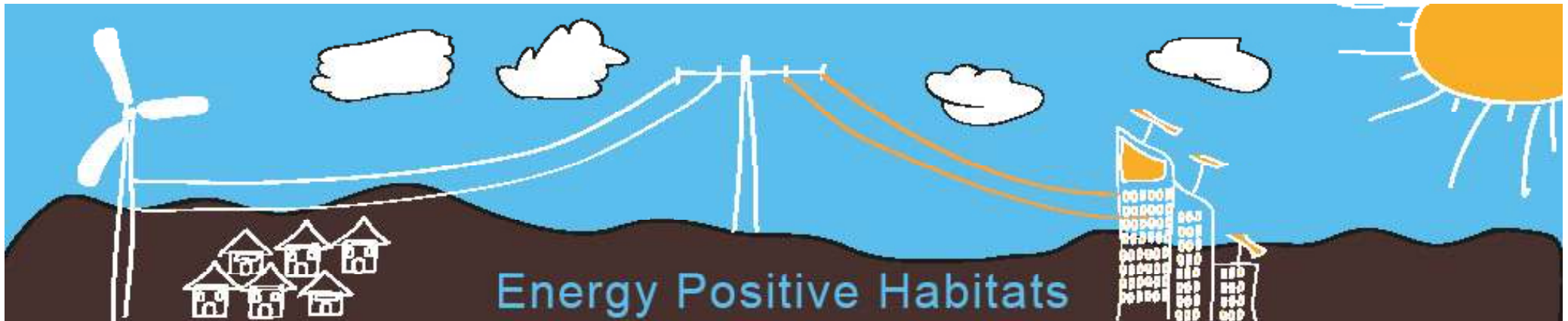


Auroville Green Practices

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.’

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



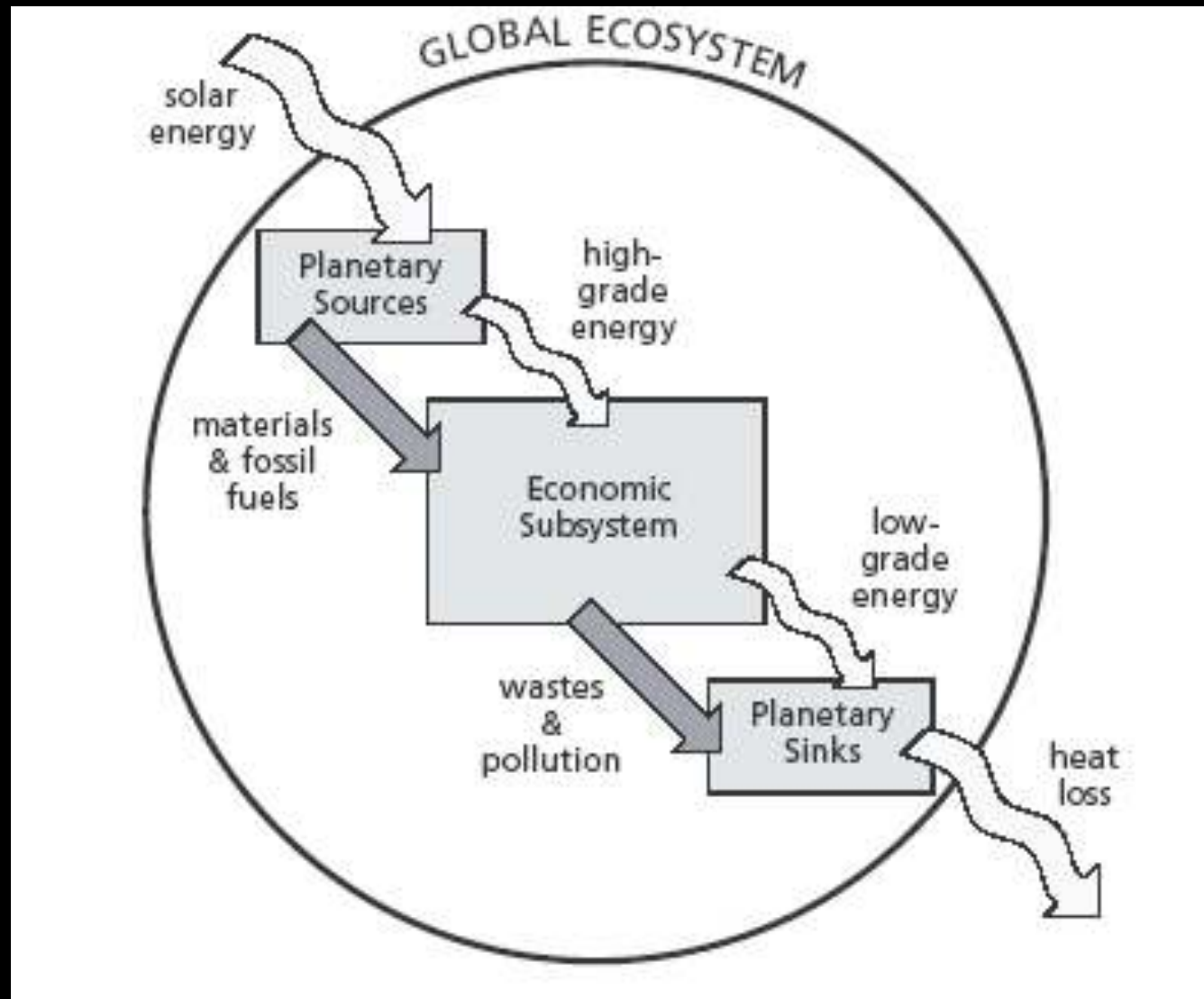
Auroville

1st September 2012



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**

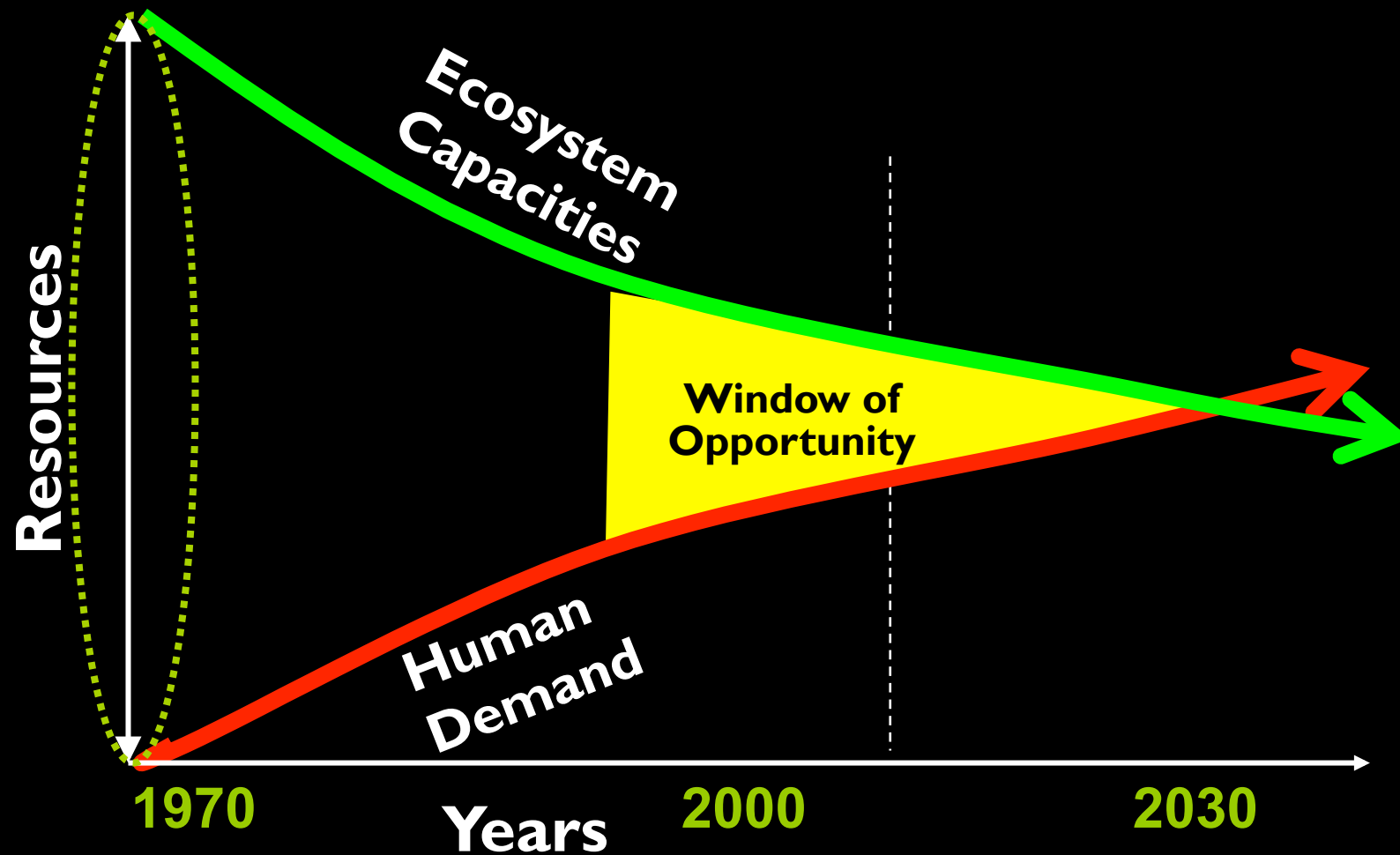


Available
only **One**
World

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

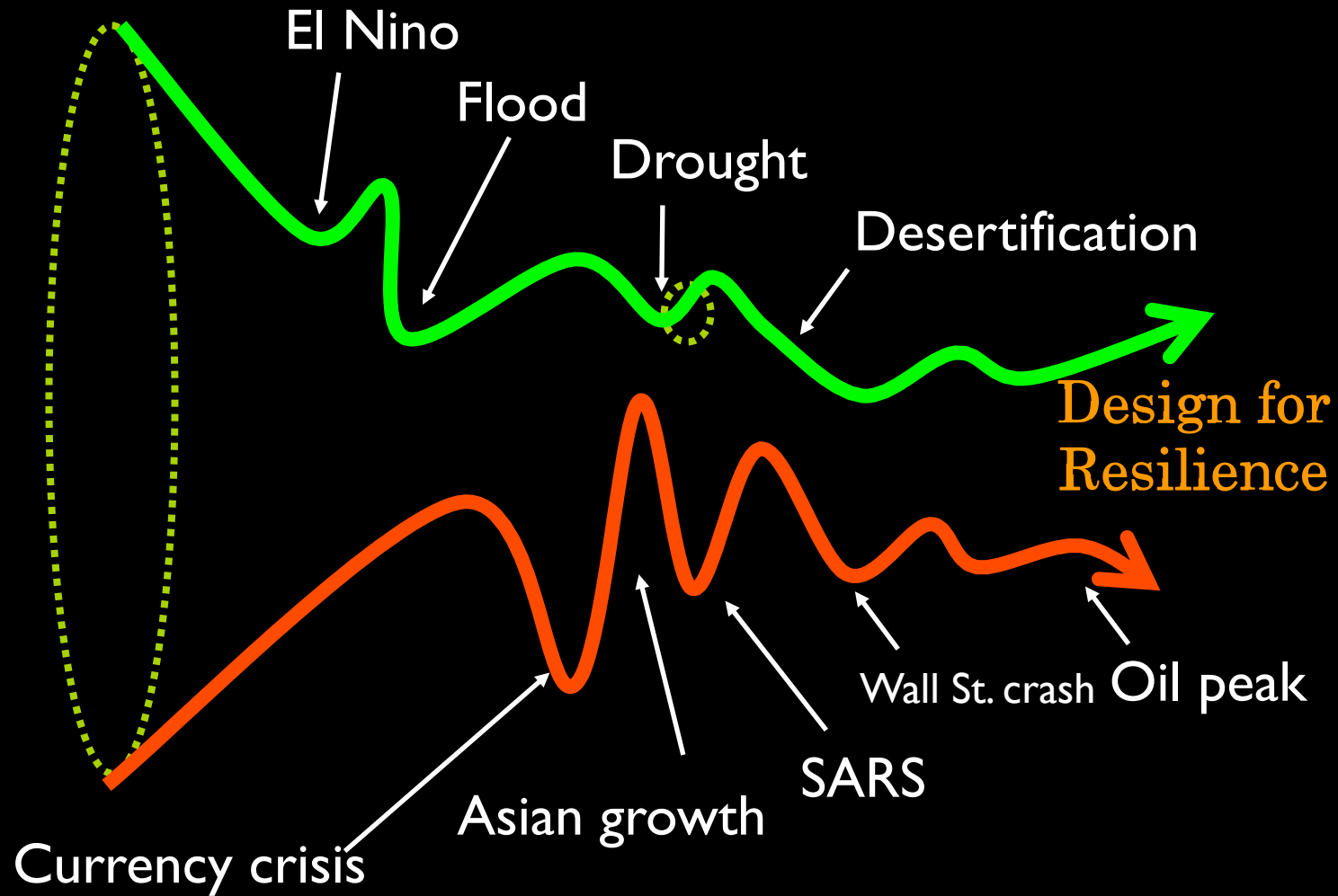
The Sustainability traverse will be largely played out in Chinese & Indian cities

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
 - Open Systems – Habitats
- Exergy or available energy
- Gibbs, Massieu-Planck, Boltzmann's 'negentropy' equations
- Shannon-Hartley theorem

Taittiriya Upanishad: Energy-Food

- **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

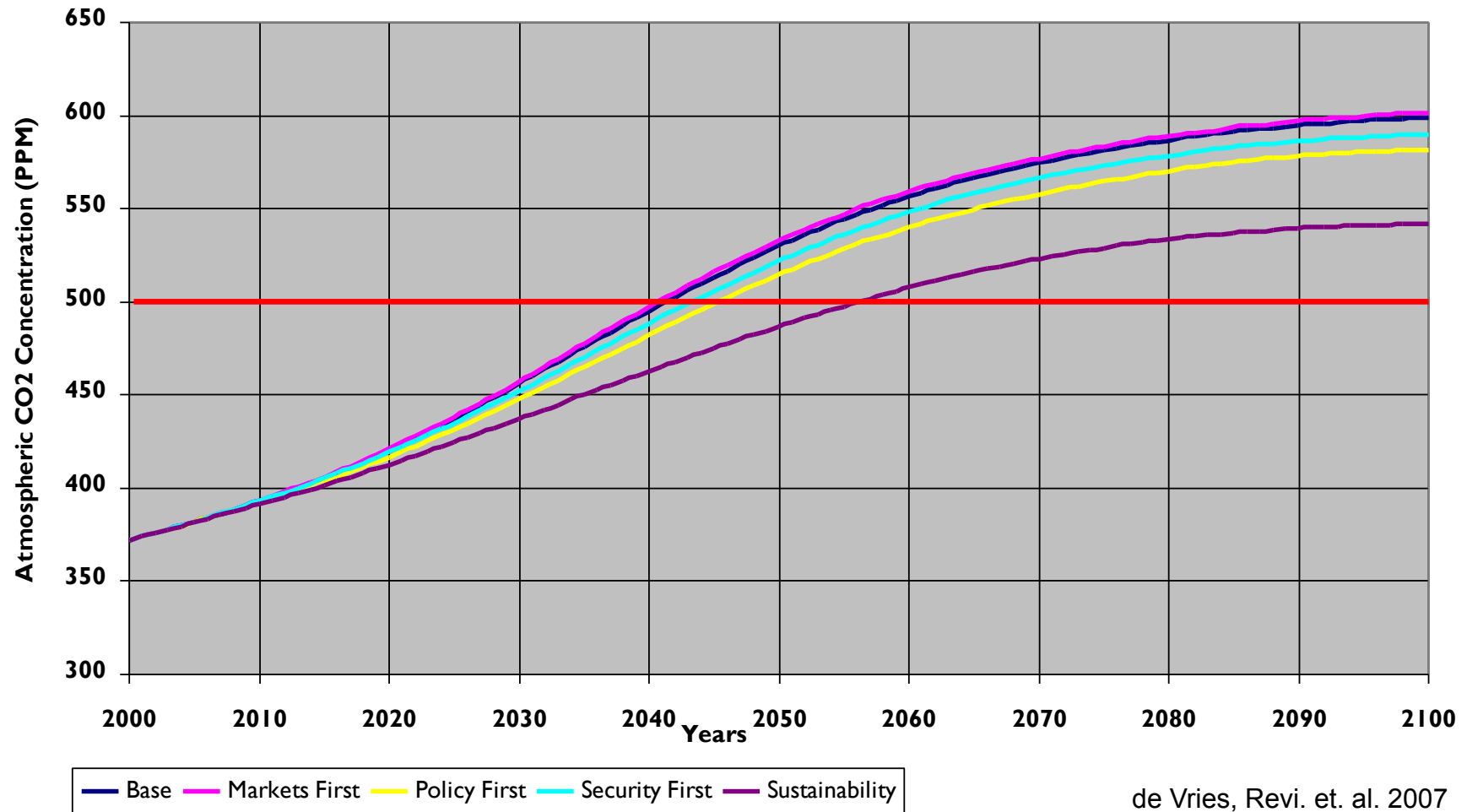
Evidence of Dangerous Climate Change

- 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
 - Arctic sea ice melt
 - Greenland icesheet loss
 - West Antarctic icesheet loss
 - East Antarctic icesheet loss
- Glacial melt

Himalayan Glacial melt (1921-2009)

