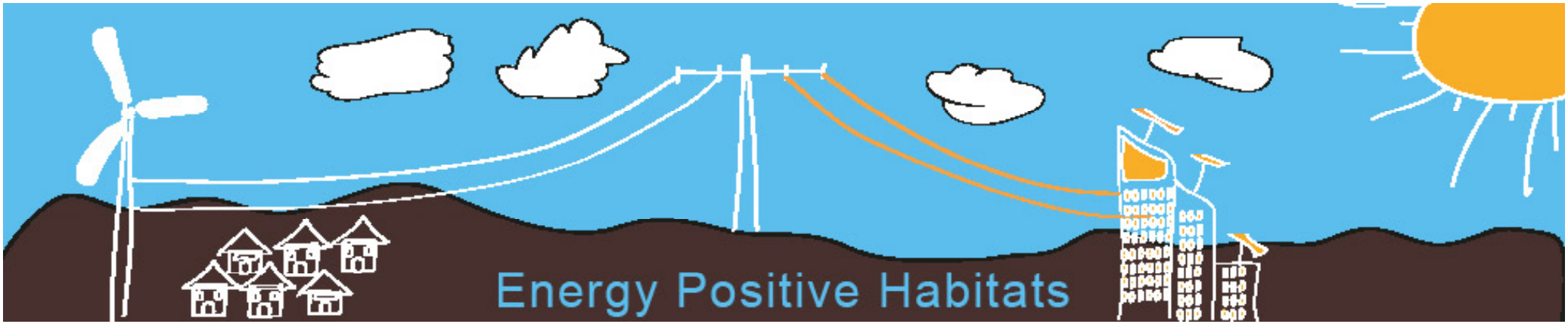
Auroville Green Practices

A Hands-on-Workshop
30 Aug to 1 Sept, 2012
Auroville (near Pondicherry)



‘Human Habitats today have become centers of energy consumption. By conserving energy with appropriate building design, reducing energy by efficient energy management and producing energy with decentralized systems that allows feeding surplus energy into the grid, we can create a shift towards energy positive habitats. Essential to this movement is the fact that humans have to change their life styles to consume less energy.‘

htpp://agp.aurovilleconsulting.com

Futures: from Energy Positive to Exergy efficient & Negentropy concentrating habitats

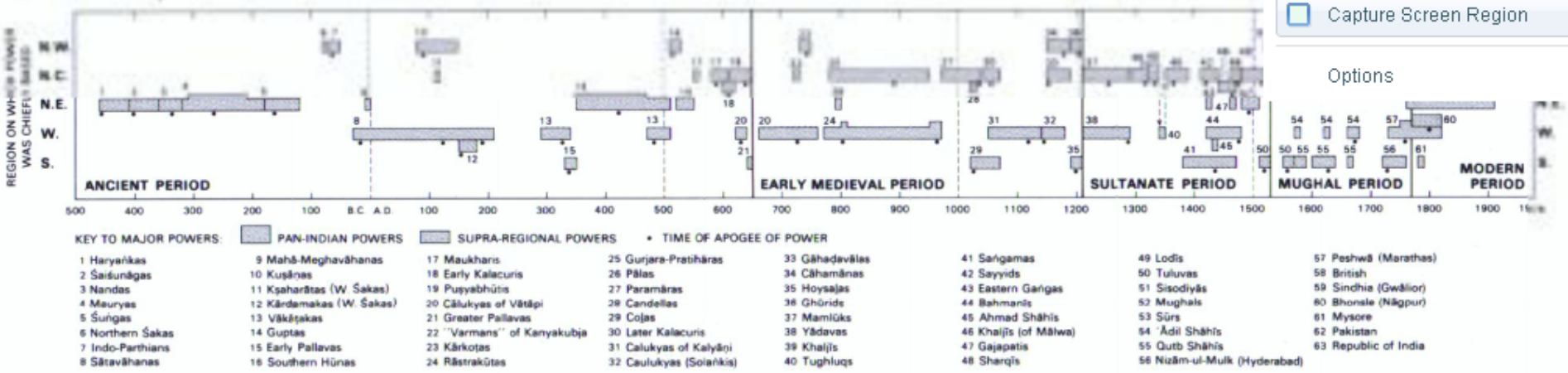
Aromar Revi

arevi@iihs.co.in

AromarRevi

Auroville 1st September 2012

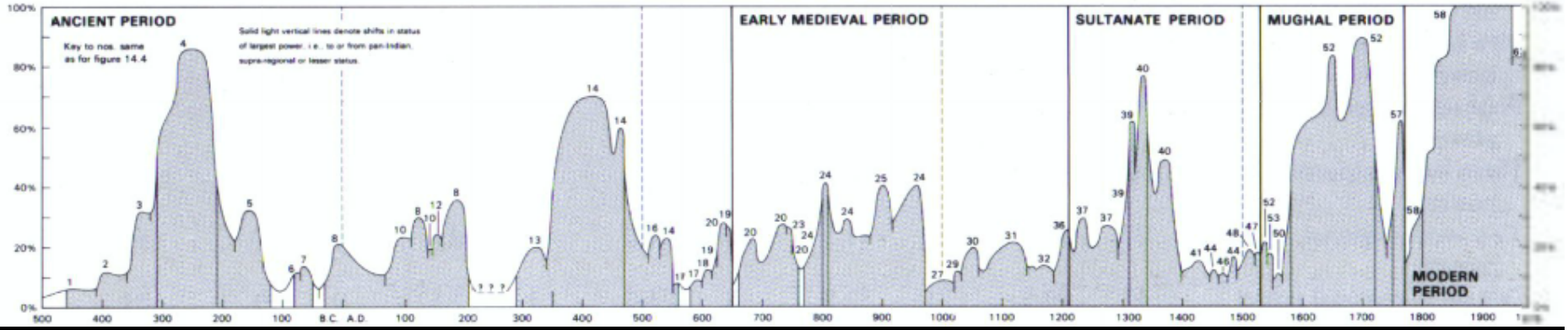
Figure 14.4 MAJOR POWERS OF THE INDIAN SUBCONTINENT, 500 B.C.–1976 A.



KEY TO MAJOR POWERS: PAN-INDIAN POWERS SUPRA-REGIONAL POWERS • TIME OF APOGEE OF POWER

1 Haryaṅkas
2 Śaiśunāgas
3 Nandas
4 Mauryas
5 Śuṅgas
6 Northern Śakas
7 Indo-Parthians
8 Sātavāhanas
9 Mahā-Meghavāhanas
10 Kuṣāṇas
11 Kṣaharātas (W. Śakas)
12 Kārdamakas (W. Śakas)
13 Vākāṭakas
14 Guptas
15 Early Pallavas
16 Southern Hūṇas
17 Maukharis
18 Early Kalacuris
19 Puṣyabhūtis
20 Cālukyas of Vātāpi
21 Greater Pallavas
22 "Varmans" of Kanyakubja
23 Kārkoṭas
24 Rāstrakūṭas
25 Gurjara-Pratihāras
26 Pālas
27 Paramāras
28 Candellas
29 Coḷas
30 Later Kalacuris
31 Calukyas of Kalyāṇi
32 Caulukyas (Solaṅkis)
33 Gāhaḍavālas
34 Cāhamānas
35 Hoysaḷas
36 Ghūrids
37 Mamlūks
38 Yādavas
39 Khaljīs
40 Tughluqs
41 Saṅgamas
42 Sayyids
43 Eastern Gaṅgas
44 Bahmanīs
45 Ahmad Shāhīs
46 Khaljīs (of Mālwa)
47 Gajapatis
48 Sharqīs
49 Lodīs
50 Tuluvas
51 Sisodiyās
52 Mughals
53 Sūrs
54 'Ādil Shāhīs
55 Qutb Shāhīs
56 Nizām-ul-Mulk (Hyderabad)
57 Peshwā (Marathas)
58 British
59 Sindhia (Gwālior)
60 Bhonsle (Nāgpur)
61 Mysore
62 Pakistan
63 Republic of India

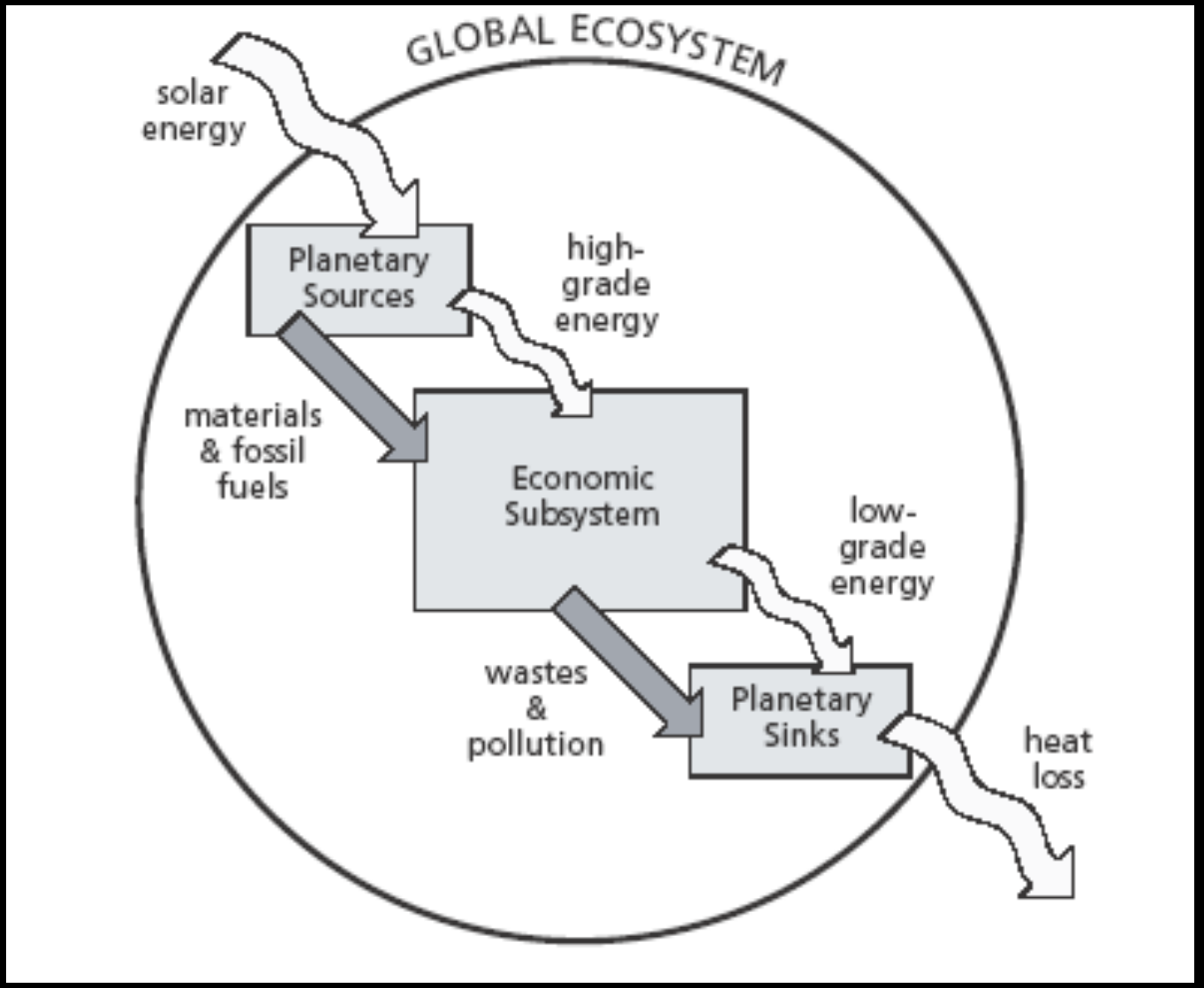
Figure 14.5 AREA OF LARGEST INDIAN POWER AS A PERCENTAGE OF AREA OF INDIAN SUBCONTINENT, 500 B.C.–1976 A.D.

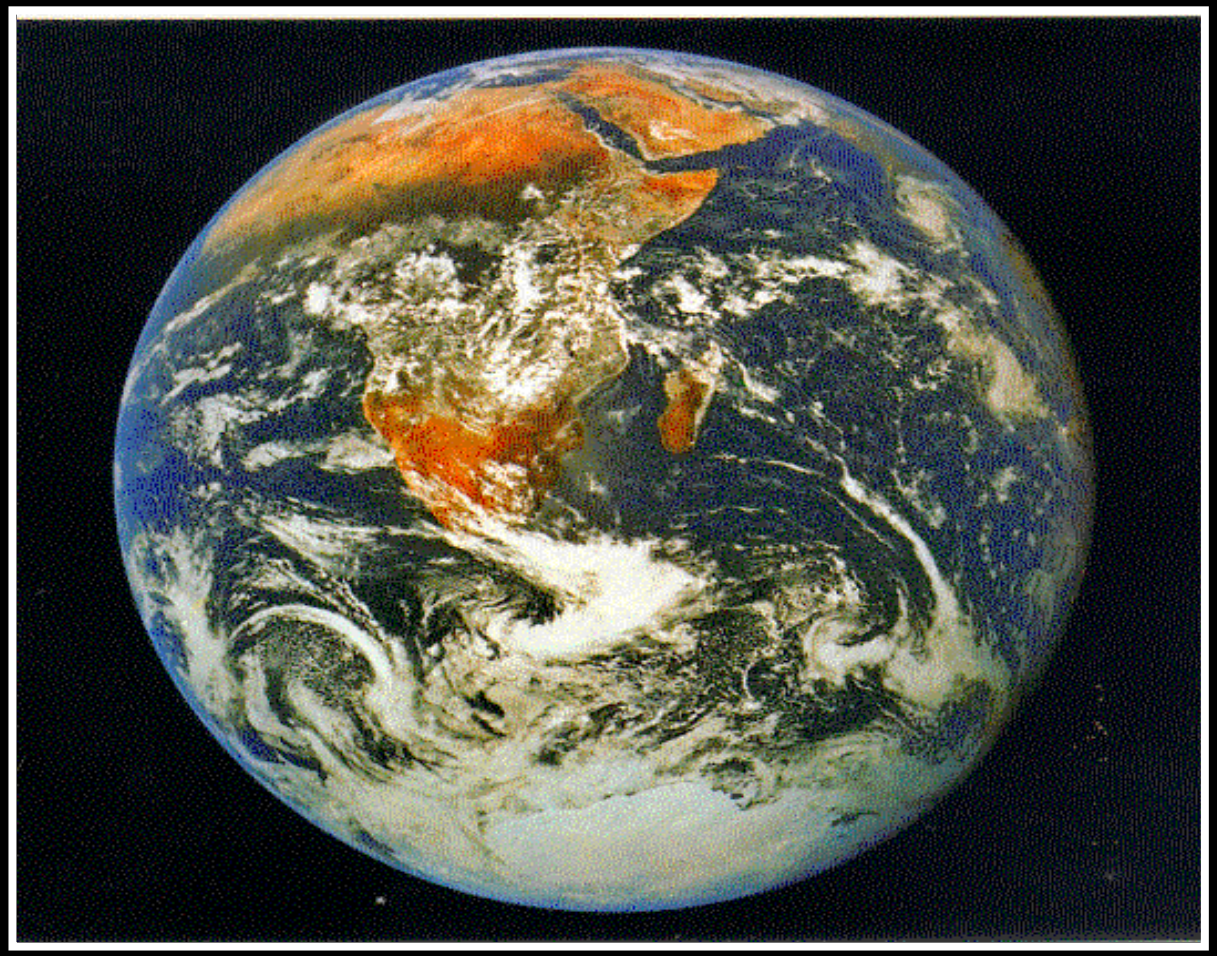


Capture Whole Page
Capture Screen Region
Options

The Global context: 2000-2100

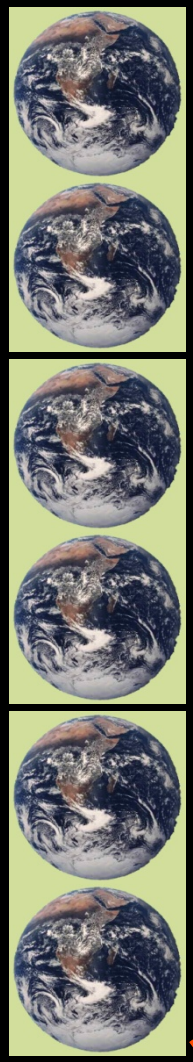
This earth-system is largely closed (Daly et. al., 1972)





There is Only One Earth and its in a small corner of the known Universe (Gagarin, Armstrong et. al. 1960s)

The Challenge of the 21st century Sustainability Transition



Present consumption requires ~2.0 worlds

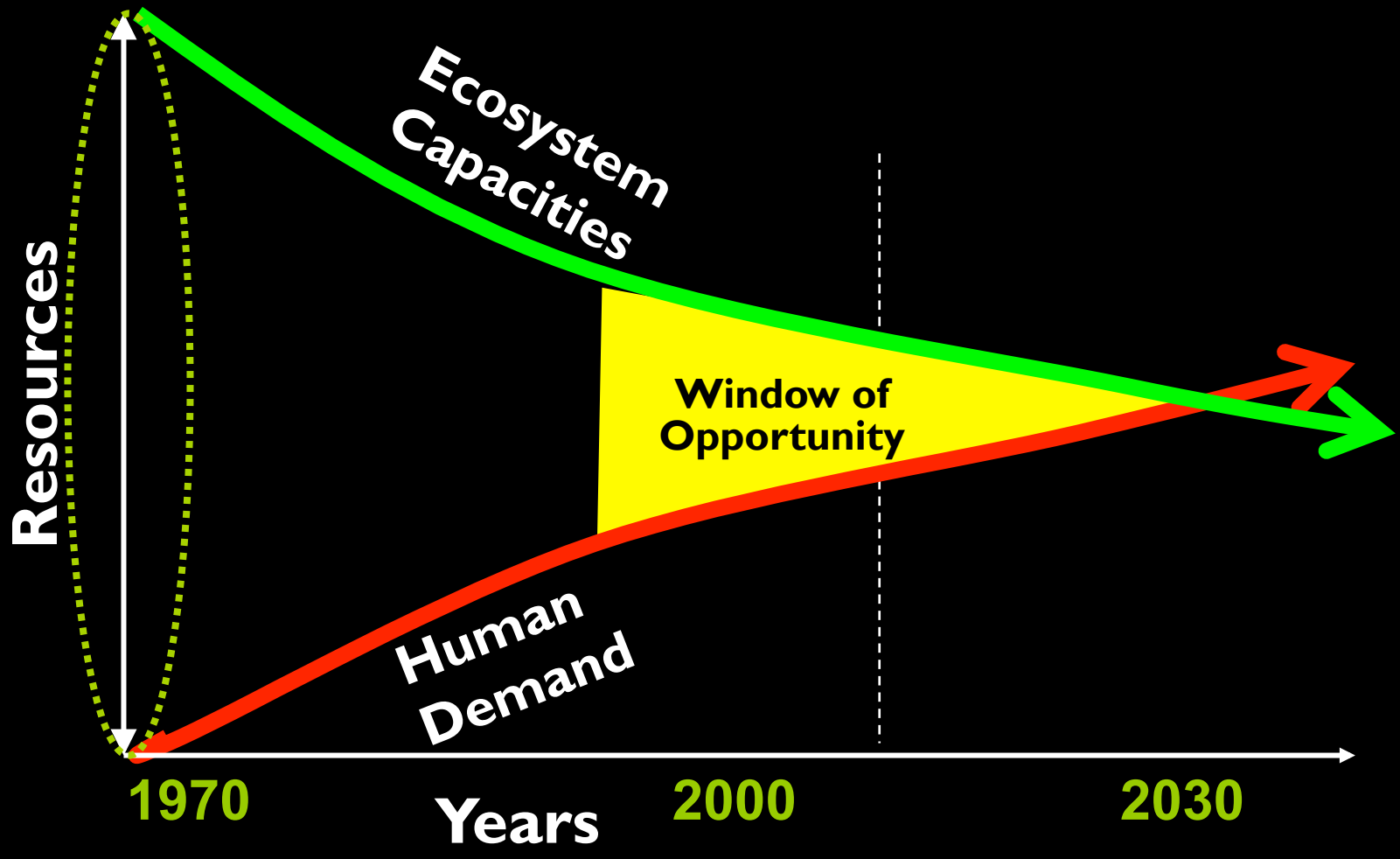
21st century Population growth needs **1.5+ worlds**

Available **only** One World

Ending poverty at present throughput **~2.0 worlds**

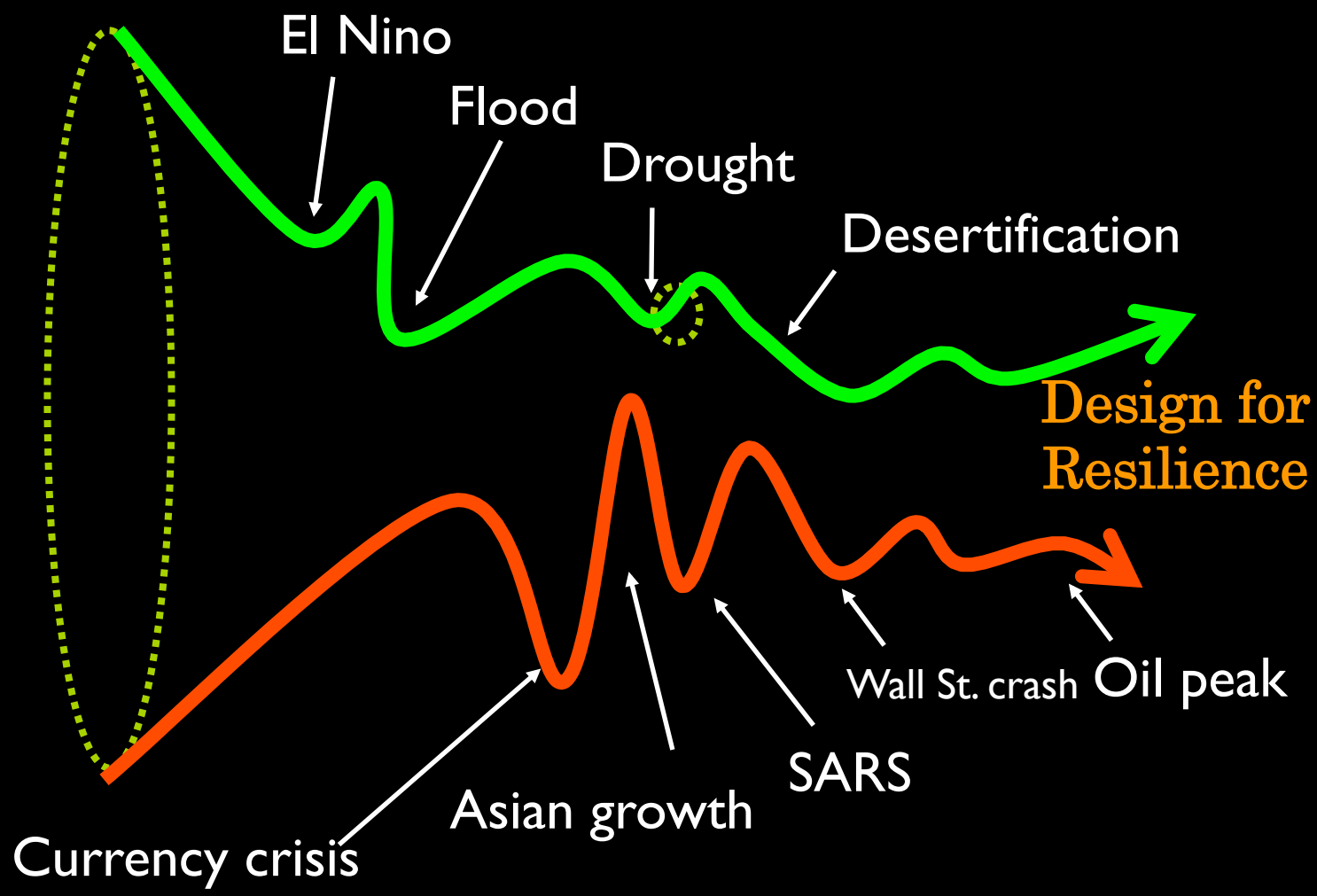
The Sustainability traverse will be largely played out in Chinese & Indian cities

