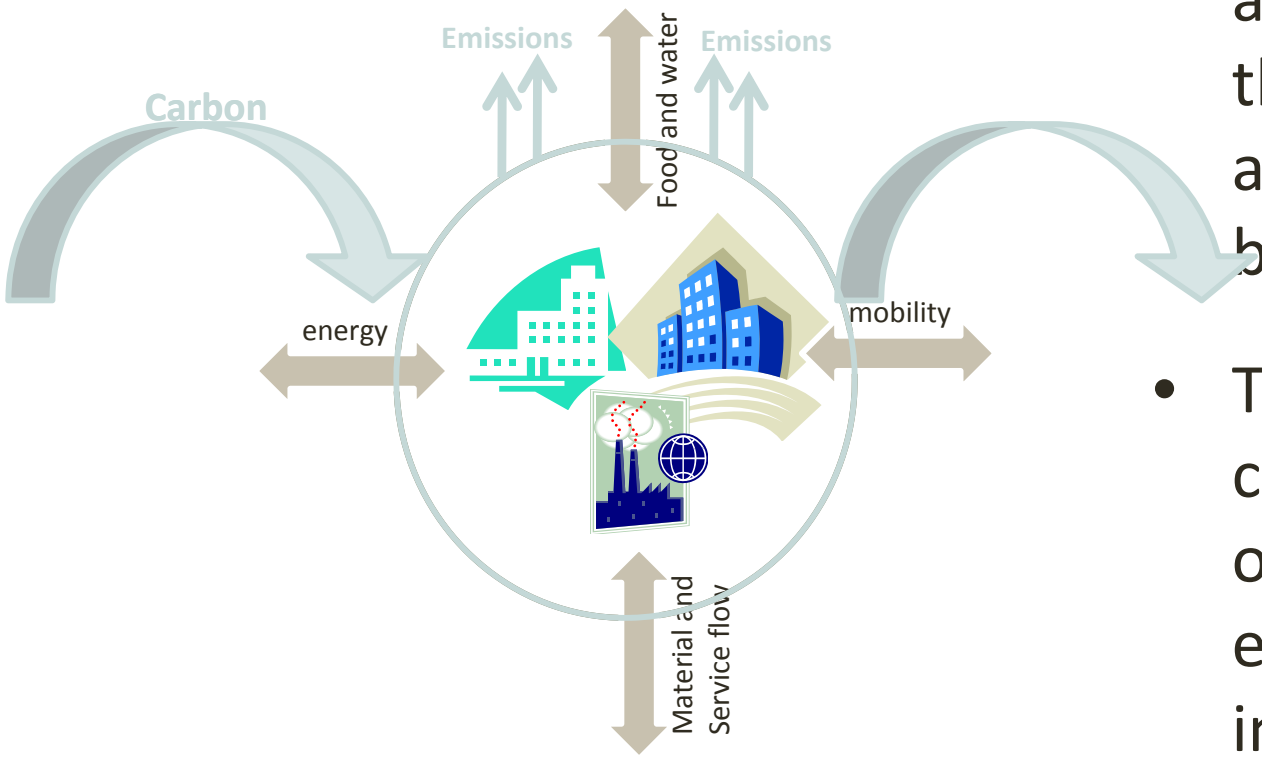
Increasing level of urban policy leverage

Fossil fuel CO_2 emissions (GtC)