Global Climate Change: An Inconvenient Overshoot

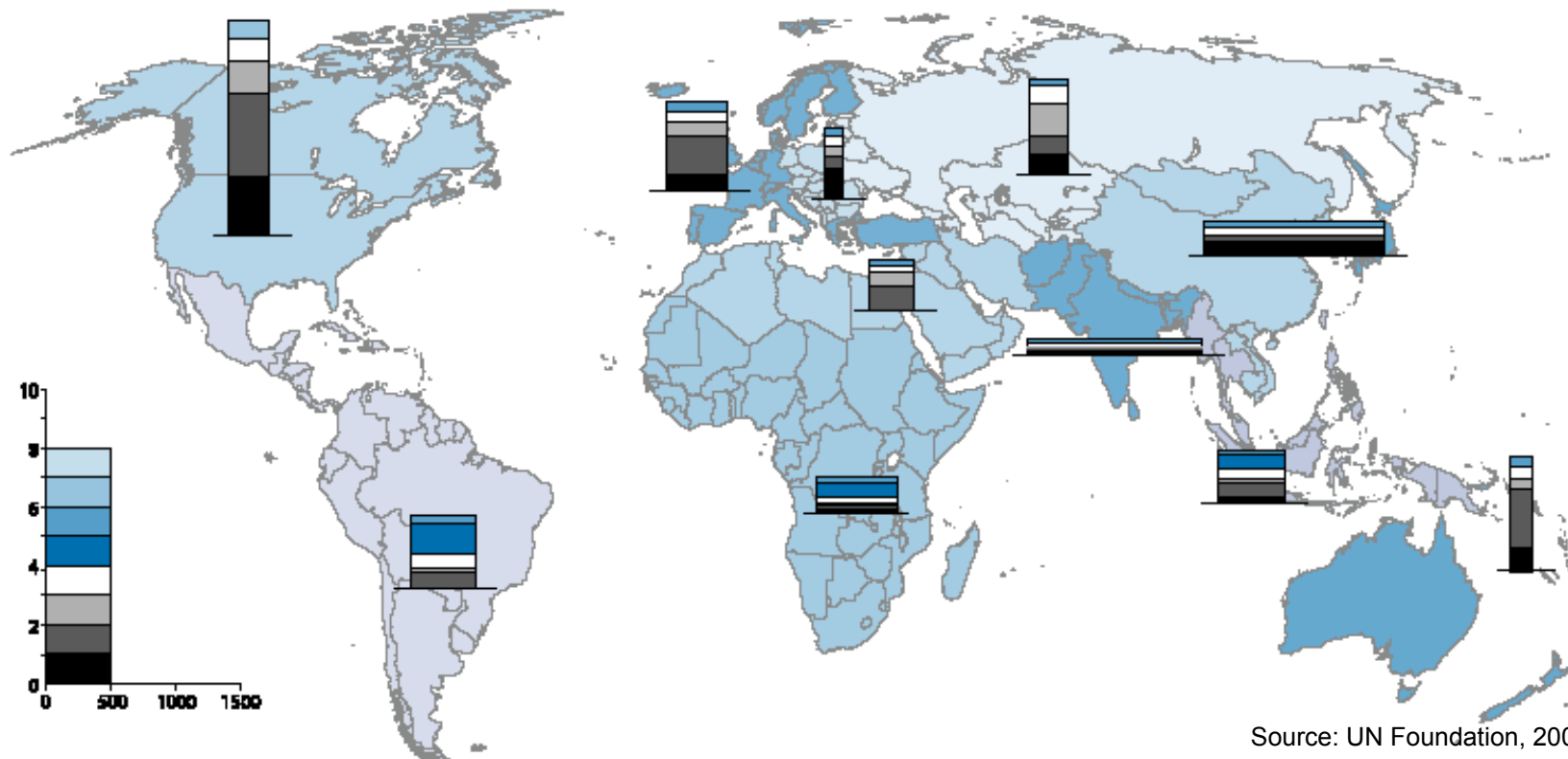
IFs Scenario Changes in Global CO₂ Concentration (PPM)



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

Per Capita & Total GHG emissions (2000)

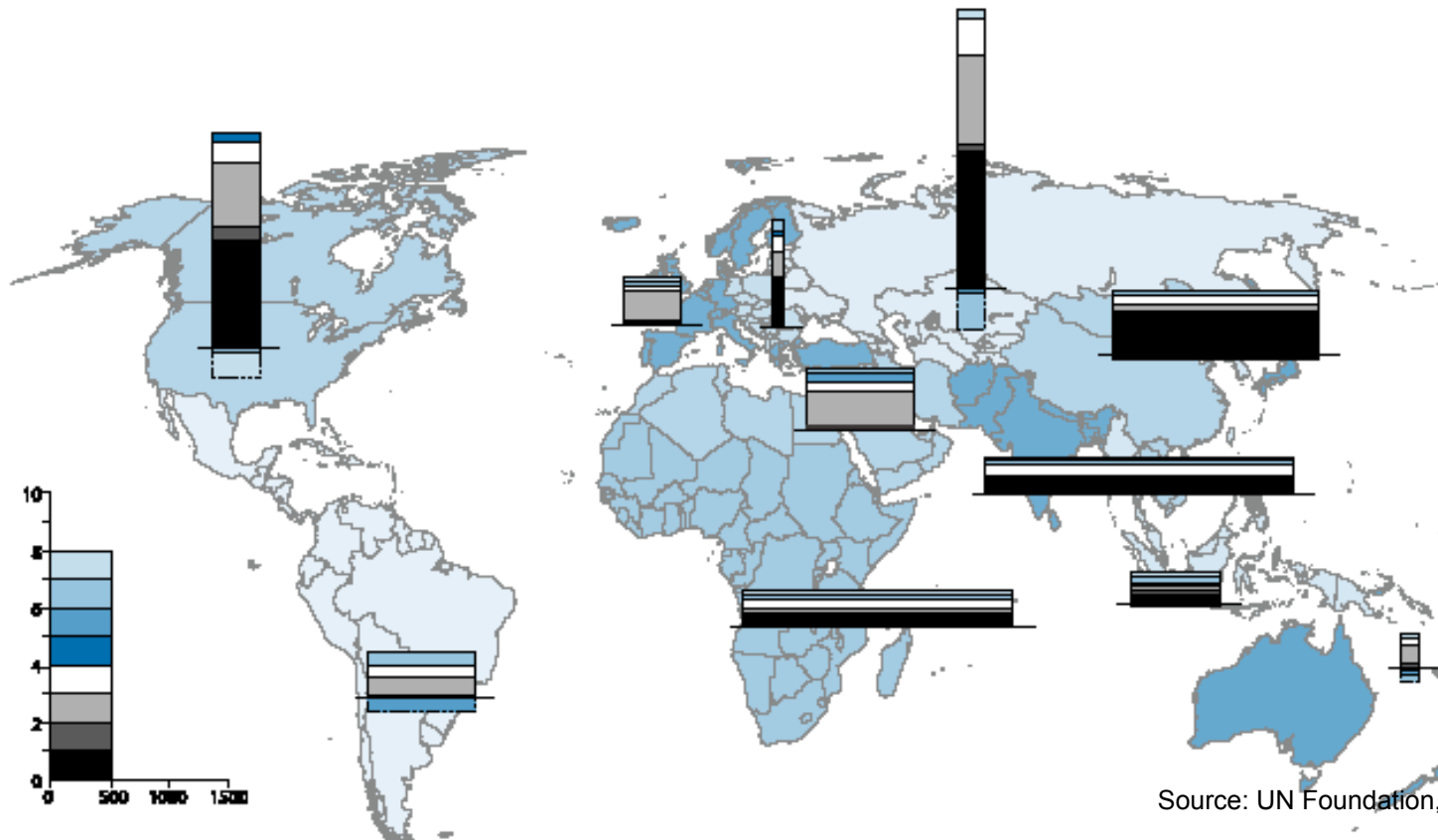
Per Capita and Total Emissions of Greenhouse Gases in Year 2000.



Source: UN Foundation, 2007

Per Capita & Total GHG emissions (2100)

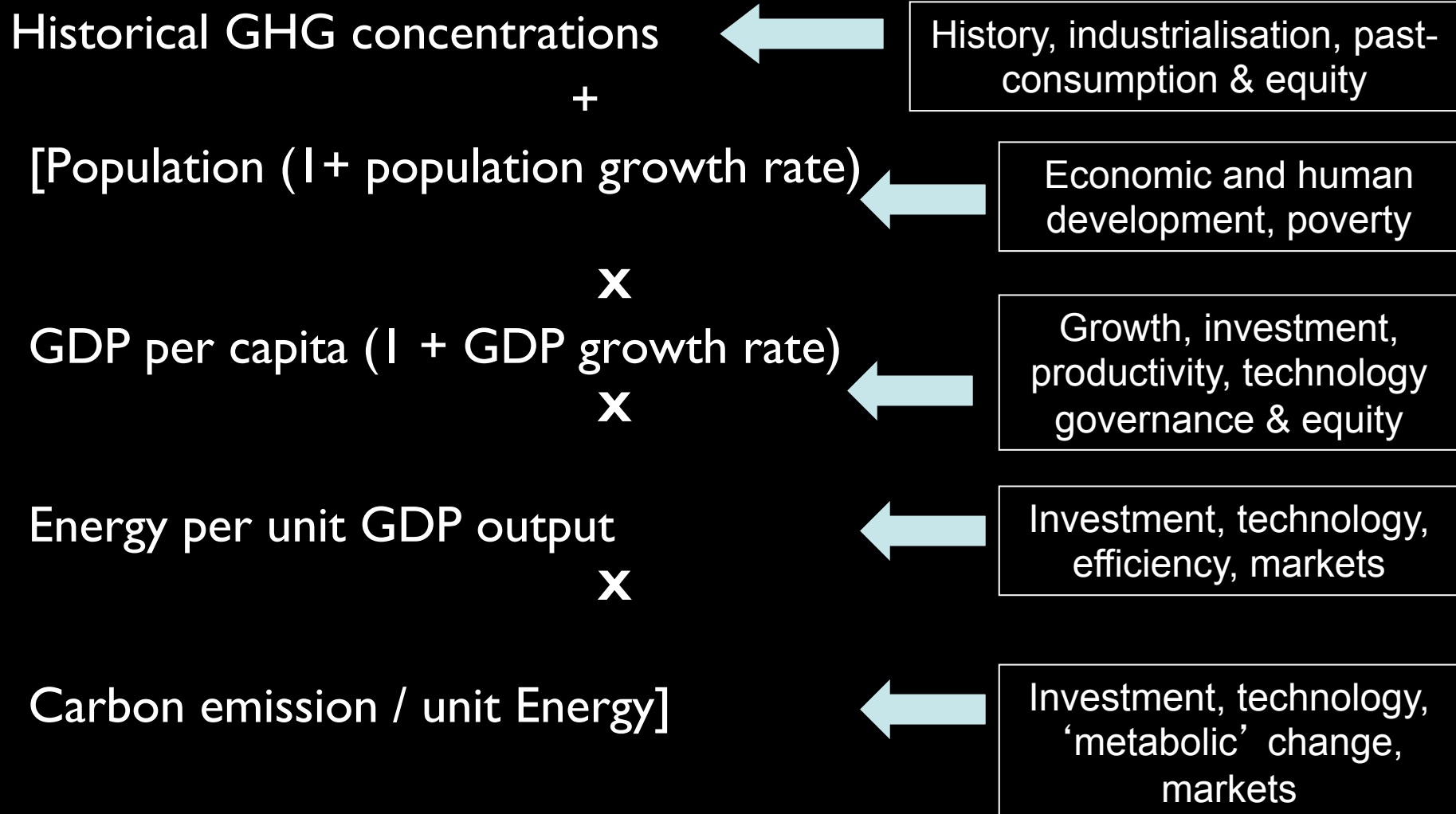
Per Capita and Total Emissions of Greenhouse Gases in 2100



Source: UN Foundation, 2007

A 'naïve' Climate Change Impact Equation

Atmospheric Greenhouse Gas Concentrations =

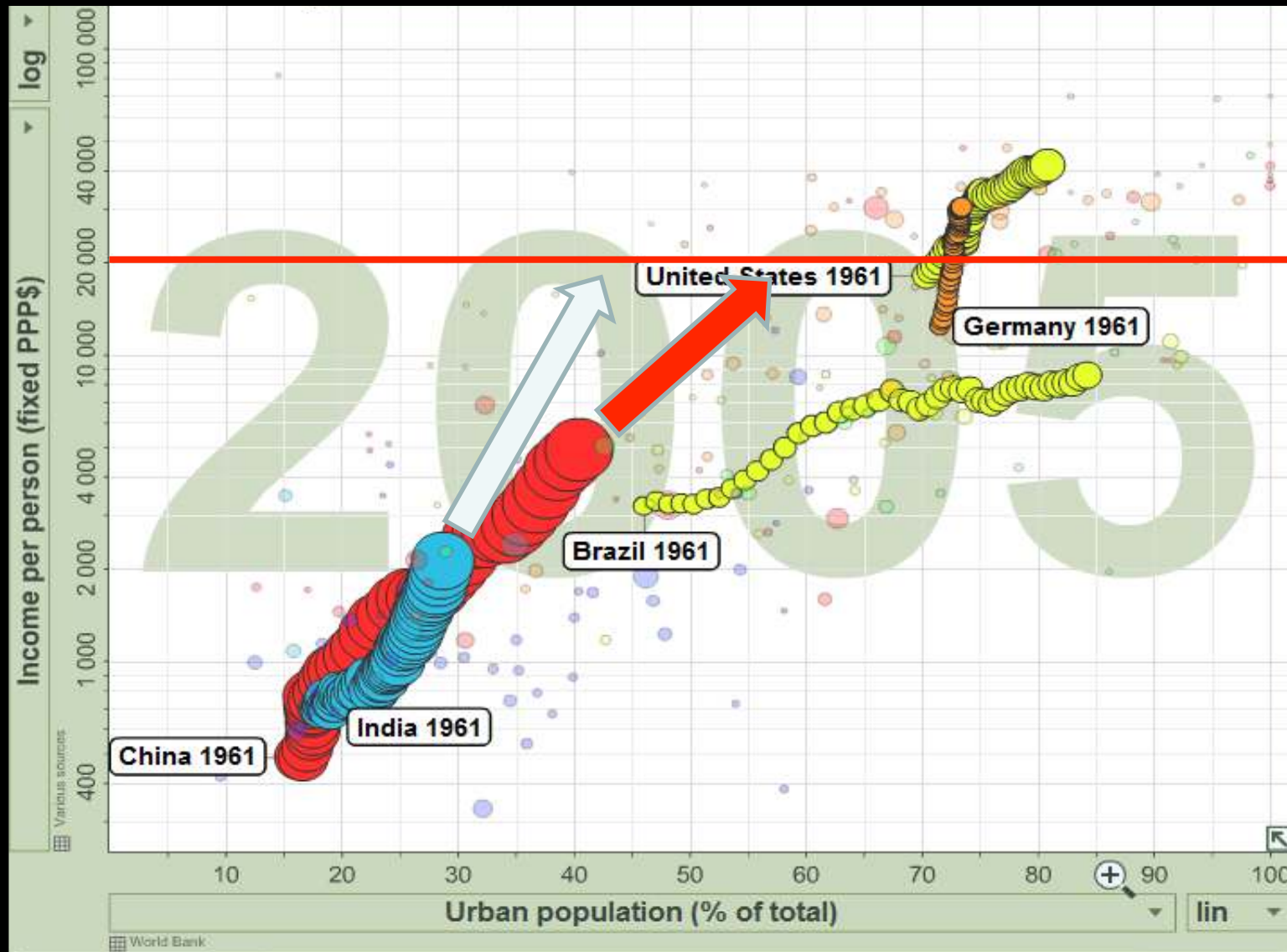


The built environment & the Energy-Climate debate

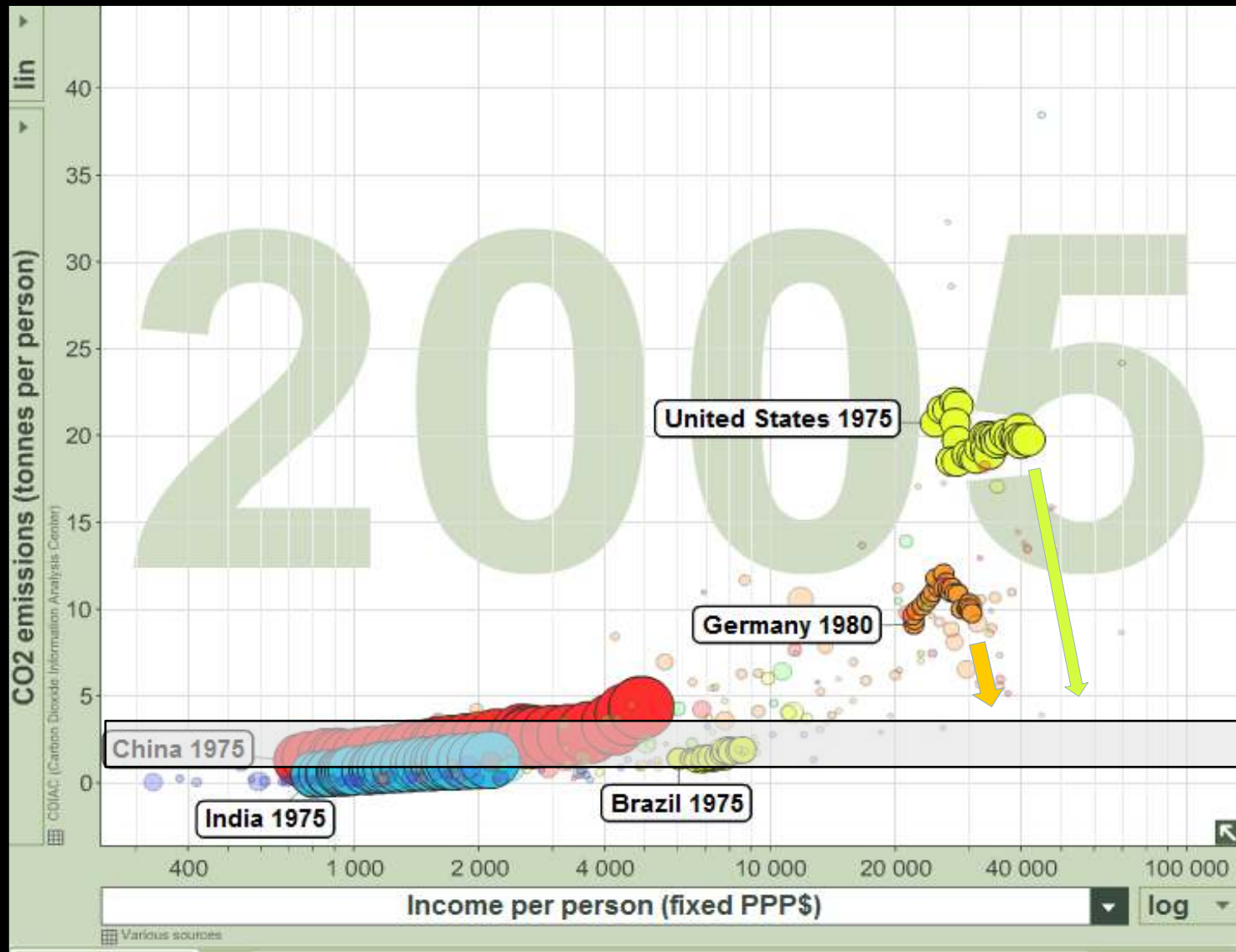
Relative National Share of Global Economic Output (1500 to 2050)

