

A mission oriented approach in Horizon Europe

Climate-neutral and smart cities

Paulo Ferrão

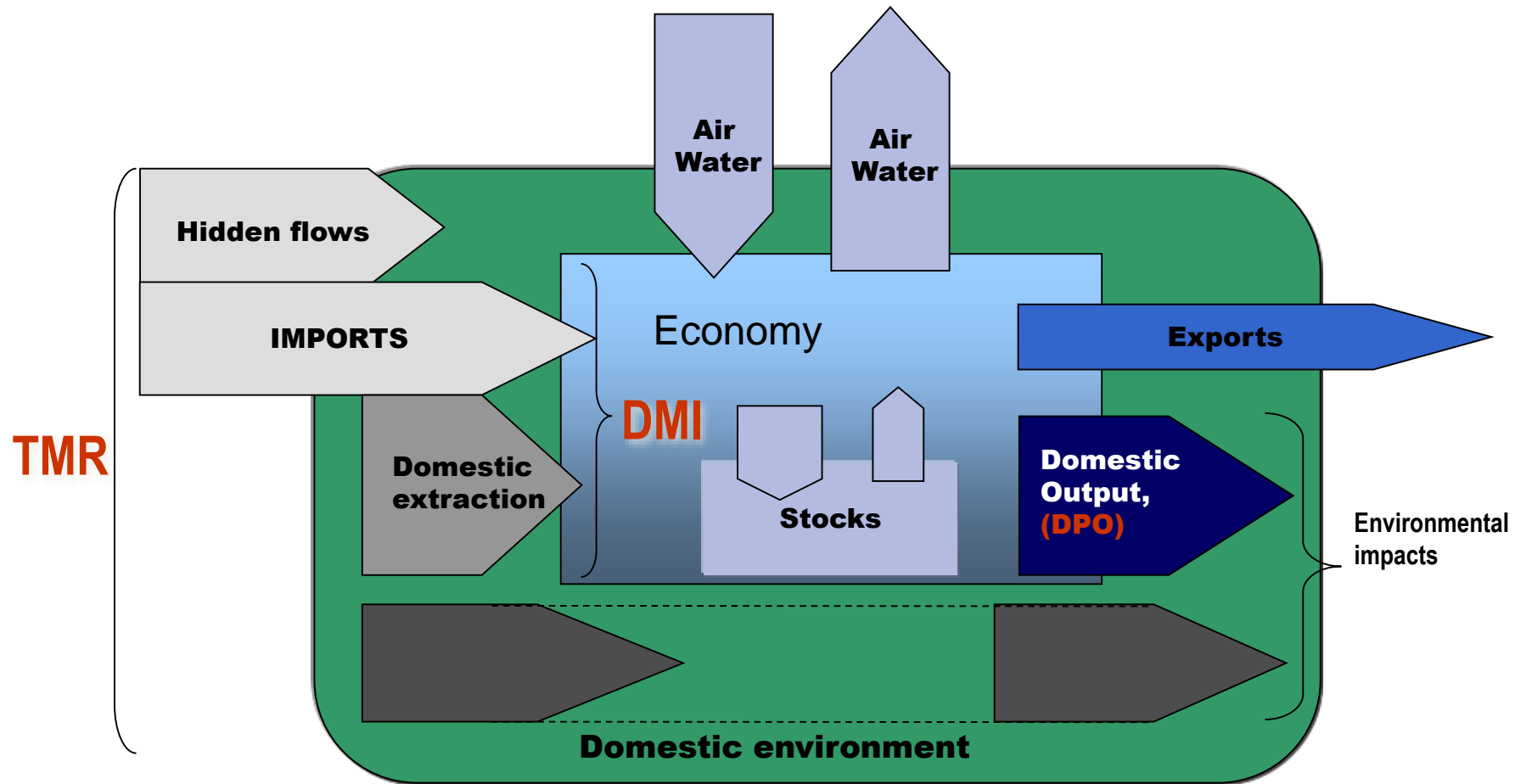
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Mariana Mazuccato,

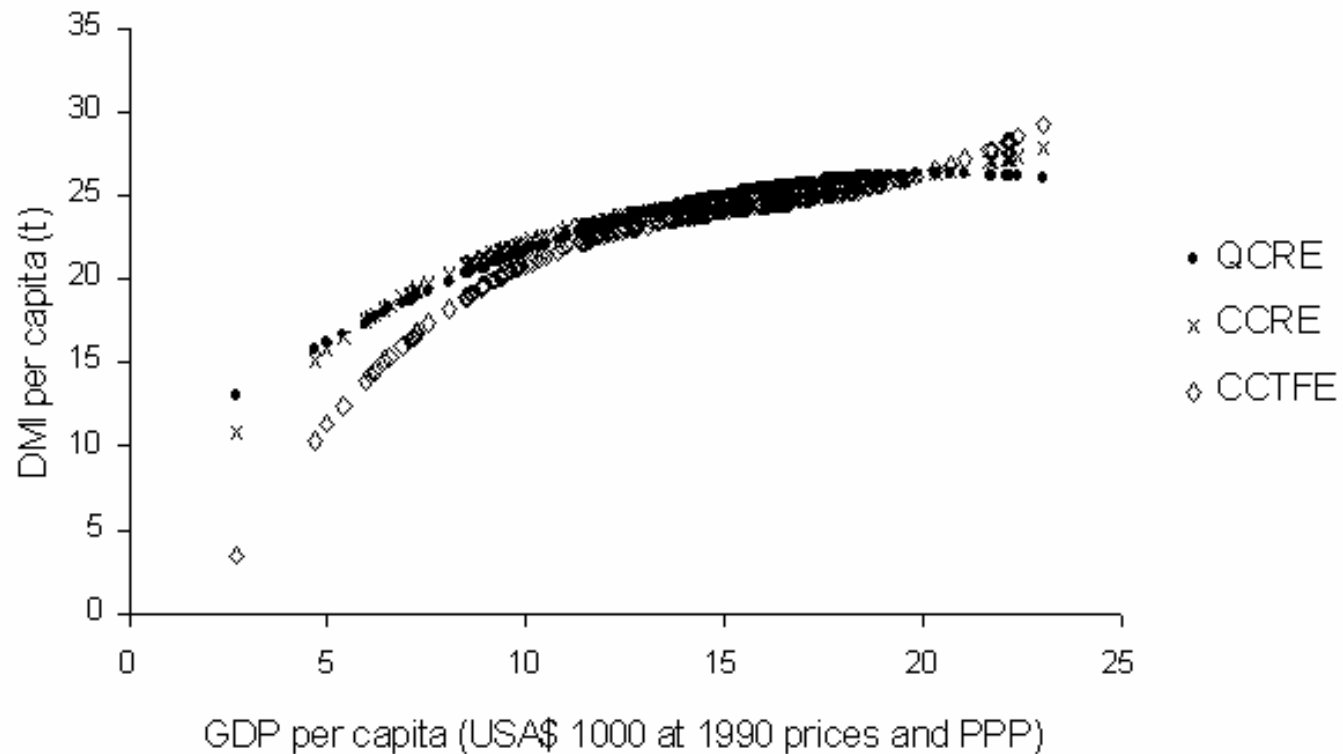
MISSIONS SHOULD :