Peters et al. 2011, Nature CC

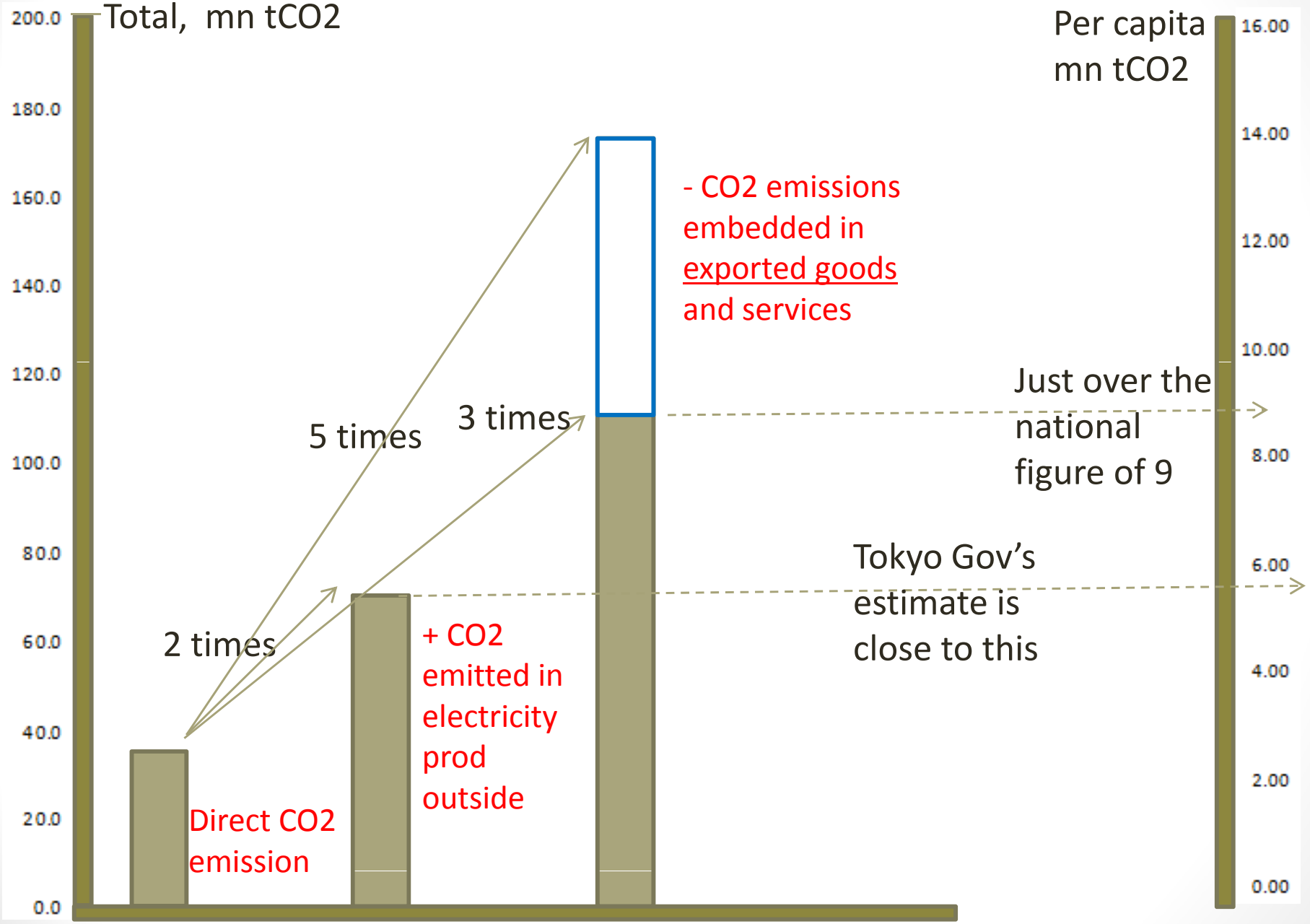
City as a complex open system



- The catchment of urban activities goes beyond the administration or agglomeration boundary
- The indirect/embodied carbon emissions flows overwhelm total carbon emissons (direct + indirect carbon)

Tokyo for illustration

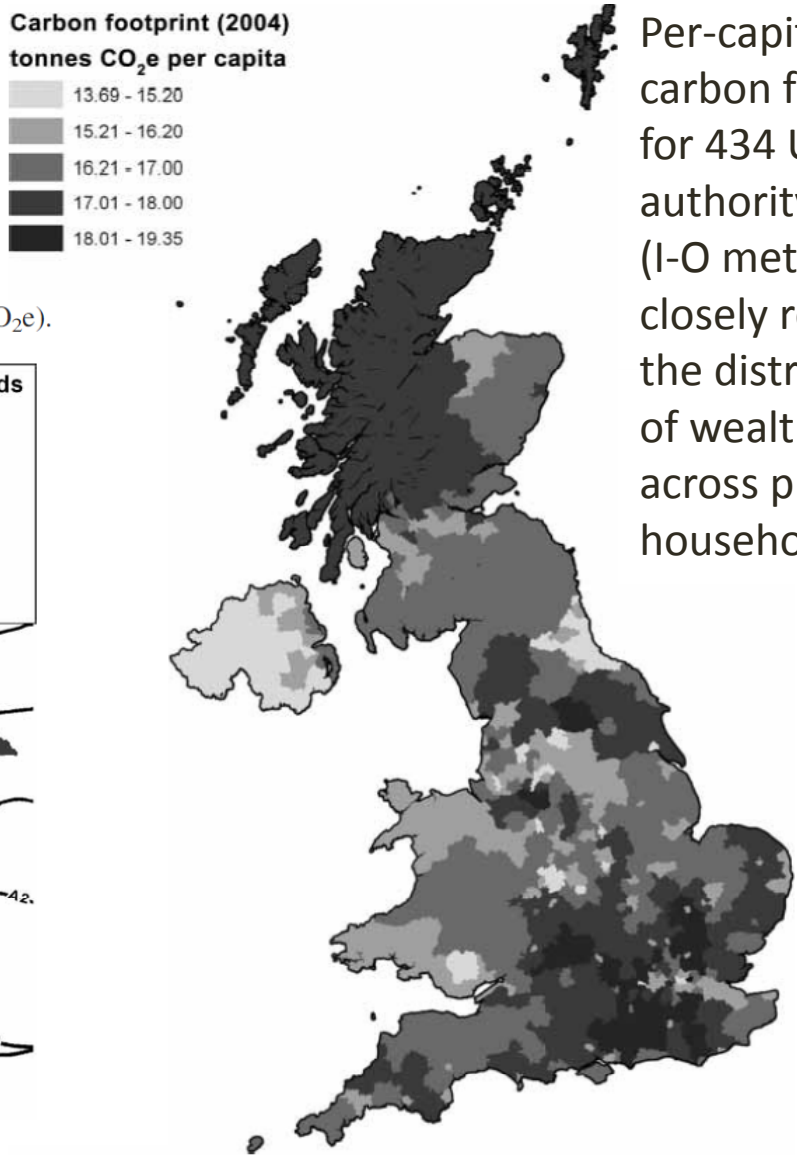
Tokyo direct + indirect CO2 emissions
Using Economic I-O analyses