A Narrowing Global Window of Opportunity



A narrowing ‘window of opportunity’ beyond which irreversible changes will take place

Reality is more complex: punctuated by multiple Shocks



We need to design our economic and urban systems for both performance & resilience

Sustainable Habitat: Key Governing Equations

- Entropy *aka* Second Law of Thermodynamics
  - Closed Systems - Earth

$$\frac{dS}{dt} = \dot{S}_i \text{ with } \dot{S}_i \geq 0$$

  - Open Systems – Habitats

$$\frac{dS}{dt} = \frac{\dot{Q}}{T} + \dot{S} + \dot{S}_i \text{ with } \dot{S}_i \geq 0$$

- Exergy or available energy

$$B = Q(1 - \frac{T_o}{T_{source}})$$

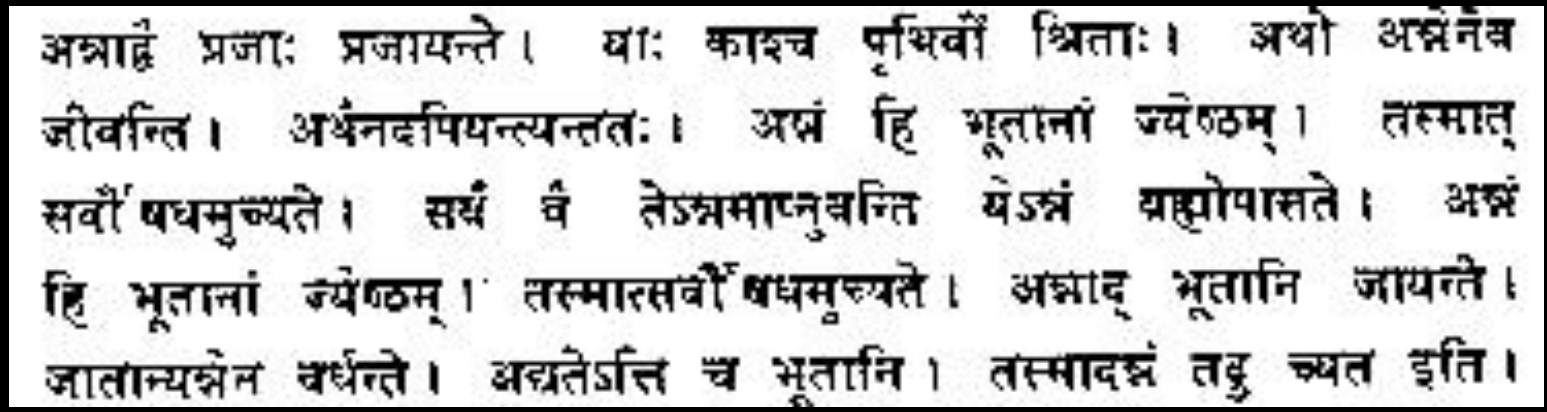
- Gibbs, Massieu-Planck, Boltzmann's 'negentropy 'equations

$$J = S_{\max} - S = -\Phi = -k \ln Z$$

- Shannon-Hartley theorem

$$C = B \log_2 \left(1 + \frac{S}{N}\right)$$

Taittiriya Upanishad: Energy-Food



अन्नाद्धे प्रजाः प्रजायन्ते। याः काश्च पृथिवीं श्रिताः। अथो अन्नेनैव
जीवन्ति। अथैनदपियन्त्यन्ततः। अन्नं हि भूतानां ज्येष्ठम्। तस्मात्
सर्वौषधमुच्यते। सर्वं वै तेऽन्नमाप्नुवन्ति येऽन्नं ब्रह्मोपासते। अन्नं
हि भूतानां ज्येष्ठम्। तस्मात्सर्वौषधमुच्यते। अन्नाद् भूतानि जायन्ते।
जातान्यन्नेन वर्धन्ते। अद्यतेऽत्ति च भूतानि। तस्मादन्नं तदुच्यत इति।

- Verily, all sorts and races of creatures that have their refuge upon earth, are begotten from food; thereafter they live also by food and it is to food again that they return at the end and last.
- For food is the eldest of created things and therefore they name it the Green Stuff of the universe. Verily, they who worship the Eternal as food, attain the mastery of food to the uttermost; For Food is the eldest of created things and therefore they name it the Green Stuff of the universe.
- From food all creatures are born and being born they grow by food. Lo, it is eaten and it eats; Yea, it devours the creatures that feed upon it, therefore it is called food from the eating.

Sri Aurobindo, The Upanishads pp 328

Exergy efficient

Consciousness/Negentropy concentrative

The Climate challenge: 2000-2100

Evidence of Dangerous Climate Change

- Cumulative mean global temperature impact
  - Total anthropogenic GHG emissions to 2008 — 0.8 °C
  - Thermal inertia — 0.6 °C
  - Albedo flip — 0.3 °C
  - Slow feedback impacts — 0.3 °C

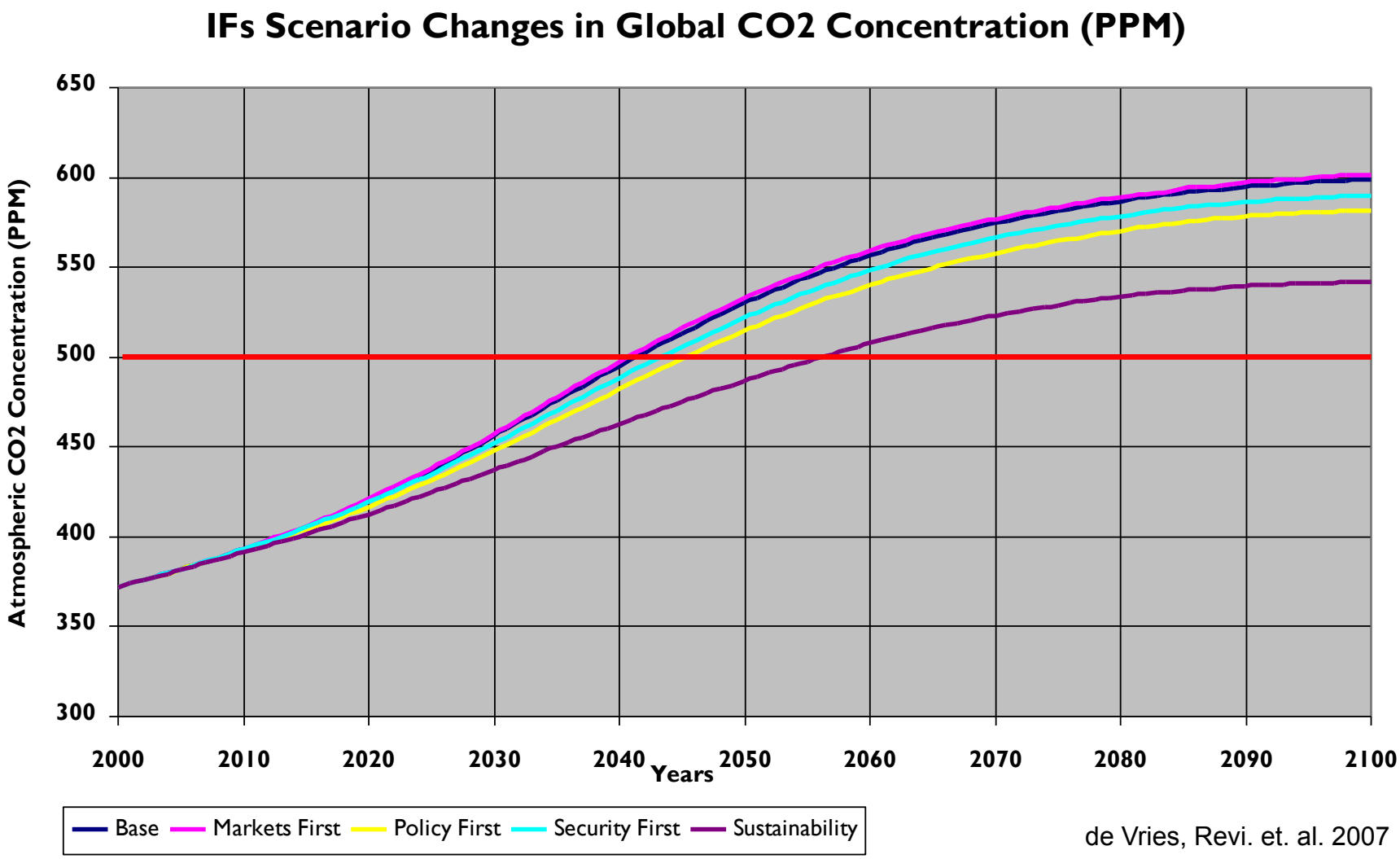
  Impact of historical emissions & lag — **2.0 °C**

  (2 °C mean implies > 4 °C inland and over 6 °C at the poles)
  - Current emissions to 2030 — 0.4 °C
  - Addition emissions due to growth — 0.6 °C

  BAU Global mean temperature deviation — **3.0 °C**
- 3 to 5 m Sea Level Rise by 2100
  - Thermal expansion
  - Artic sea ice melt
  - Greenland icesheet loss
  - West Antartic icesheet loss
  - East Antartic icesheet loss
- Glacial melt

Himalayan Glacial melt (1921-2009)

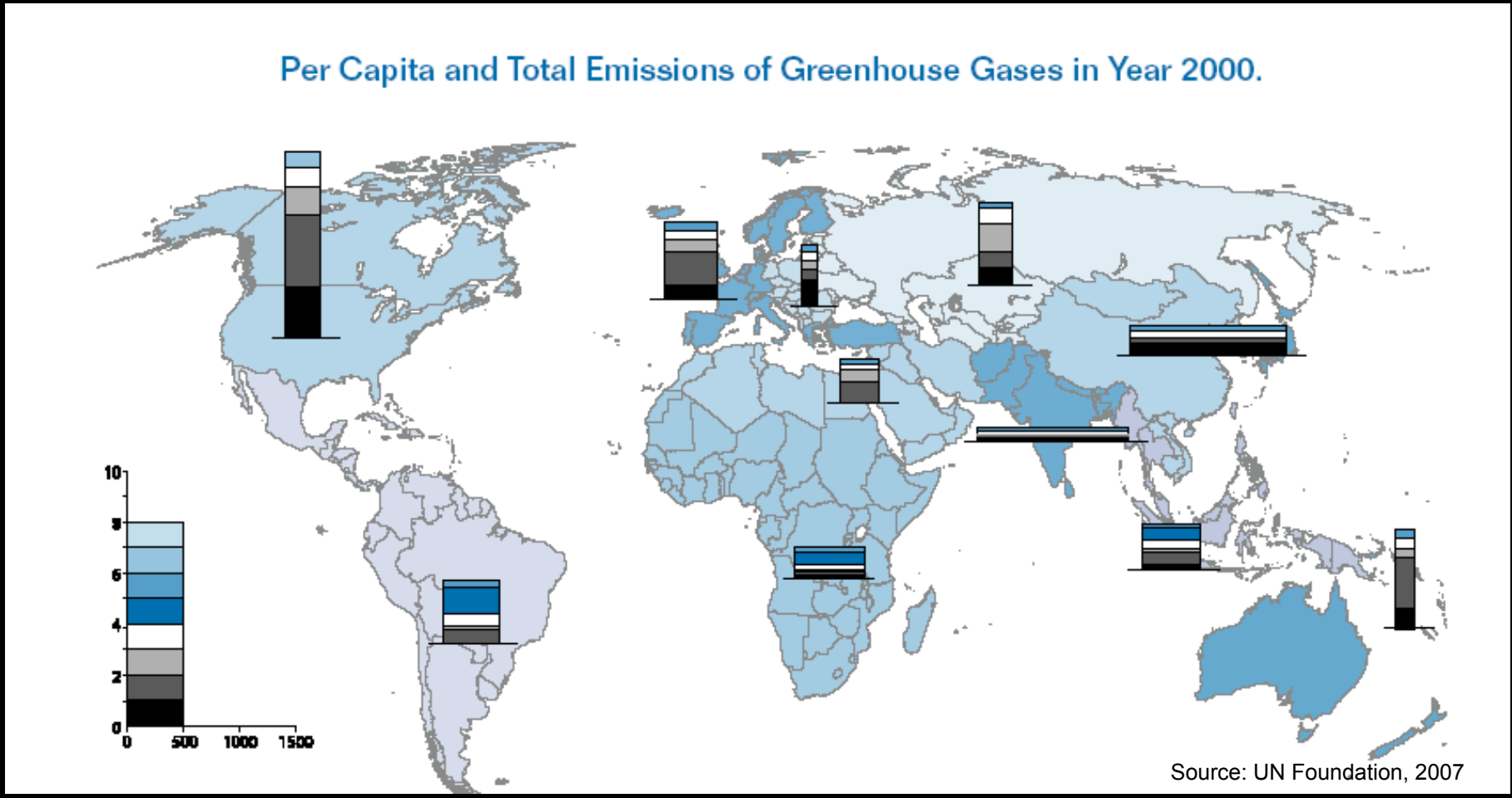
Global Climate Change: An Inconvenient Overshoot



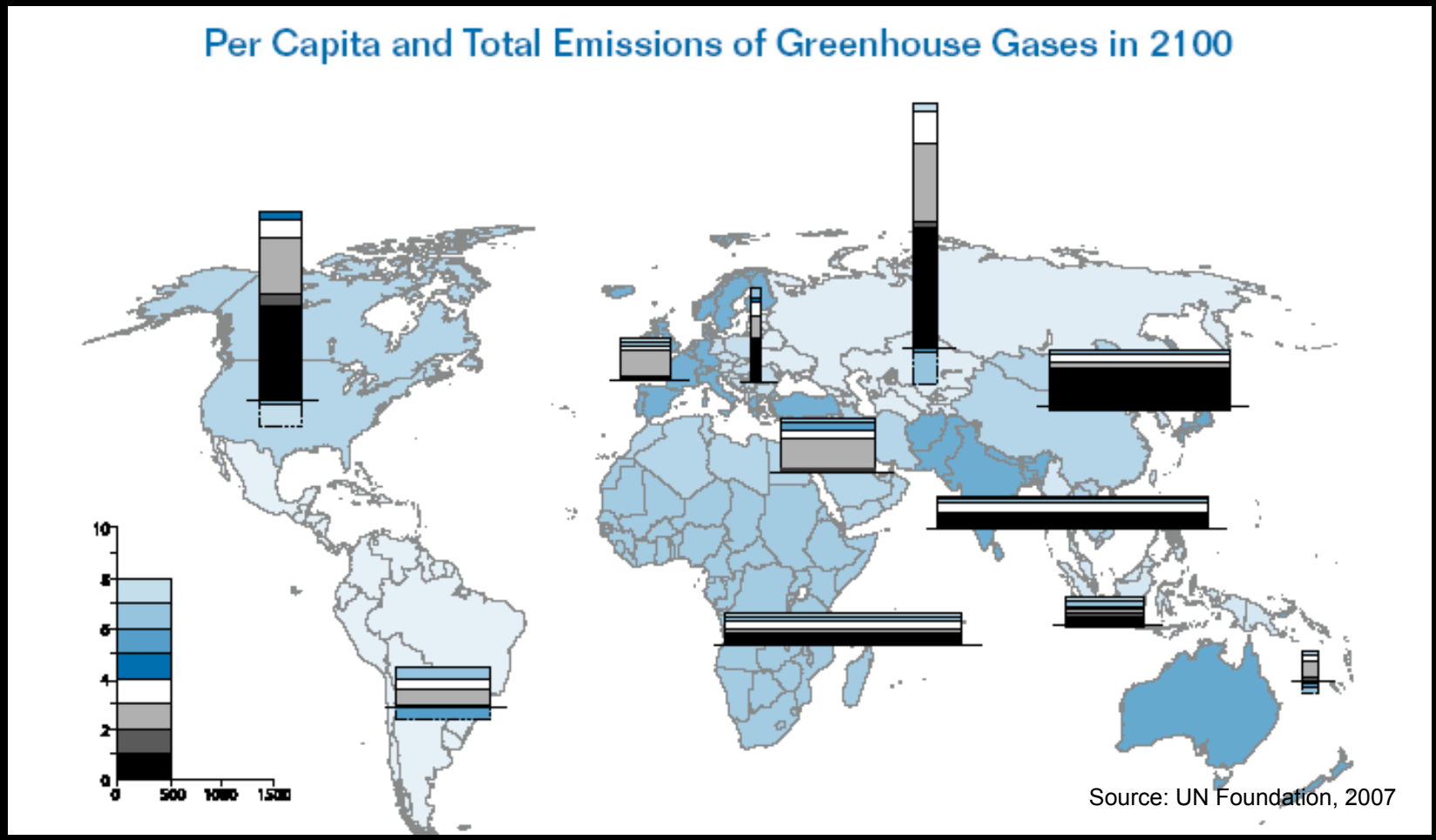
de Vries, Revi. et. al. 2007

Climate change emerges as a serious threat as all GEO 4 scenarios overshoot targets

Per Capita & Total GHG emissions (2000)



Per Capita & Total GHG emissions (2100)



A 'naïve' Climate Change Impact Equation

Atmospheric Greenhouse Gas Concentrations =

Historical GHG concentrations ← History, industrialisation, past-consumption & equity

+

[Population (1+ population growth rate) ← Economic and human development, poverty

x

GDP per capita (1 + GDP growth rate) ← Growth, investment, productivity, technology governance & equity

x

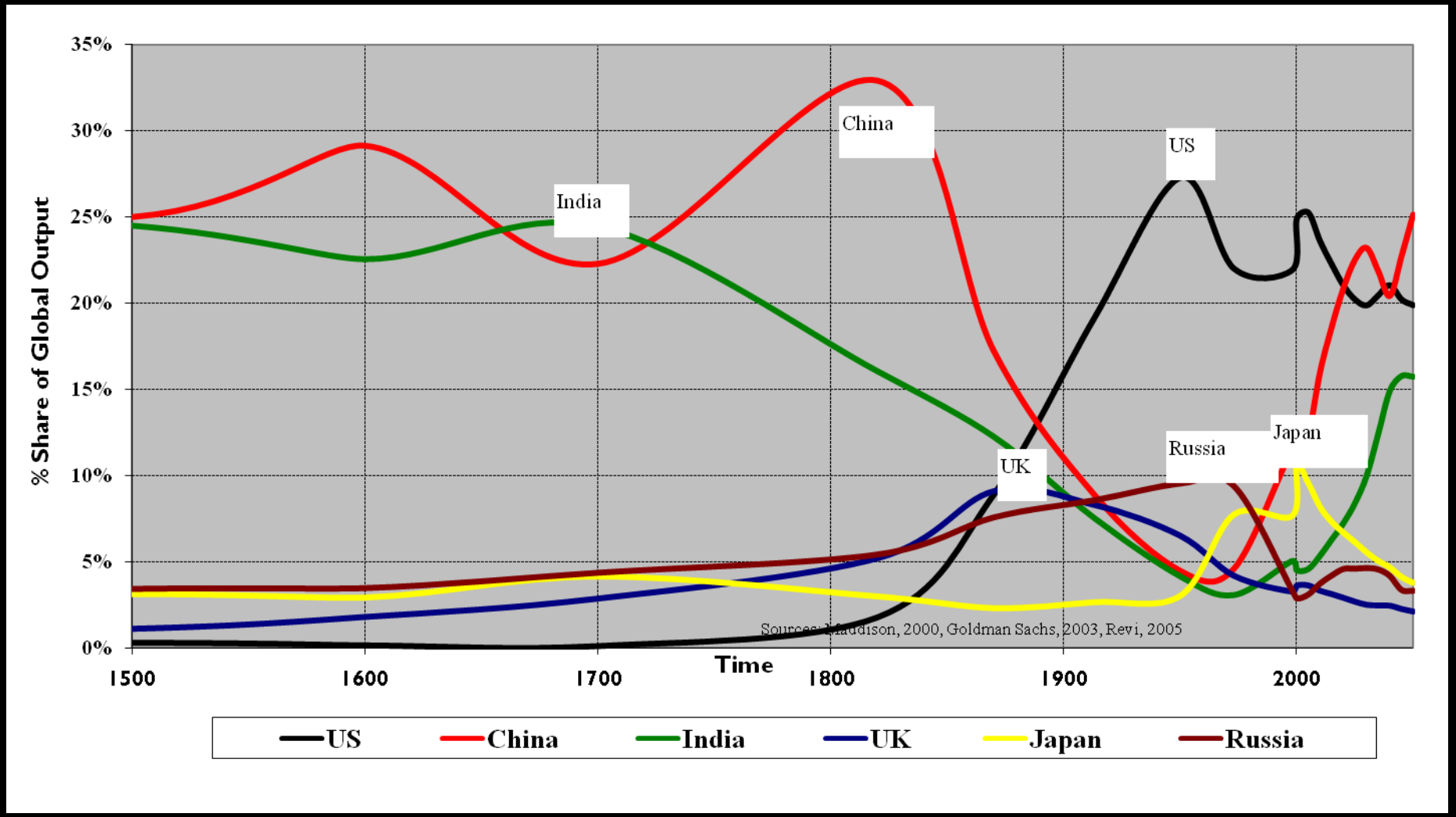
Energy per unit GDP output ← Investment, technology, efficiency, markets

x

Carbon emission / unit Energy] ← Investment, technology, 'metabolic' change, markets

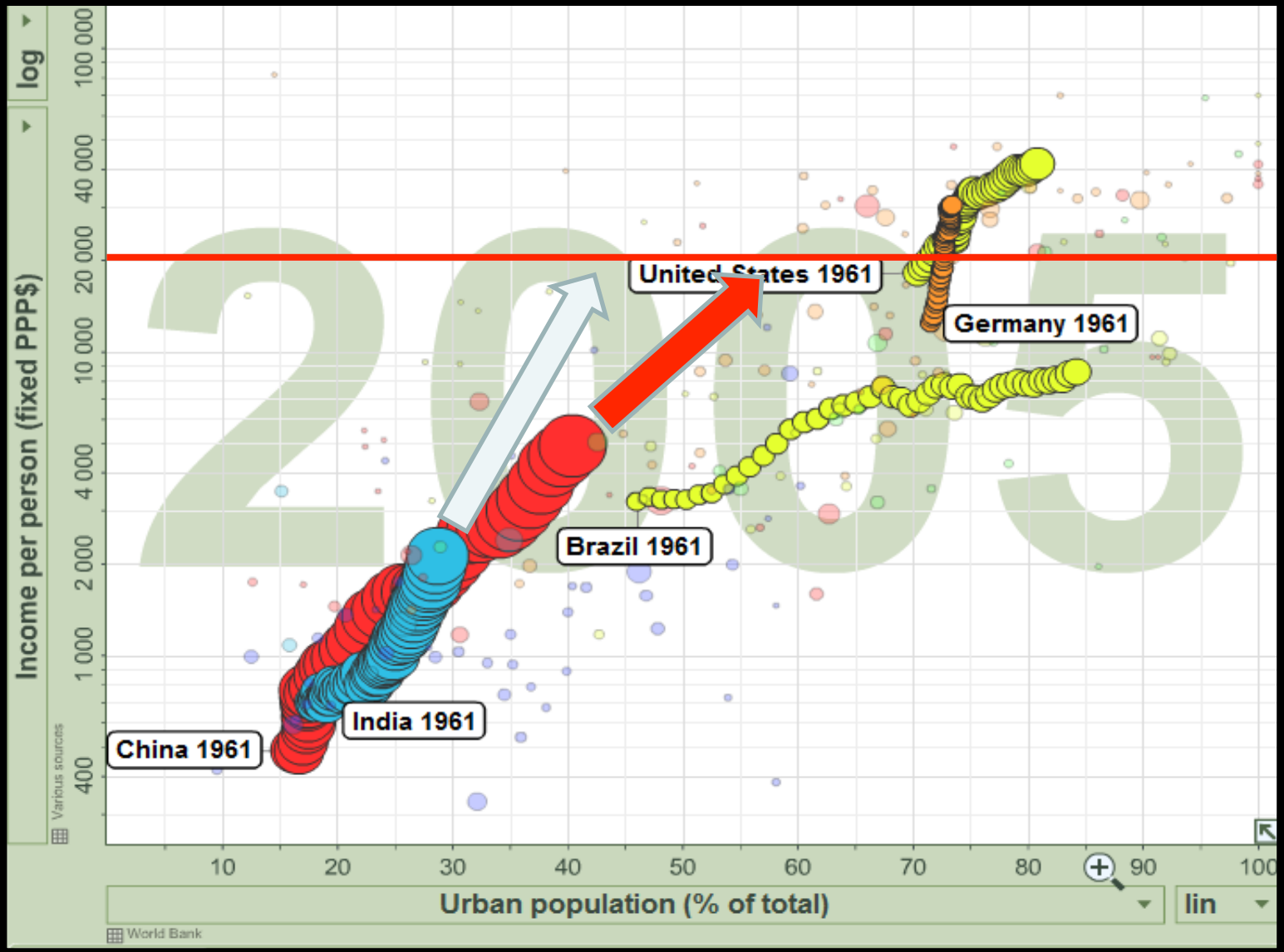
The built environment & the Energy-Climate debate

