# Mumbai:
# Urban Reconstruction or Environmental Destruction

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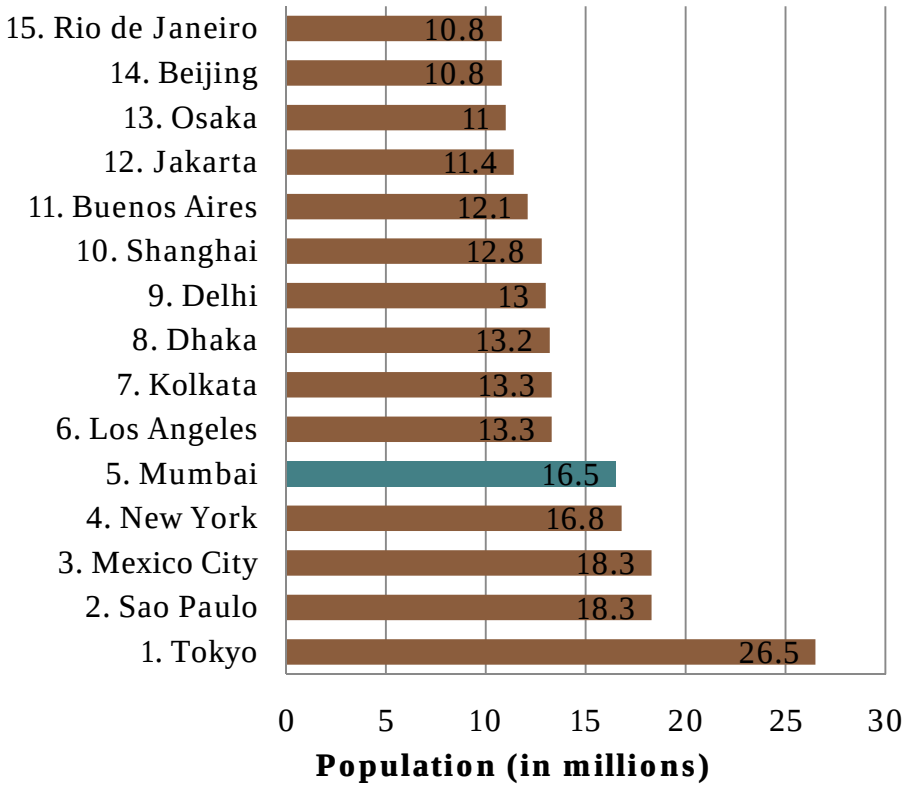
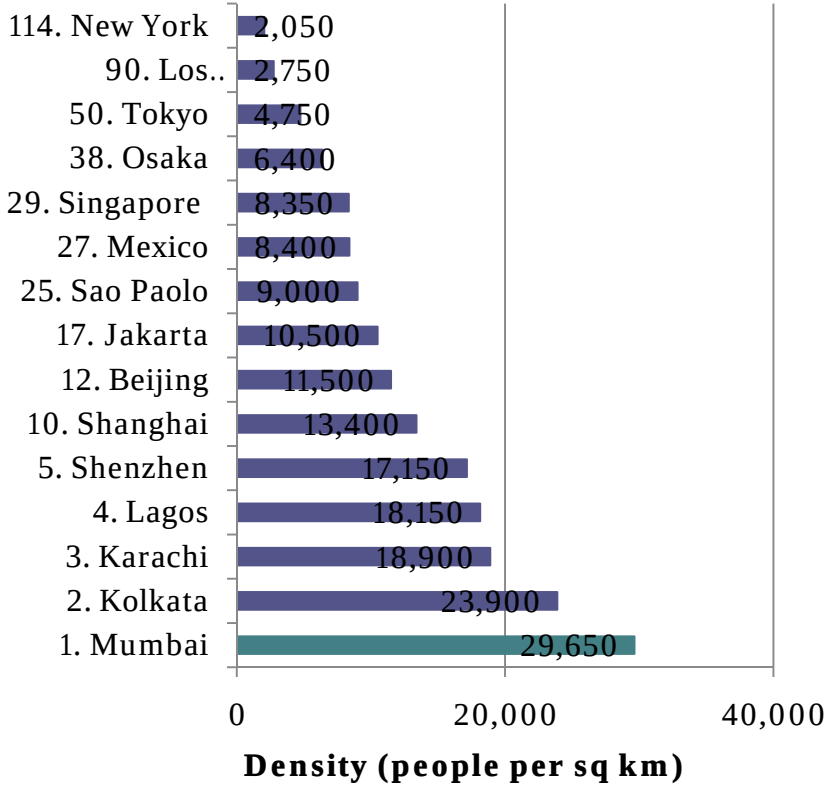
ENGINEERS WITHOUT BORDERS/NZ