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

Urbanisation: a key growth & economic development driver

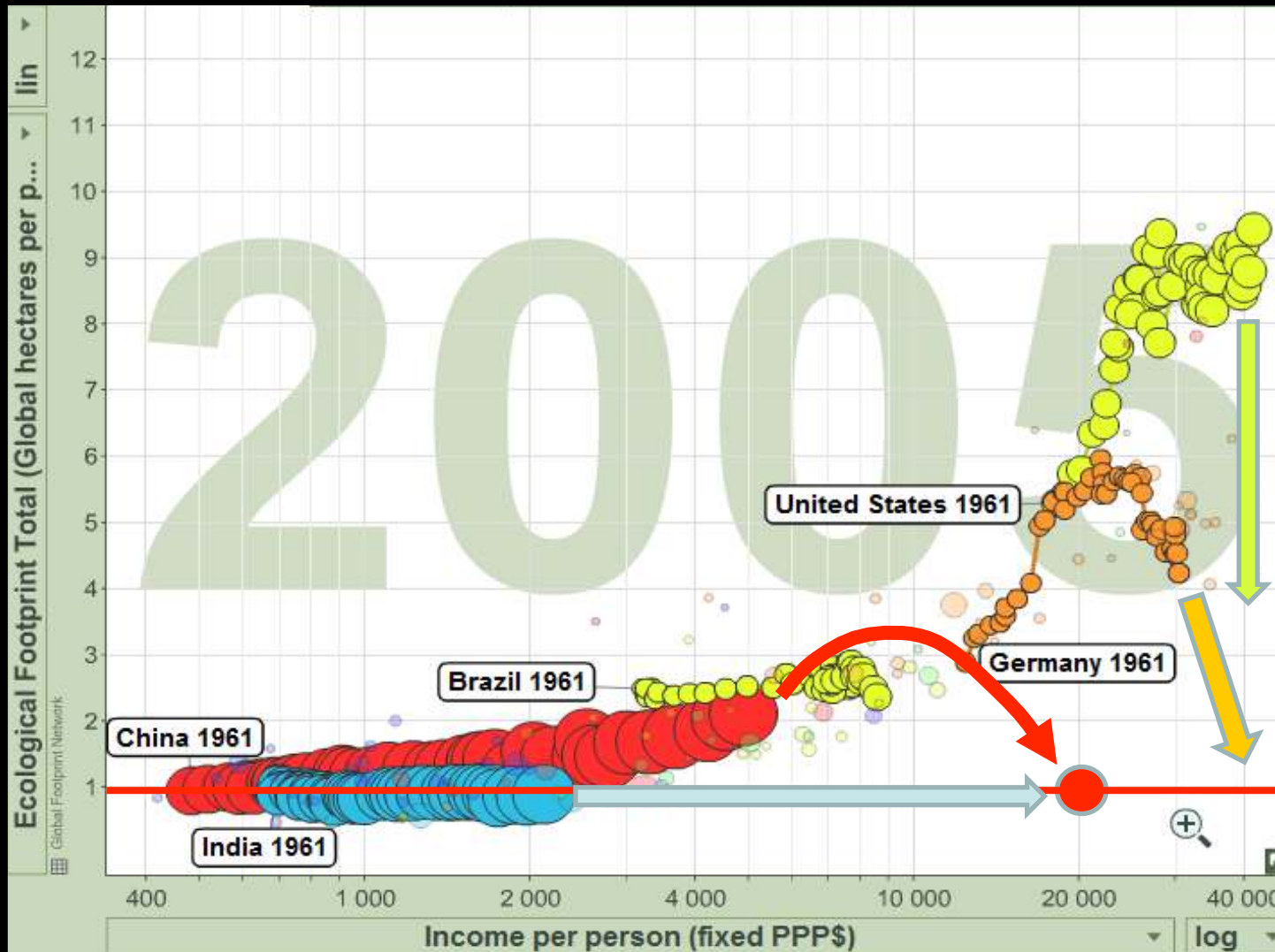


The battle for Carbon 'space' and growth potential

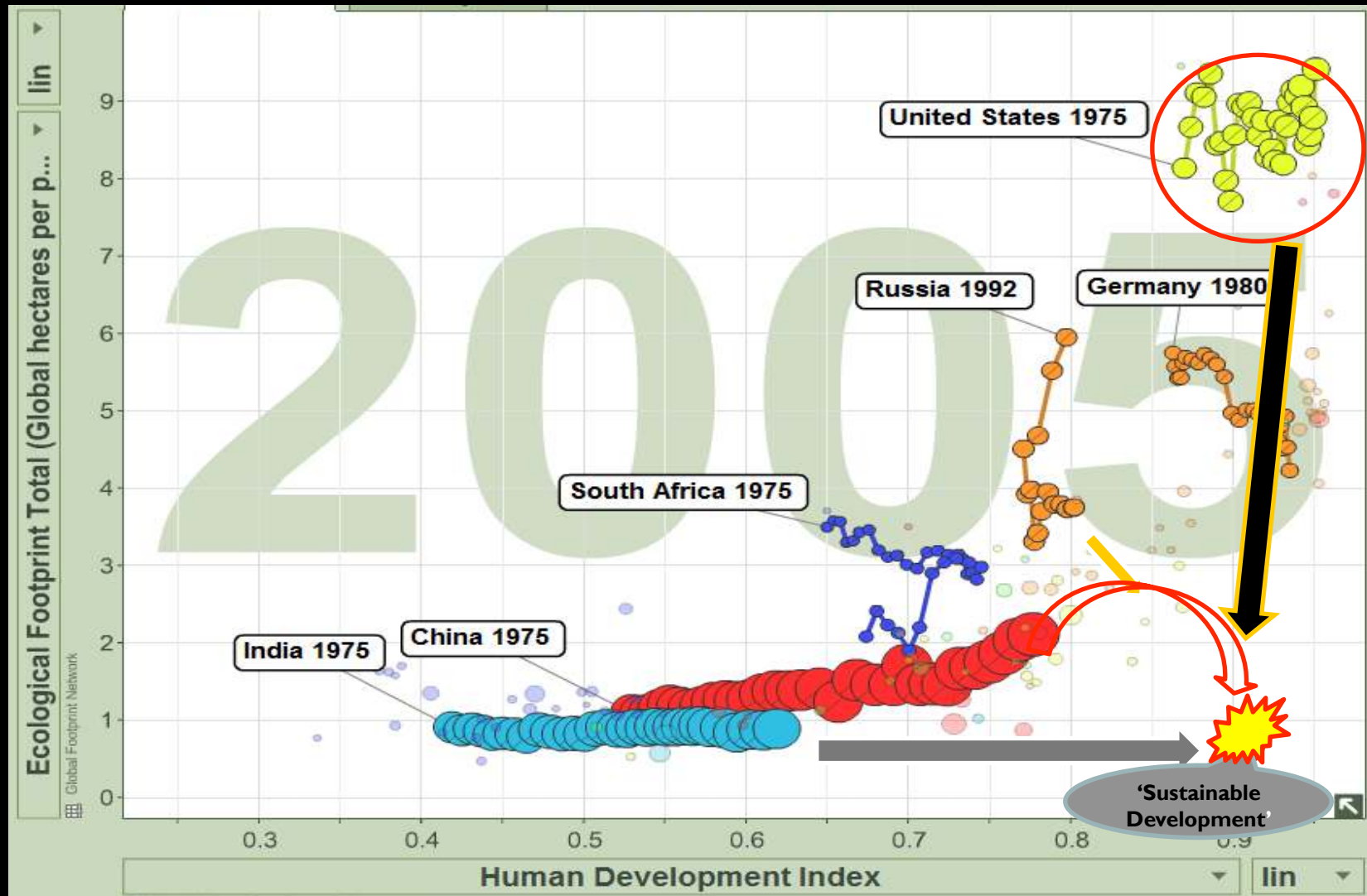


A possible reframing of India's Climate
challenge/opportunity

The Great Transition: balancing growth & ecosystem health

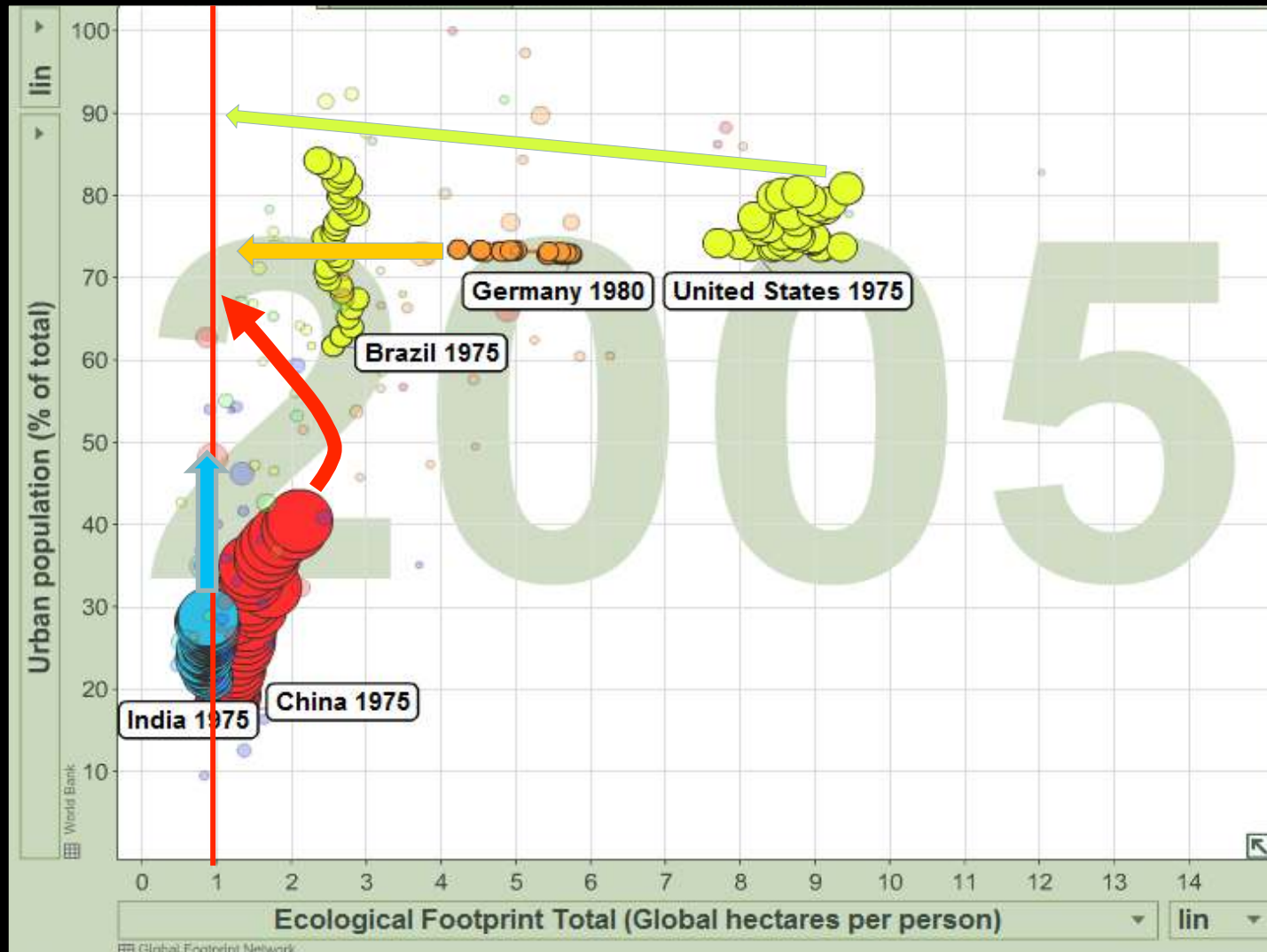


Future History - Sustainability Transitions: 2005 →



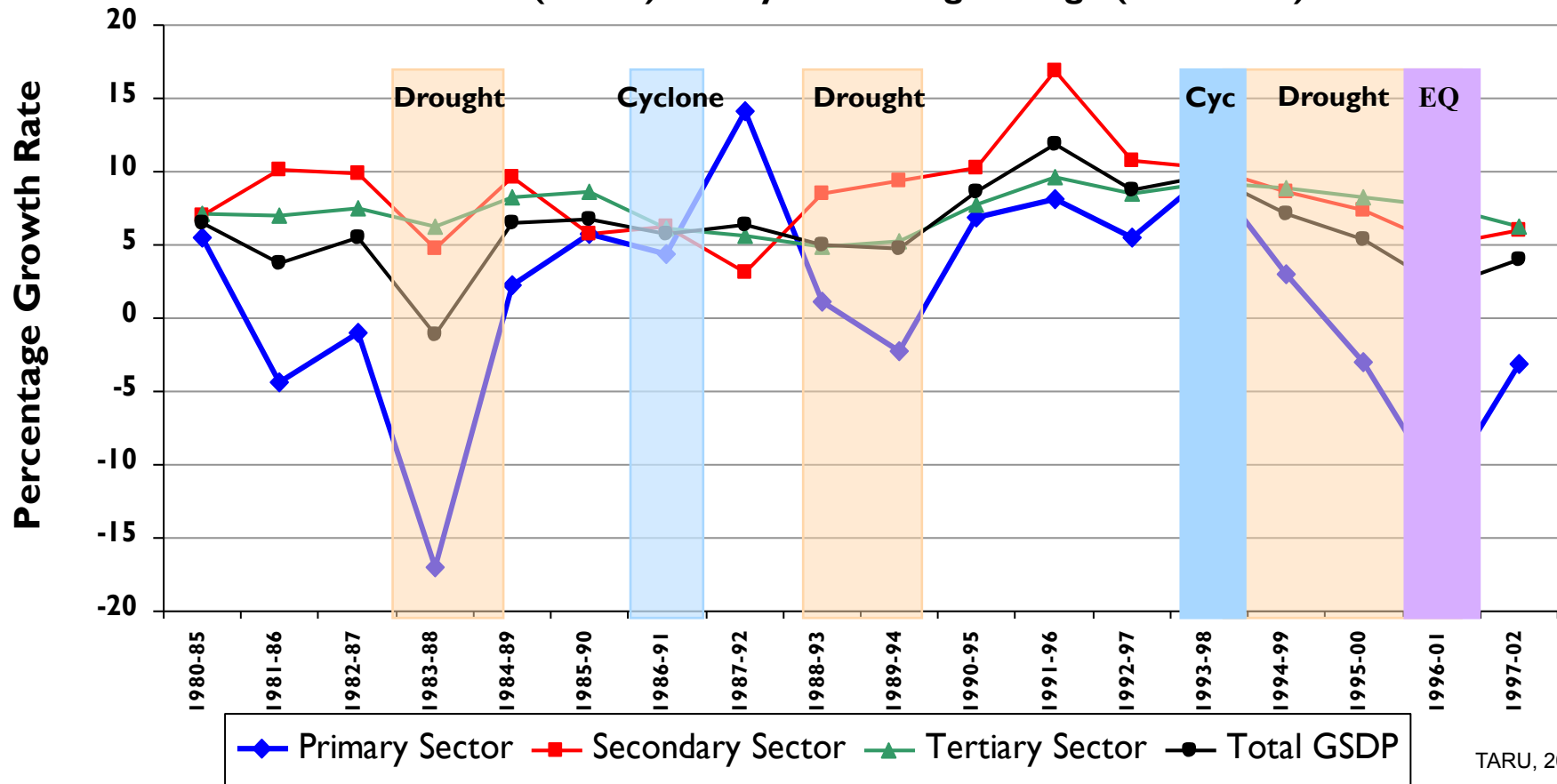
Can China traverse the environmental Kuznets curve Germany & USA converge without serious Human Development decline India 'tunnel through'; or will there be serious international 'resource' conflict?

A new form of urbanisation?