- have ambitious but realistic research and innovation actions
- be Bold, inspirational, with wide societal relevance
- have a clear direction: targeted, measurable, and time-bound
- drive multiple, Bottom-up solutions.
- be cross-disciplinary, cross-sectoral, and cross-actor innovation;

Material Flow Analysis



A Kuznets curve for resources consumption - NATIONS



$$dmi_{it} = \beta_0 + \beta_1 y_{it} + \beta_2 y_{it}^2 + \varepsilon_{it}$$

Canas, A., Ferrão, P. and Conceição, P. (2003) "A new environmental kuznets curve? Relationship between direct material input and income per capita: evidence from industrialized countries". *Ecological Economics*. Volume 46, Issue 2, September 2003, Pages 217-229.

Urbanization and Sustainability

Urban Population

- Greater than 75%
- 50% - 75%
- 25% - 50%
- Less than 25%

URBAN WORLD 1980

unicef

AN URBAN WORLD

This graphic depicts countries and territories with 2050 urban populations exceeding 100,000. Circles are scaled in proportion to urban population size. Hover over a country to see how urban it is (percentage of people living in cities and towns) and the size of its urban population (in millions).

Urban Population

- Greater than 75%
- 50% - 75%
- 25% - 50%
- Less than 25%

1980

United States
169M

Brazil
80M

Russian
Federation
97M

China
190M

Japan
70M

India
160M

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URBAN WORLD 2010



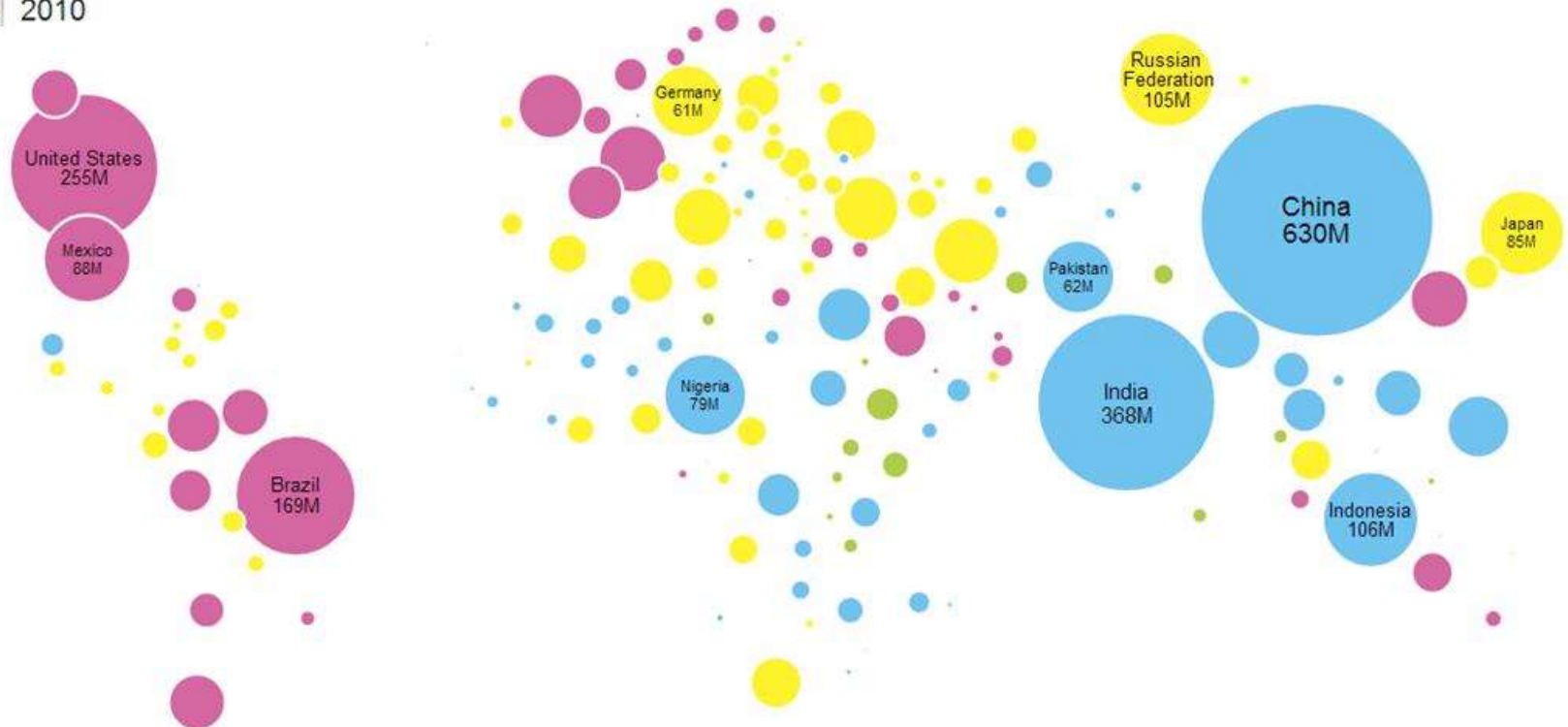
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2010