Relative National Share of Global Economic Output (1500 to 2050)

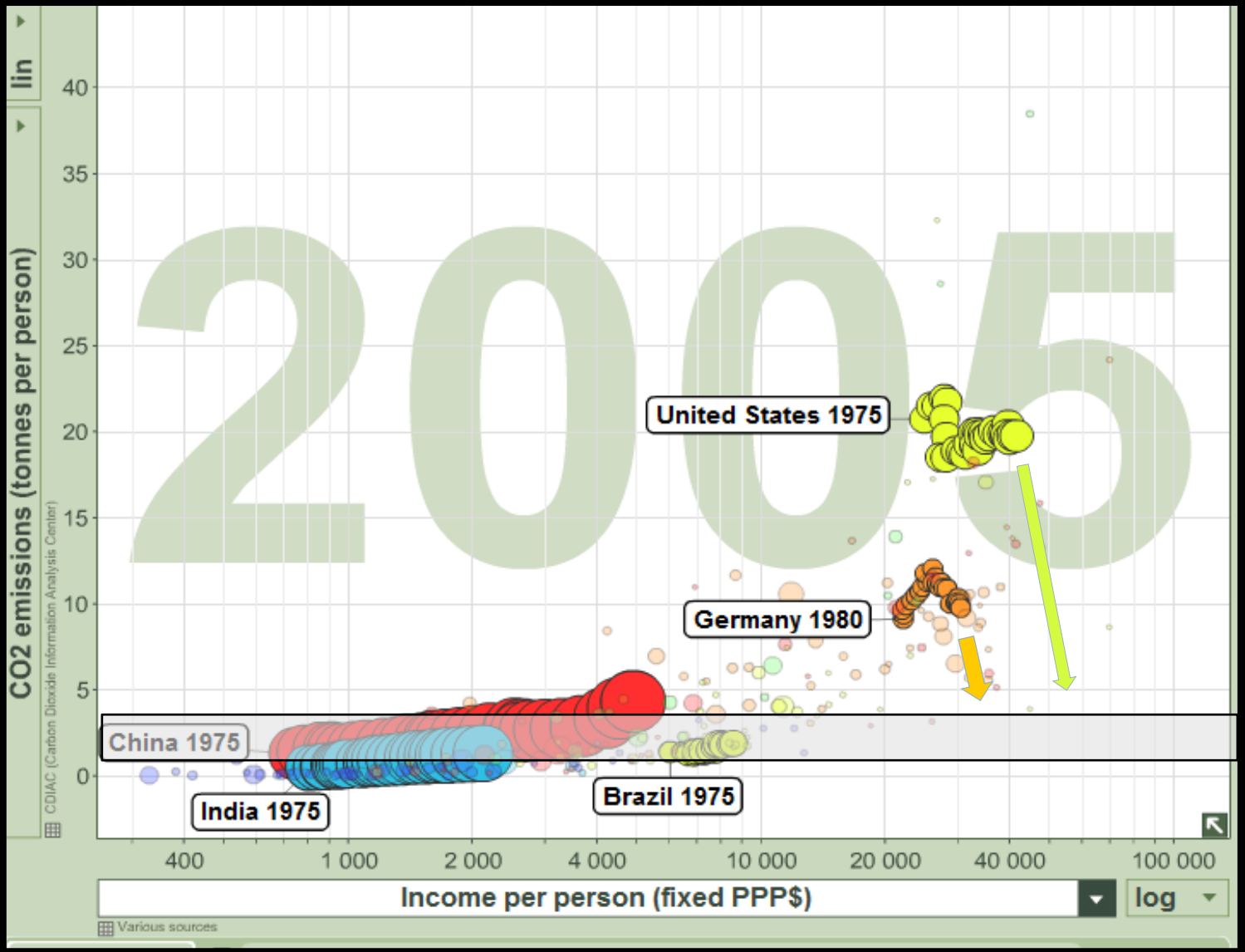


Asia returns to centre of the global economy after a gap of 250 years

Urbanisation: a key growth & economic development driver

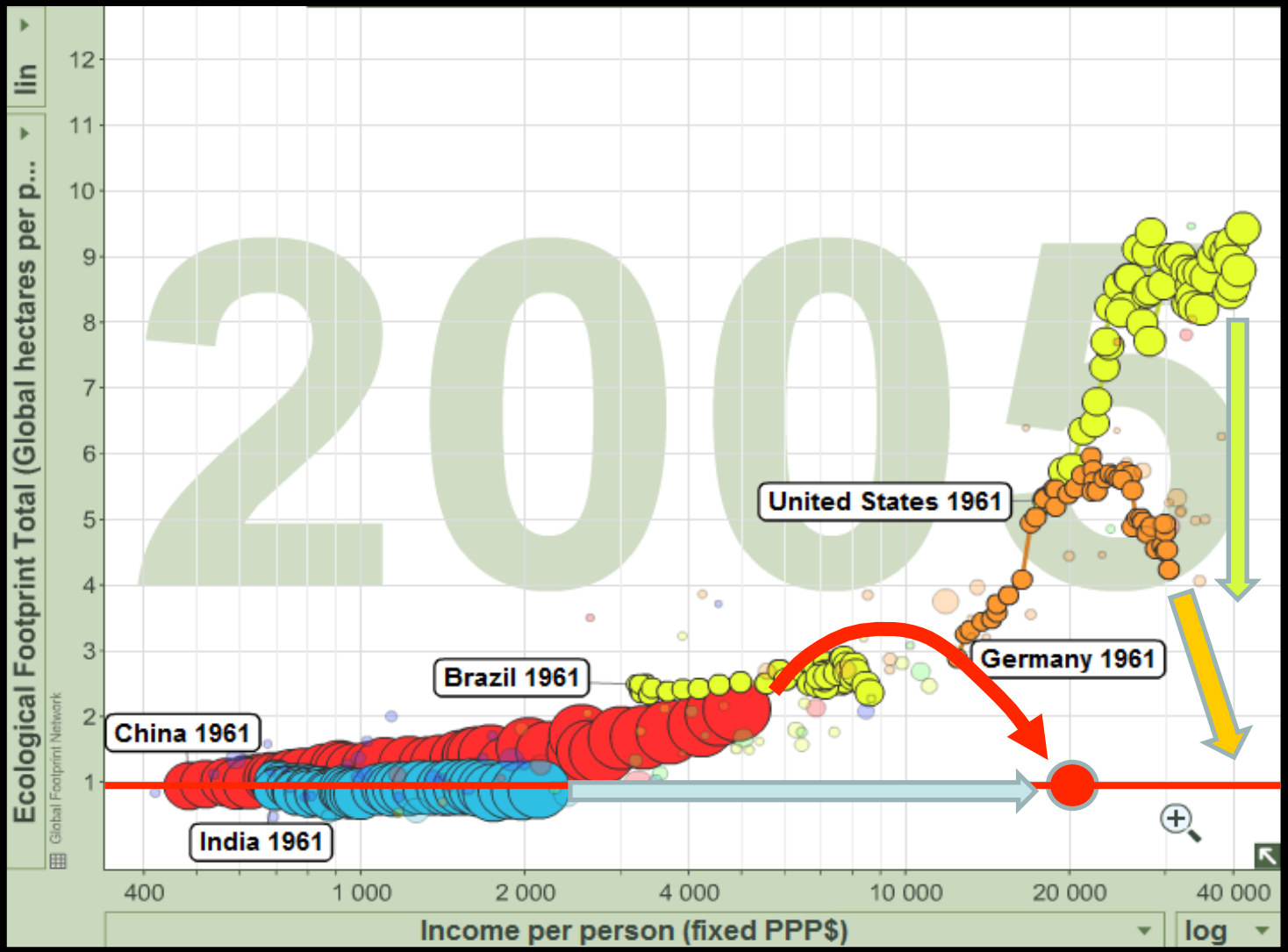


The battle for Carbon 'space' and growth potential

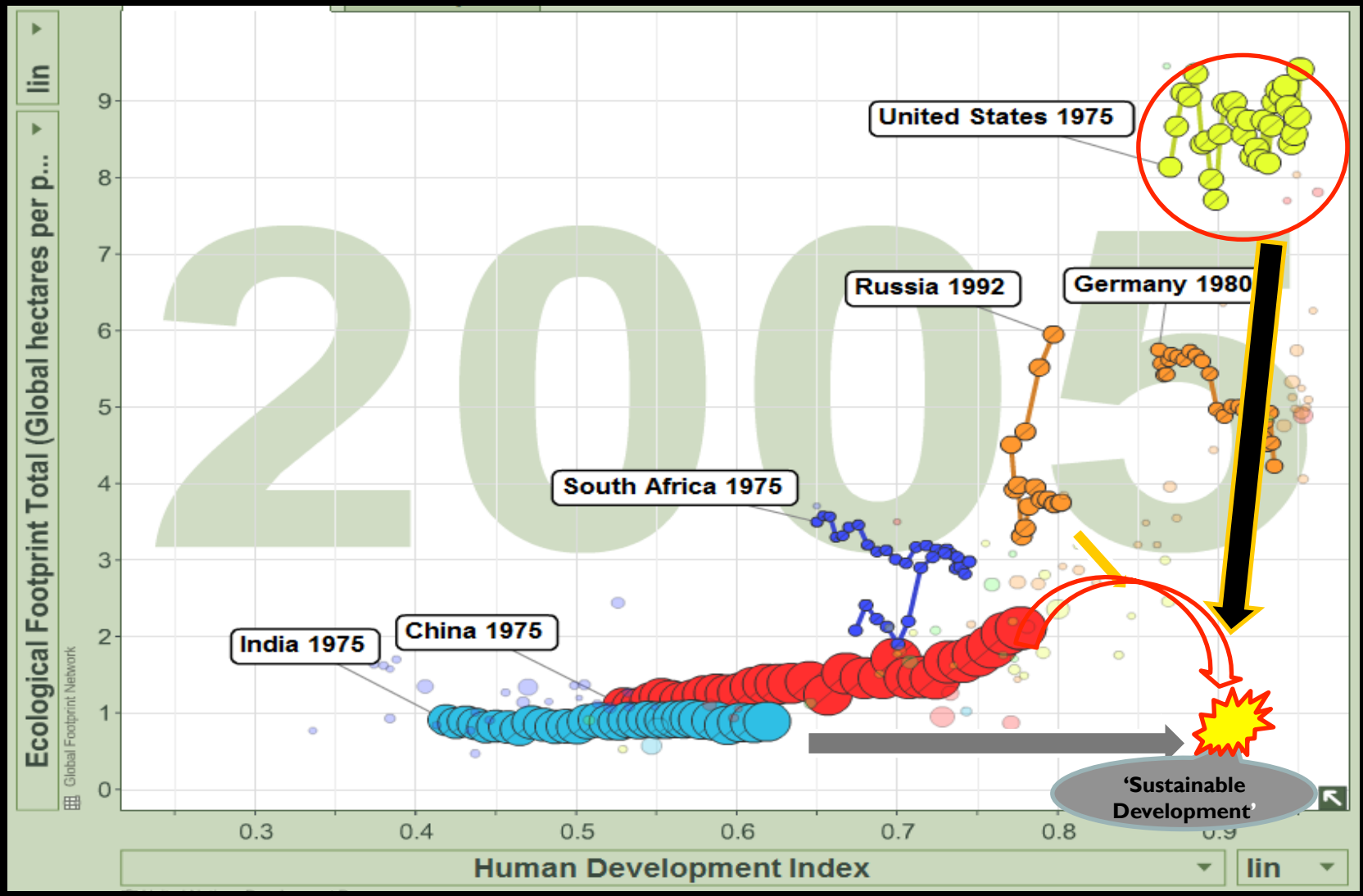


A possible reframing of India's Climate challenge/opportunity

The Great Transition: balancing growth & ecosystem health

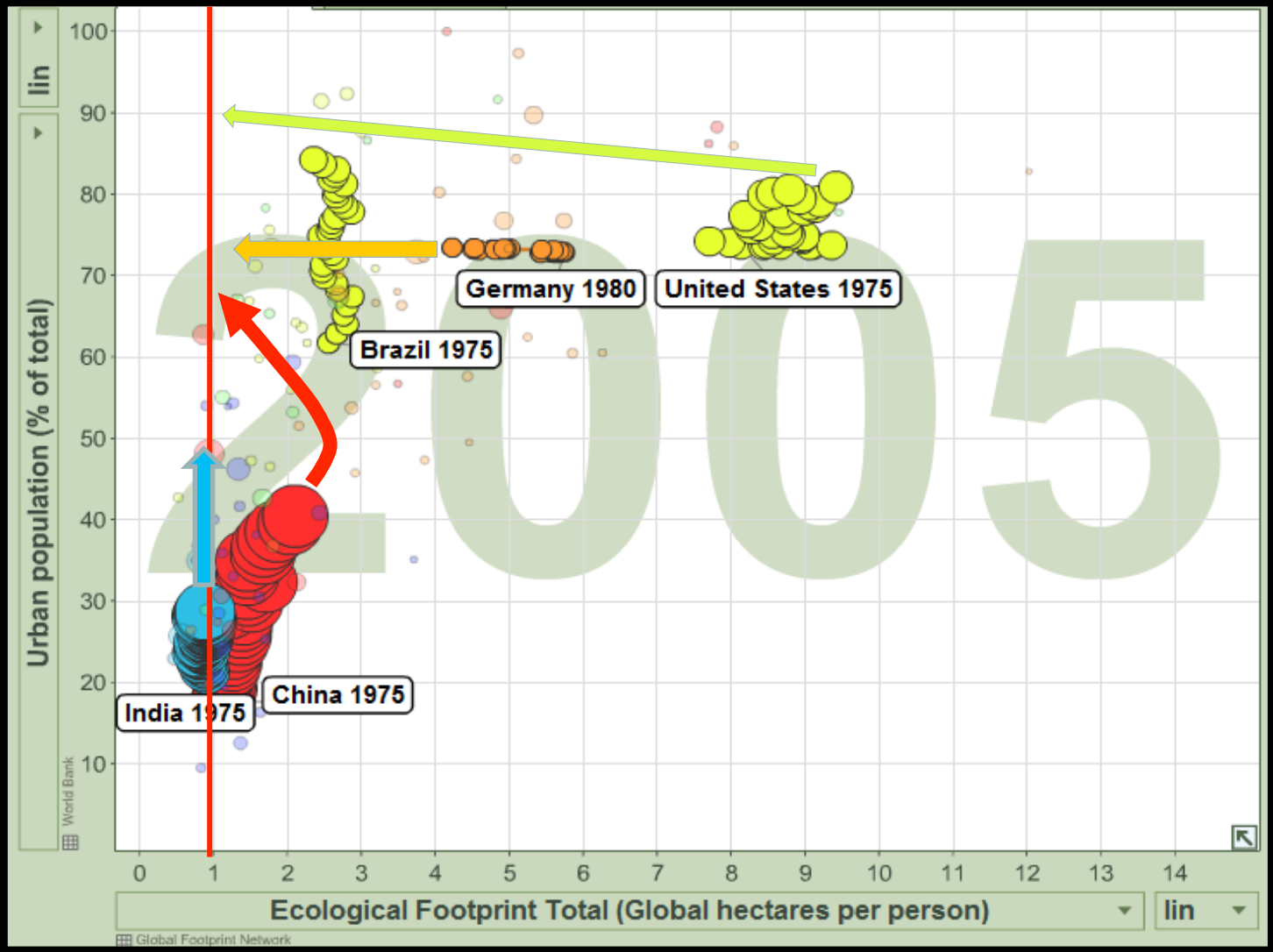


Future History - Sustainability Transitions: 2005 →

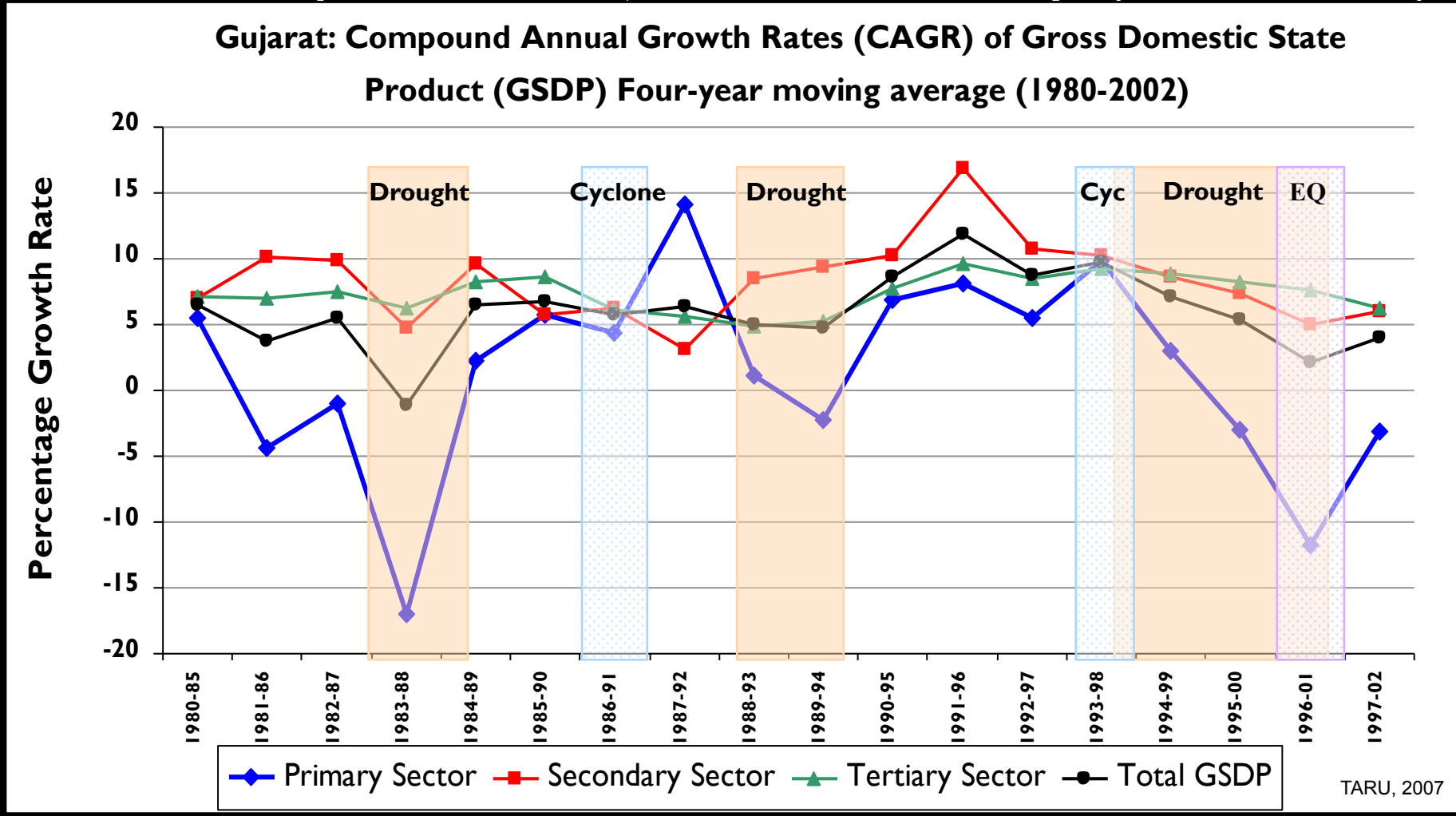


Can China traverse the environmental Kuznets curve Germany & USA converge without serious Human Development decline India 'tunnel through';
or will there be serious international 'resource' conflict?

A new form of urbanisation?



Hazard Impact on Gujarat's Economy (1980-2002)



Gujarat's annualised Natural Hazards Risk exposure: ~ - 2.5% of GSDP

Drought Risk ~ 1.8% of GSDP without Climate change.

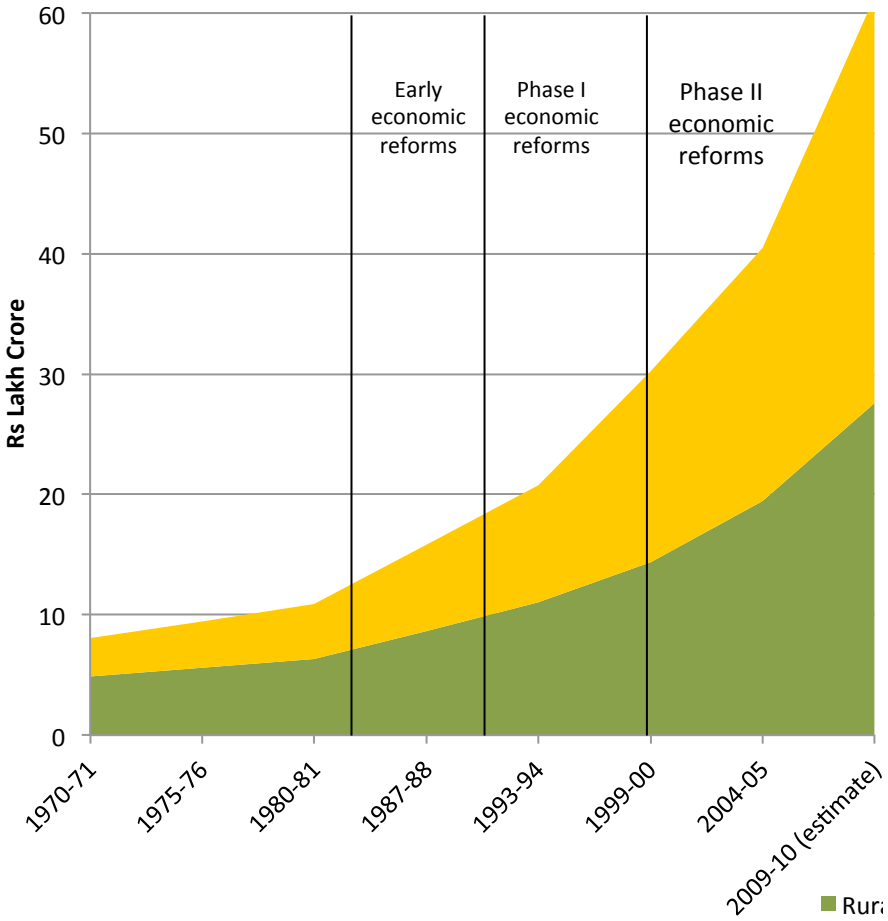
The national context: 1970-2030

India: the opportunity of ten simultaneous Transitions

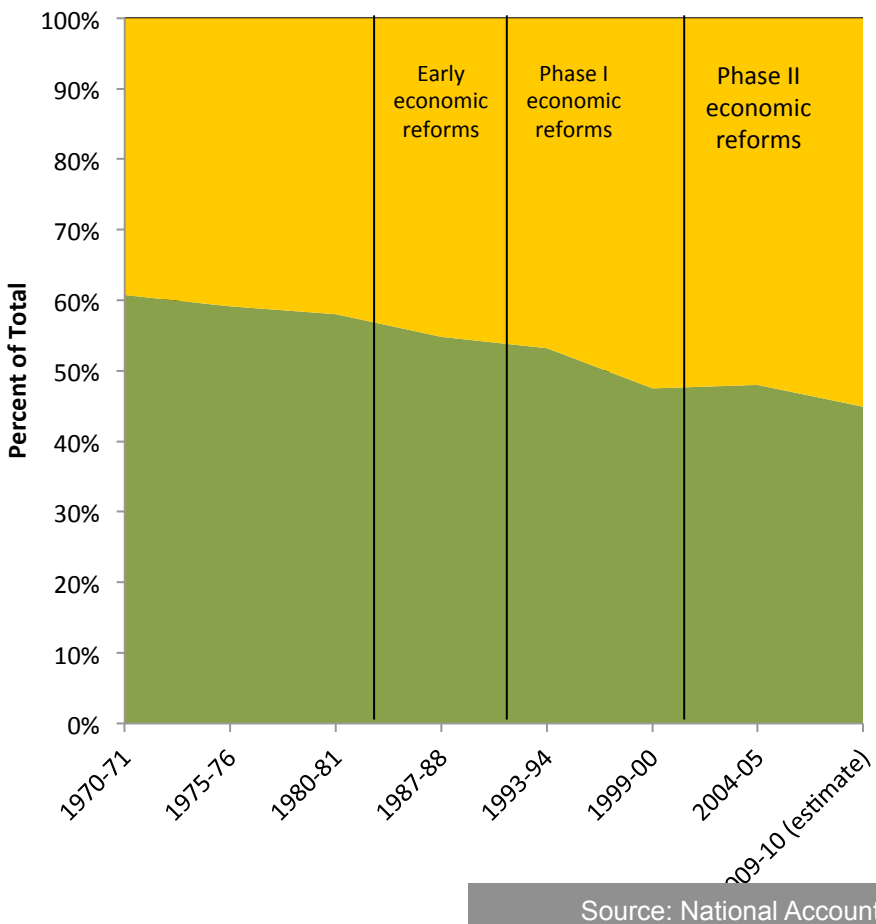
1. Demographic transition: population stabilisation & aging
2. Health transition: infectious + lifestyle disease burden
3. Education transition: elementary → secondary→ tertiary
4. Energy transition: oil + coal → gas + renewables
5. Environmental transition: 'brown' + 'grey' + 'green' agendas
6. Information transition: post →phone→ cell phone + www
7. Livelihoods transition: agrarian → green + knowledge jobs
8. Economic transition: primary + secondary → tertiary-led
9. Political transition: decentralised, youth and urban
10. Urban transition: rural → 'urban'