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

Gujarat: Compound Annual Growth Rates (CAGR) of Gross Domestic State Product (GSDP) Four-year moving average (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

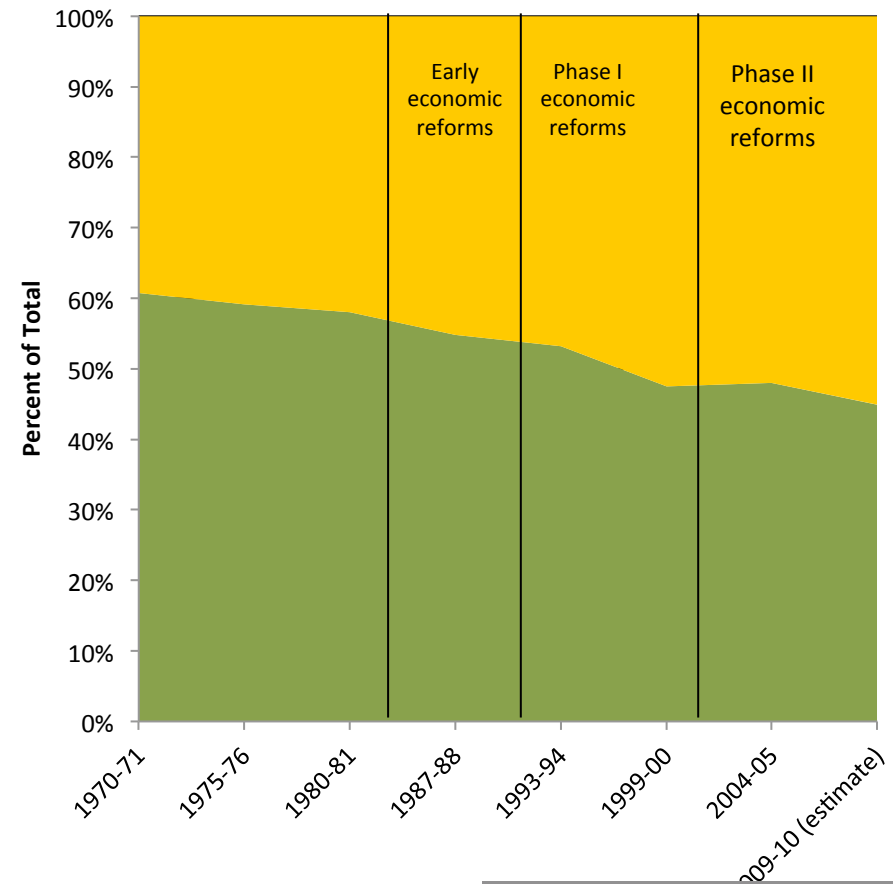
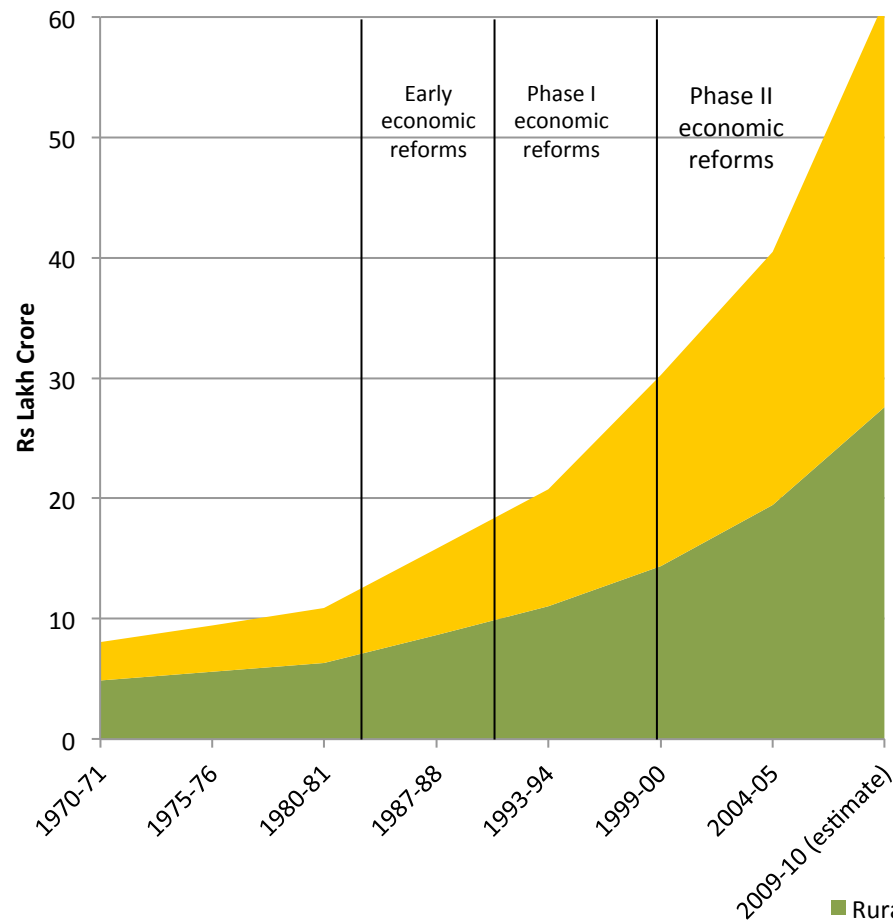
India: the opportunity of ten simultaneous Transitions

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)

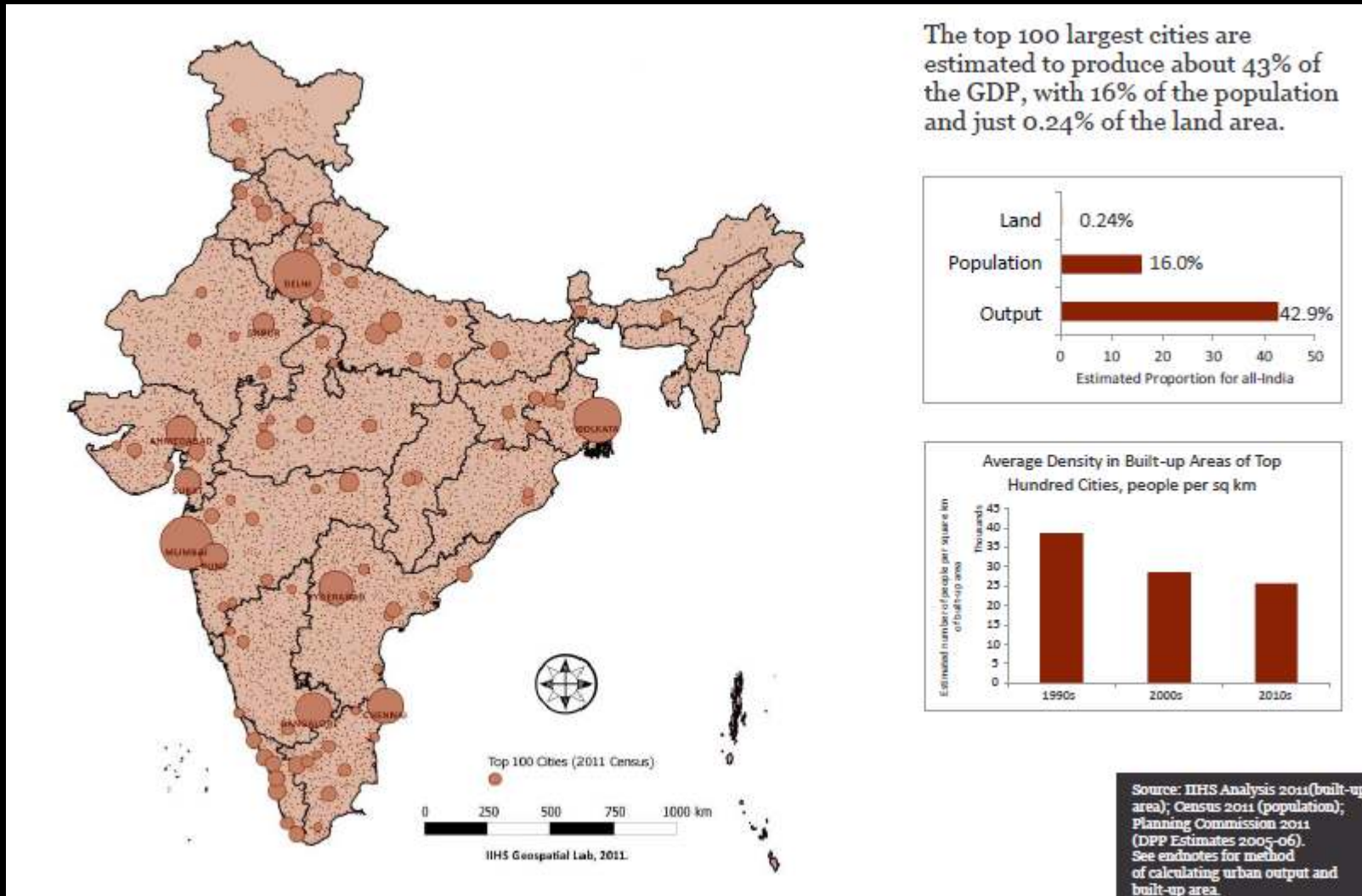
Rural: Urban GDP fraction
(1970-2009)



Source: National Accounts Statistics

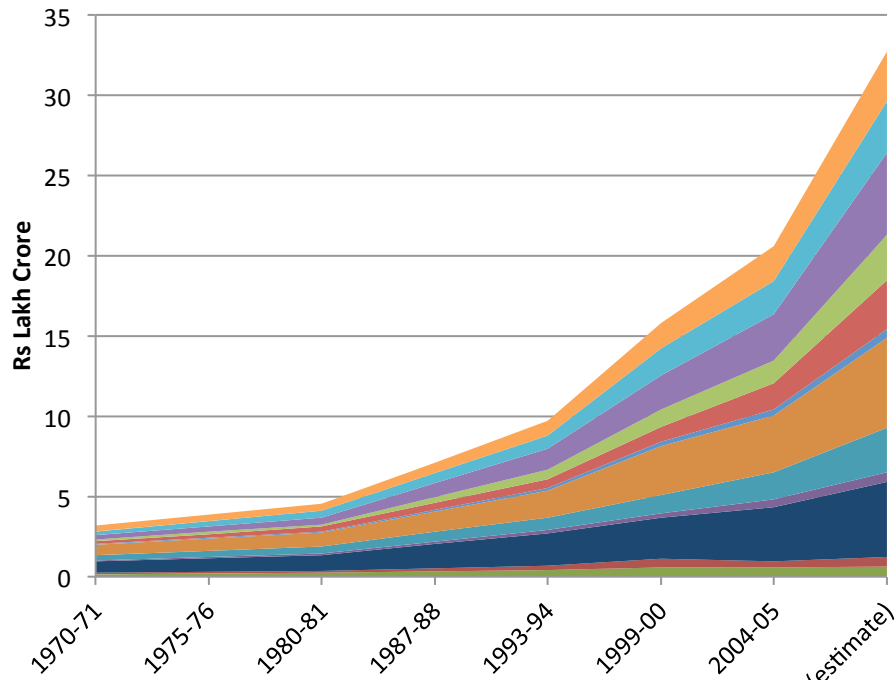
Close to 60% of India's GDP comes from Urban areas

India: Concentration of Economic Output (2009)

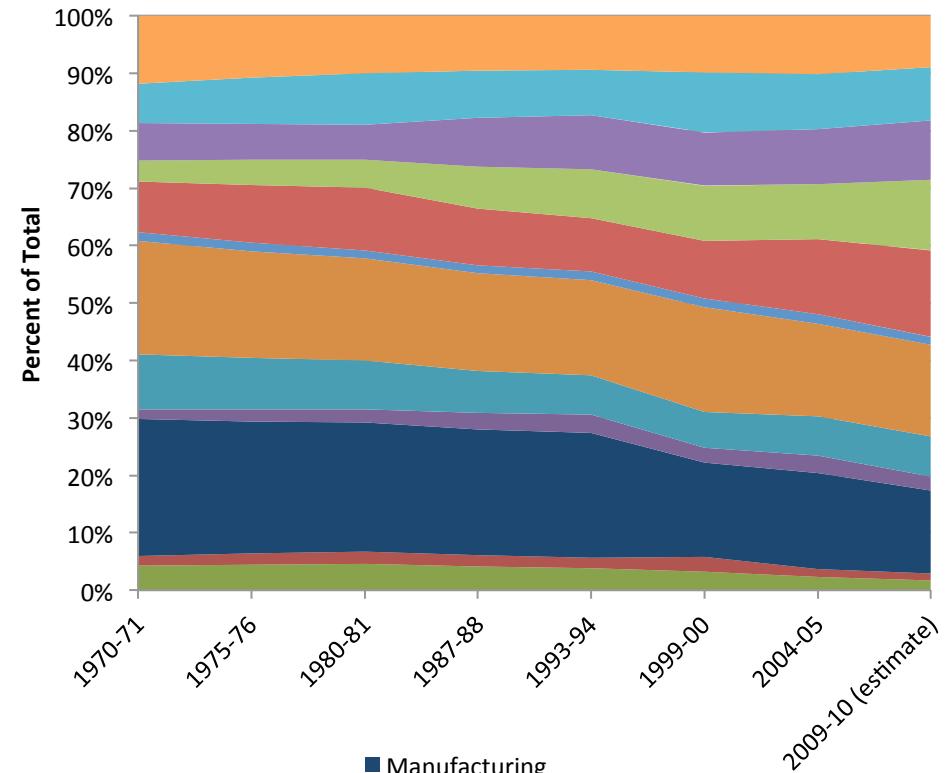


India: Urban Sectoral GDP

Urban sectoral GDP growth (1970 – 2009)

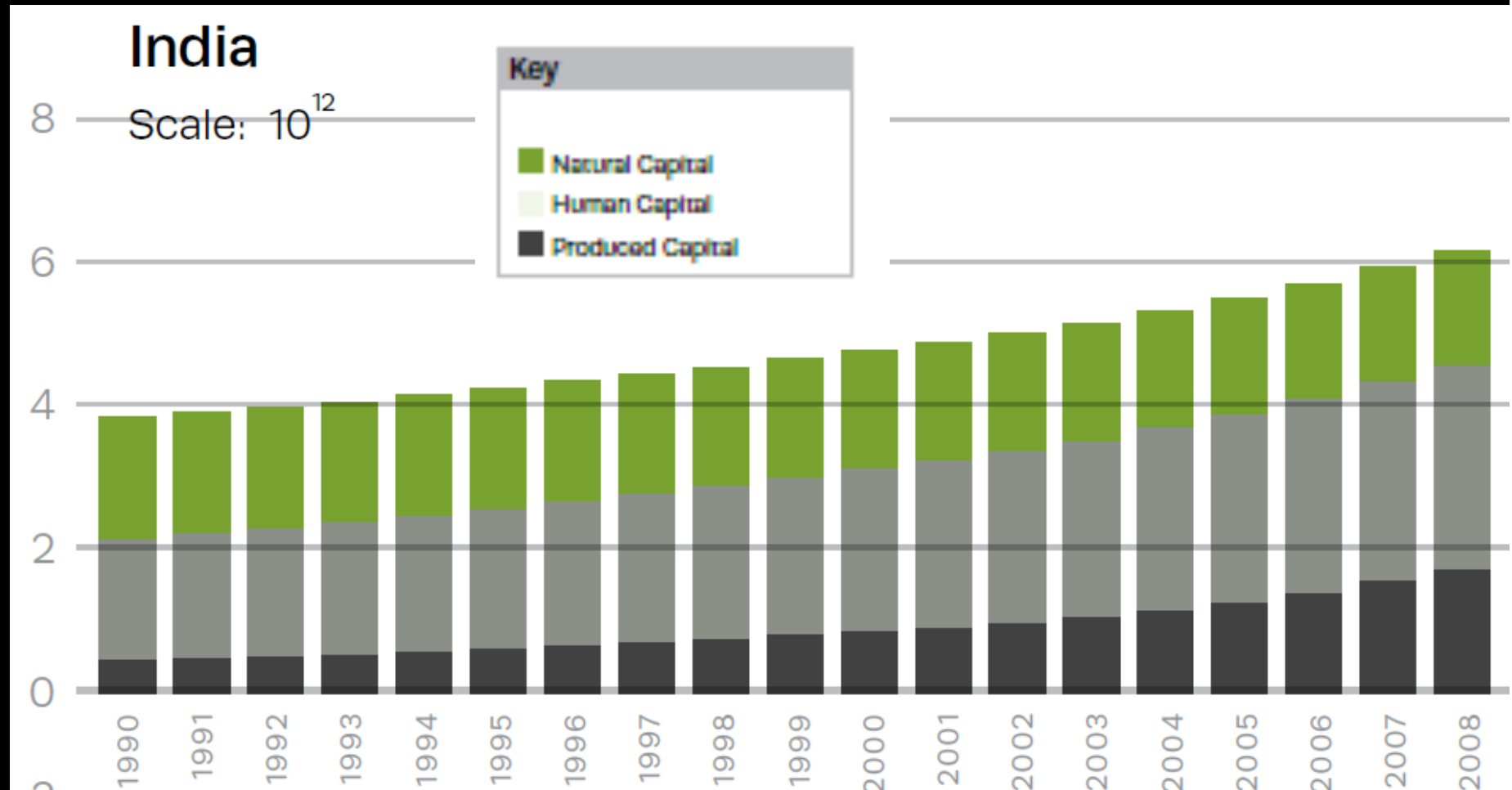


Urban sectoral GDP structure (1970 – 2009)