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URBAN WORLD 2050



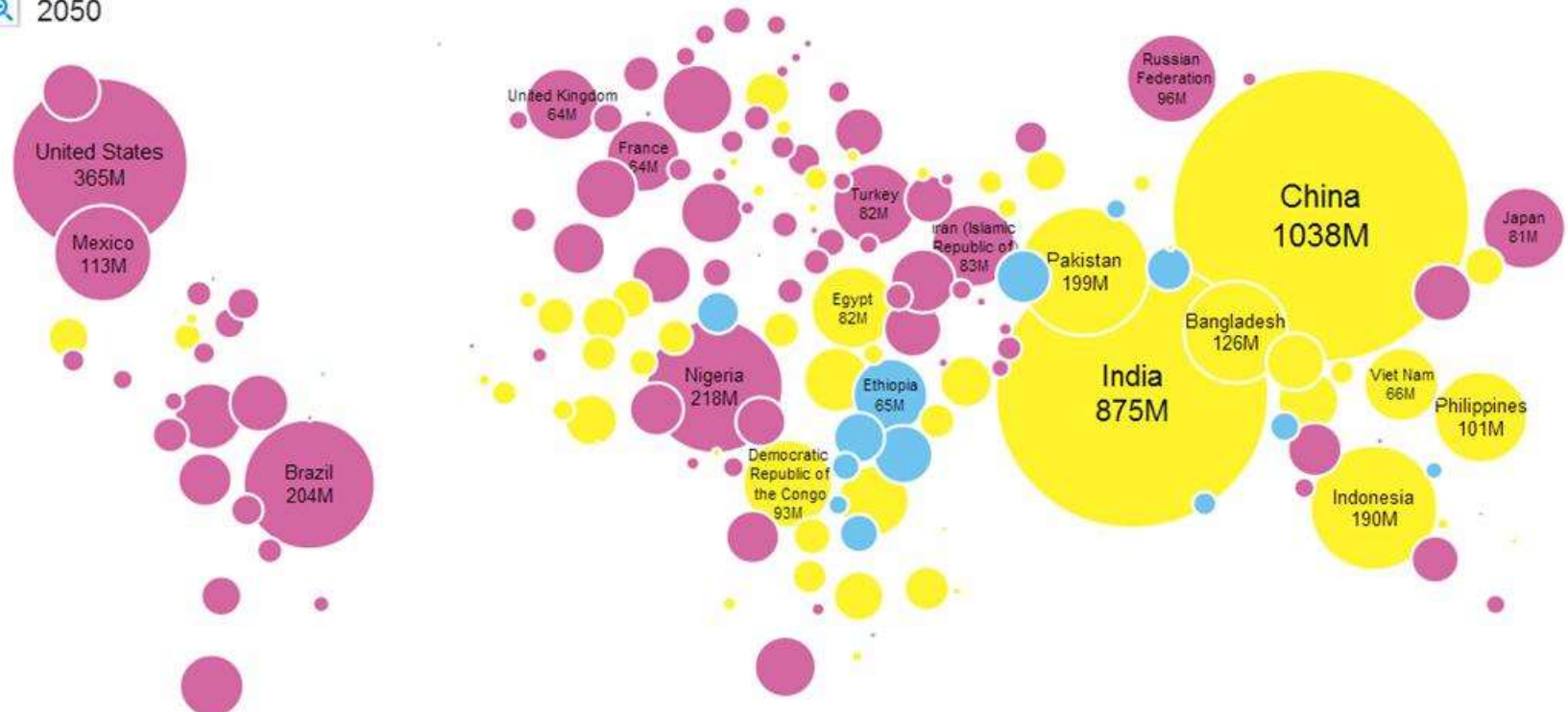
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Urban Population

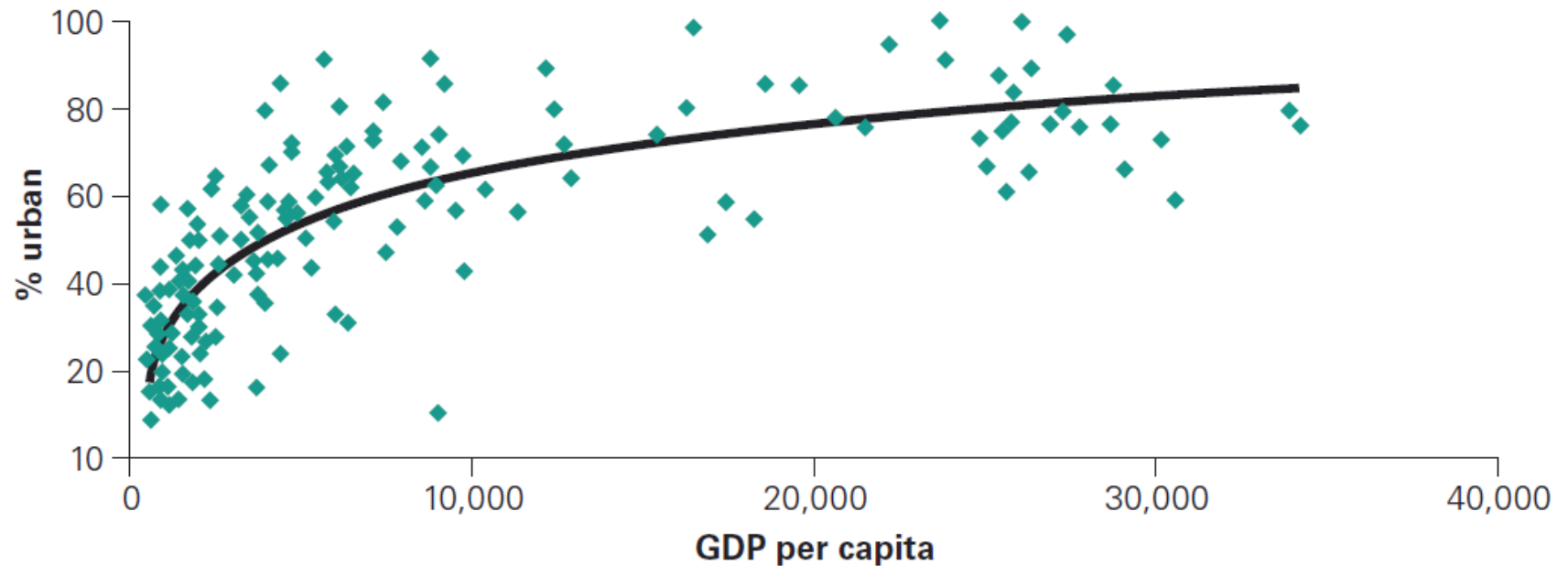
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2050



