Looking beyond buildings - Sustainability and the city

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Urban Growth

If the current pattern of development and the trends in the growth of major metropolises of the country continue unabated, we are probably building an environmentally unsustainable future for our cities.
We seem to be caught in the vortex of a vicious cycle propelled by a complex interrelationship between five factors:
We seem to be caught in the vortex of a vicious cycle propelled by a complex interrelationship between five factors:

• Growing dependence on personalized motor vehicles for mobility.

• Growing dependence on refrigerant based air-conditioning for thermal comfort.

• Growing demand for water for non-domestic uses.

• Growing gross densities of development of land.

• Growing dependence on the speculative value of land as an economic asset.
Low carbon imperative

The macro view of mitigating climate change requires a low carbon pattern of urban life.

This means minimizing energy intensity while constructing an improved quality of life.

Mobility and thermal comfort increase energy intensity several fold, and these two factors are the primary engines of the vicious cycle.
Growing dependence on refrigerant based air conditioning for thermal comfort.

Growing dependence on personalized motorized transport

Primary engines of the vicious cycle
Night time land surface temperatures for Delhi, compiled from ASTER data for 2 October 2005 at 10:35pm, local time.

Source:
Urban remote sensing for a fast-growing megacity: Delhi, India
Netzband Maik and Atiqur Rahman
Bengaluru

Source: Landscape Modeling for Sustainable Urban Management
Energy and Wetlands Research Group
Noise
Increasing CO2 emissions
Dust, fumes
With Ultimate Congestion!

Cover Land
with Tarmac or concrete

Enjoy flora fauna
Recharge water table
Walk Play Plant

Individual transport motorization on oil

Transport/mobility linking

Pedestrians localized transport mass rapid transit

MOBILITY/MODE MODEL
Heat Island, Water Run off, Water Pollution, Dust, Noise.

Rising temperatures, (Water shortage)

Rising CO2 Emissions

Congestion
Road Rage

Electric Power

Land for
The citizen?

Even more cars
Super Highways roads

More cars
Highways roads & parking

Cars
roads & parking

Individual motorized transport

Air - Conditioning
Inefficient air cooled systems

Air Conditioning
Inefficient air cooled systems

Rising CO2 Emissions

Heat

Hotter Air

Even more cars
Super Highways roads

More cars
Highways roads & parking

Cars
roads & parking

Land for
The citizen?
Increasing CO2 Emissions

Rising Temperatures
Increasing Noise
Increasing Pollution

Vicious Cycle

- Decreasing Soft ground
- Decreasing Green cover
- Less water percolation
- Increasing water contamination

Individual Motorized Transport dependency

Air Conditioning Dependency

Increasing CO2 emissions

- Rising Air temperatures
- Depleting Water resource
Sketch of an Urban Heat-Island Profile

Late Afternoon Temperature

- Rural
- Commercial
- Urban Residential
- Suburban Residential

Increasing Density

Reduced water percolation due to increase in hard surfaces
Building
Building
Building

Water percolation

Reduction due to increase in hard surfaces

Decreasing Ground water

No Ground Water

Fully Air Conditioned!

High Density

Two Cars per Household

Vicious Cycle in full Steam!!

Water from Ganga!
Today... Water percolation, Recharge of Ground Water.

Tomorrow!!

Watch out for the effect of split units hanging out of all the flats in hundreds of thousands of middle class homes!
The economics of land coupled with segregated land use creates a distribution of population in an inverse ratio to land value and this results, overall, in longer man-trips for work for more and more citizens.

Longer travel distances combined with private motorized transport inevitably leads to higher carbon intensity for mobility in the city.
**Reflex reaction**: in order to economize on carbon emissions in the operation of the city infrastructure – transportation, conveyance of water, electricity and waste – we must densify and go high-rise.

Paradoxically this results in exchanging shorter runs of horizontal movement with increased movement vertically – of people, goods, water – against gravity. Vertical conveyance, needless to say, is much more energy intensive than rolling along the ground. Also, the height of structures calls for more carbon emissions per unit area of built space on account of the increased consumption of structural steel and cement to withstand earthquakes and high winds.
Prescription for low carbon urban system

1. Prioritize public transport plus pedestrian access over private motorized transport.

2. Maximize soft ground and vegetation.

3. Design buildings to minimize need for air conditioning.

4. Avoid high building densities to minimize heat island effect.

5. Yet manage all of the above in a compact urban form!

Three technical studies are recommended:
1. Carbon Emissions of total urban system as a function of density and height

The commonly held view that “going for high rise is a solution” needs careful technical evaluation from the low-carbon point of view (there are also the sociological and cultural implications of this pattern of development, though not in the scope of this presentation that needs serious study). What is needed, therefore, is a total-energy-systems study to evaluate the relative carbon intensities of different patterns and densities in urban form.
2. Carbon Emissions in transportation as a function of land value and land use patterns