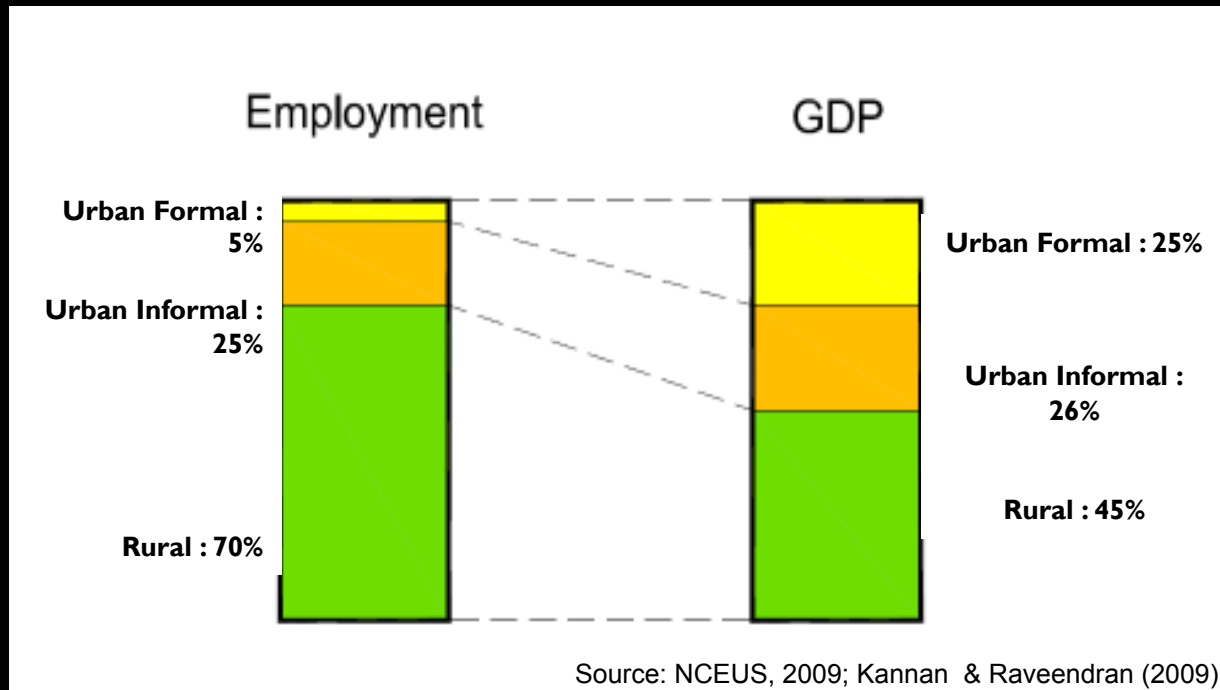
Decoupling of energy/carbon systems and the real economy have to be sector specific

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)



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

W. Pakistan

Tibet

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



Urban Population Growth

Kolkata
(5.7)

Population Size
(millions)

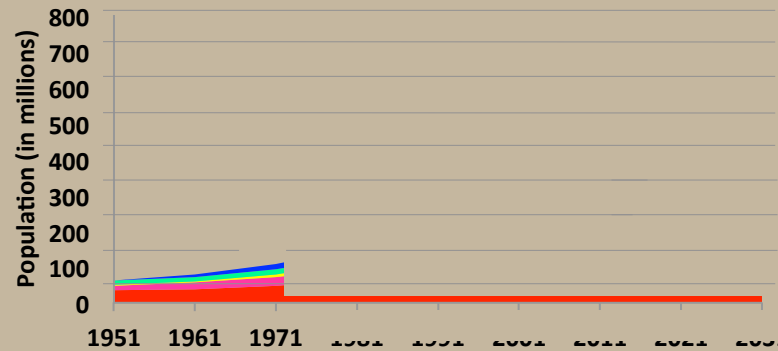
- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- > 5

Source: Census of India, 1971-2001
UN, 2007
U.S. analysis, 2006-10



Large Urban Settlement Growth

1971



Urban Population Growth

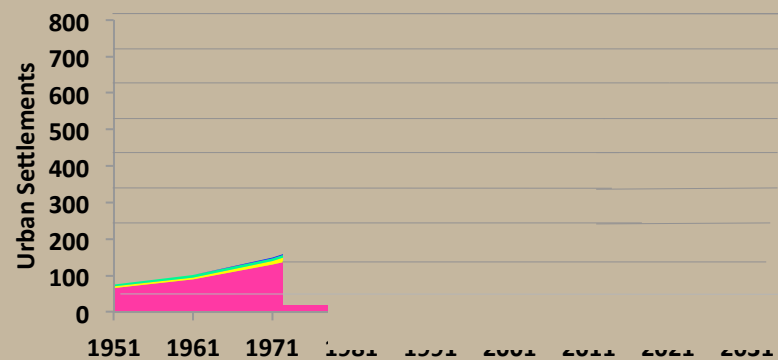
Mumbai
(5.8)

Kolkata
(6.9)

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



Large Urban Settlement Growth

1981

Delhi
(5.6)

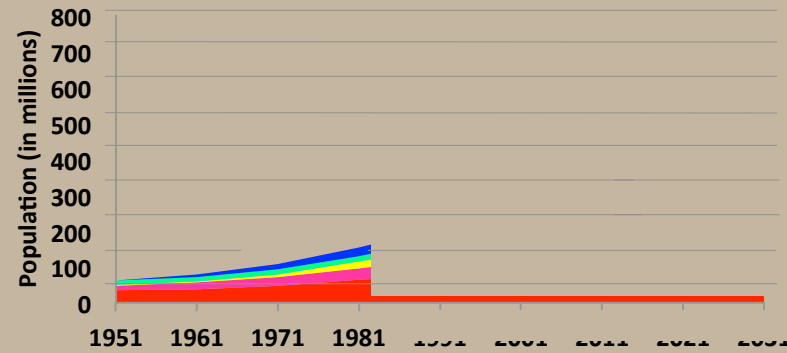
Mumbai
(8.6)

Kolkata
(9)

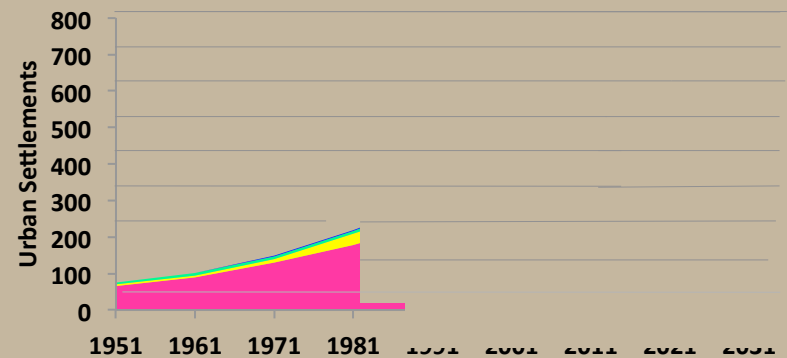
Population Size
(millions)

- < 0.1
- 0.1 – 0.5
- 0.5 - 1
- 1 - 5
- > 5

Source: Census of India, 1971-2001
UN, 2007
UIC analysis, 2006-10



Urban Population Growth



Large Urban Settlement Growth

1991

Delhi
(8.2)

Mumbai
(12.3)

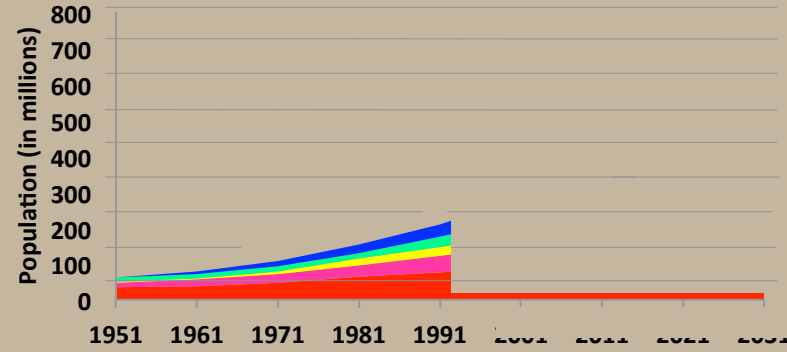
Kolkata
(10.9)

Chennai
(5.3)

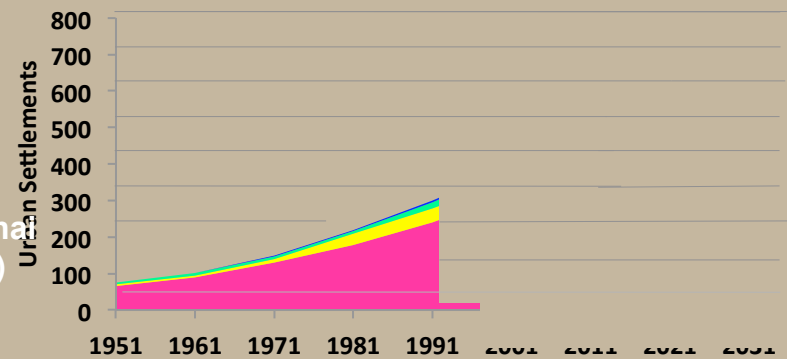
Population Size
(millions)

- < 0.1
- 0.1 – 0.5
- 0.5 - 1
- 1 - 5
- > 5

Source: Census of India, 1971-2001
UN, 2007
IIHS analysis, 2009-10

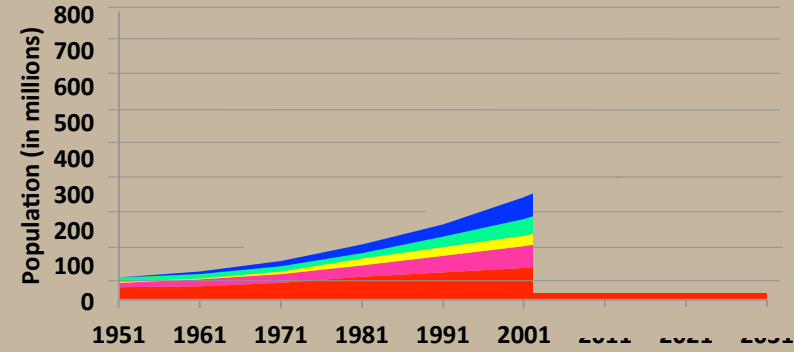


Urban Population Growth



Large Urban Settlement Growth

2001



Urban Population Growth

Delhi
(12.4)

Kolkata
(13.1)

Mumbai
(16.1)

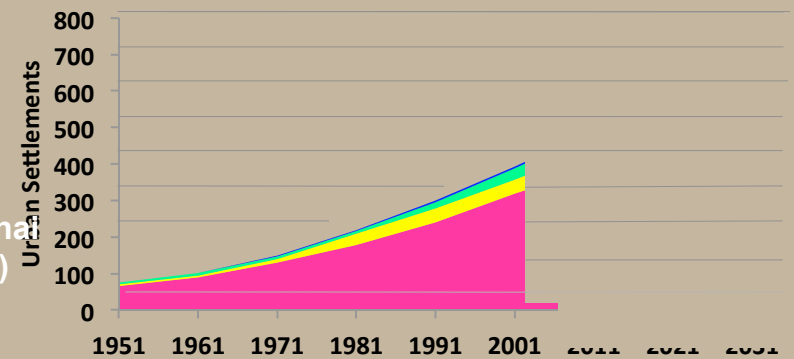
Hyderabad
(5.4)

Population Size
(millions)

- < 0.1
- 0.1 – 0.5
- 0.5 - 1
- 1 - 5
- > 5

Bangalore
(5.6)

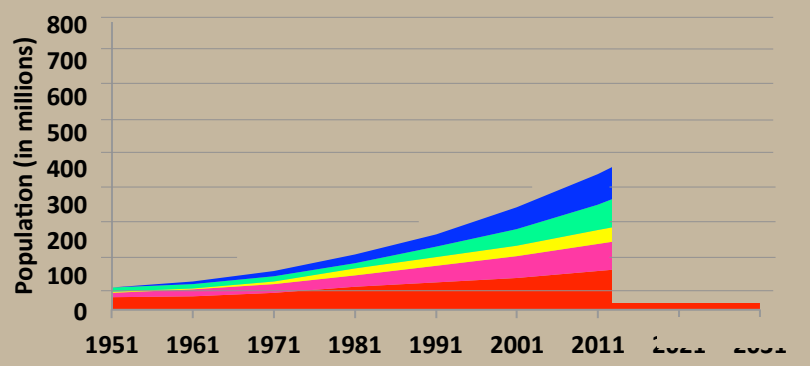
Chennai
(6.6)



Large Urban Settlement Growth

Source: Census of India, 1971-2001
UN, 2007
IIHS analysis, 2009-10

2011



Urban Population Growth

Delhi
(16.9)

Ahmedabad
(5.7)

Kolkata
(15.5)

Mumbai
(20)

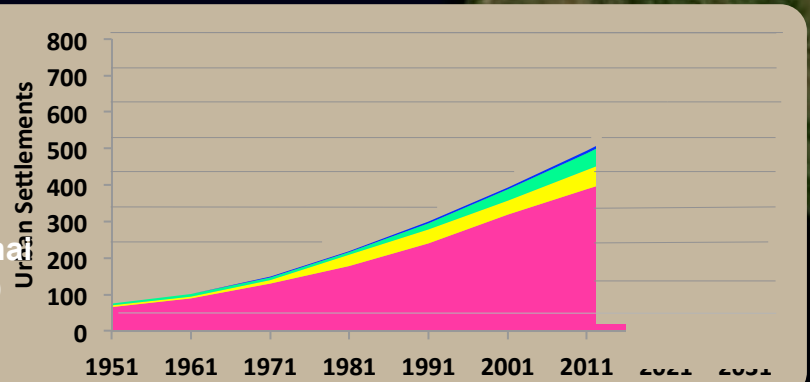
Hyderabad
(6.7)

Pune
(5.0)

Bangalore
(7.2)

Chennai
(7.5)

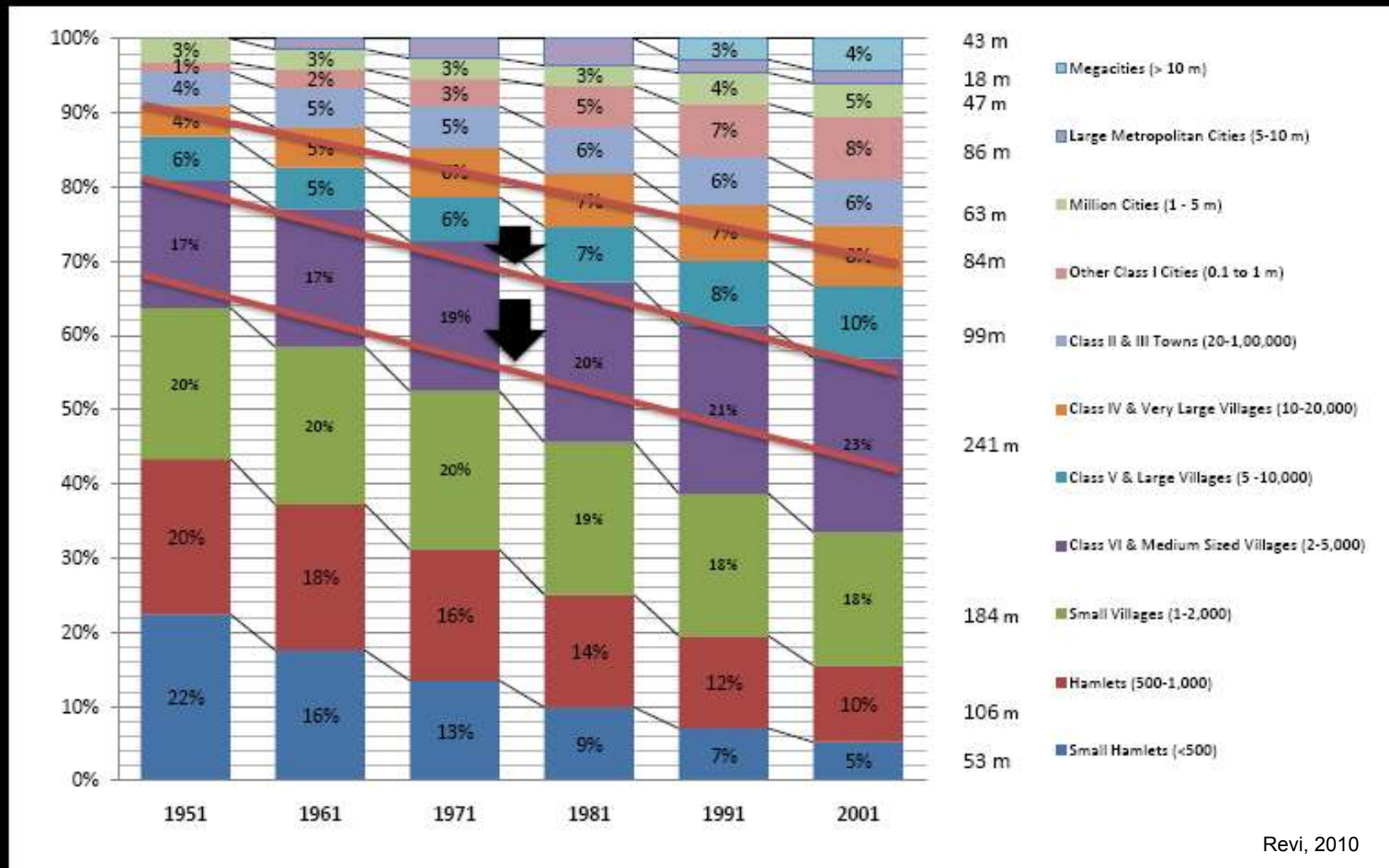
- Population Size (millions)
- < 0.1
 - 0.1 - 0.5
 - 0.5 - 1
 - 1 - 5
 - > 5



Large Urban Settlement Growth

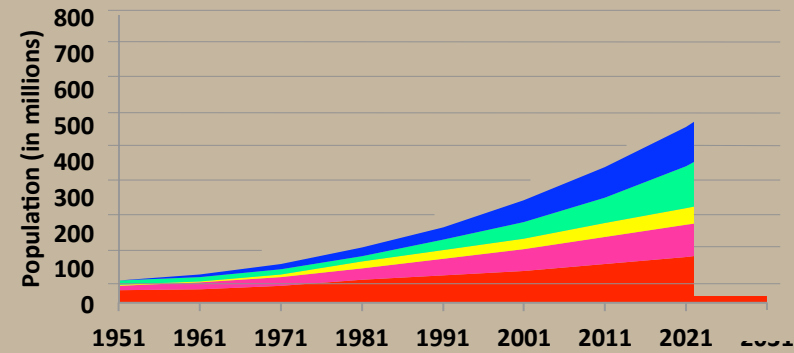
Source: Census of India, 1971-2001
UN, 2007
IHS analysis, 2009-10

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



Urban Population Growth

Delhi
(20.4)

Ahmedabad
(5.7)

Surat
(5.1)

Kolkata
(18.6)

Mumbai
(23.9)

Hyderabad
(8.2)

Pune
(6.1)