The Urban Century

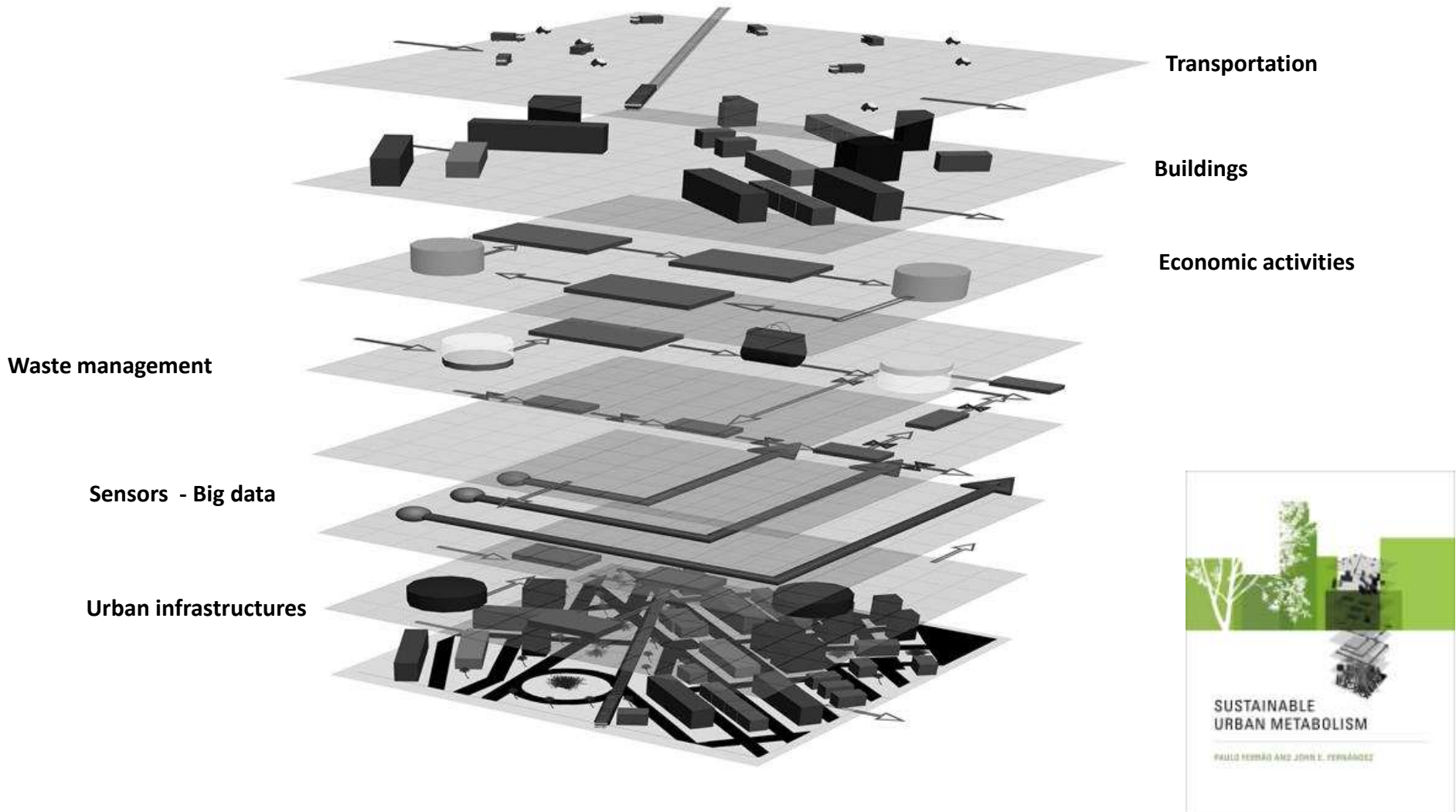
Urbanization and Per Capita GDP across Countries, 2000 (1996 US\$)
World Bank 2009



Source: Data on urbanization: World Bank World Development Indicators 2005. Data on per capita GDP: Heston, Summers, and Aten n.d.; Penn World Table Version 6.2; Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, real 1996 GDP per capita (chain), September 2006 (<http://pwt.econ.upenn.edu/>).