India: Rural-Urban GDP

Rural: Urban GDP share (1970-2009)



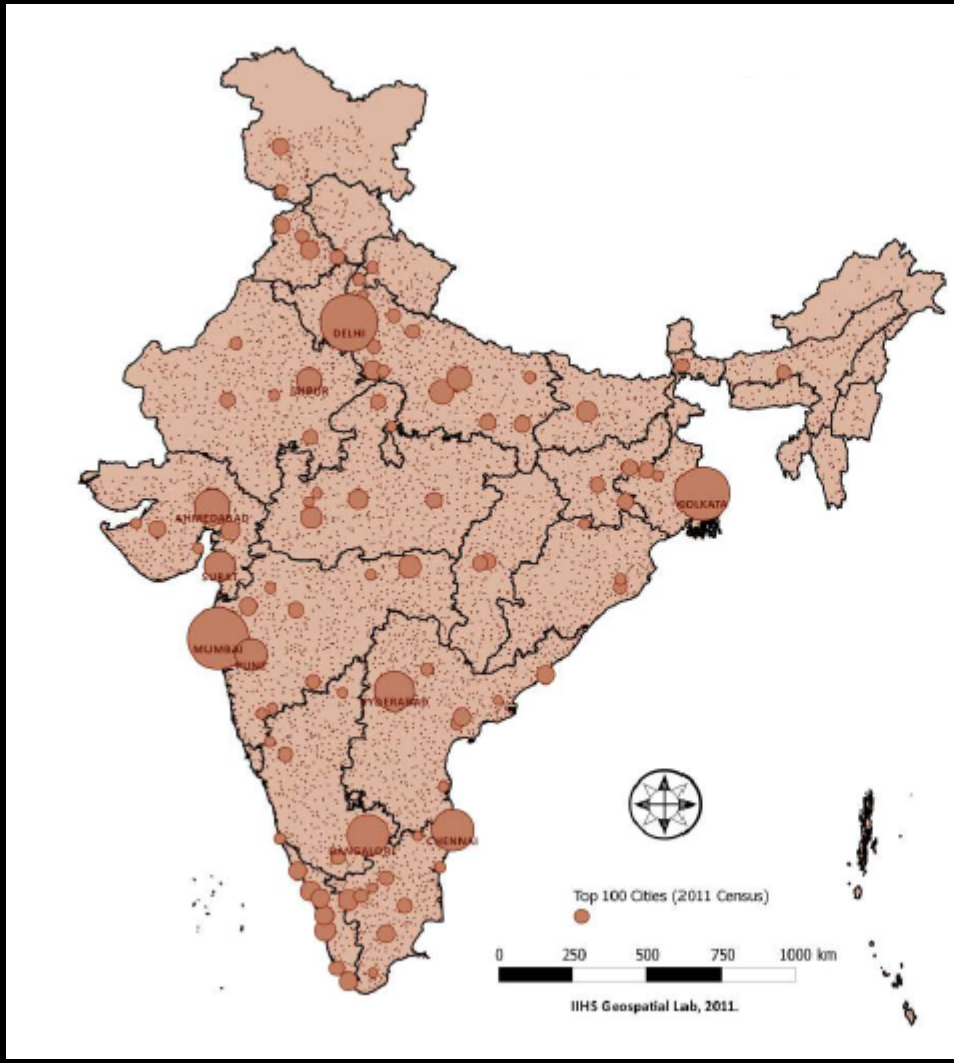
Rural: Urban GDP fraction (1970-2009)



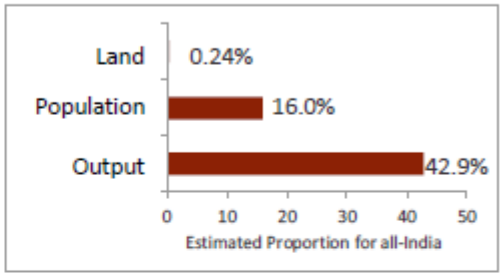
Source: National Accounts Statistics

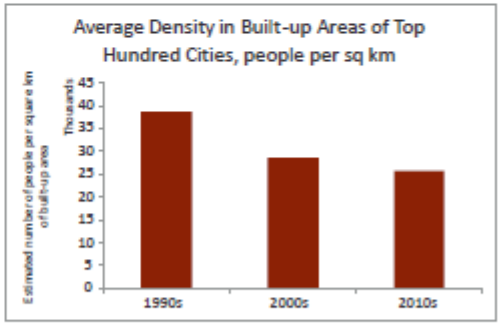
Close to 60% of India's GDP comes from Urban areas

India: Concentration of Economic Output (2009)



The top 100 largest cities are estimated to produce about 43% of the GDP, with 16% of the population and just 0.24% of the land area.

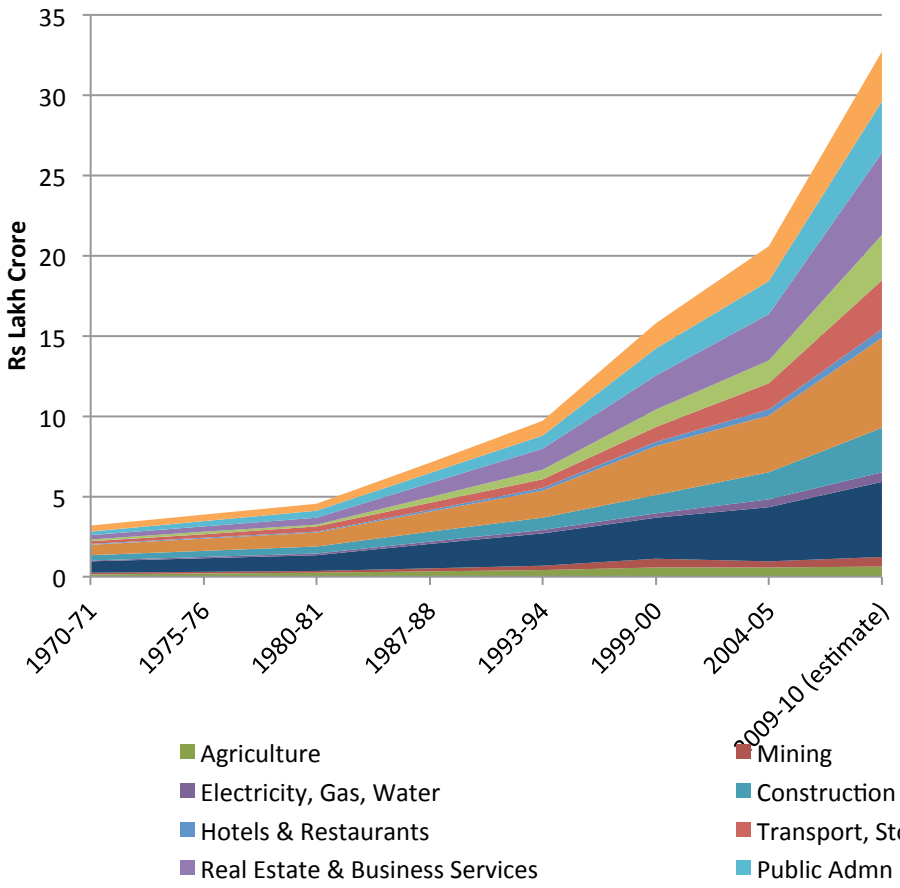




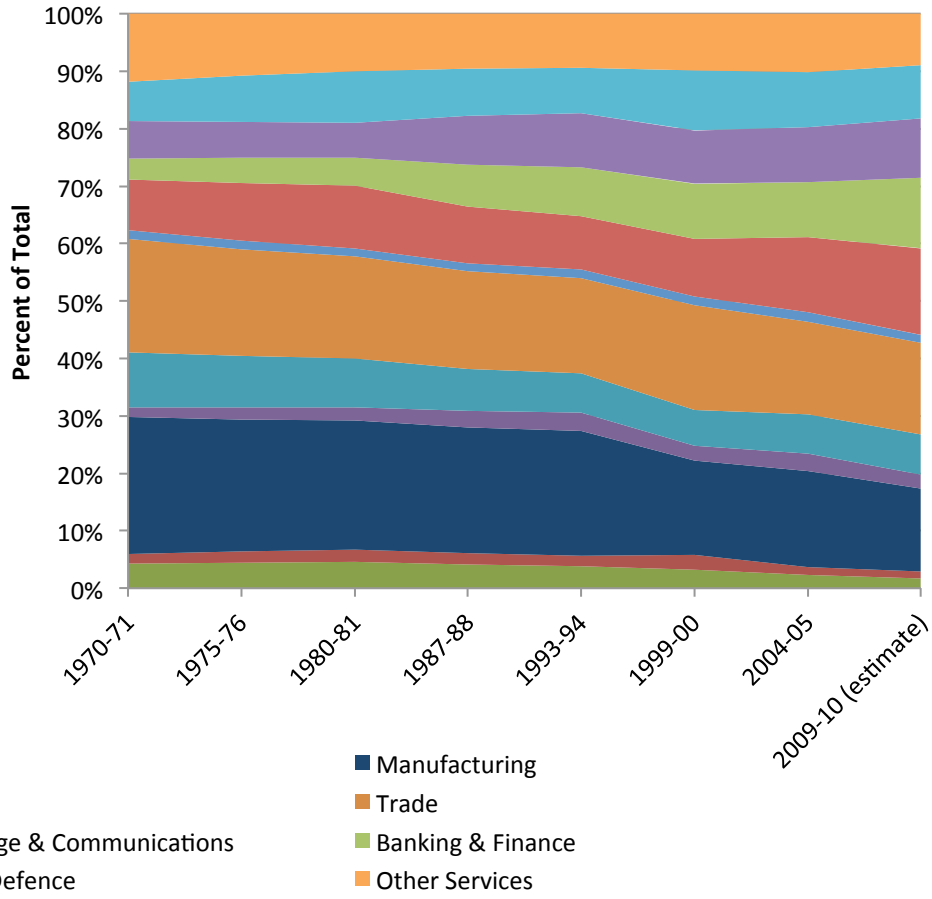
Source: IIHS Analysis 2011(built-up area); Census 2011 (population); Planning Commission 2011 (DPP Estimates 2005-06).
See endnotes for method of calculating urban output and built-up area.

India: Urban Sectoral GDP

Urban sectoral GDP growth (1970 – 2009)



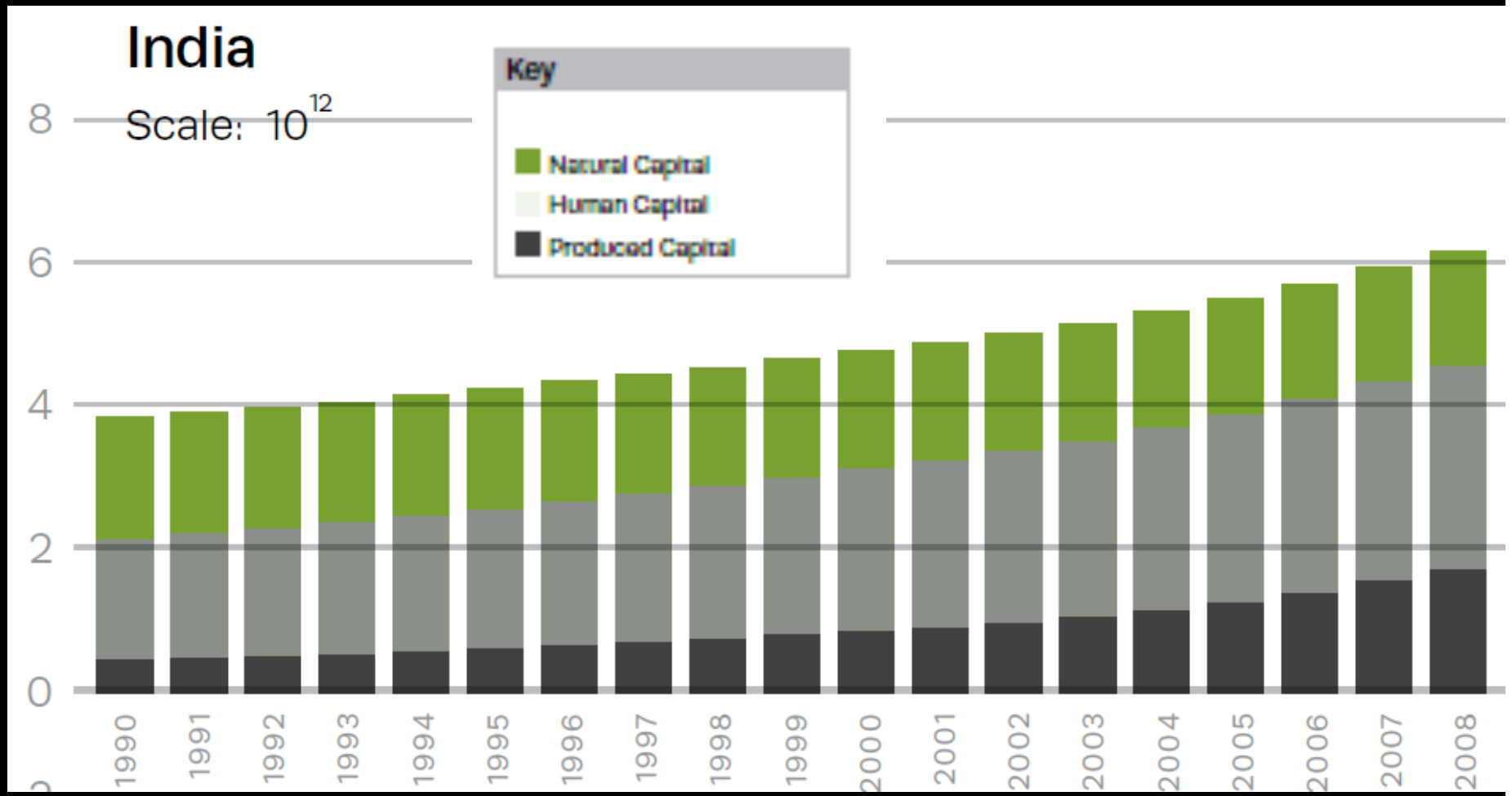
Urban sectoral GDP structure (1970 – 2009)



Agriculture
Mining
Manufacturing
Electricity, Gas, Water
Construction
Trade
Hotels & Restaurants
Transport, Storage & Communications
Banking & Finance
Real Estate & Business Services
Public Admn & Defence
Other Services

Decoupling of energy/carbon systems and the real economy have to be sector specific

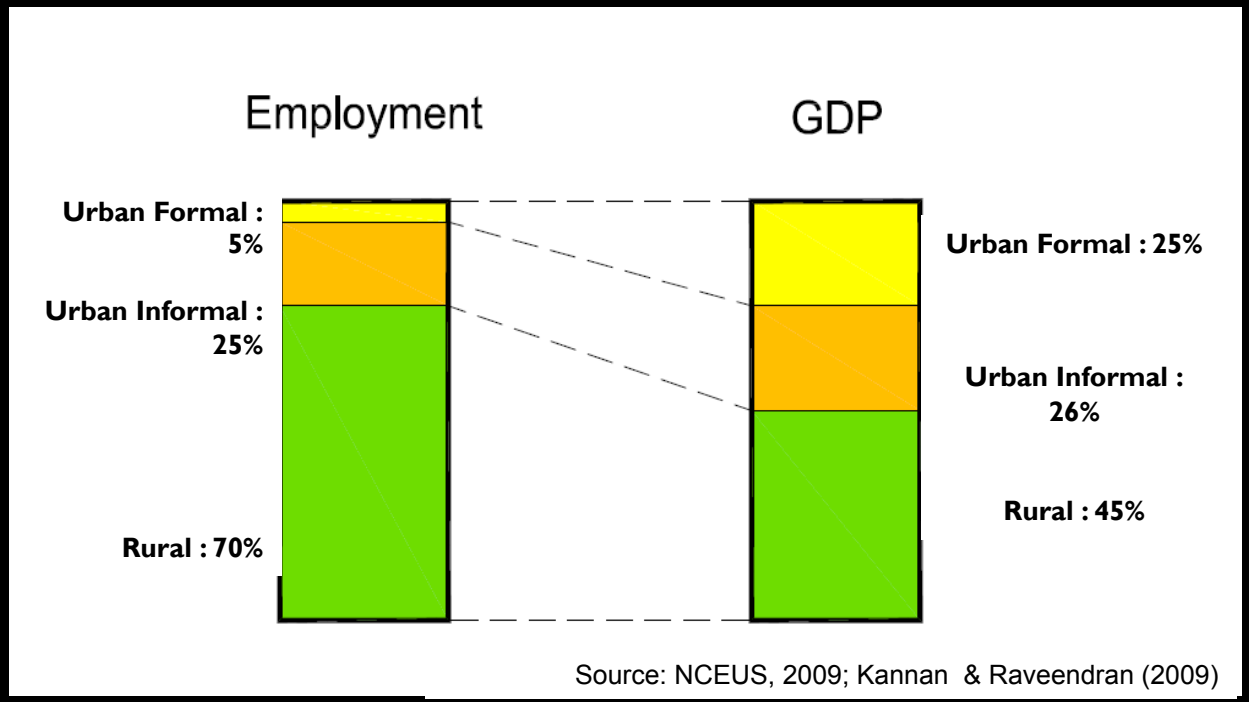
India: Inclusive Wealth trends (1990-2008)



India's Inclusive Wealth base is about 4 times its GDP.

Of this, the largest component is 'human capital'

India: GDP & Employment structure (2009)



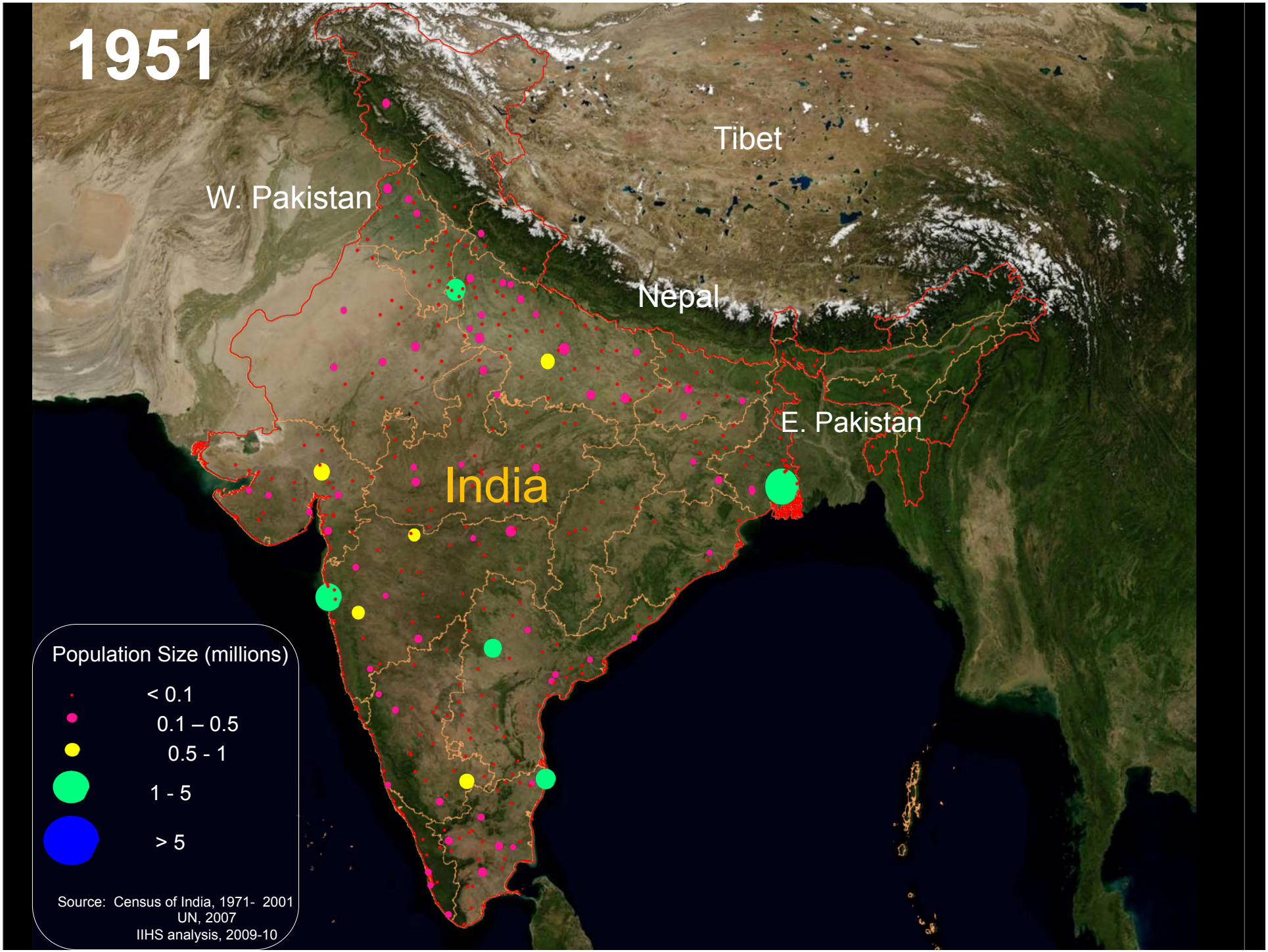
Source: NCEUS, 2009; Kannan & Raveendran (2009)

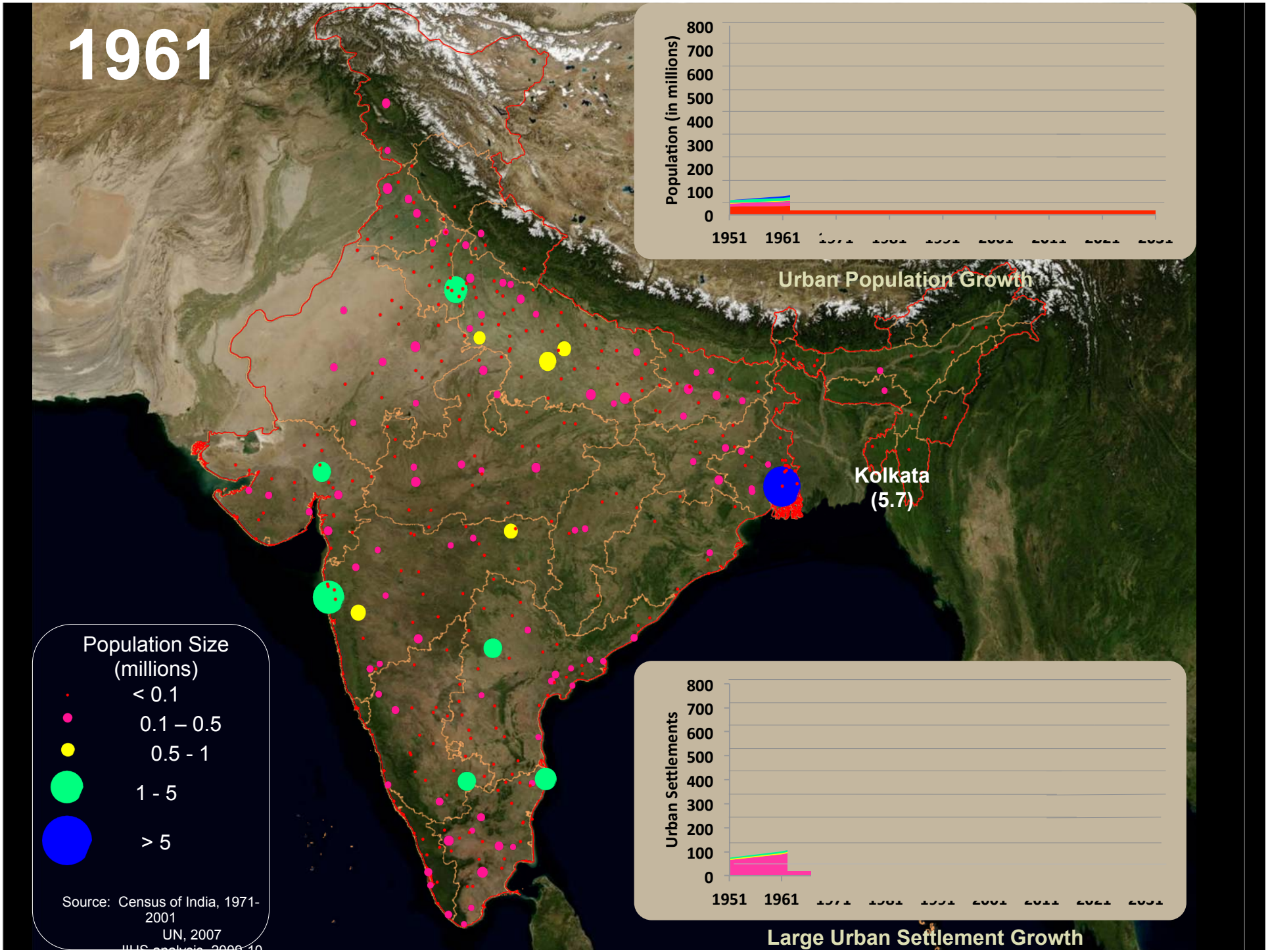
The urban informal sector with a quarter of the workers produces roughly a quarter of the GDP. The urban formal sector with 5 percent of the workers produces a similar share of the GDP.