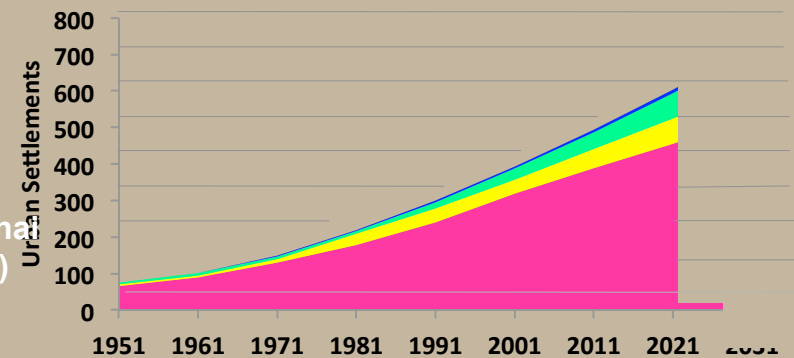
Bangalore
(8.8)

Chennai
(9.1)

Population Size
(millions)

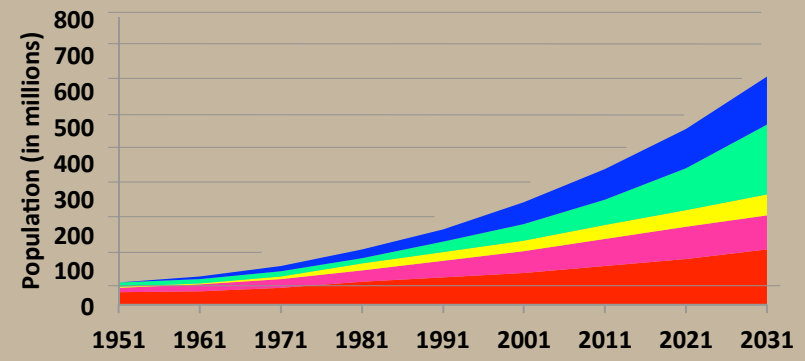
- < 0.1
- 0.1 – 0.5
- 0.5 - 1
- 1 - 5
- > 5

Source: Census of India, 1971-2001
UN, 2007
IIHS analysis, 2009-10



Large Urban Settlement Growth

2031



Urban Population Growth

Delhi
(24.4)

Kanpur
(5.1)

Ahmedabad
(8.5)

Surat
(6.3)

Kolkata
(22.3)

Mumbai
(28.6)

Hyderabad
(9.9)

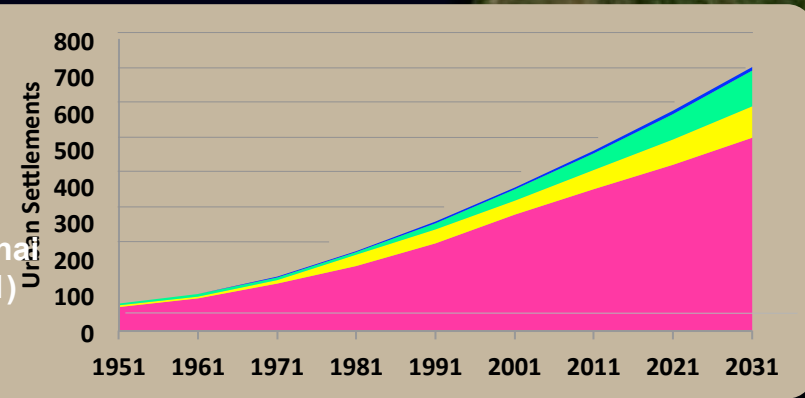
Pune
(7.4)

Bangalore
(10.6)

Chennai
(11.1)

- Population Size (millions)
- < 0.1
 - 0.1 – 0.5
 - 0.5 - 1
 - 1 - 5
 - > 5

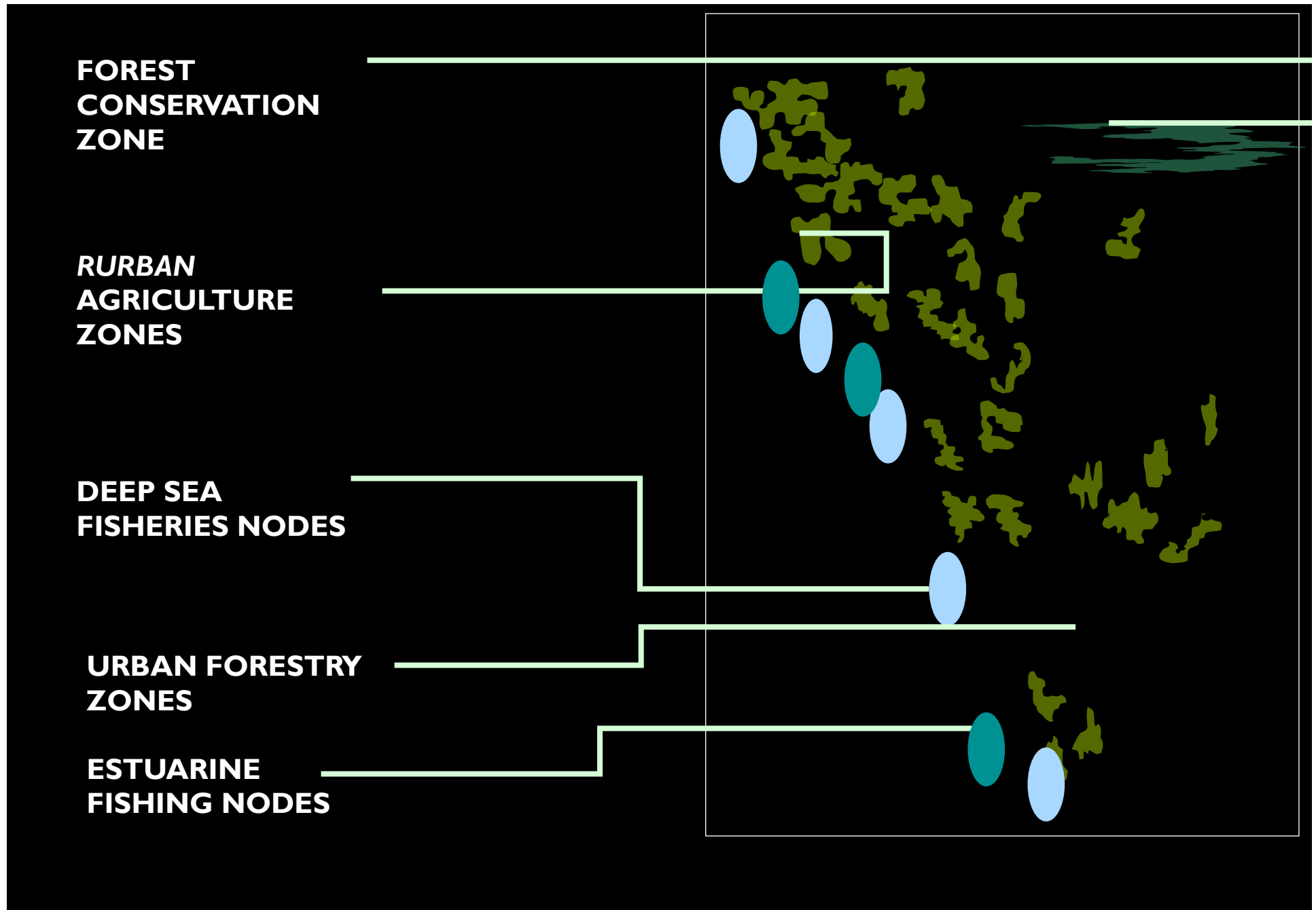
Source: Census of India, 1971-2001
UN, 2007
IIHS analysis, 2009-10



Large Urban Settlement Growth

**Goa 2030:
the Challenge of Scale-up ..**

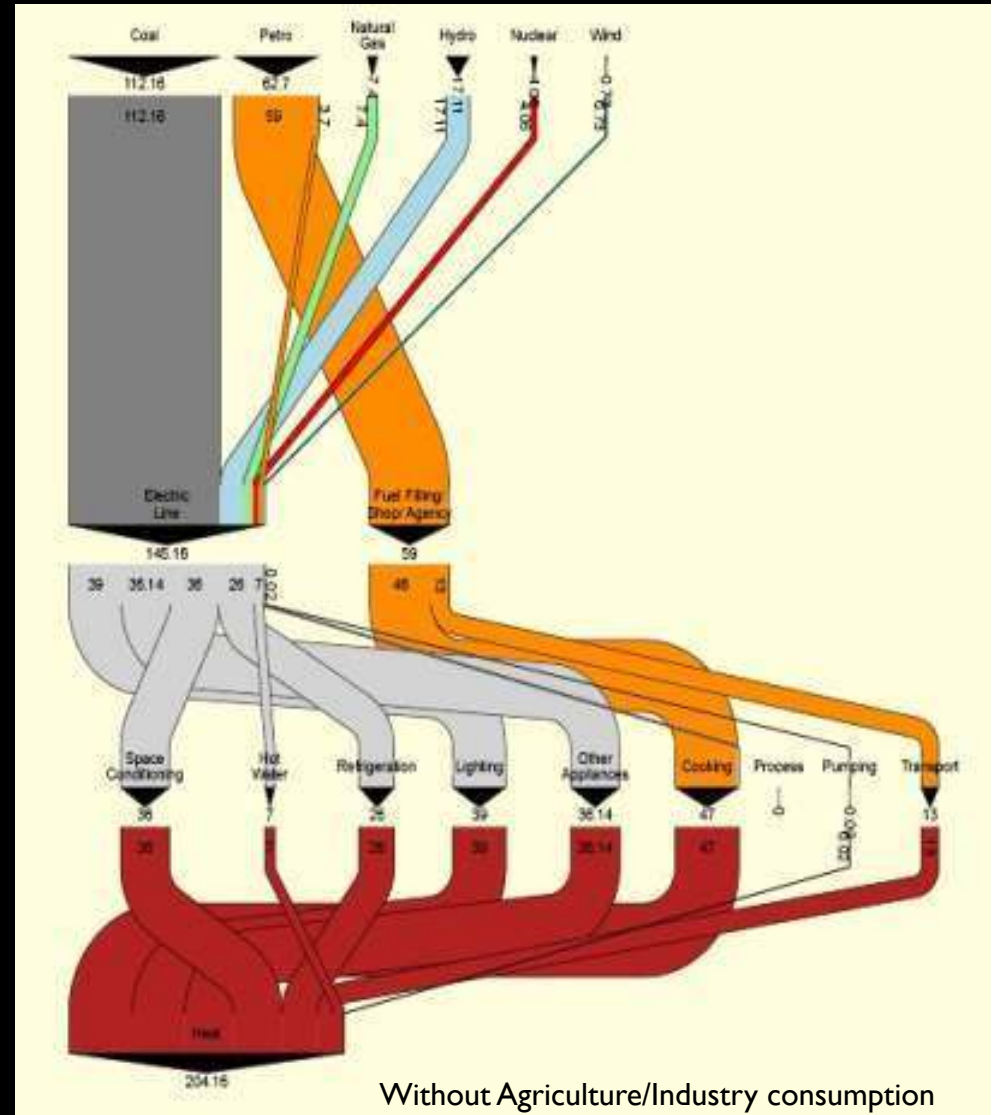
Sustainable Forest, Food and Fisheries Production



Goa 2030: Energy Futures

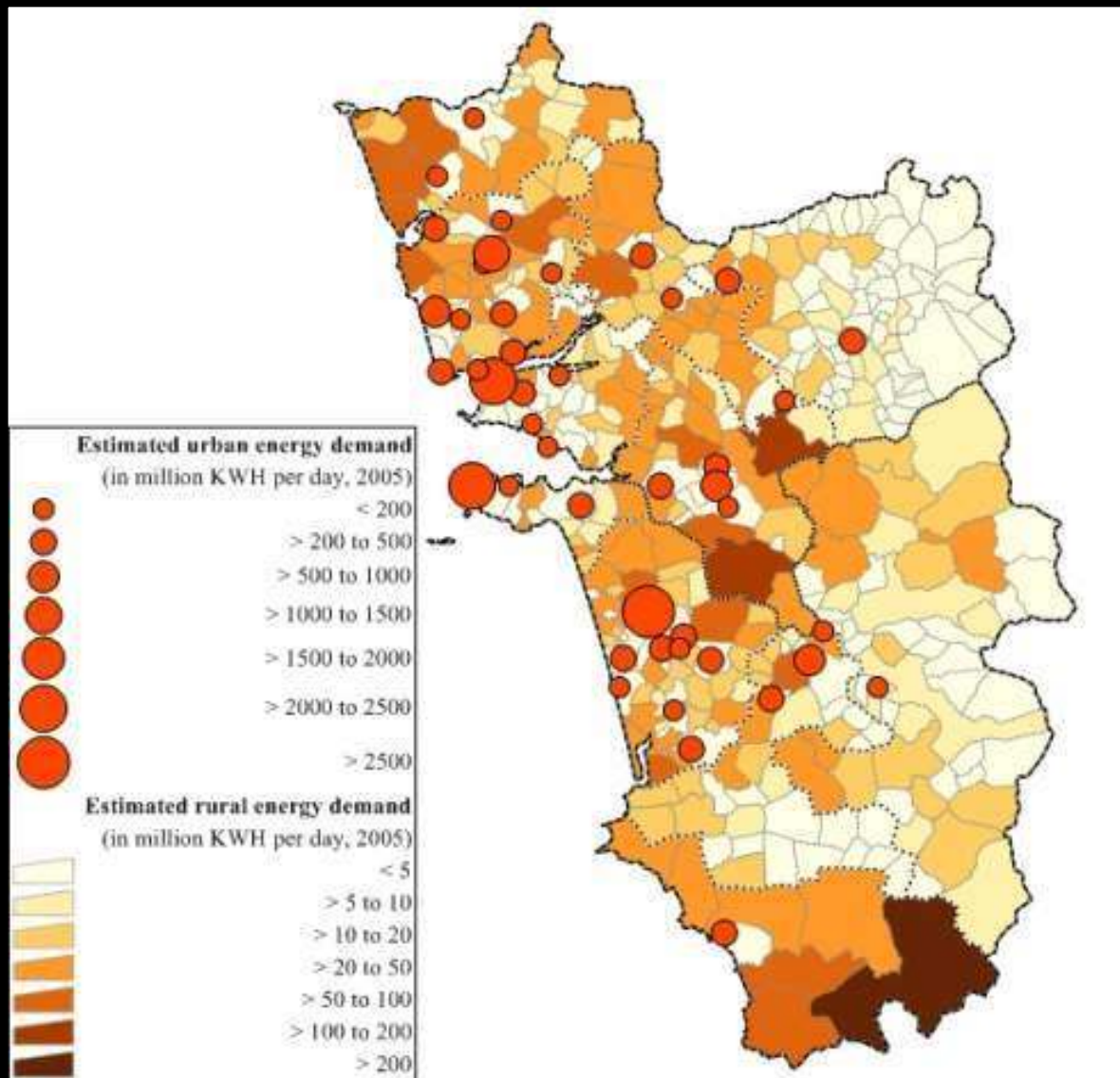
Goa Urban Energy Consumption (2005)

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



Goa Consumption Energyscape (2005)

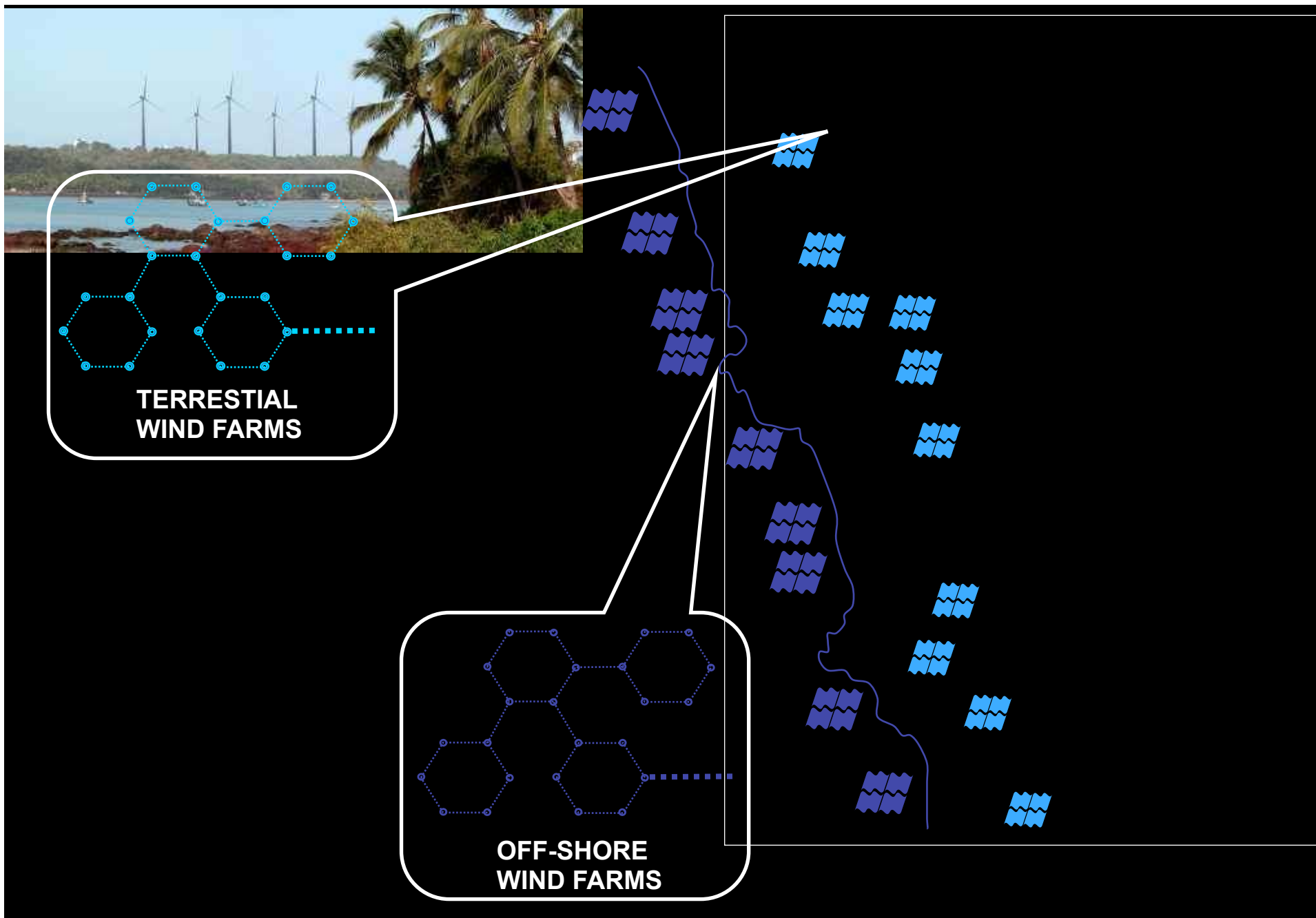
- Great difference between rural and urban demands
- Specific energy consumption is low