Kaneko & Dhakal (2012), donot quote, under publication

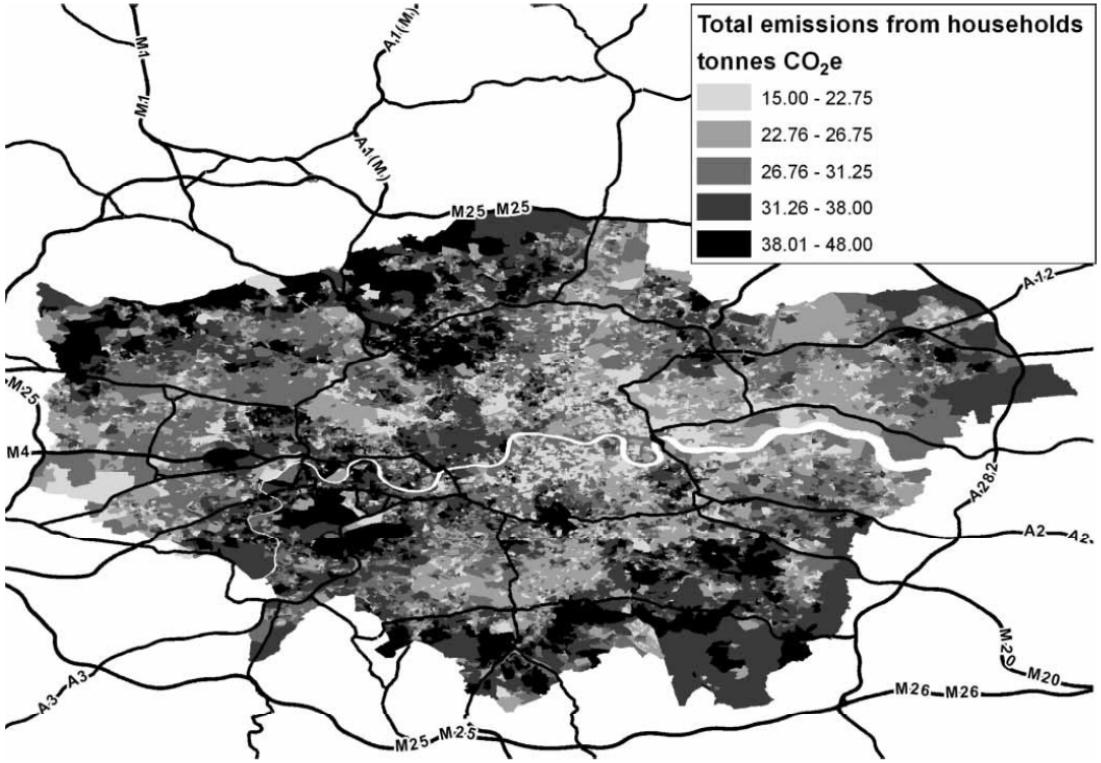
Carbon footprint of UK local authority areas

London's 2008 Official figure: 5.8 tCO2e



Per-capita carbon footprint for 434 UK local authority areas (I-O methods) closely related to the distribution of wealth across private households

FIGURE 11. Per-household carbon footprint of London by Super Output Area in 2004 (t CO_2e).