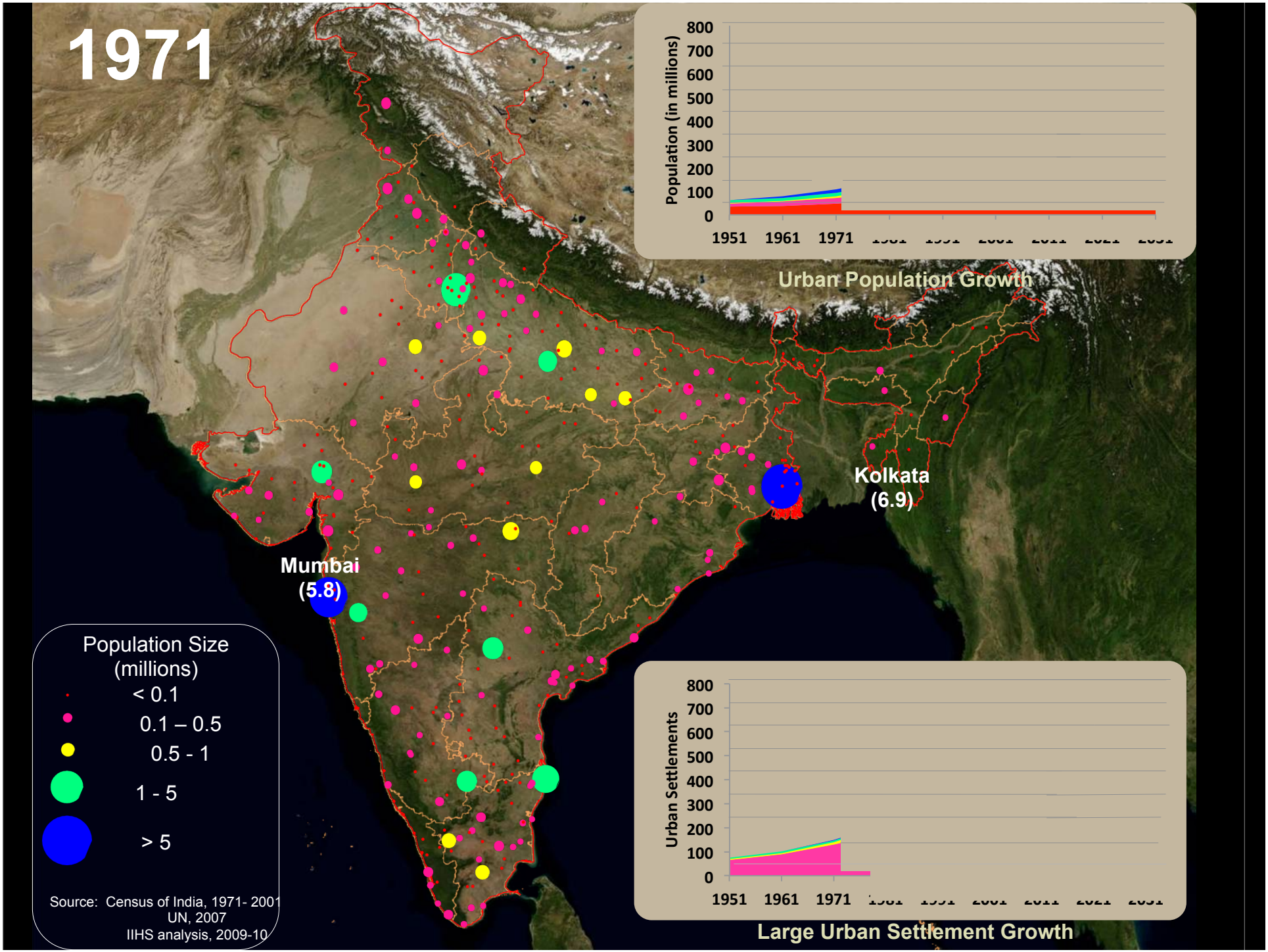
The Dynamics of Indian Urbanisation (1951-2031)

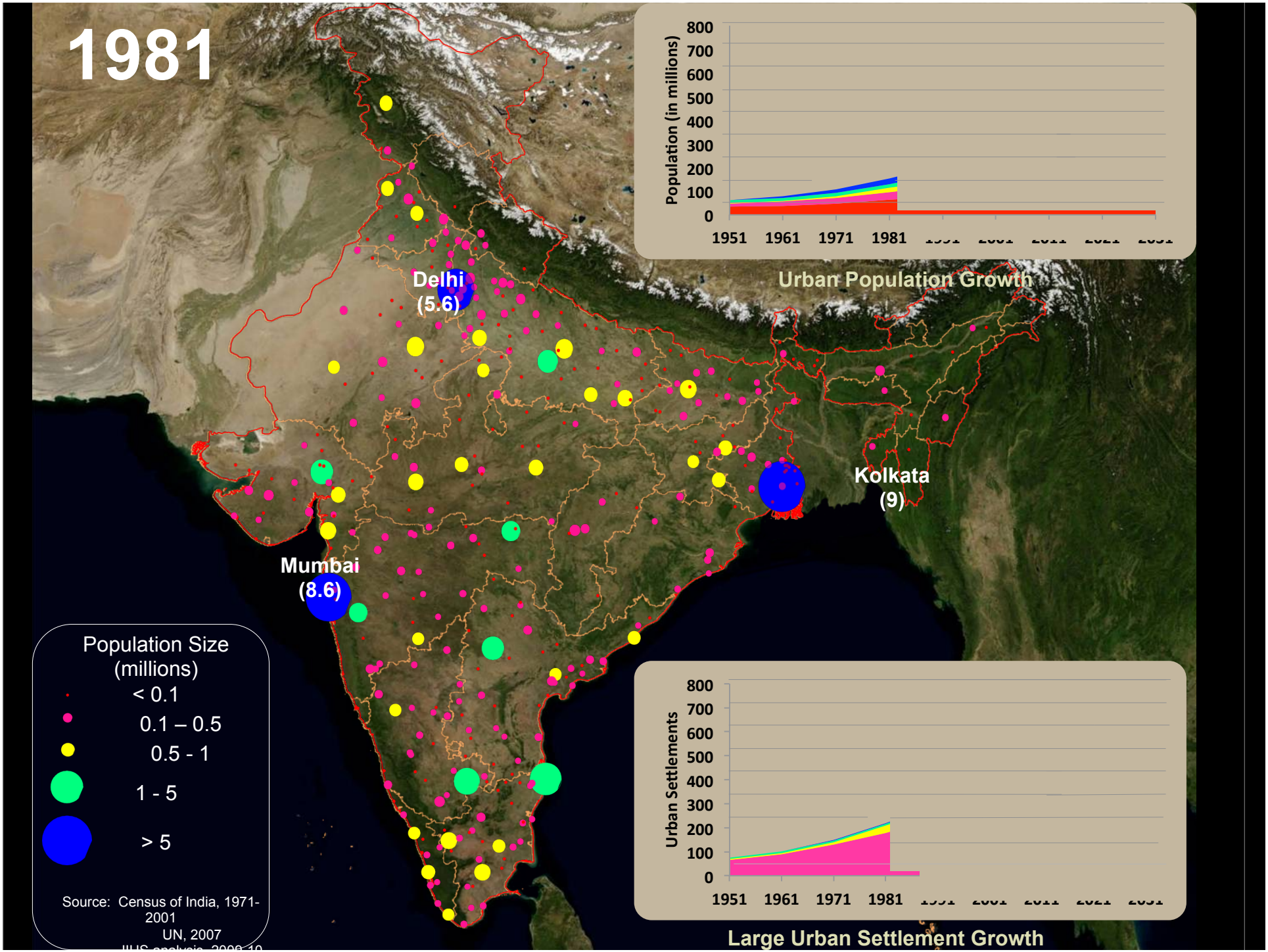
India's Coming transition (2011-2031)

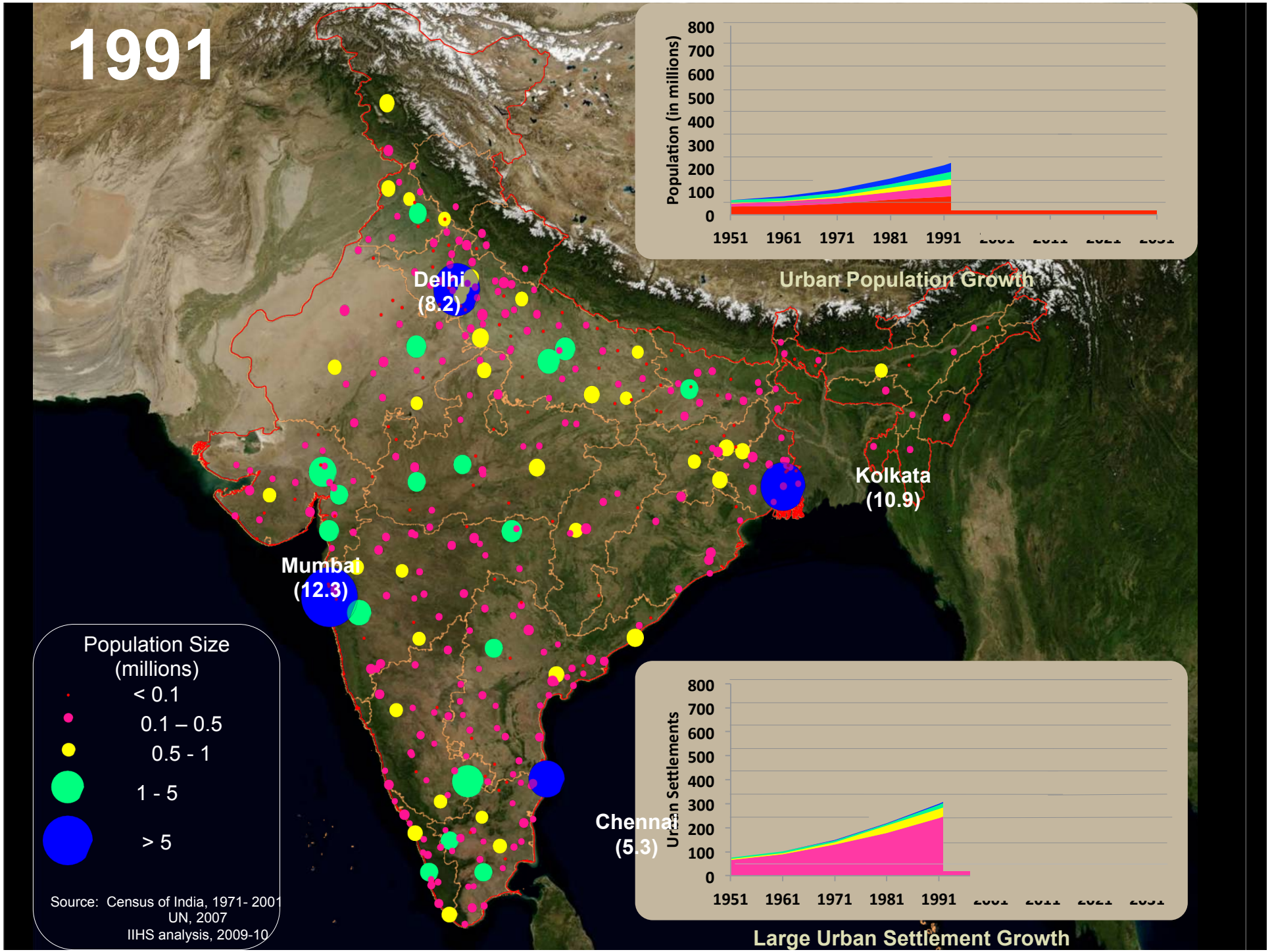
- India will add at least 300 million new people to its cities in the next 30 years
- This is on top of the current urban population of ~300 million, of whom over 70 million are poor
- In 2031, three of the ten largest megacities in the world will be in India: Delhi, Mumbai, Kolkata
- Over 75 other cities will have a population of over 1 million
- This will be the second largest urbanisation in human history creating huge market opportunities and development challenges
- The only option to avoid complete systemic urban breakdown is the simultaneous transformation of India's cities and its villages
- A wide range of technical, institutional and social innovations will be required to enable this

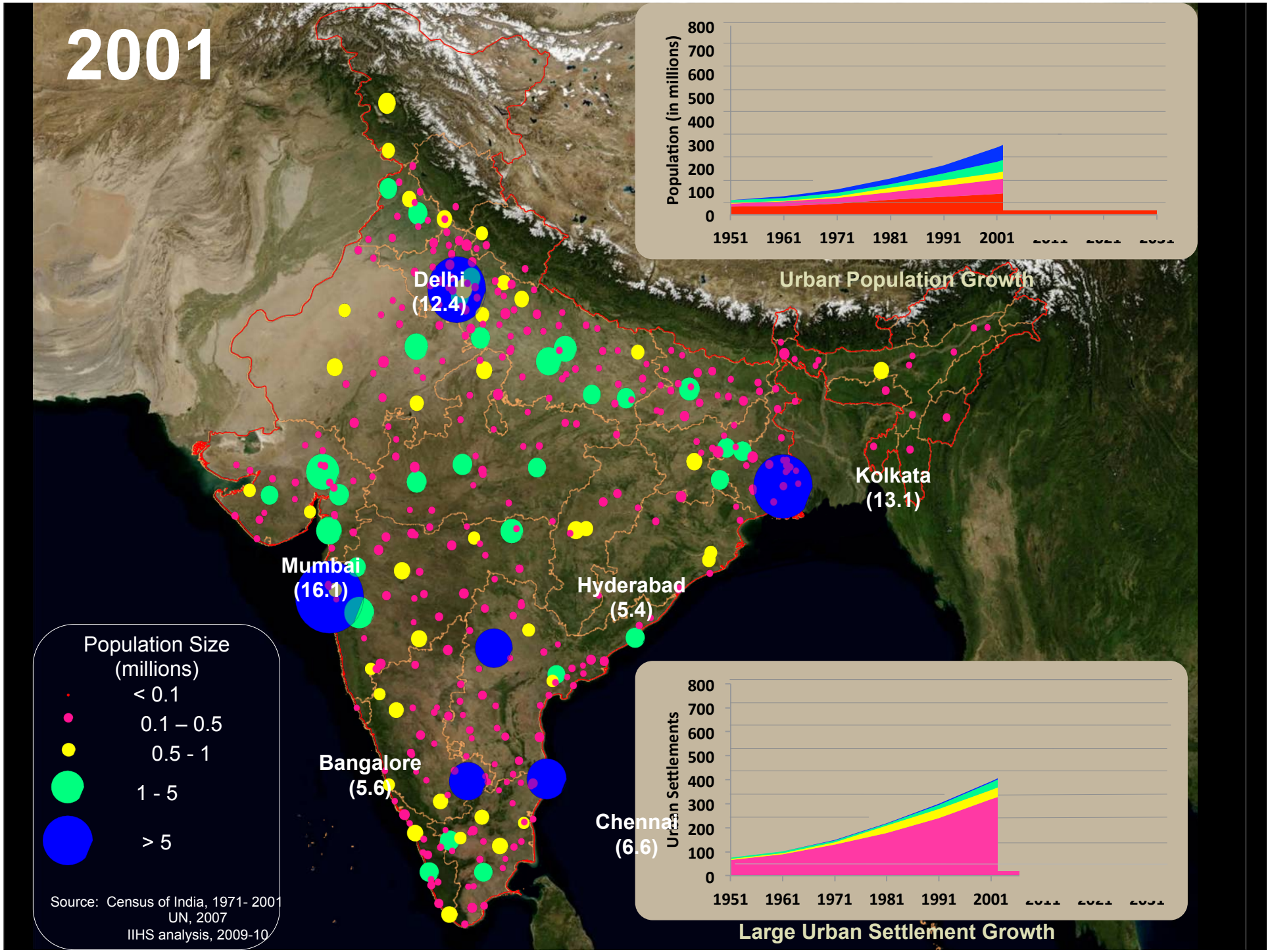

1951
Tibet
W. Pakistan
Nepal
E. Pakistan
India
Population Size (millions)
< 0.1
0.1 – 0.5
0.5 - 1
1 - 5
> 5
Source: Census of India, 1971- 2001
UN, 2007
IIHS analysis, 2009-10

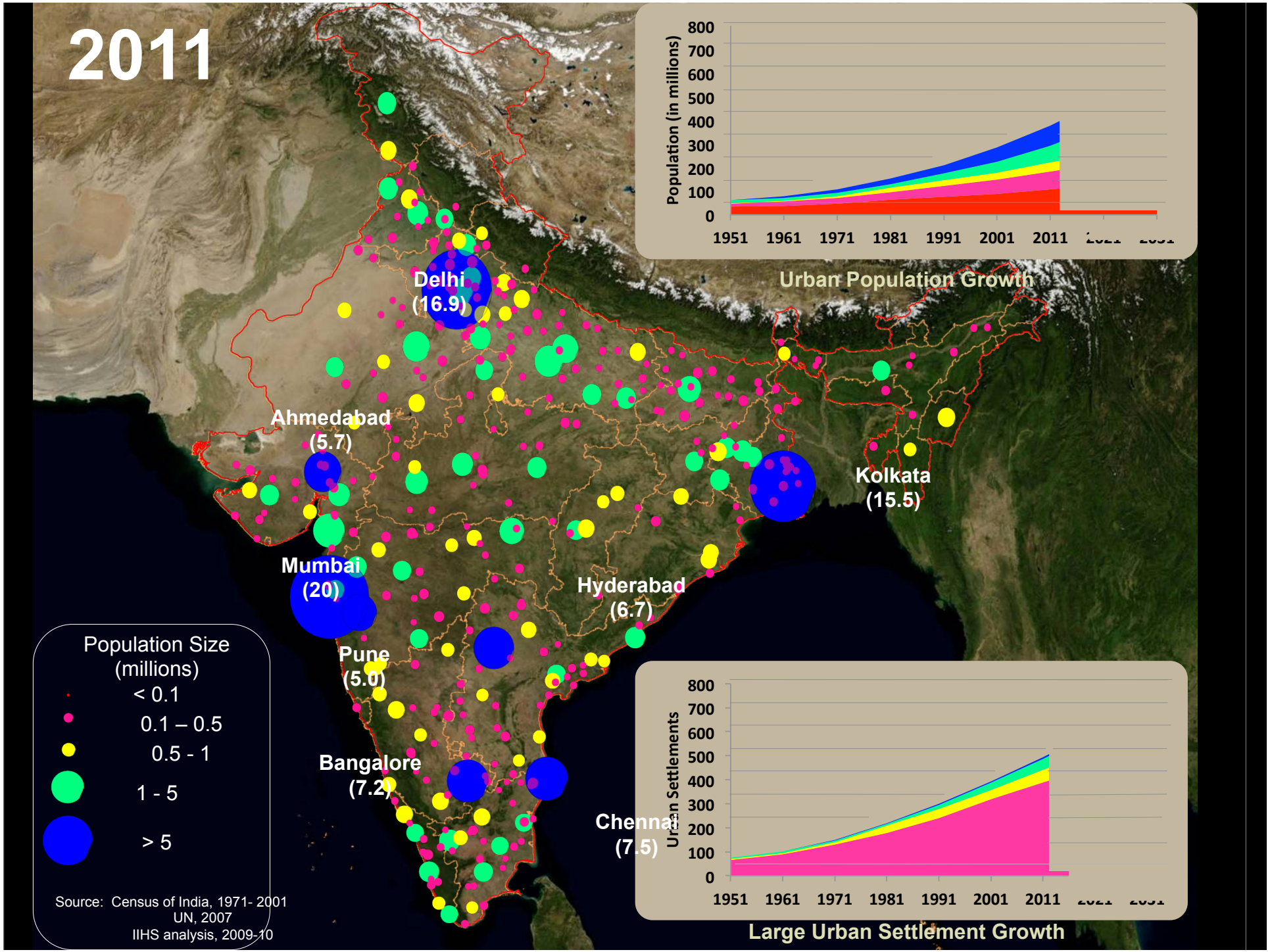

1961
Population (in millions)
800
700
600
500
400
300
200
100
0
1951
1961
Urban Population Growth
Kolkata
(5.7)
Population Size
(millions)
< 0.1
0.1 – 0.5
0.5 - 1
1 - 5
> 5
Source: Census of India, 1971-2001
UN, 2007
Urban Settlements
800
700
600
500
400
300
200
100
0
1951
1961
Large Urban Settlement Growth


1971
Population (in millions)
800
700
600
500
400
300
200
100
0
1951
1961
1971
Urban Population Growth
Kolkata
(6.9)
Mumbai
(5.8)
Population Size
(millions)
< 0.1
0.1 – 0.5
0.5 - 1
1 - 5
> 5
Source: Census of India, 1971- 2001
UN, 2007
IIHS analysis, 2009-10
Urban Settlements
800
700
600
500
400
300
200
100
0
1951
1961
1971
Large Urban Settlement Growth