# Population and Density




**By Population (number of people)**[4]




**By Population Density**[5]

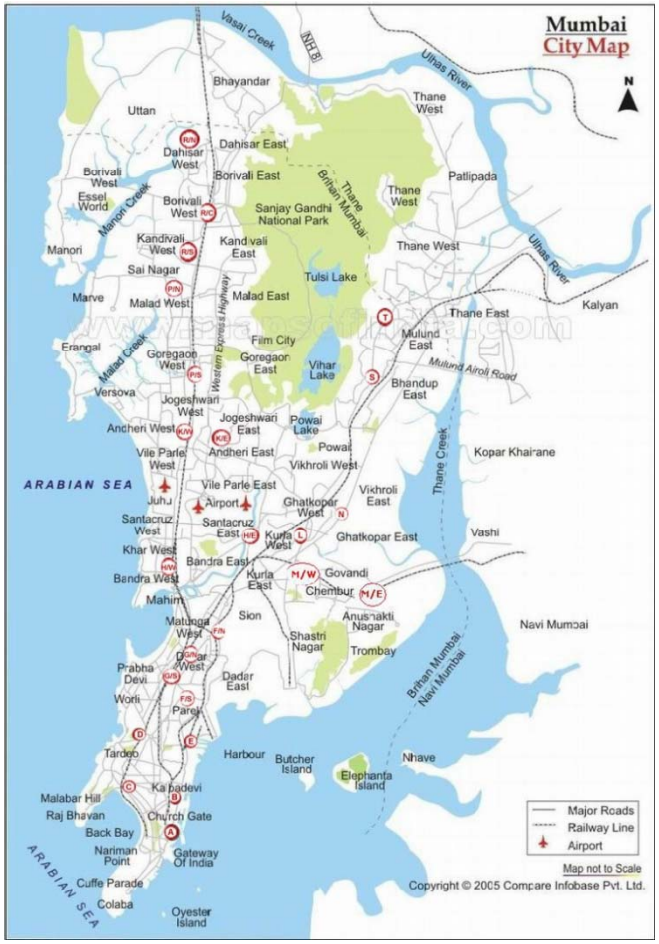
- Second largest of Asia's mega-cities in terms of population
- With an average population density of **29,650 per sq km** it is one of the most crowded cities in the world[2]
- However, the redevelopment proposals for the city promote further densification.

***Reference:***

[4] *Adapted from World Urbanisation Prospectus – The 2001 Revision (United Nations)*