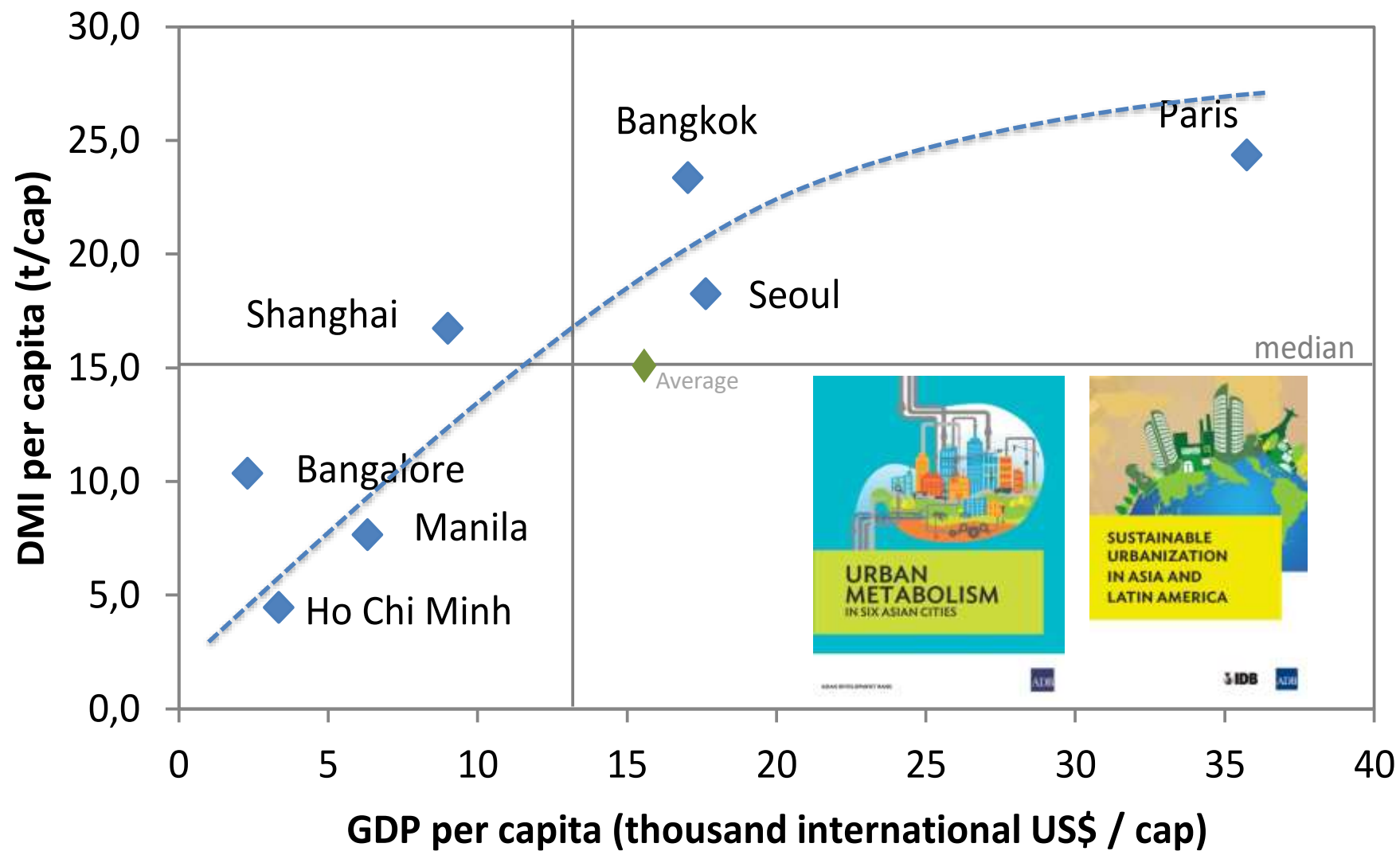
Urban Systems - complexity

Need for an interdisciplinary approach



Paulo Ferrão and John Fernandez (2013) "Sustainable Urban Metabolism", **MIT-Press**. ISBN: 9780262019361, 232 pages.

Urban metabolism – “From Ho Chi Minh to Seoul”



ADB (2014) “Urban Metabolism in Six Asian Cities”

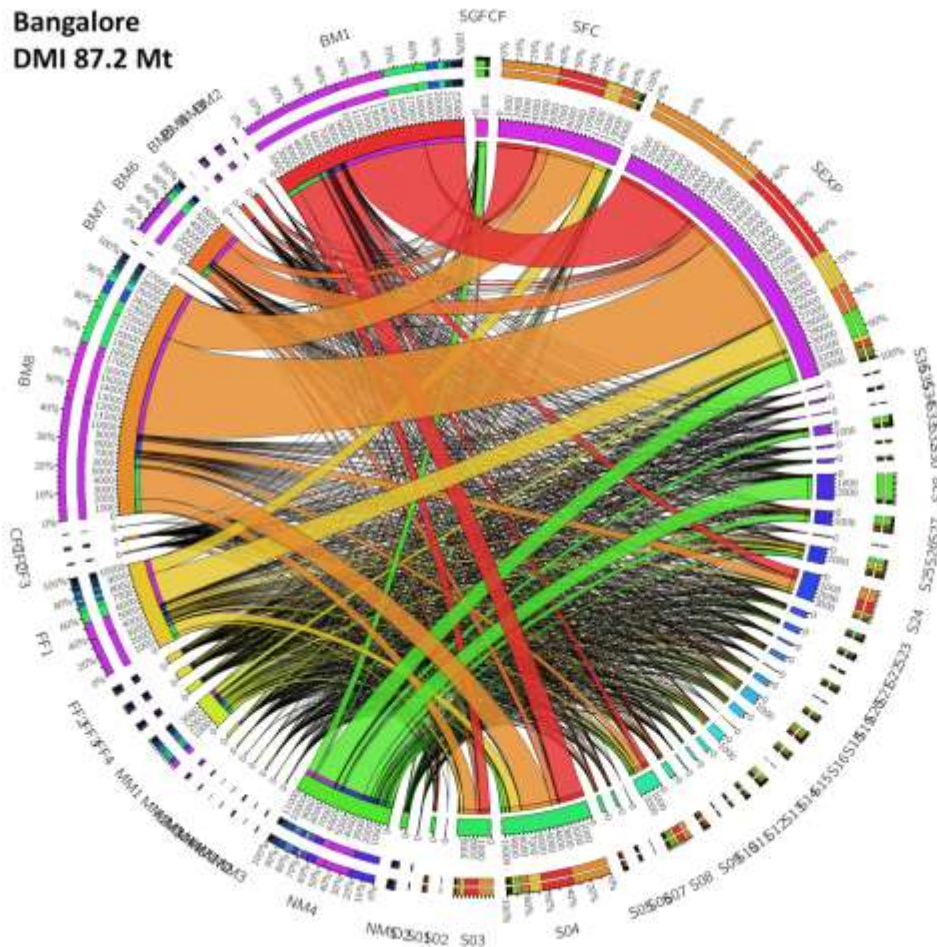
ADB, IDB (2014) “Sustainable Urbanization in Asia and Latin America”