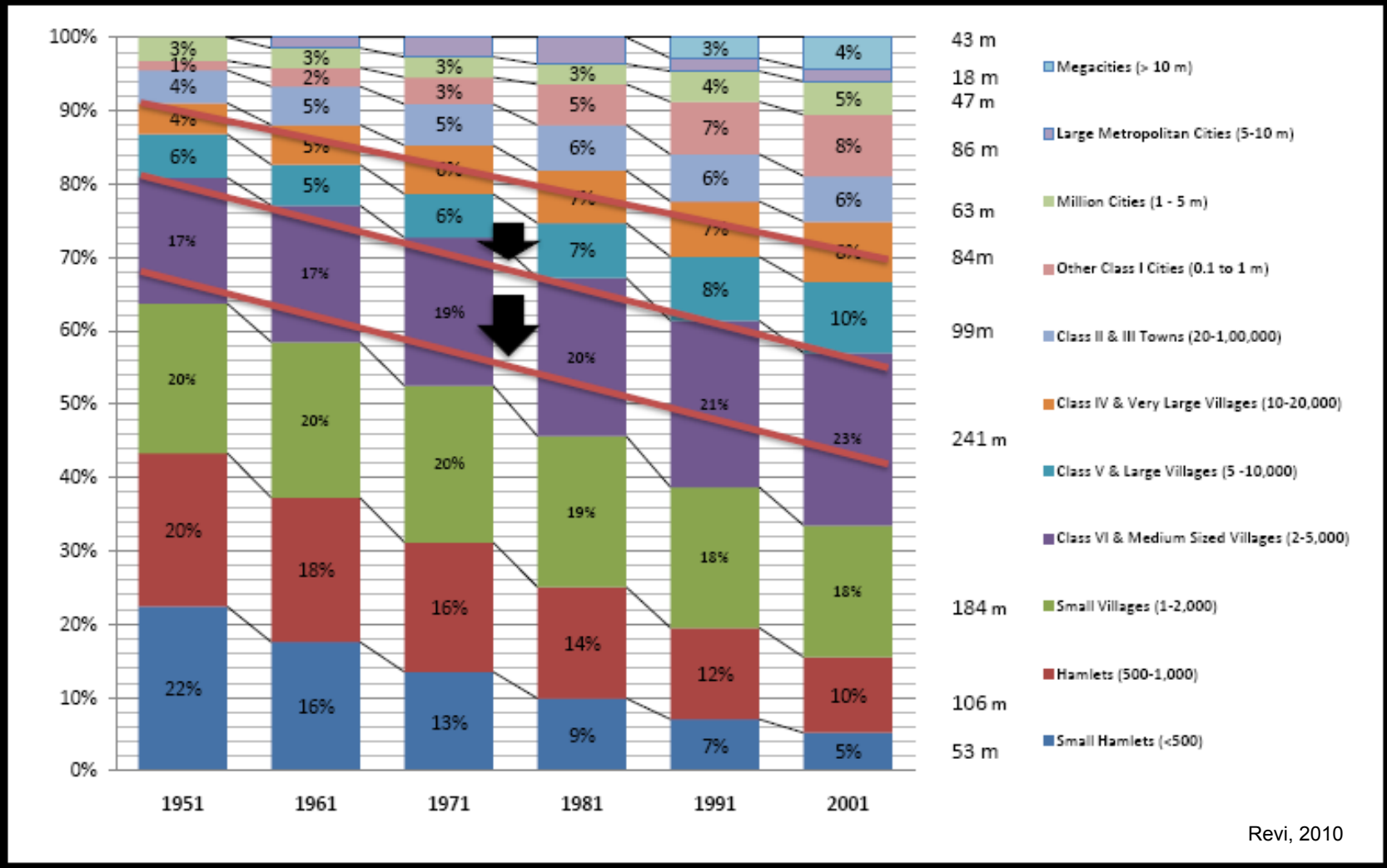

1981
Delhi
(5.6)
Mumbai
(8.6)
Kolkata
(9)
Population Size
(millions)
< 0.1
0.1 – 0.5
0.5 - 1
1 - 5
> 5
Source: Census of India, 1971-2001
UN, 2007
Population (in millions)
800
700
600
500
400
300
200
100
0
1951
1961
1971
1981
Urban Population Growth
Urban Settlements
800
700
600
500
400
300
200
100
0
1951
1961
1971
1981
Large Urban Settlement Growth


1991
Population (in millions)
800
700
600
500
400
300
200
100
0
1951
1961
1971
1981
1991
Urban Population Growth
Delhi
(8.2)
Kolkata
(10.9)
Mumbai
(12.3)
Chennai
(5.3)
Urban Settlements
Large Urban Settlement Growth
Population Size
(millions)
< 0.1
0.1 – 0.5
0.5 - 1
1 - 5
> 5
Source: Census of India, 1971- 2001
UN, 2007
IIHS analysis, 2009-10

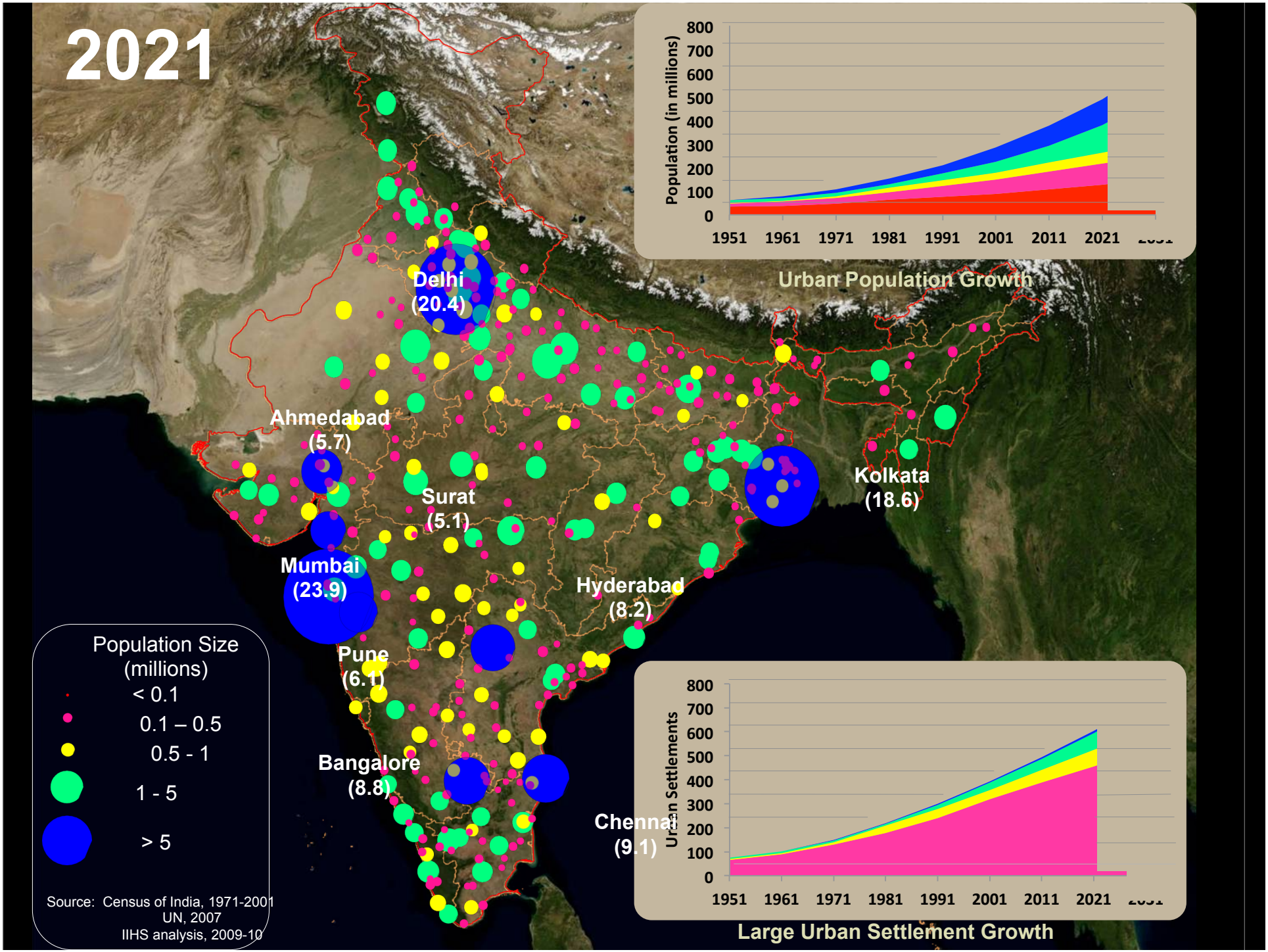

2001
Population (in millions)
800
700
600
500
400
300
200
100
0
1951
1961
1971
1981
1991
2001
Urban Population Growth
Delhi
(12.4)
Kolkata
(13.1)
Mumbai
(16.1)
Hyderabad
(5.4)
Bangalore
(5.6)
Chennai
(6.6)
Population Size
(millions)
< 0.1
0.1 – 0.5
0.5 - 1
1 - 5
> 5
Source: Census of India, 1971- 2001
UN, 2007
IIHS analysis, 2009-10
Urban Settlements
800
700
600
500
400
300
200
100
0
1951
1961
1971
1981
1991
2001
Large Urban Settlement Growth

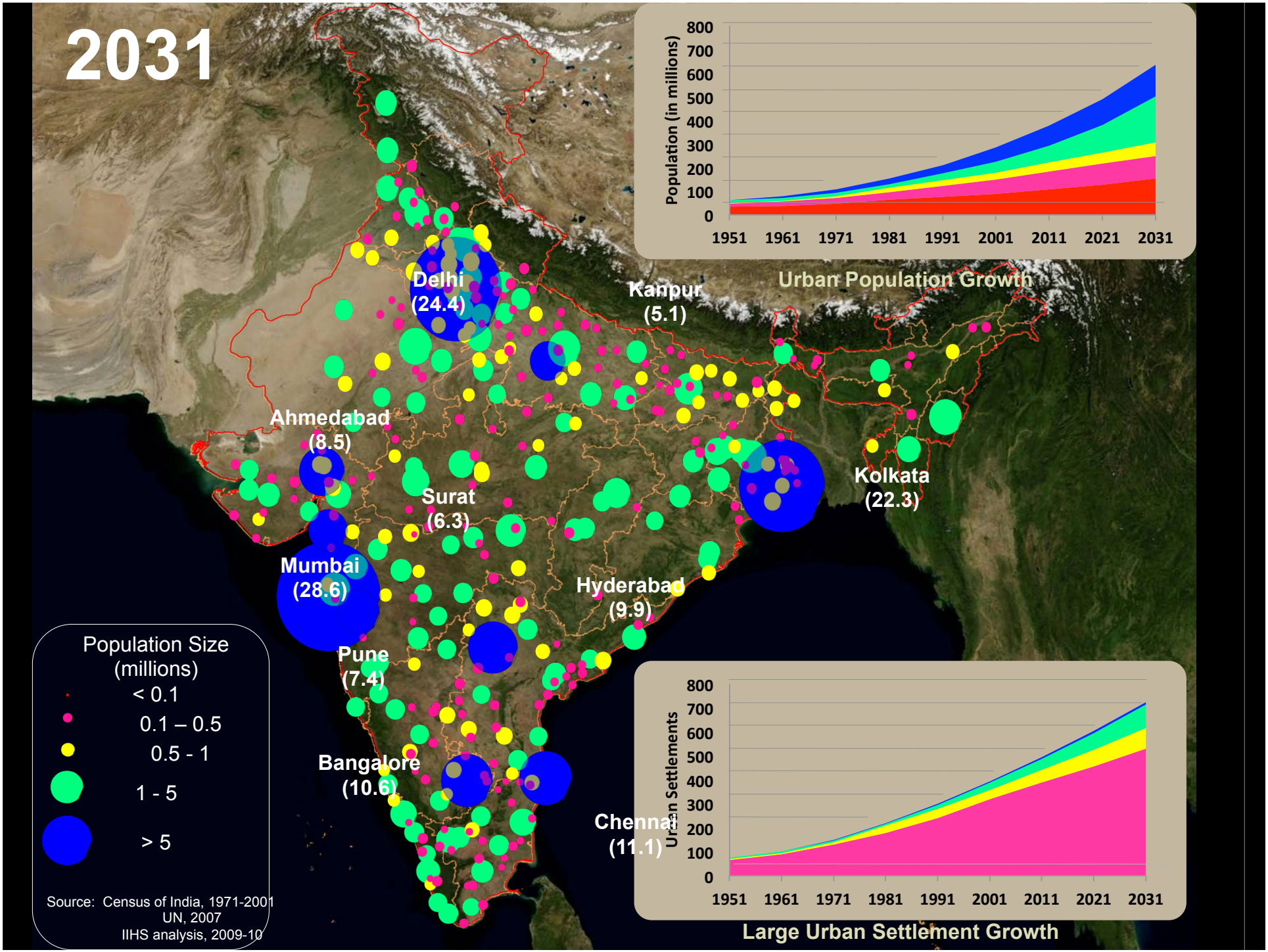

2011
Population (in millions)
800
700
600
500
400
300
200
100
0
1951
1961
1971
1981
1991
2001
2011
Urban Population Growth
Delhi
(16.9)
Ahmedabad
(5.7)
Kolkata
(15.5)
Mumbai
(20)
Hyderabad
(6.7)
Pune
(5.0)
Bangalore
(7.2)
Chennai
(7.5)
Population Size
(millions)
< 0.1
0.1 – 0.5
0.5 - 1
1 - 5
> 5
Source: Census of India, 1971- 2001
UN, 2007
IIHS analysis, 2009-10
Urban Settlements
800
700
600
500
400
300
200
100
0
1951
1961
1971
1981
1991
2001
2011
Large Urban Settlement Growth

India's Settlement structure matched to deliver a sustainable future



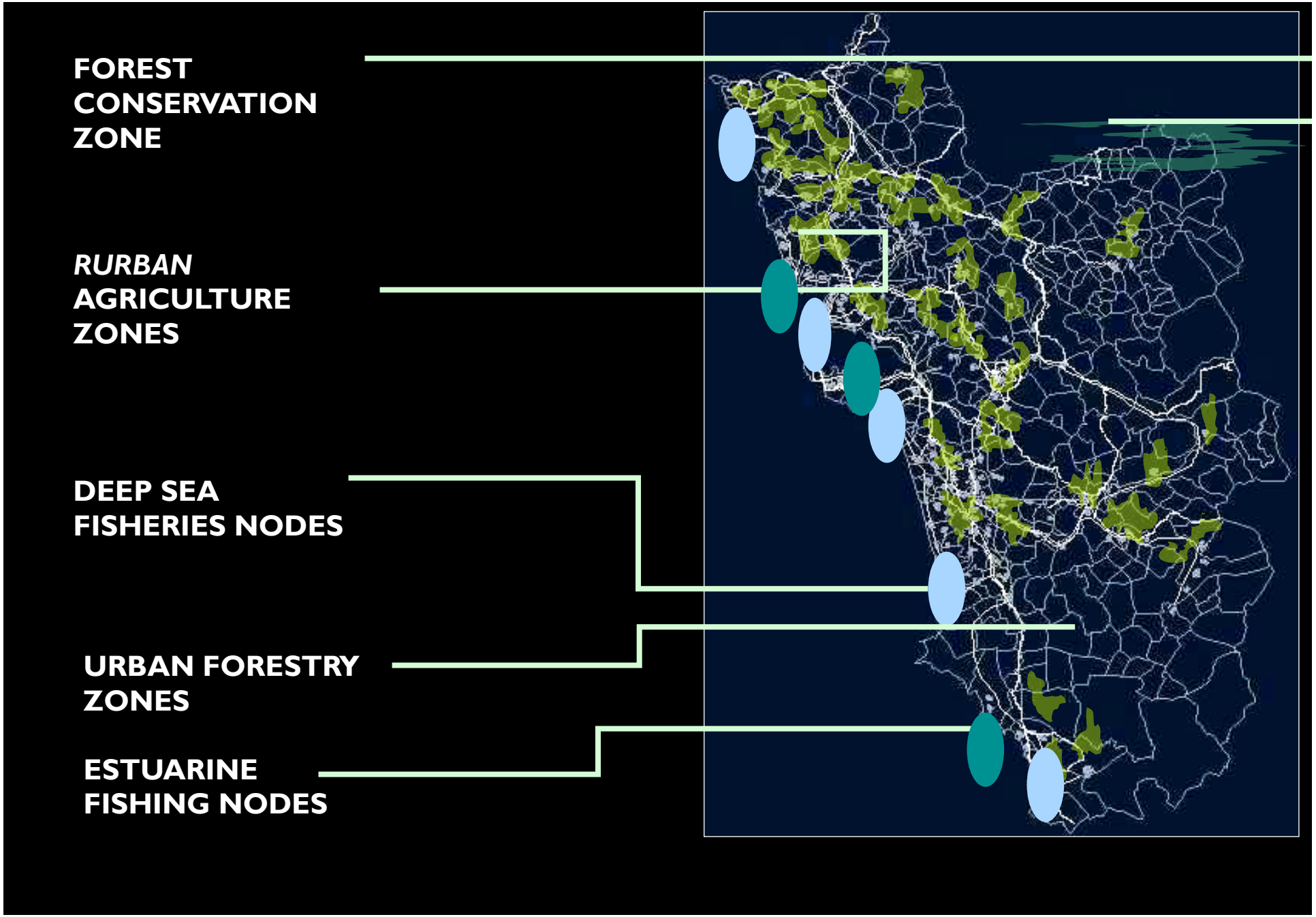
~ 5,00 urban areas and ~ 0.5 million rural settlements in 2001 – the opportunity for decentralised production and consumption systems and economic structure


2021
Population (in millions)
800
700
600
500
400
300
200
100
0
1951
1961
1971
1981
1991
2001
2011
2021
Urban Population Growth
Delhi
(20.4)
Ahmedabad
(5.7)
Surat
(5.1)
Mumbai
(23.9)
Pune
(6.1)
Bangalore
(8.8)
Chennai
(9.1)
Hyderabad
(8.2)
Kolkata
(18.6)
Population Size
(millions)
< 0.1
0.1 – 0.5
0.5 - 1
1 - 5
> 5
Source: Census of India, 1971-2001
UN, 2007
IIHS analysis, 2009-10
Urban Settlements
800
700
600
500
400
300
200
100
0
1951
1961
1971
1981
1991
2001
2011
2021
Large Urban Settlement Growth


2031
Delhi
(24.4)
Kanpur
(5.1)
Urban Population Growth
Ahmedabad
(8.5)
Surat
(6.3)
Kolkata
(22.3)
Mumbai
(28.6)
Hyderabad
(9.9)
Pune
(7.4)
Bangalore
(10.6)
Chennai
(11.1)
Population Size
(millions)
< 0.1
0.1 – 0.5
0.5 - 1
1 - 5
> 5
Source: Census of India, 1971-2001
UN, 2007
IIHS analysis, 2009-10
Population (in millions)
800
700
600
500
400
300
200
100
0
1951 1961 1971 1981 1991 2001 2011 2021 2031
Urban Settlements
800
700
600
500
400
300
200
100
0
1951 1961 1971 1981 1991 2001 2011 2021 2031
Large Urban Settlement Growth

Goa 2030:
the Challenge of Scale-up ..

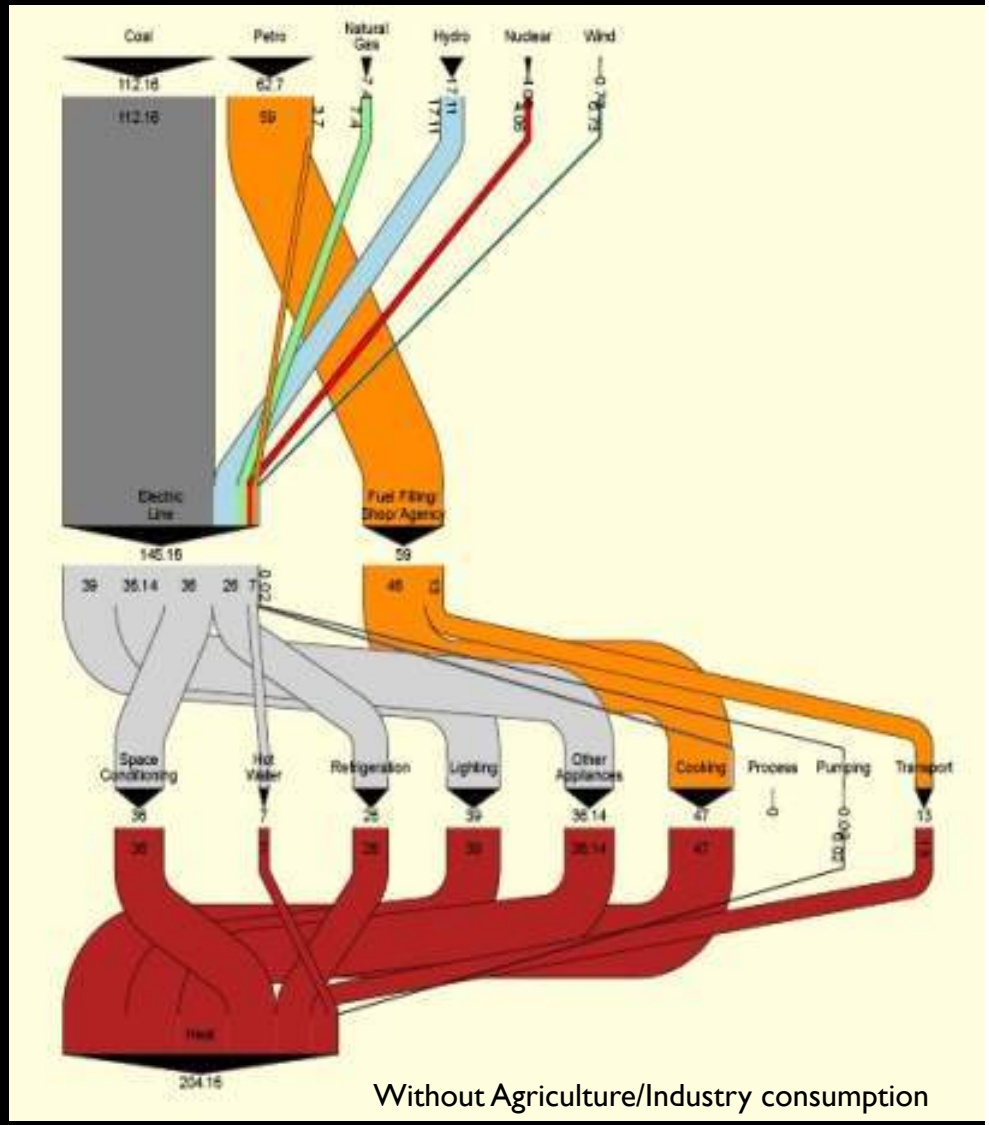
Sustainable Forest, Food and Fisheries Production



Goa 2030: Energy Futures

Goa Urban Energy Consumption (2005)