The policy relating to land - the intensity of development and land use, combined with the operation of speculation on land value, has a direct impact on the pattern of city growth. The land policy is, perhaps, the most critical instrument in influencing the carbon intensity of the urban system.
3. Balancing the urban ecology

- Waste treatment
- Vegetation & Food
- Urban Micro climate (Cool Temperatures)
- Paved/ Soft Surfaces
- Density/height
- Rainwater Harvesting

Green Park, New Delhi
Alaknanda, New Delhi
Patpargunj, New Delhi
METRICS : DESIGN STAGE PARAMETERS

A. COMPACTNESS

• Land Consumption: Land area / Capita

• Building Consumption: Built Area/ Capita (resident)
  Built area / Capita (direct employee)

B. ROBUSTNESS

• Energy resource dependency: Backup generation capacity/Capita

• External water resource dependency: Water demand as a factor of natural precipitation
• CO2 Emissions / capita (gross)

• CO2 Emissions for city infrastructure/ capita

• CO2 Emissions in local city level mobility and transportation/ capita

• CO2 Emissions from embodied energy in buildings/ capita (gross)

• CO2 Emissions from operational energy in buildings/ capita (gross)
The establishment of new townships on greenfield sites with an ambition of setting ‘world class’ benchmarks requires:

- Innovation of city governments and management structures committed to environmental sustainability and energy efficiency
- Establishment of legislative framework to drive environmental objectives
- Envisioning a quality of life for all citizens ensuring convenience comfort and security at minimal environmental costs
Recognizing the physical reality of lived experience in the city as its truth.
Understanding quality of life in the city as the citizens experienced on the ground
Envisioning Transformation

Today

Tomorrow
Restructuring Mobility
Public Transport – Bus & Rail
Local Slow Transport Connectivity
Pedestrianisation & Pedestrian Access
• Reclaiming soft ground from paved streets
• Developing recreational parks
• Using these for rain water collection and waste water treatment.
• Reserving land for urban agriculture
• Regenerating wilderness ecologies
Bowl Garden – Rainwater Harvesting Amphitheatre
STRATEGY
The strategy for electricity is for the state to install PV trees on public and institutional lands and buildings, and along public rights of way. The PV trees clear the height of natural trees. They integrate seamlessly with the environment, as elements of public art, reducing urban heat island effect; they shave the peak demand by linking to the city’s electricity grid. This allows rapid switch over to renewable energy at the city level. In turn BIPV is encouraged to follow suit.

DELHI ENERGY BALANCE

DEMAND
As per master plan for Delhi 2011-2021
- Projected population = 24,000,000
- Electricity demand = 11000 MW
- Potential of demand reduction by energy efficiency = 30% of 11000 MW
- Potential of offset by solar water heating, bio methanation, bio gasification = 5% of 11000 MW
- Reduced demand = 7150 MW
- Per capita demand at the city level = 7150 x 10^3/24 x 10^6 watts = 298 Watts

SUPPLY
- Electricity supplied by building integrated PV = 45%
- Electricity supplied by photovoltaic trees = 30%
- Electricity supplied by national grid powered by renewable sources = 25%

TRANSECT ENERGY BALANCE

DEMAND
- Per capita demand = 298 Watts
- Transect projected population = 1,11,062
- Transect demand = a x b = 33,096,476 Watts

SUPPLY
- Solar trees on site = 9,928,942 Watts (30%)
- Building integrated PV on site = 14,893,416 Watts (45%)
- Supplied by national grid = 8274119 Watts (25%)

OTHER RENEWABLE ENERGY
- Solar water heating
- Biogas
- Solar cooking
Today majority of households in Delhi are meeting their needs for drinking, cooking, bathing, washing and cleaning with 80 lpcd. With recycling potential the demand for fresh water can be reduced to 35 lpcd.

<table>
<thead>
<tr>
<th>per capita demand</th>
<th>recycling potential</th>
<th>net per capita demand</th>
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<tbody>
<tr>
<td>80 lpcd</td>
<td>45 lpcd</td>
<td>35 lpcd</td>
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WATER IS SCARCE. ANNUAL RAINFALL IS 620 MOST OF WHICH FALLS DURING THE SUMMER MONSOON.

- First claim on water is the universal right to safe drinking water
- Each building and building cluster directly stores rainwater for drinking and cooking. Remainder is directed to recharge aquifer.
- Capture water of seasonal watercourse for aquifer recharge.
- The rest is under strict rationing recycling is resorted for all domestic uses.
- Urban agriculture is designed to utilize and be limited to recycling of treated black water – MORE ORCHARDS, LESS VEGETABLES!
Take away cars and you have a market. Shade of the trees shelters open stalls and street vendors. The road goes back to agriculture.