Urban metabolism of Bangalore

- High export share, with 39% of the materials that pass through the city being exported
- The most material intensive sector is the textile products industry
- Low use of materials for Gross Fixed Capital Formation (buildings and infrastructure)
- Biomass materials are responsible for 66% of the DMI of Bangalore

BM1 – Agricultural biomass
 BM2 – Animal biomass
 BM3 – Textile biomass
 BM4 – Oils and fats
 BM5 – Sugars
 BM6 – Woods
 BM7 – Paper and board
 BM8 – Unspecified biomass
 CF1 – Alcohols
 CF2 – Chemicals and pharmaceuticals
 CF3 – Fertilizers and pesticides
 FF1 – Low ash fuels
 FF2 – High ash fuels
 FF3 – Lubricants and oils and solvents
 FF4 – Plastics and rubbers
 MM1 – Iron, steel alloying and ferrous metals
 MM2 – Light metals
 MM3 – Non-ferrous heavy metals
 MM4 – Special metals
 MM5 – Nuclear fuels
 MM6 – Precious metals
 NM1 – Sand
 NM2 – Cement
 NM3 – Clay
 NM4 – Stone
 NM5 – Others
 O1 – Non-specified
 O2 – Liquids

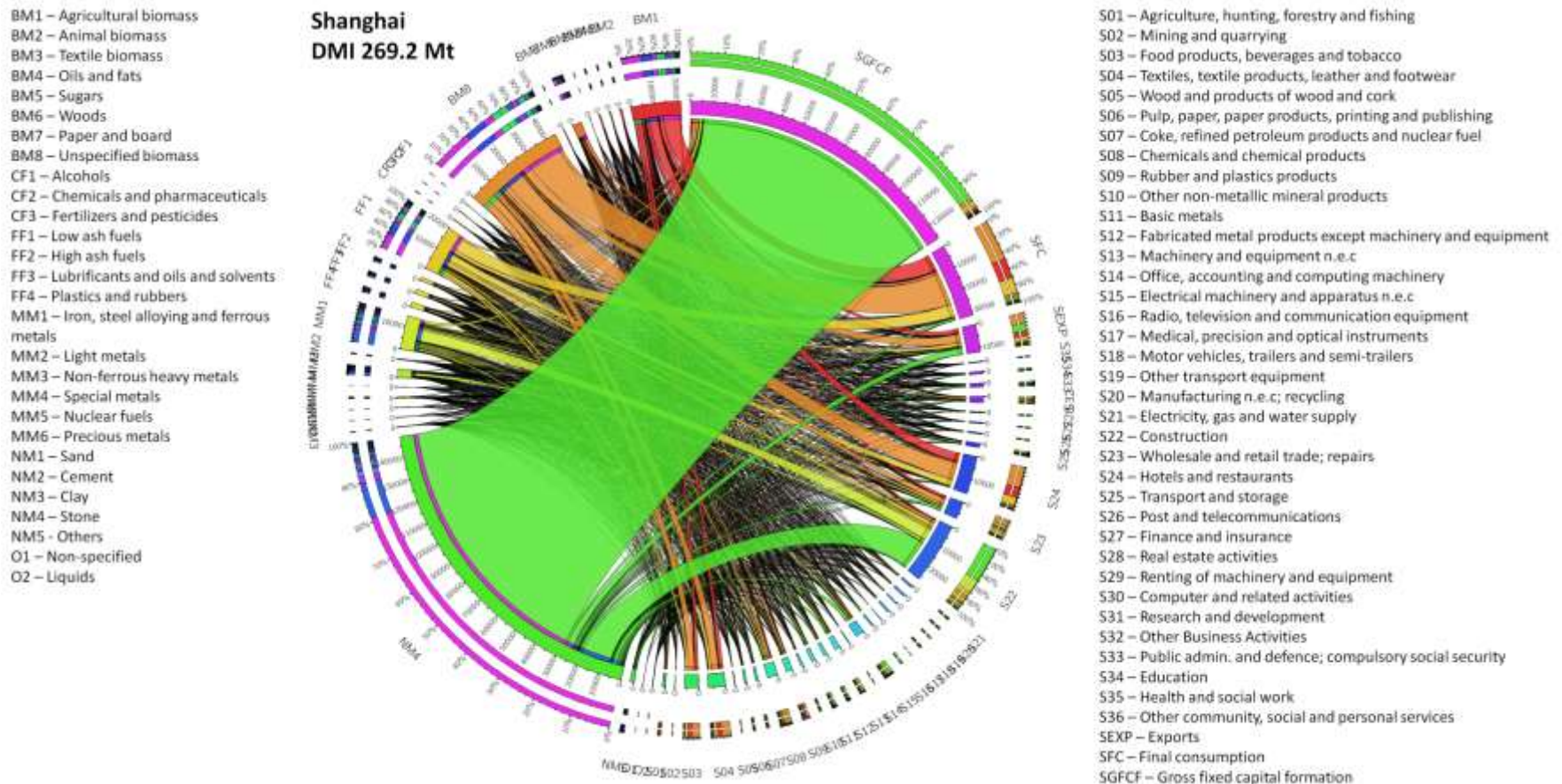
Bangalore
DMI 87.2 Mt



S01 – Agriculture, hunting, forestry and fishing
 S02 – Mining and quarrying
 S03 – Food products, beverages and tobacco
 S04 – Textiles, textile products, leather and footwear
 S05 – Wood and products of wood and cork
 S06 – Pulp, paper, paper products, printing and publishing
 S07 – Coke, refined petroleum products and nuclear fuel
 S08 – Chemicals and chemical products
 S09 – Rubber and plastics products
 S10 – Other non-metallic mineral products
 S11 – Basic metals
 S12 – Fabricated metal products except machinery and equipment
 S13 – Machinery and equipment n.e.c
 S14 – Office, accounting and computing machinery
 S15 – Electrical machinery and apparatus n.e.c
 S16 – Radio, television and communication equipment
 S17 – Medical, precision and optical instruments
 S18 – Motor vehicles, trailers and semi-trailers
 S19 – Other transport equipment
 S20 – Manufacturing n.e.c; recycling
 S21 – Electricity, gas and water supply
 S22 – Construction
 S23 – Wholesale and retail trade; repairs
 S24 – Hotels and restaurants
 S25 – Transport and storage
 S26 – Post and telecommunications
 S27 – Finance and insurance
 S28 – Real estate activities
 S29 – Renting of machinery and equipment
 S30 – Computer and related activities
 S31 – Research and development
 S32 – Other Business Activities
 S33 – Public admin. and defence; compulsory social security
 S34 – Education
 S35 – Health and social work
 S36 – Other community, social and personal services
 SEXP – Exports
 SFC – Final consumption
 SGFCF – Gross fixed capital formation