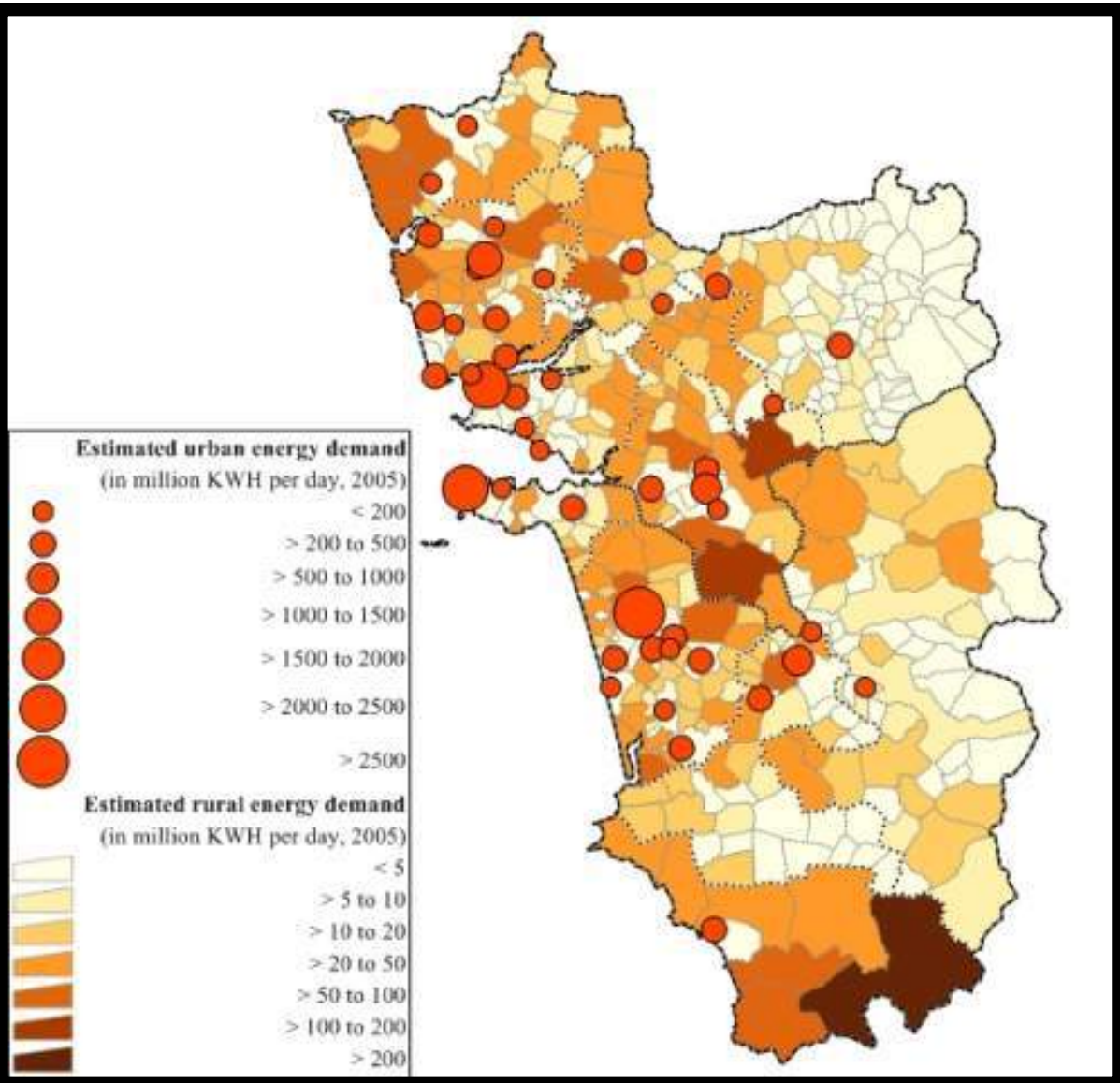
- Main sources: Electricity and LPG
- Relatively high demands
- No heat recovery or efficiency



Without Agriculture/Industry consumption

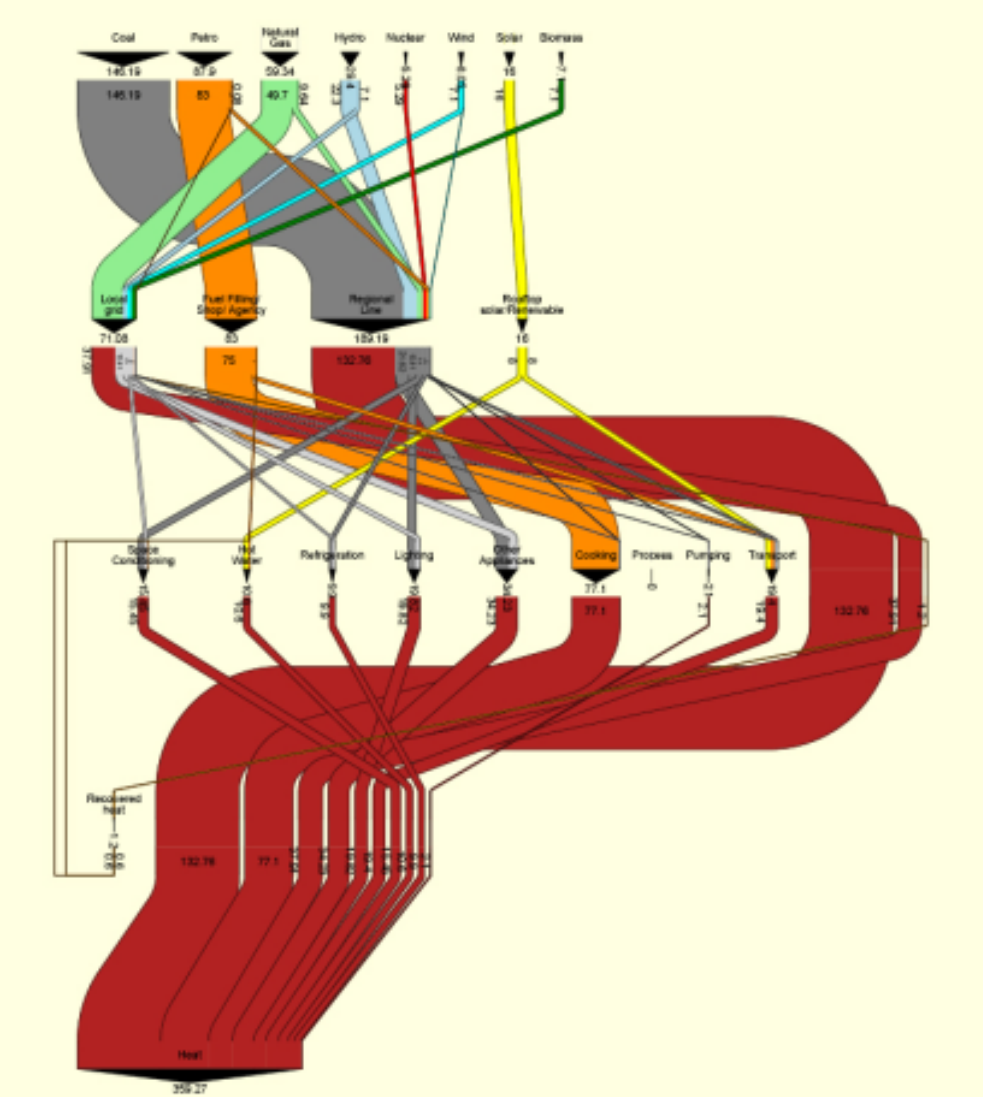
Goa Consumption Energyscape (2005)

- Great difference between rural and urban demands
- Specific energy consumption is low



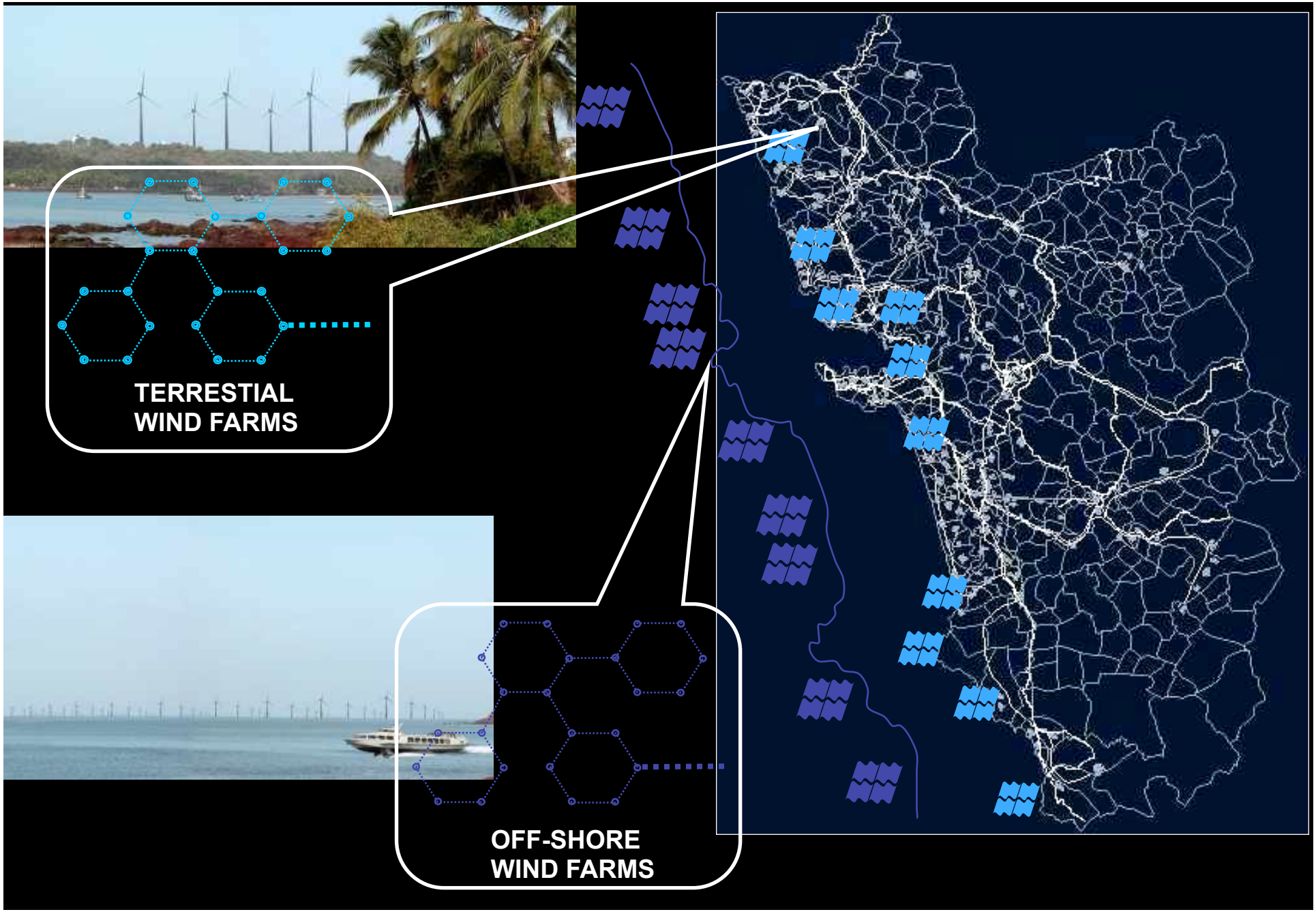
Sustainable Goa Energy Fluxes (2030)

- Two grids: Local and Regional
- Local Grid is Fed by Gas, Wind, and Biomass
- Increasing Demand with Conservation
- Moderate heat recovery
- Moderate rooftop harvesting