Jan Minx et al. 2009, Economic Systems Research, 2009, Vol. 21(3)
SEI, 2007

Why consider out-of-boundary items?

- Logic: Electricity produced "outside" is already being counted; boundary is blurred
- More holistic: Per capita city-scale emissions from in boundary activities typically less than national per capita in developed countries
- City comparison makes a better sense: Can we otherwise compare Shanghai with London? Not to penalize industrial cities in low carbon debate !!!!
- Avoid Perverse Incentives: Avoid crediting emission shifts to the "outside": e.g., hydrogen fueled transport
- Create win-win policies: Incentivize cross-boundary, cross-sector policies: e.g., sustainable food diets, green concrete, ICT strategies (e.g., teleconferencing)
- Communicate consistently with public: Consistently include major human activities at all scales from personal-scale to city-scale to national-scale

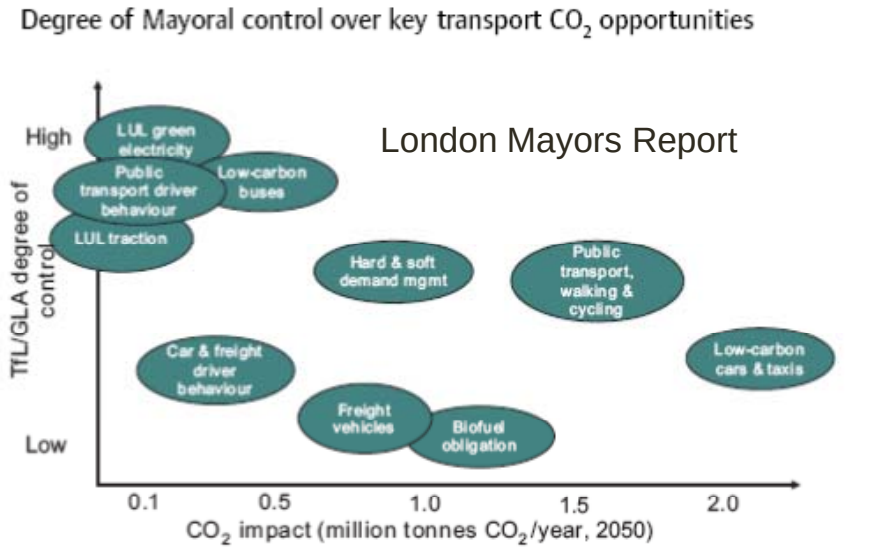
Adapted from Kennedy, Ramaswami, Carney and Dhakal, 2009 (URS 2009 Symposium, Marseille, The World Bank)

Key messages

- **Unprecedented urbanisation**: Past and future: immense implications to the low-carbon future
- **Three key avenues**: (a) Rapidly urbanizing developing world with new infrastructure (b) Retrofitting or re-engineering existing cities (c) behavioral changes
- A new framework/criteria to define and compare low carbon cities, transitions, responsibilities, and actions needed
- **Challenges are many**
  - Systems understanding (accounting/modeling, clear view of responsibility, visioning low carbon pathways)
  - Addressing systemic and structural issues
  - Enhancing governance for low carbon urban development
  - Research policy dialogues/interfacing

Future research needs

- Various configurations of low carbon city, especially maximizing “spatial aspects” and structural reorganization of cities
- Understanding of carbon emissions and mitigation potentials at urban agglomeration level for optimized urban carbon strategies ‘in addition to the administrative unit’- where, who and how?
- Understanding of urban system as an open system with extensive cross boundary interactions for food, water, energy, mobility, material and services.
  - City wide understanding of the embedded emissions and carbon responsibility. New methodologies and overcoming data barriers
- New matrix/criteria/method to evaluate/compare cities’ emissions performance- **<u>new framework for low carbon cities</u>**



Future research needs

- More city case-studies, especially in the developing world
- Scaling up to derive patterns: Understanding of urban development pathways and their GHG consequences for various urban typologies

- key avenues: (a) Rapidly emerging developing world with new infrastructure (b) Retrofitting or re-engineering existing cities

Thank you !!

Comparative advantages of developing country cities

- Lifestyle is yet modest- re-orienting some of the trends may not impossible if difficult- people are getting more aware of West's problems
- Cities are being built and resource base is increasing- window of opportunities is narrowing yet exists
- Co-benefits and low hanging fruits- plenty available yet
- Late-comers' advantage - technology and knowledge
- Greater flexibility-space in shaping economic growth-sustainability relations- e.g West has no opportunity to increase emissions developing countries' have such opportunities
- Serious policy initiatives can make huge impacts- enabling environment and sound governance are key urgent needs