Urban metabolism of Shanghai

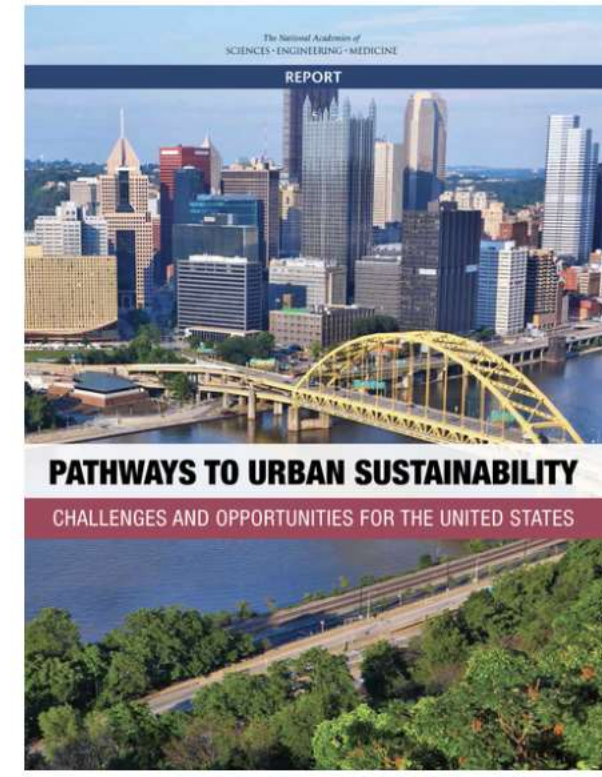
- Low export share, with only 4% of the materials that pass through the city being exported
- Construction, hotels and restaurants, food and textile products are important sectors
- Very high use of materials (47% of DMI) for Gross Fixed Capital Formation (buildings and infrastructure)
- Non-metallic minerals (56% of DMI) and biomass (27%) are the main materials used



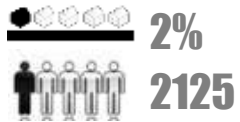
U. S. National Academies of Science

- Urban leaders should integrate sustainability across spatial and administrative scales, from block to city, region, state and the nation.
- Urban leaders should gather scientific input.
- The need for sustainability **indicators and metrics**

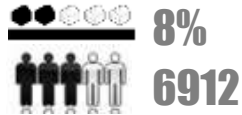
- > Integrated Urban models



From Archetypes to full urban models



R3_SF_C



R4_MF_I



R4_MF_C



R5_MF_C



R6_MF_C

BIM

Building Information Modeling



From Archetypes to full urban models



MODEL INPUTS

CATEGORY	FAMILY	Material	Thick (m)	R (m2.K/W)	k (W/mK)	c_p (J/kg.K)	ρ (kg/m3)	Therm. ϵ	Solar α	Visual α
SuperStructure	Rectangular Footing	Concrete	0,5	0,025	2	840-1040	2300-2400	0,92-0,97	-	-
	Rectangular Beams	Concrete	0,4	0,025	2	840-1041	2300-2401	0,92-0,98	-	-
	Rectangular Columns	Concrete	0,5	0,025	2	840-1042	2300-2402	0,92-0,99	-	-