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

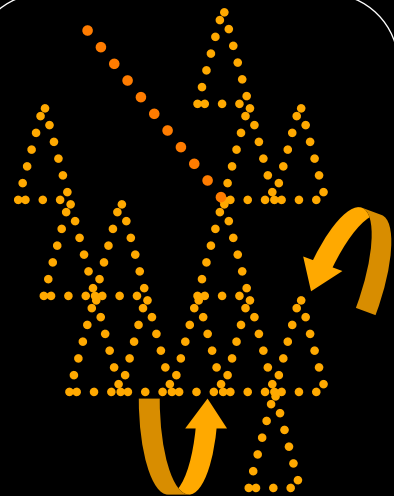
500 MW of terrestrial & 1000 MW off-shore wind power



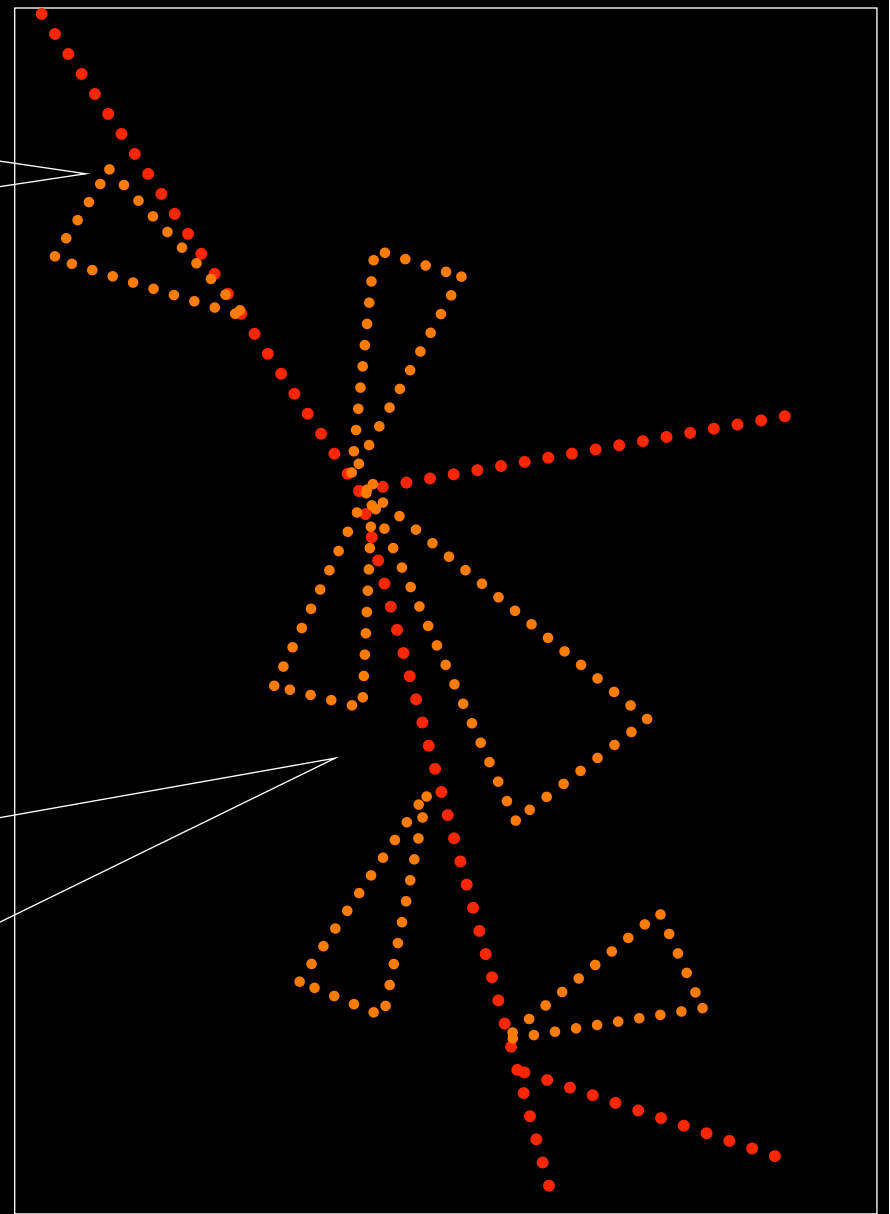
Two way Power networks & a possible Gas network



BIO-GASIFIERS



LOCAL NETWORKS



Other Renewable & Soft Power sources



SOLAR WATER HEATING



TRI-GENERATION



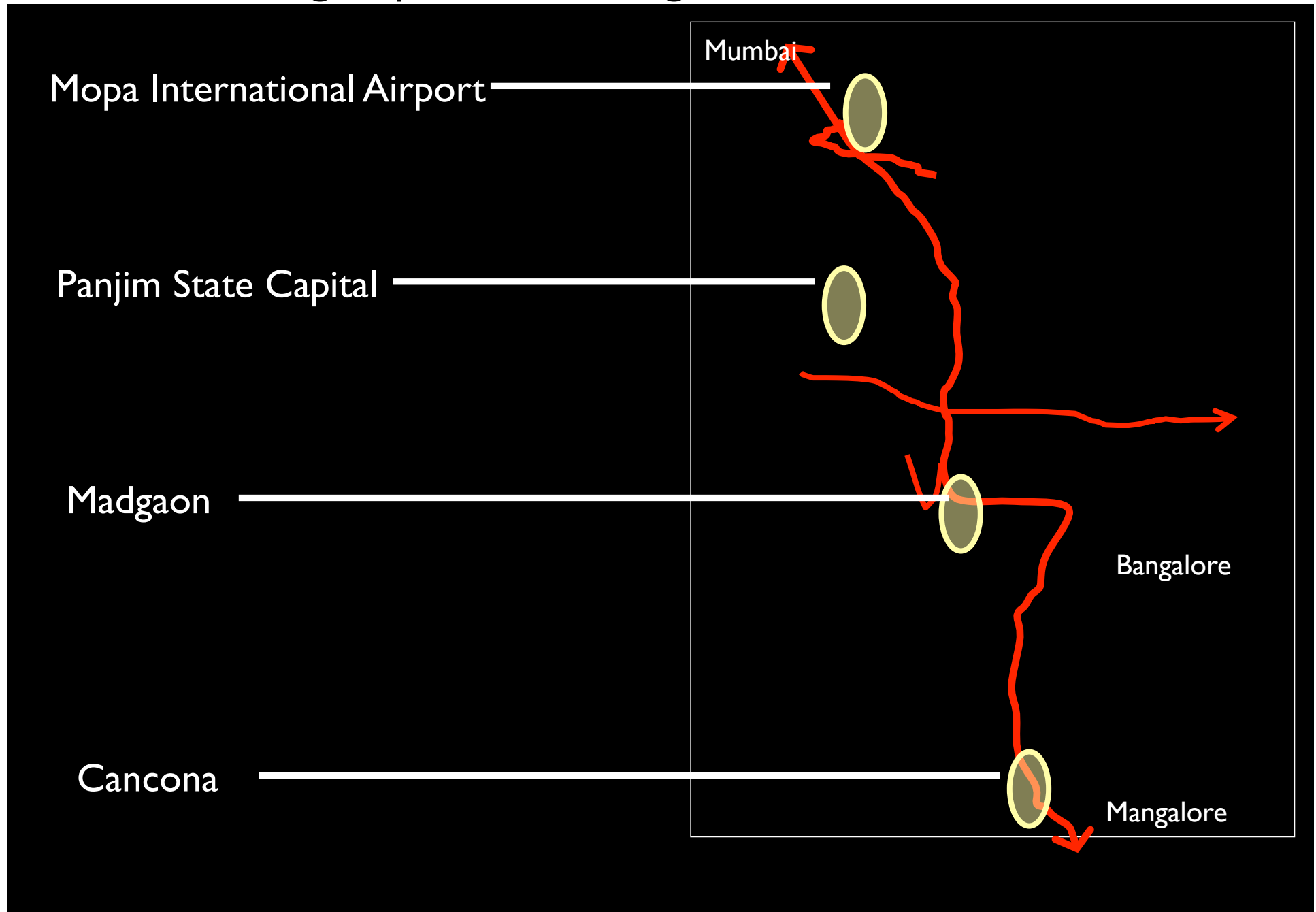
BIO-METHANATION



Offshore and onshore wind turbines punctuate the Panjim skyline by 2030

**A Key Change Driver:
Sustainable Transportation Networks**

High Speed Inter-regional Rail corridor



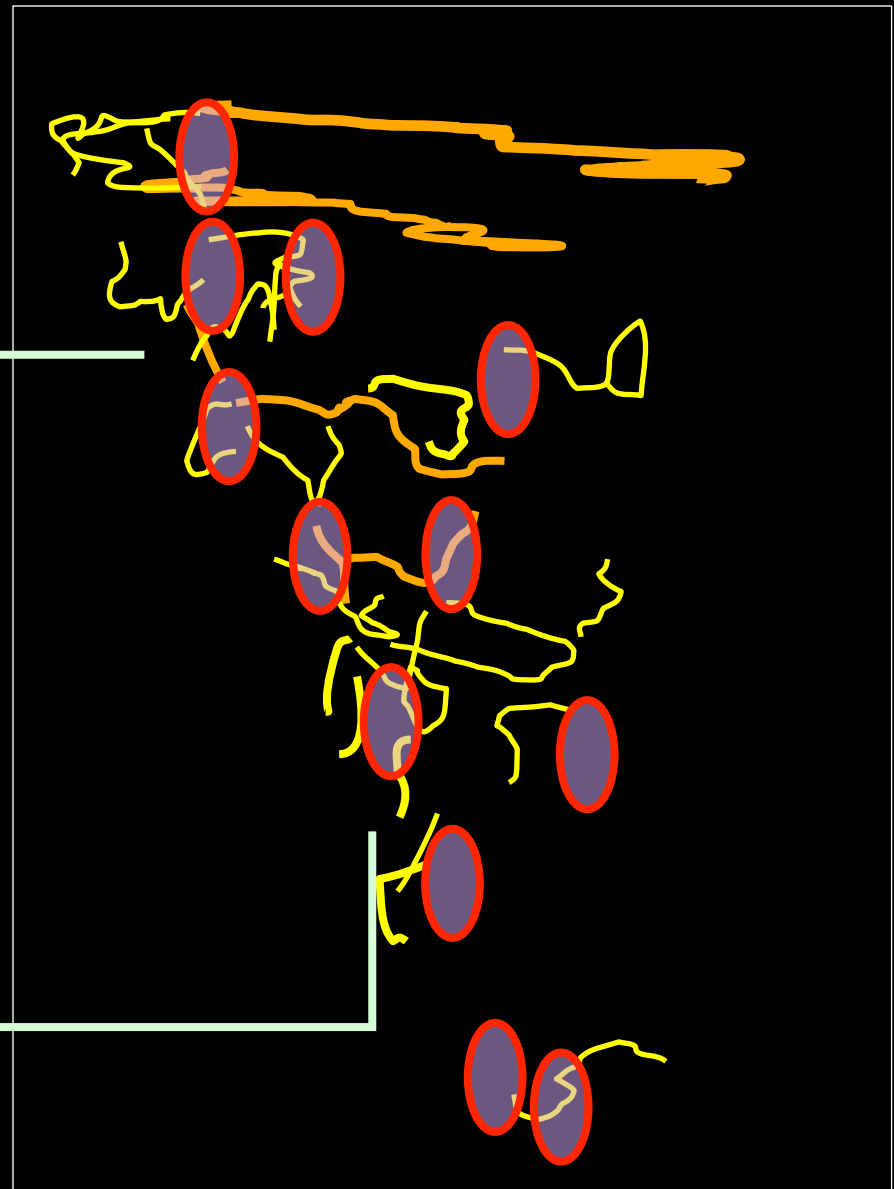
Intercity Light Rail & High Capacity Bus systems