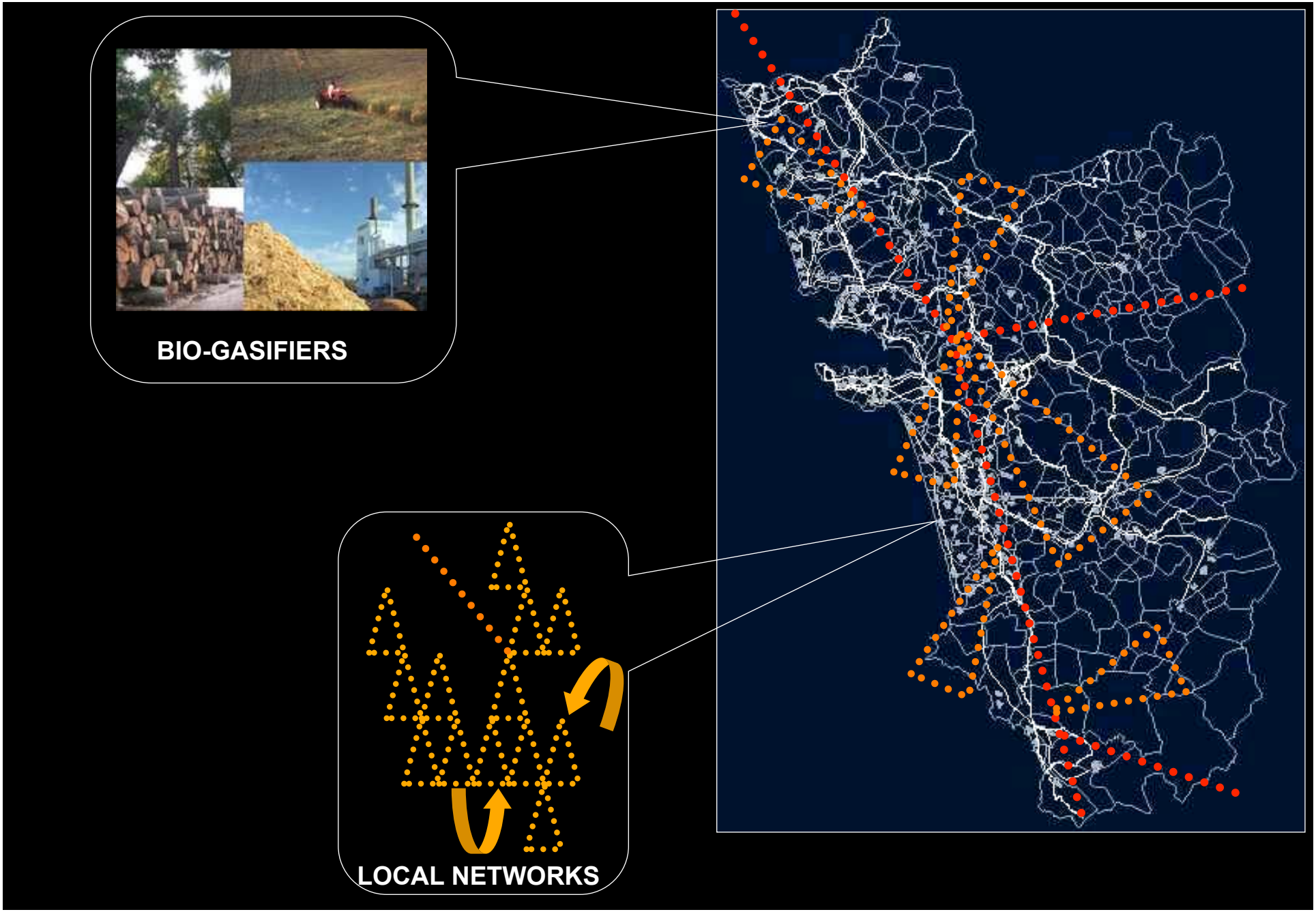


Without Agriculture/Industry consumption

500 MW of terrestrial & 1000 MW off-shore wind power



Two way Power networks & a possible Gas network

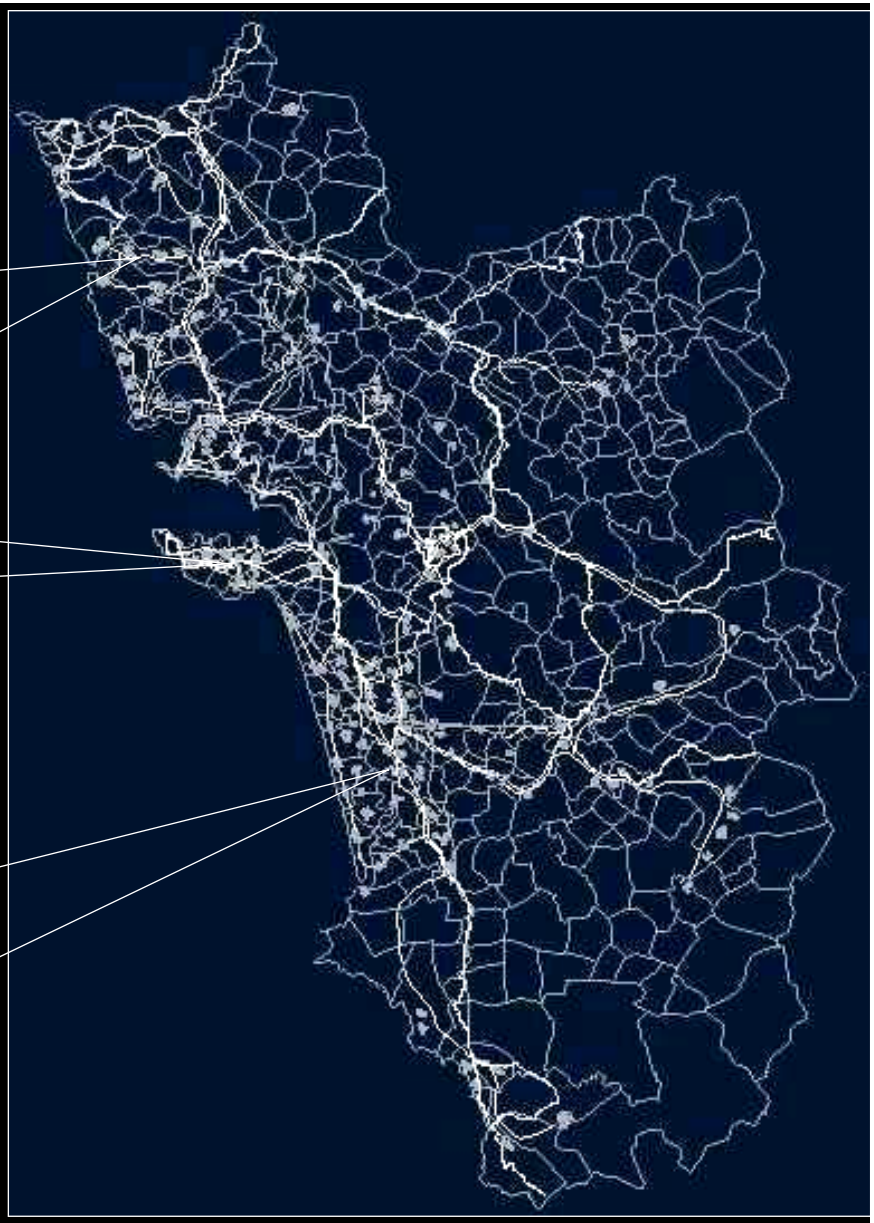


Other Renewable & Soft Power sources

SOLAR WATER HEATING

TRI-GENERATION

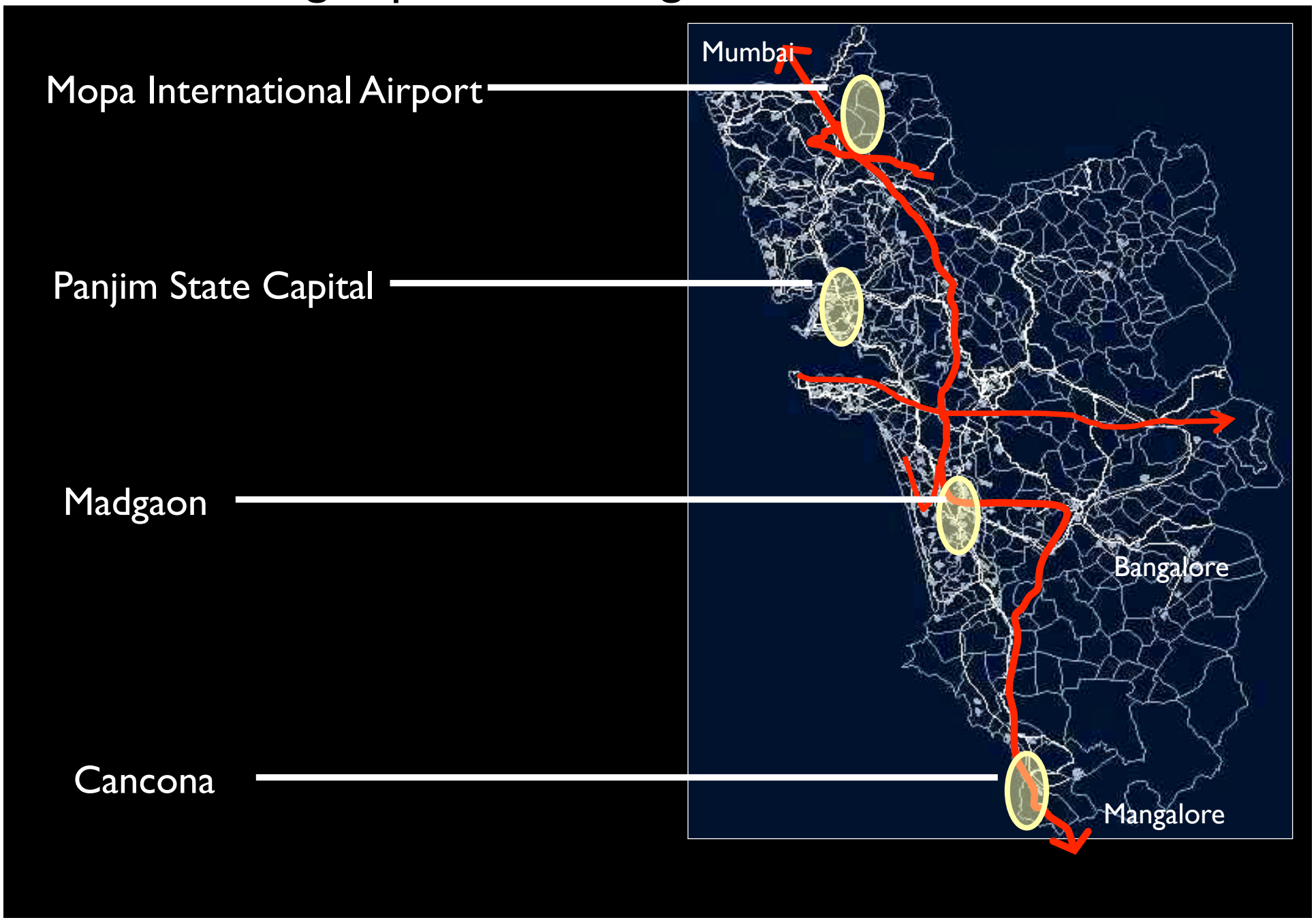
BIO-METHANATION



Offshore and onshore wind turbines punctuate the Panjim skyline by 2030

A Key Change Driver:
Sustainable Transportation Networks

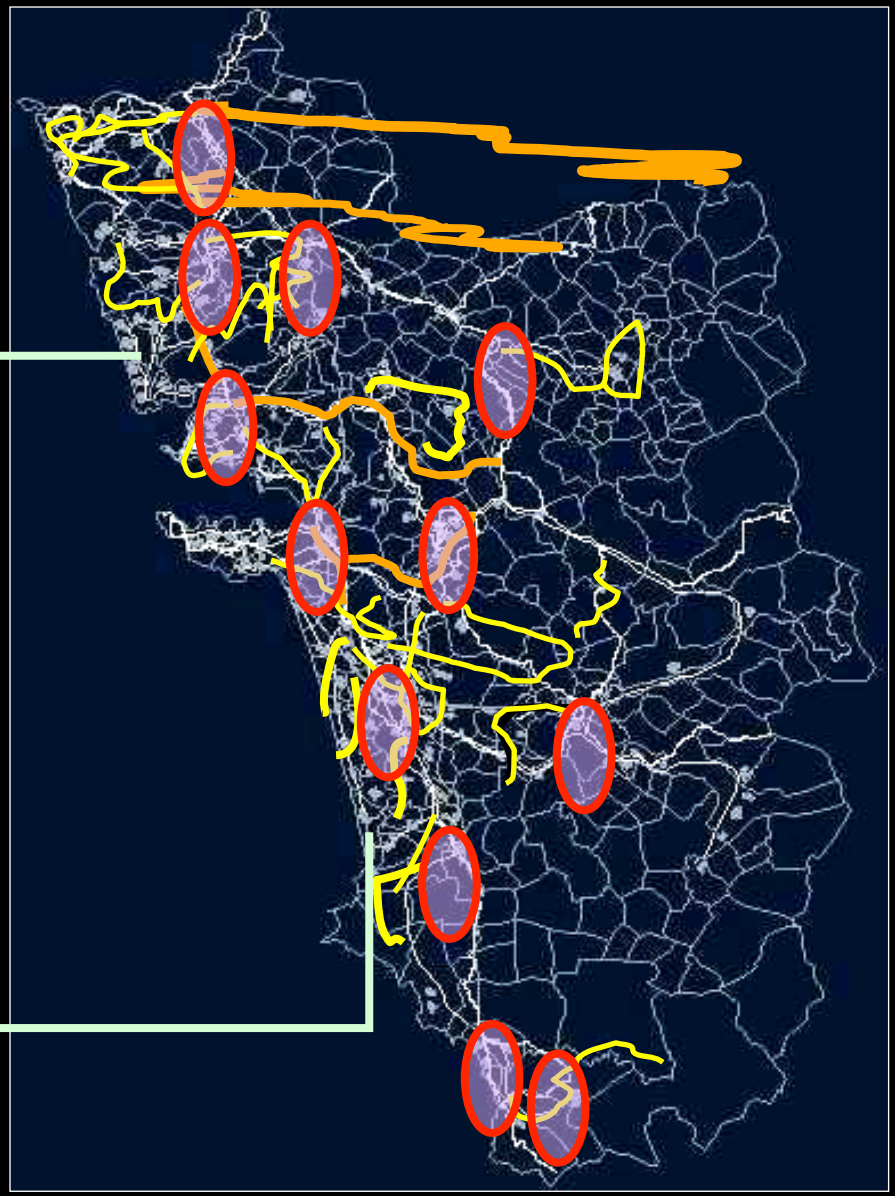
High Speed Inter-regional Rail corridor



Intercity Light Rail & High Capacity Bus systems

INTERCITY LIGHT RAIL NETWORK

INTER-NUCLEI HIGH CAPACITY BUS SYSTEM NETWORK



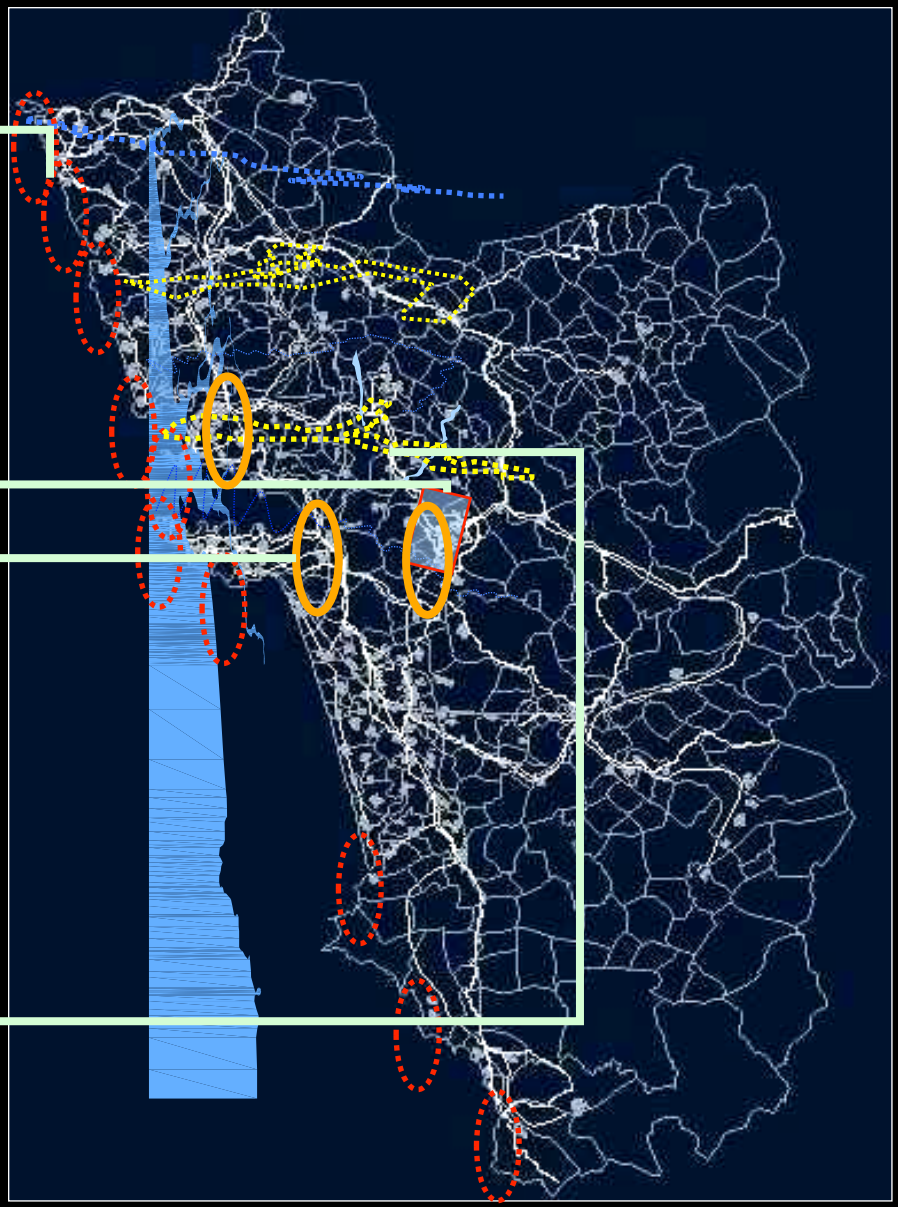
Hydrofoil and All season River Transport Systems

HYDROFOIL NODES

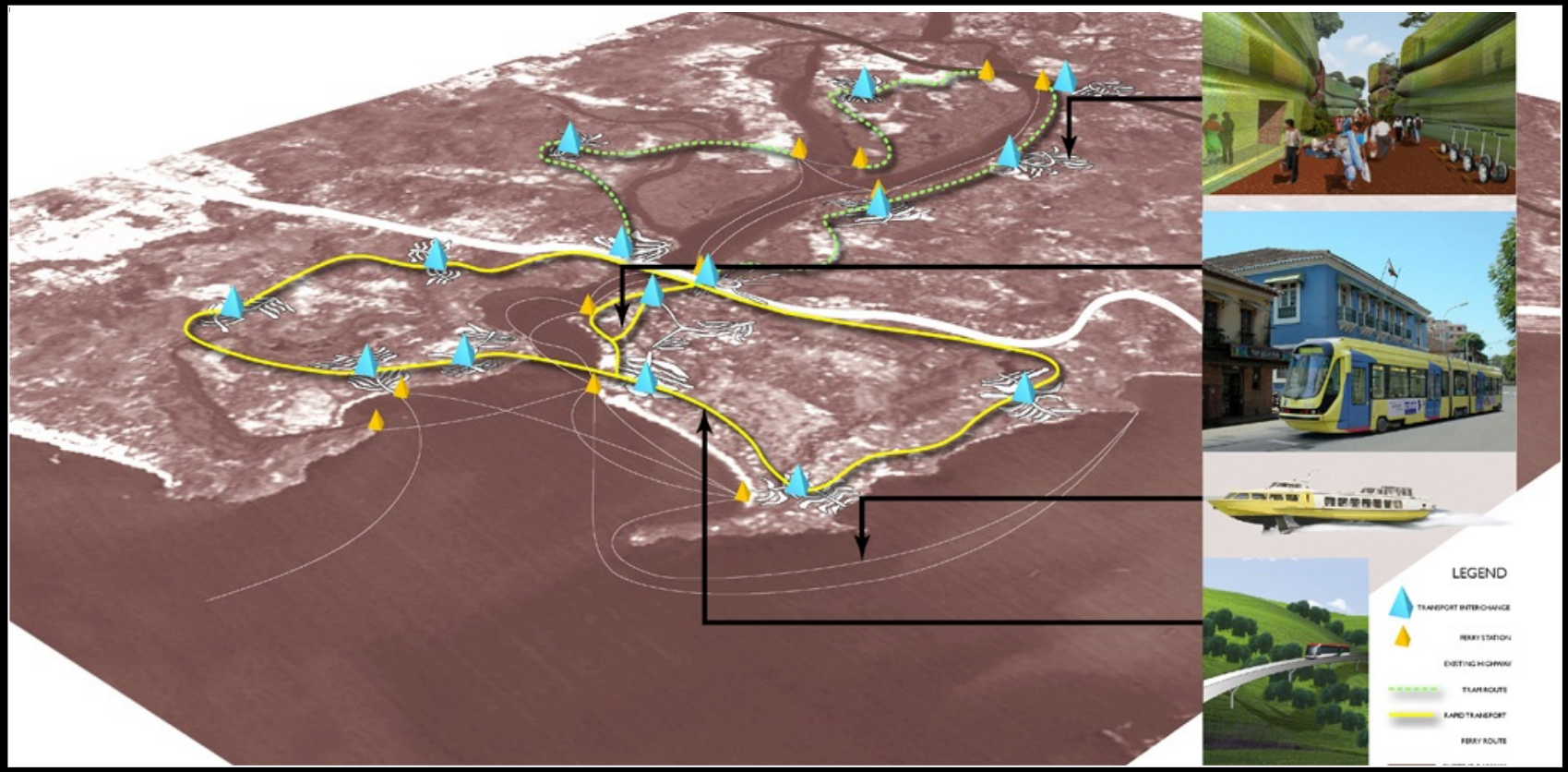
NEW CANAL NETWORK FOR MAJOR URBAN CENTRES

THREE INTRA-MODAL TERMINII

SOLAR FERRY NETWORKS

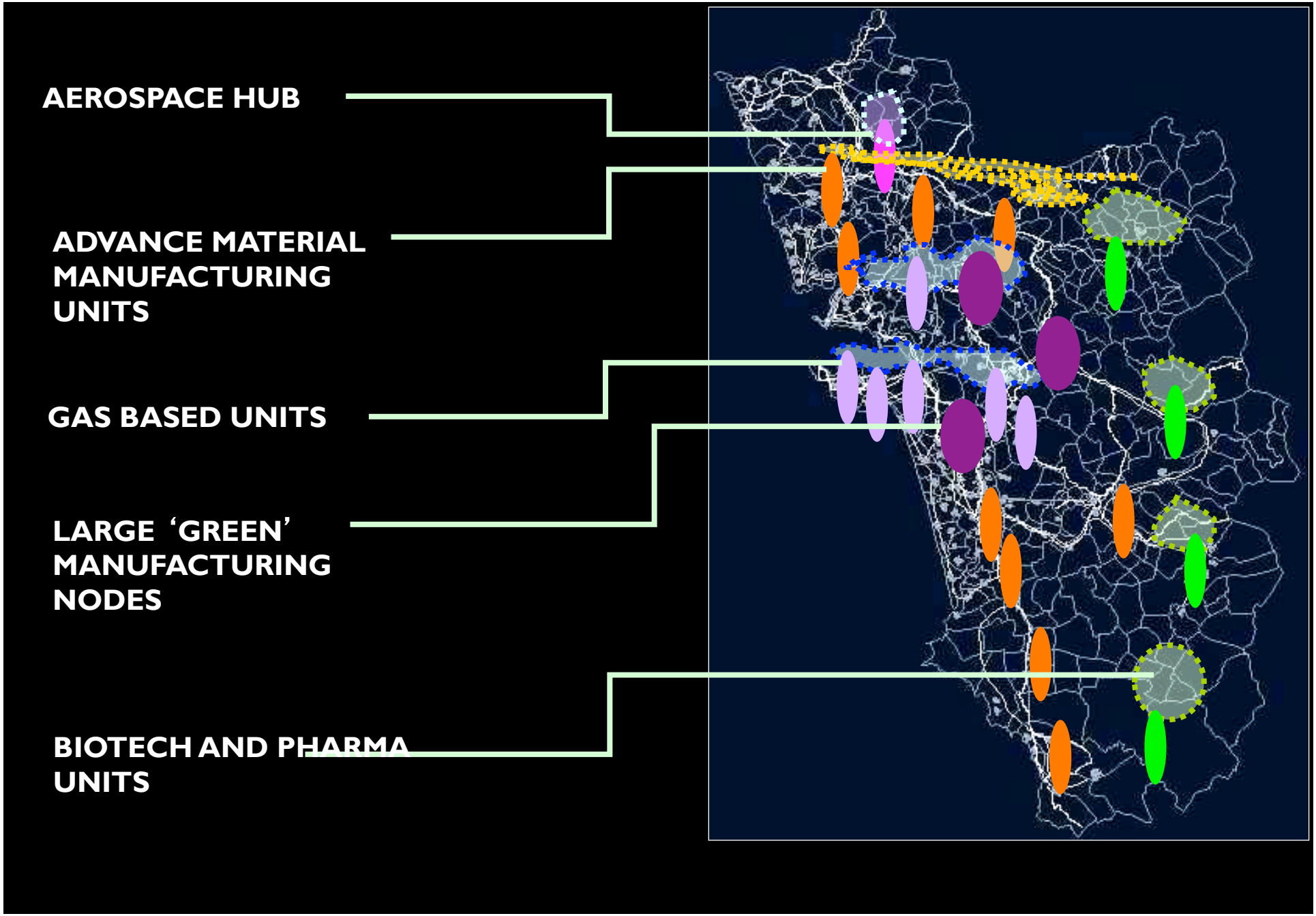


RUrban scale Mobility systems



Key Change Driver:
Clean ‘Factor 4’ Manufacturing

‘Green’ manufacturing zones



Key Change Driver:
Service-sector led development

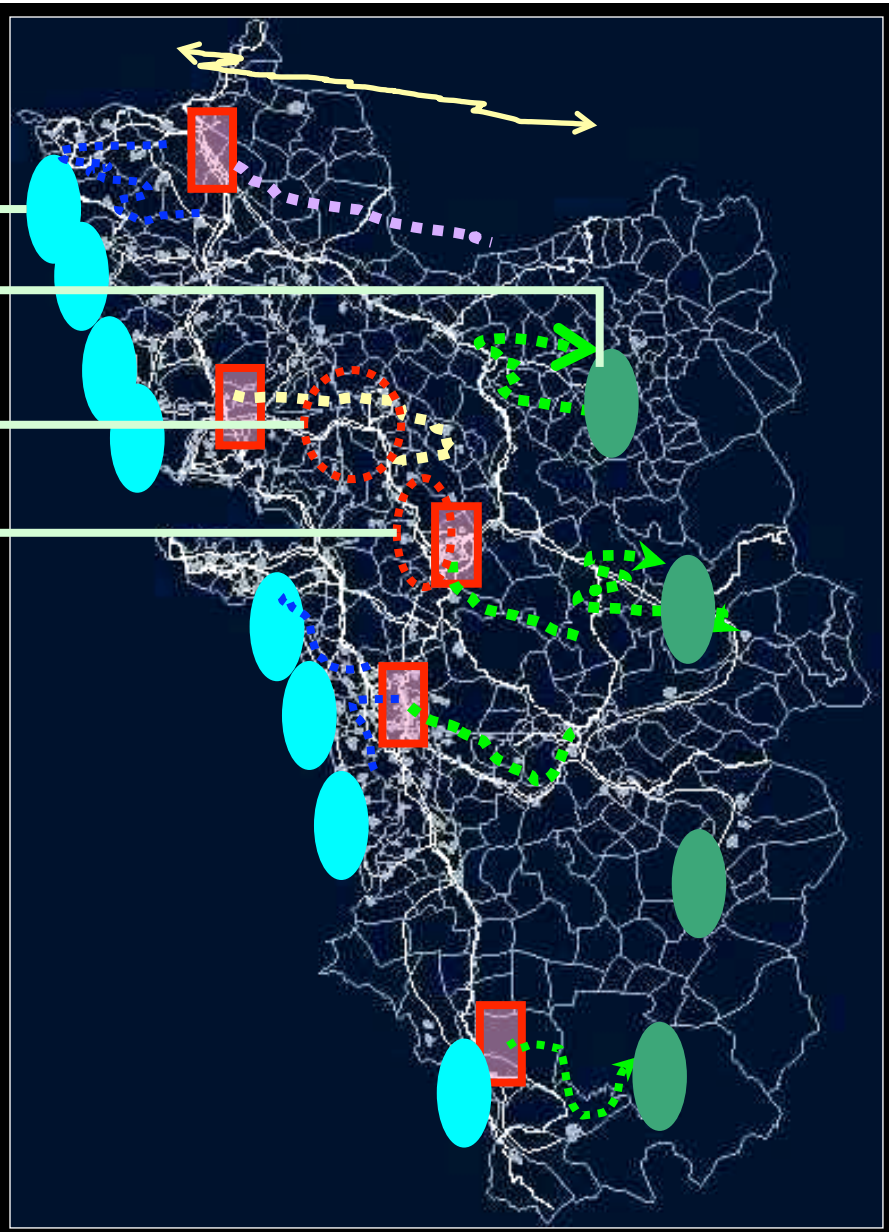
Tourism Networks

BEACH TOURISM NETWORK

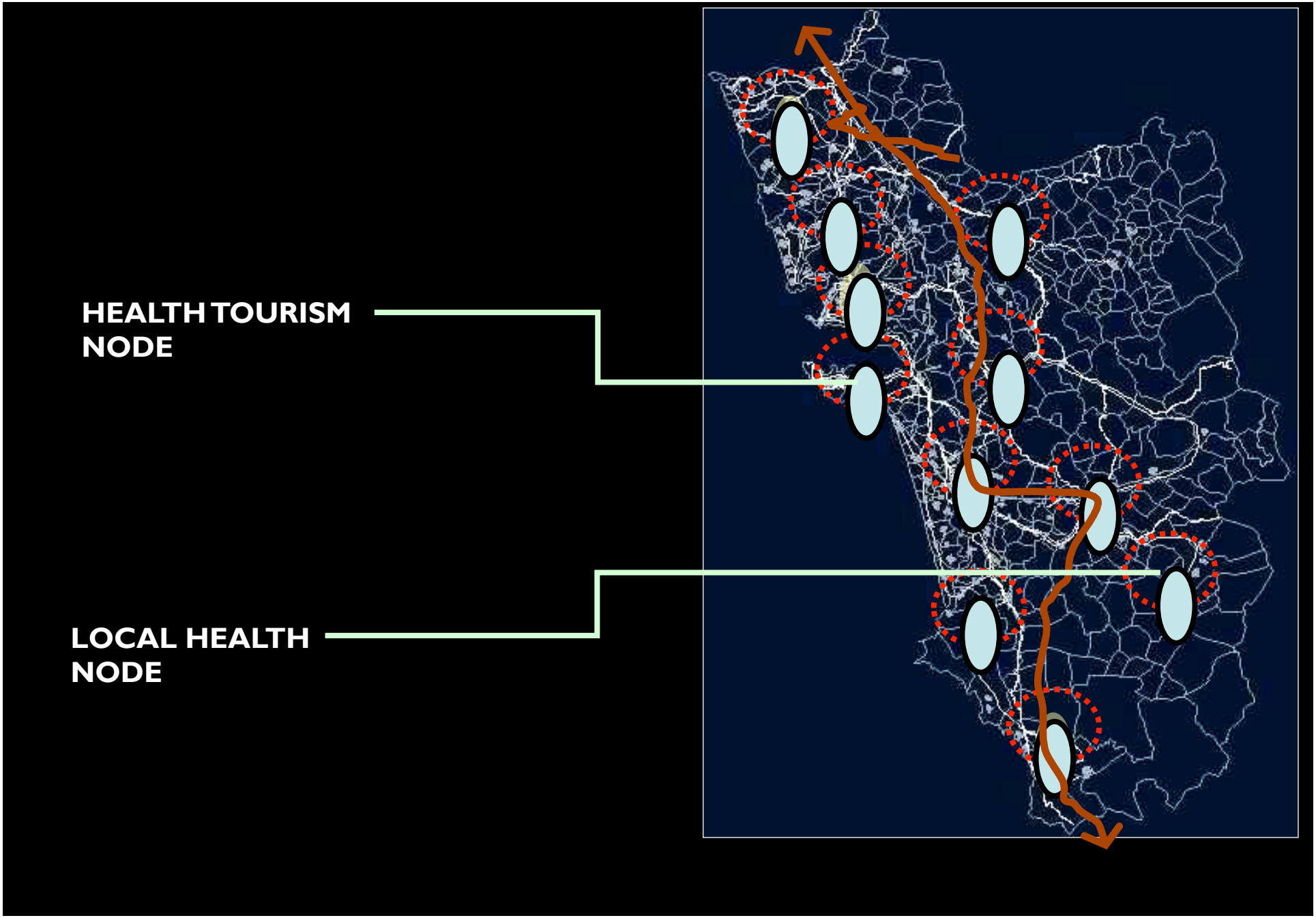
ECO- TOURISM NETWORK

HERITAGE TOURISM NETWORK

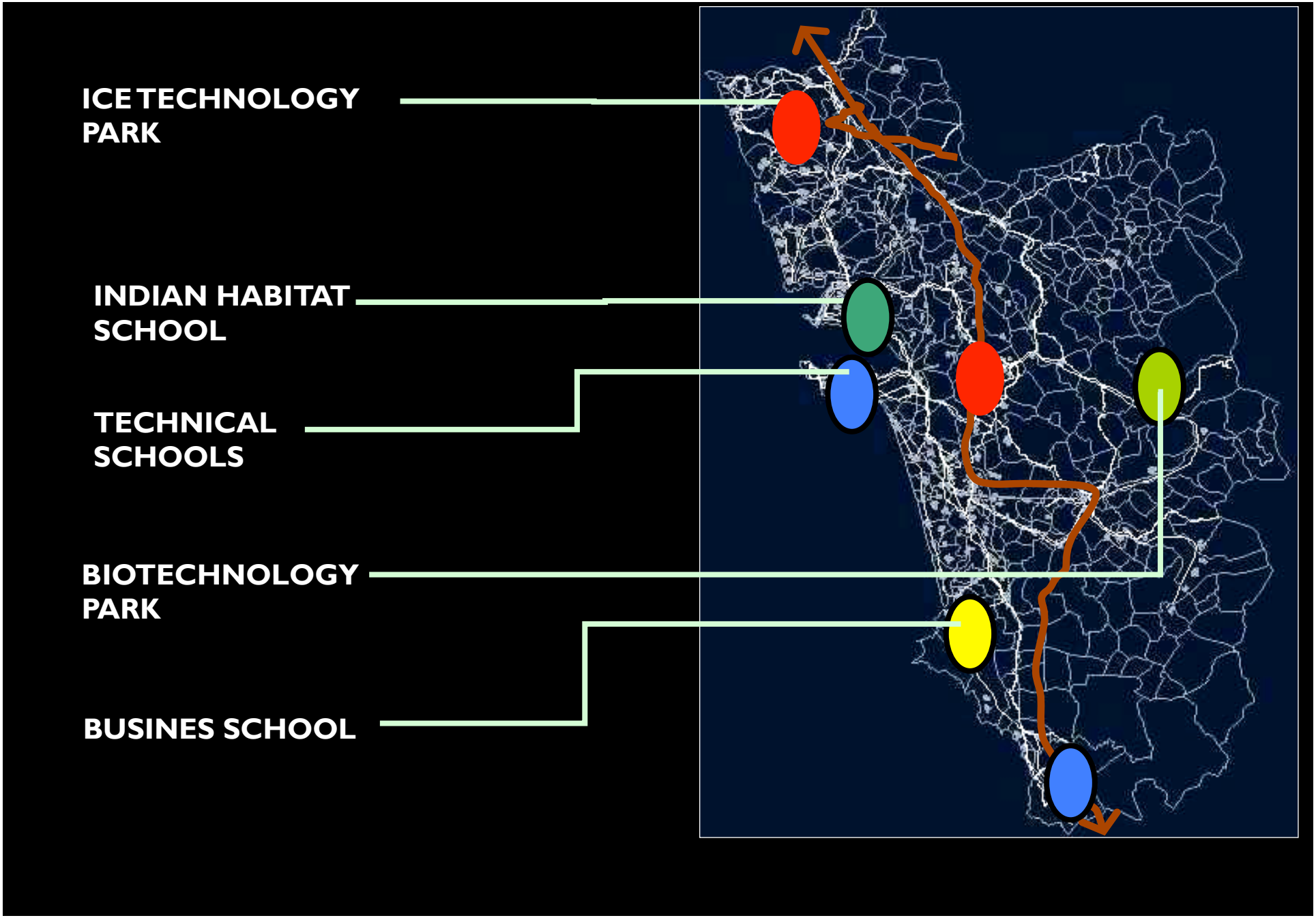
RELIGIOUS TOURISM NETWORK



Wellness nodes & networks



Educational & Technology networks



Goa 2030: Sustainability Investment Plan (2005-2030)

A Sustainability transition is economically and financially viable within the following envelope:

- A 30-year transition to a service-sector dominated economy with low material-energy throughput
- Steady improvement in the quality of life, but voluntary restraints on unsustainable consumption combined with efficiency, dematerialisation and high savings rates
- An investment of between $ 15 to $ 18 billion over 30 to 50 years, financed by internal using soft credit and innovative financing mechanisms e.g. CDM

Conclusion

Four Transformative Challenges

- Transformation of exploitative and an increasingly unsustainable agrarian and Biomass-based economy to become more equitable, productive, eco-efficient and resilient (Mollison 1990)

- Transformation of industrial ecologies from linear source to sink processes to resource-conserving cyclic processes with dramatically lower environmental impacts (Hawken et. al. 1999).

- Reversal of the livelihood shift from industrial employment back to sustainable ecological services (e.g. sustainable agriculture, ecosystem services management and recycling) (Revi. et. al. 2006)

- Within the Knowledge Economy spreading the access to and benefits further along with a greater emphasis on dematerialization, lifestyle choices and embracing more community-oriented initiatives (Revi et. al. 2006)