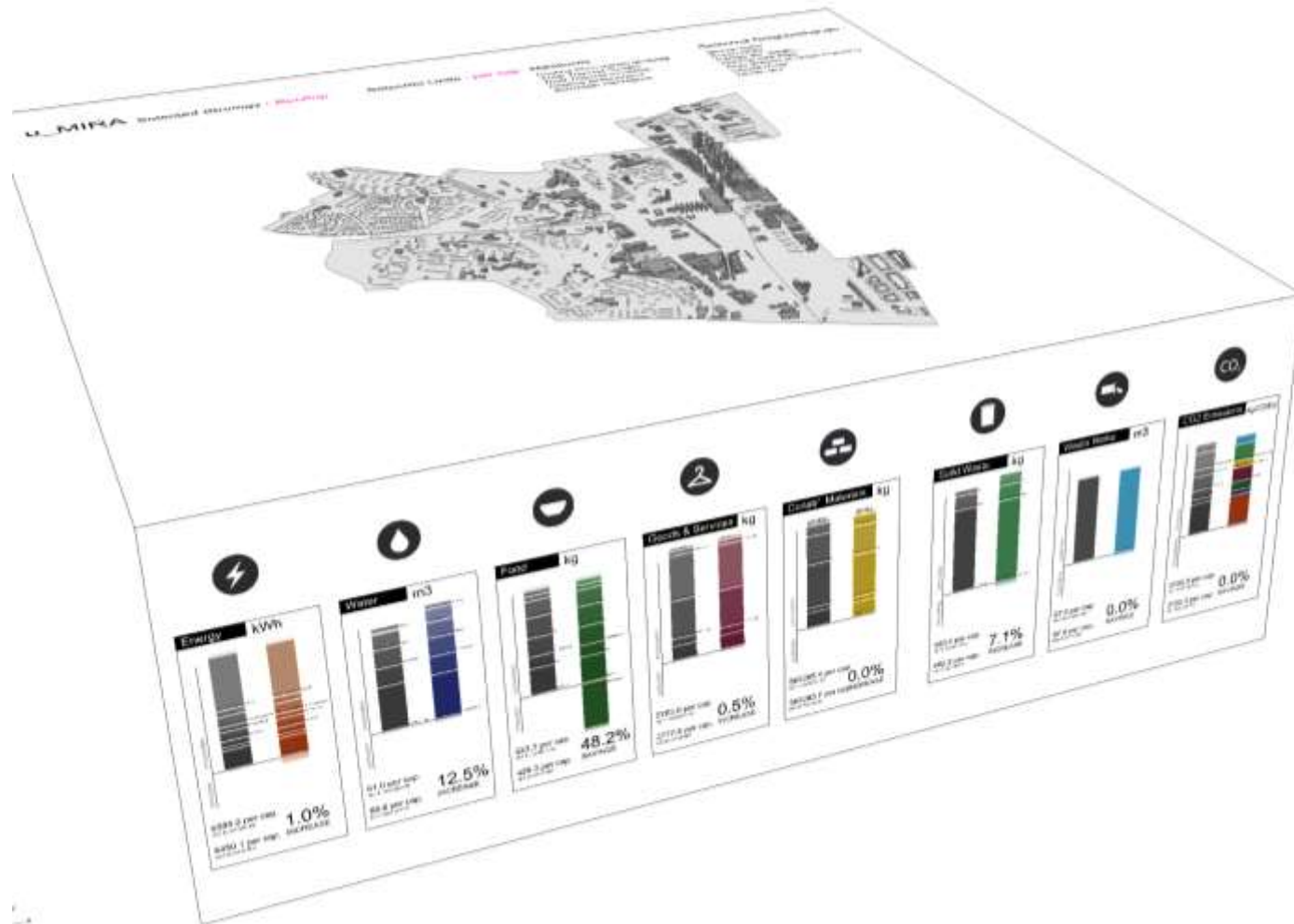
CATEGORY	FAMILY	Material	Thick (m)	R (m2.K/W)	k (W/mK)	c_p (J/kg.K)	ρ (kg/m3)	Therm. ϵ	Solar α	Visual α
Floor	Interior Floor	Ceramic tiles	0,02	0,015	1,3	745	2300	-	-	-
		Reinforced Concrete slab	0,05	0,025	2	840-1040	2300-2400	0,92-0,97	-	-
		Hollow Brick Blocks	0,06	0,146	0,41	920-1000	1000-1200	0,93	-	-
		Finishing - plaster	0,03	0,038	0,8	<1600		0,87	-	-
	Ground Floor	Ceramic tiles	0,02	0,015	1,3	745	2300	-	-	-
		Reinforced Concrete Slab	0,15	0,075	2	840-1040	2300-2400	0,92-0,97	-	-
		Damp-Proofing	0,008	0,007	1,15	920	<2100	-	-	-
		Poor Concrete	0,1	0,061	1,65	840-1040	2000-2300	0,92-0,97	-	-
		Gravel	0,1	0,050	2	-	1700-2200	-	-	-

CATEGORY	FAMILY	Material	Thick (m)	R (m2.K/W)	k (W/mK)	c_p (J/kg.K)	ρ (kg/m3)	Therm. ϵ	Solar α	Visual α
Walls	Exterior Walls	Finishing - cement coating	0,02	0,025	0,8	1,046	1600	0,87	0,4	-
		Hollow Brick Wall	0,15	0,366	0,41	920-1000	1000-1200	0,93	-	-
		Air Gap - cavity no insulation	0,03	0,18	0,025	1000	1,23	-	-	-
		Hollow Brick Wall	0,11	0,268	0,41	920-1000	1000-1200	0,93	-	-
		Stucco	0,02	0,025	0,8	<1600		0,87	-	-
	Interior Walls	Stucco	0,02	0,025	0,8	<1600		0,87	-	-
		Hollow Brick	0,15	0,366	0,41	920-1000	1000-1200	0,93	-	-
		Stucco	0,02	0,025	0,8	<1600		0,87	-	-

CATEGORY	FAMILY	Material	Thick (m)	R (m2.K/W)	k (W/mK)	c_p (J/kg.K)	ρ (kg/m3)	Therm. ϵ	Solar α	Visual α
Roof	Sloped Roof	Clay Ceramic Tiles	0,03	0,018	1,65	840-1040	2000-2300	0,92-0,97	-	-
		Damp-Proofing	0,008	0,007	1,15	920	<2100	-	-	-
		Poor Concrete	0,04	0,024	1,65	840-1040	2000-2300	0,92-0,97	-	-
		Reinforced Concrete slab	0,05	0,025	2	840-1040	2300-2400	0,92-0,97	-	-
		Hollow Brick Blocks	0,06	0,146	0,41	920-1000	1000-1200	0,93	-	-
		Stucco	0,03	0,038	0,8	<1600		0,87	-	-

CATEGORY	FAMILY	Material	Frame Type	Solar Factor*	Glass Transmittance*	Color	Break(Y/N)	AreaRatio (%)	Operable (Y/N)
Window	Aluminium Window	Simple Glazing (4mm)	Aluminium Frame	0,88	0,9	no color	N	30	Y

Urban Model Interface



Climate-neutral and smart cities

Indeed!

Bold, inspirational, with wide societal relevance, and requires :

- **work across sectors** in a systemic way, for the definition of expected long term impacts and design of a **coherent set of activities at European and international level** to realise such impacts, rather than in terms of expertise in a single discipline or sector;
- Identify possible **solutions to broad challenges** as well as the best ways to support research and innovation that leads to develop policies for **systemic, transformative solutions in different fields including** :
 - **climate change** mitigation and adaptation; air quality;
 - **spatial planning** and development;
 - **energy efficient buildings** (retrofitting);
 - **urban infrastructures** and networks, including transport and logistics systems, energy, ICT and water;
 - clean energy transformation; urban manufacturing; **urban circularity and regeneration**; ecosystem services and nature-based solutions;
 - public health and **well-being in cities**; **urban resilience**; social impacts of climate change.