**INTERCITY
LIGHT RAIL
NETWORK**



**INTER-NUCLEI
HIGH
CAPACITY
BUS SYSTEM
NETWORK**



Hydrofoil and All season River Transport Systems



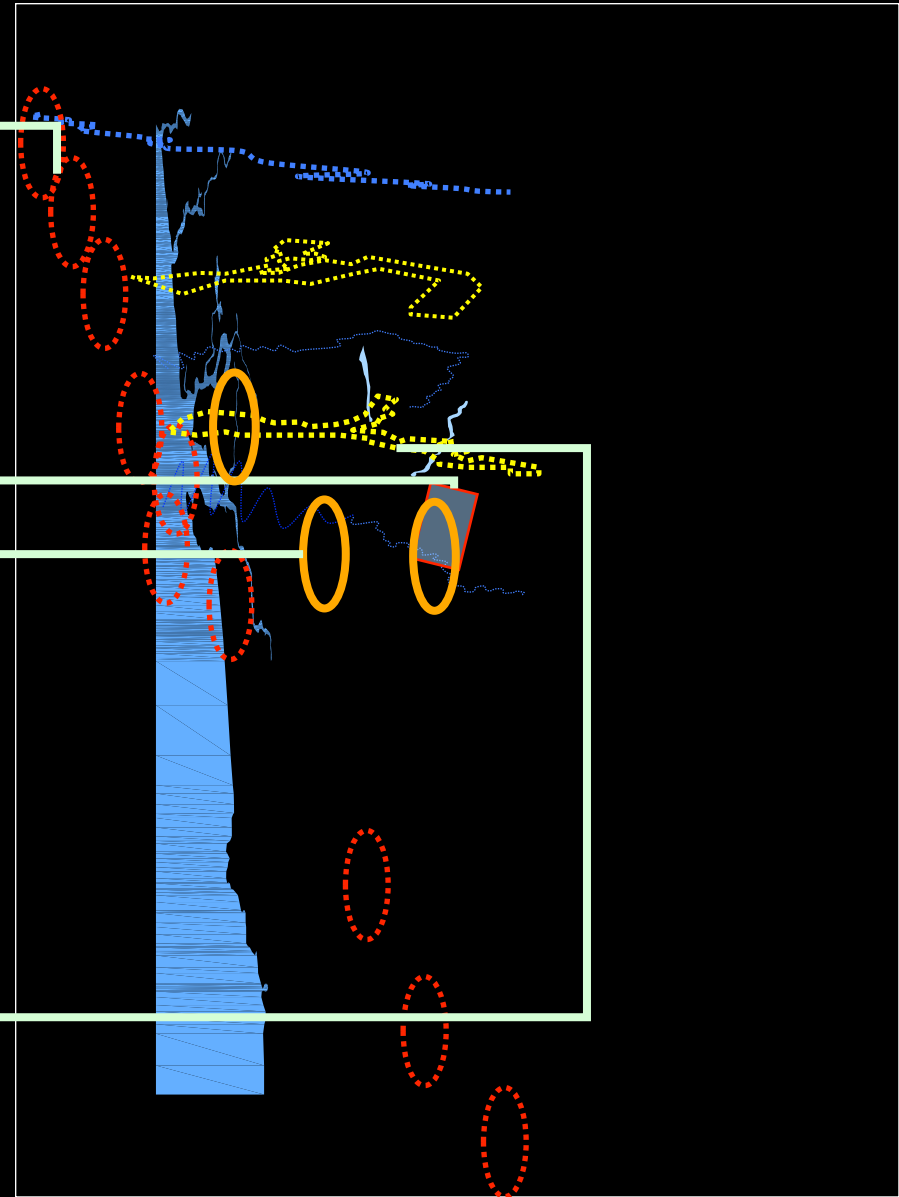
**HYDROFOIL
NODES**

**NEW CANAL NETWORK
FOR MAJOR URBAN
CENTRES**

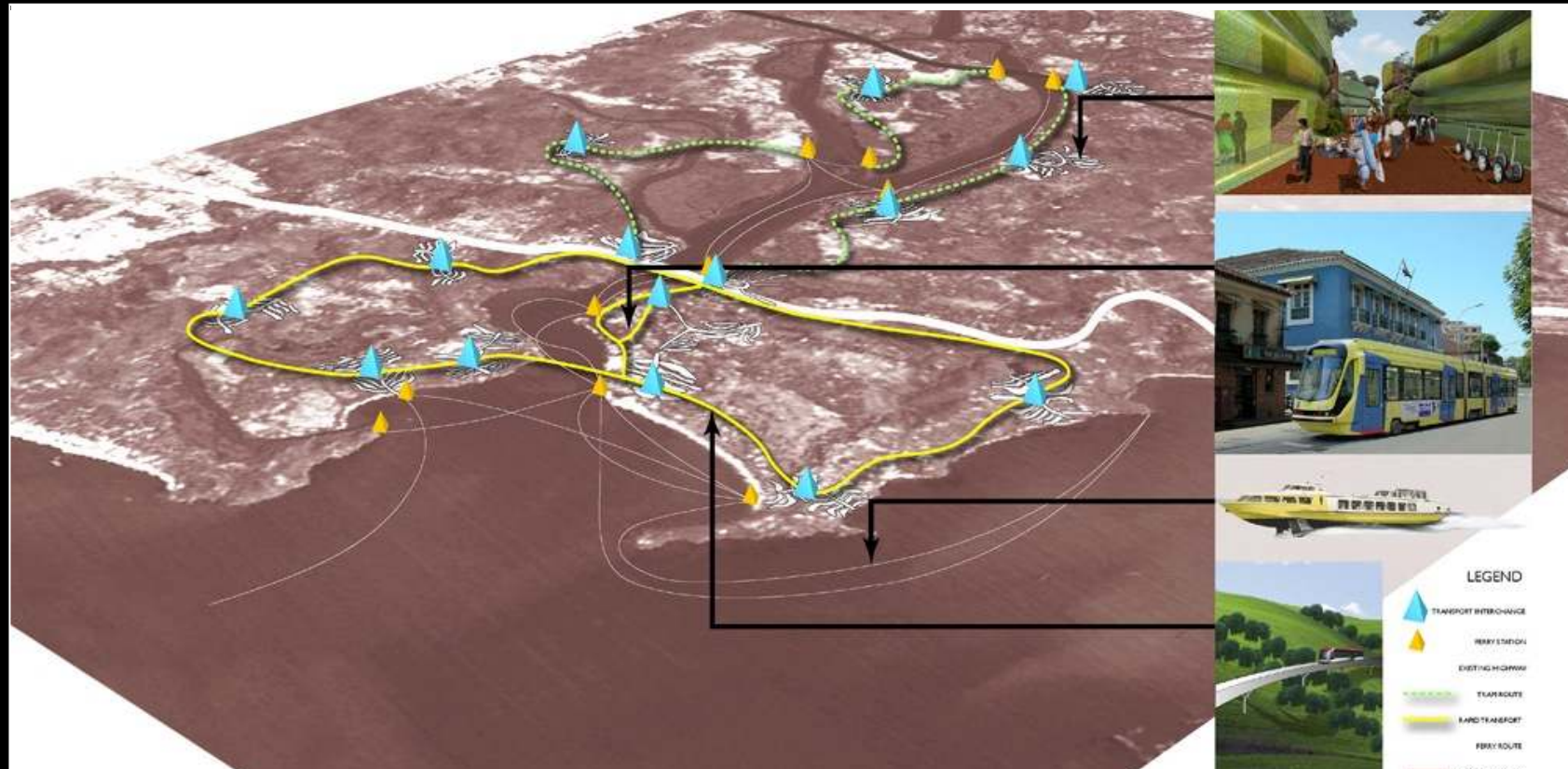
**THREE INTRA-
MODAL TERMINII**



**SOLAR FERRY
NETWORKS**

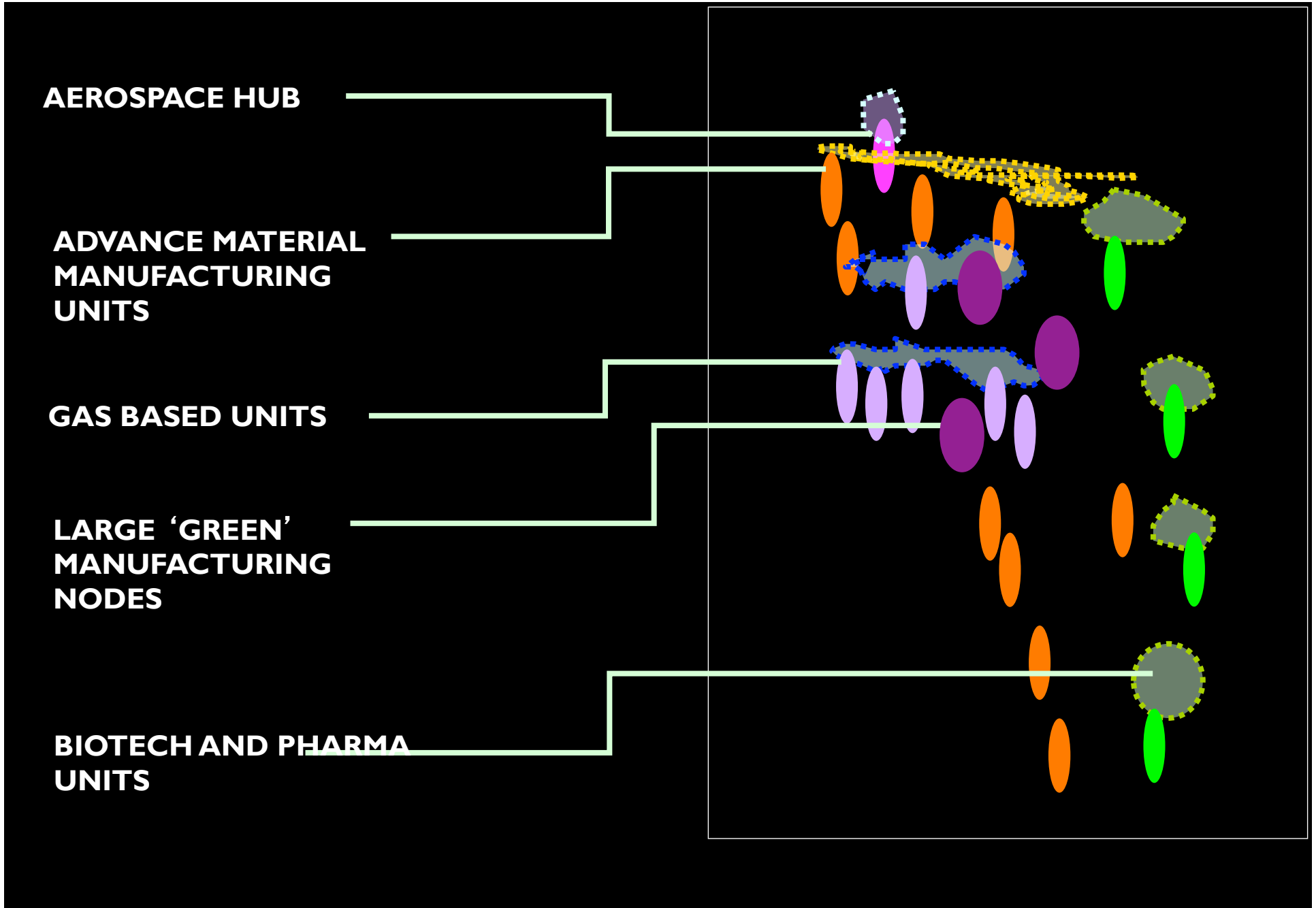


RUrban scale Mobility systems



**Key Change Driver:
Clean 'Factor 4' Manufacturing**

'Green' manufacturing zones



**Key Change Driver:
Service-sector led development**

Tourism Networks



BEACH TOURISM NETWORK



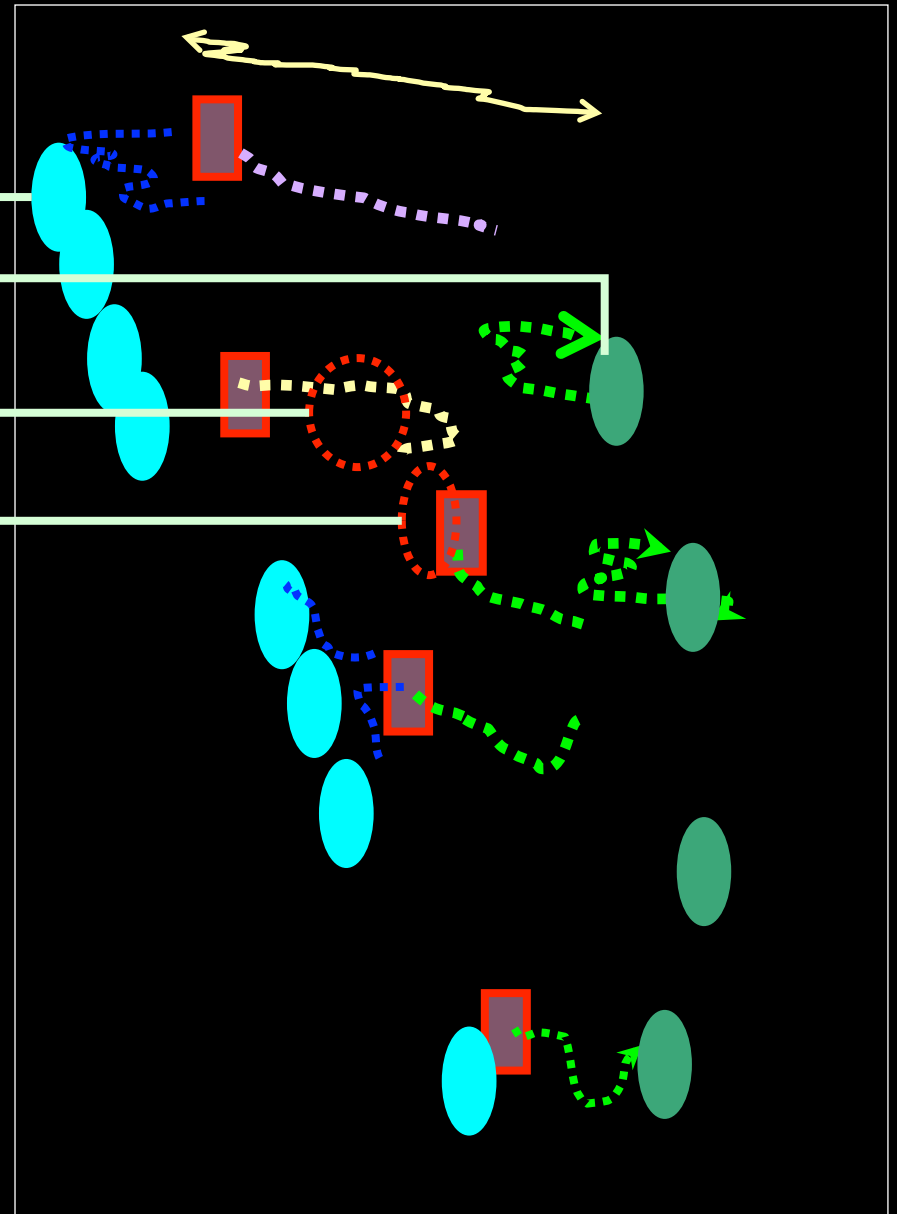
ECO-TOURISM NETWORK



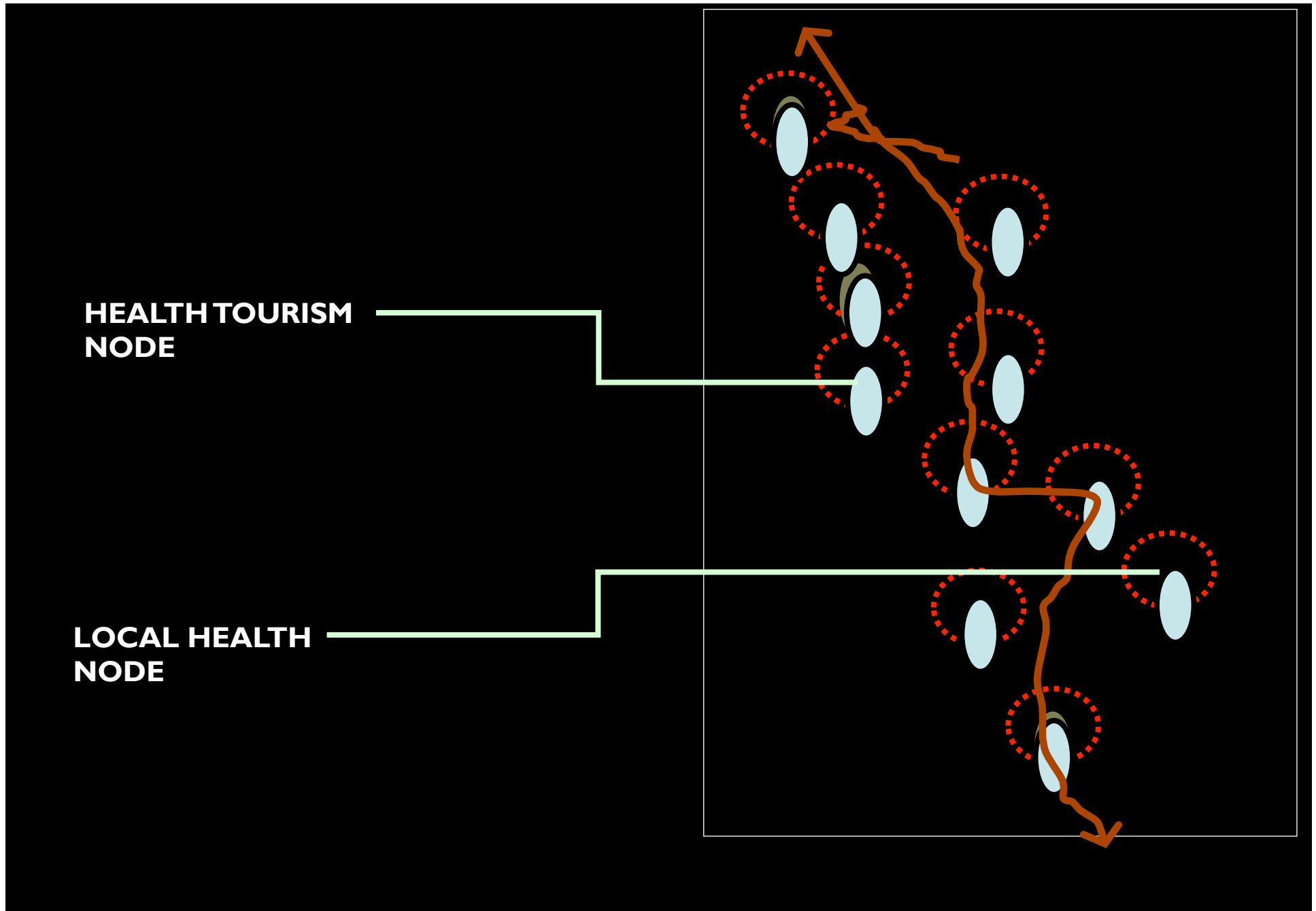
HERITAGE TOURISM NETWORK



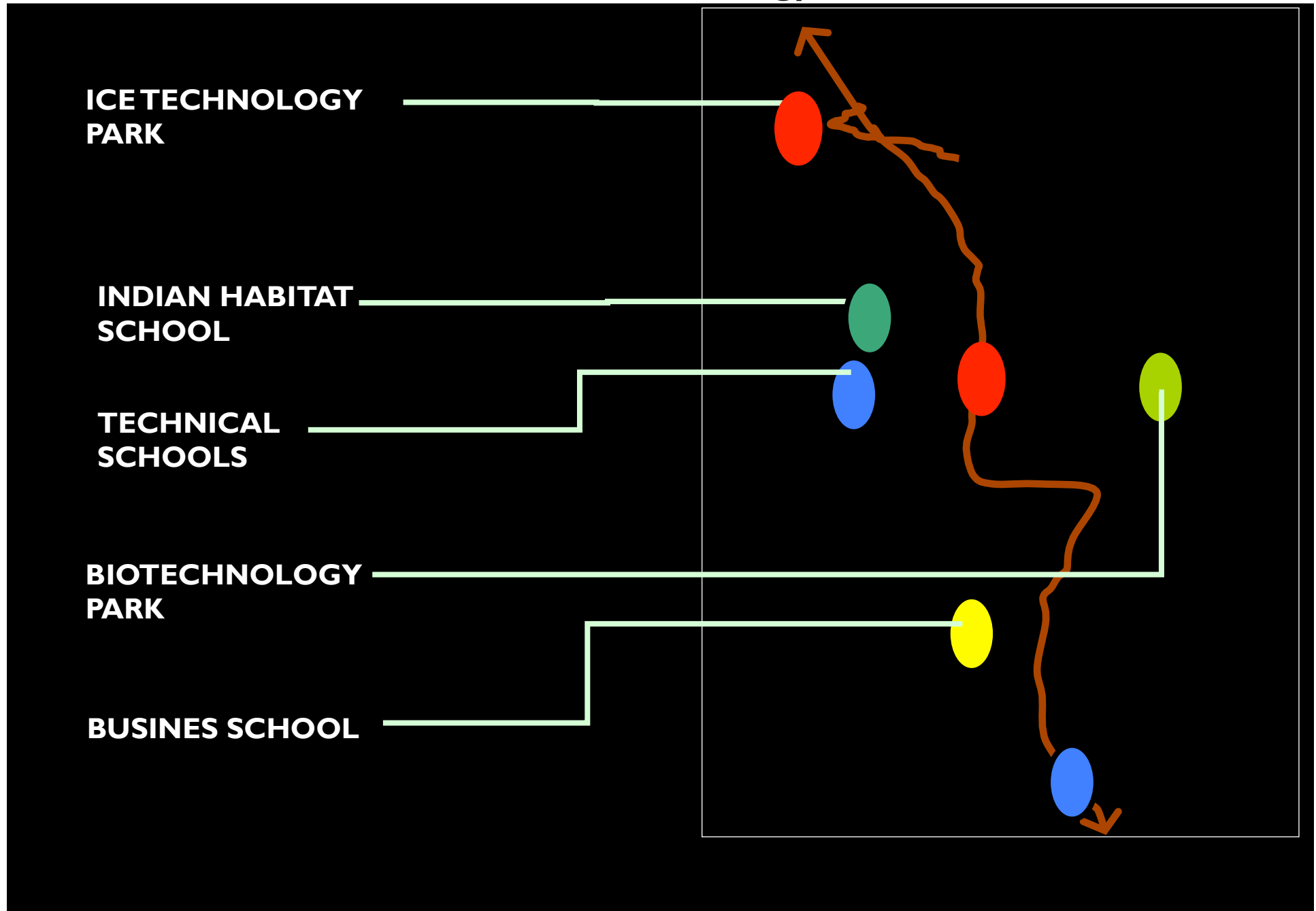
RELIGIOUS TOURISM NETWORK



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)