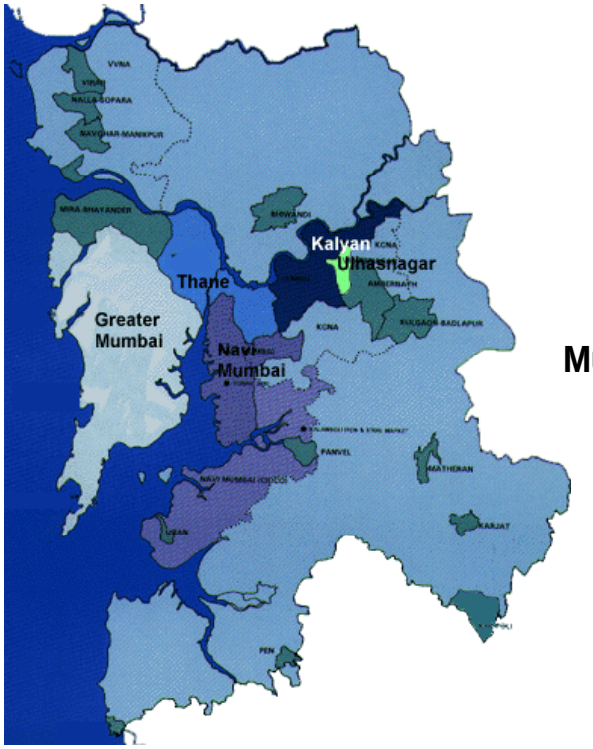
[5] http://www.citymayors.com/statistics/largest-cities-density-125.html

# Mumbai



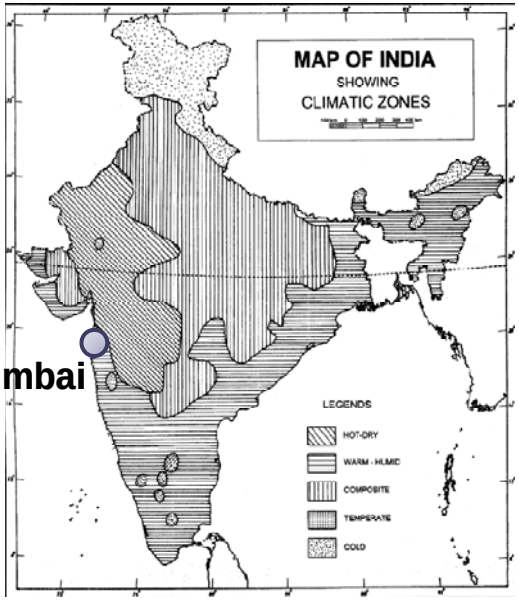

**Map of Greater Mumbai[8]**

- Mumbai lies on the west coast of India




**Map of Mumbai Metropolitan Region (MMR)[7]**

- Mumbai Metropolitan Region lies between 18°33' and 19°31' North latitude and 72°45' and 73°28' East longitude




**Map of India[6]**

- **MMR** extends over an area of **4355 sq km**[2]
- **Greater Mumbai (438 sq km)** consists of two distinct regions:
  1. **Mumbai City district** (wards A-G)
  2. **Mumbai Suburban District** (wards H-T)

***Reference:***


[6] *Bureau of Indian Standards. (2005). National Building Code of India.*

[7] *MMRDA Planning Team. (1996 - 2011). Regional Plan for Mumbai Metropolitan Region. Mumbai: MMRDA*

[8] *http://www.mapsofindia.com/maps/india/office-location-mumbai.html&u*

# Infrastructure

**Water:**

- Sources of water supply are located about 100 km outside city limits in the form of lakes [9]
- supply of water for only a few hours in the day
- Connections to any new tower, clusters or townships being suspended[10]
- level of underground water is falling and bore wells have to be dug to greater depth [11]
- Unaccounted for Water (UFW) in Mumbai is 20%[12], much higher than cities across the country and the world
- RWH made mandatory to new development having plot area 300 sq m and above from 2007


**Electricity:**

- Maharashtra, having the highest consumer base in the country [13], tops the list for more deficit compared to other states
- Consumption of electricity is growing faster than production capacity, , leading to electricity blackouts on a regular basis [14, 15]


***Reference:***

[9] *MCGM. "Greater Mumbai City Development Plan." Mumbai, (2005 to 2025).*

[10] *Sen, Somit. "No Water for New Mumbai Towers." Times of India 12 December 2009, sec. Times City. Print.*

[11] *Lewis, C. (2010, 4 June). City goes on a borewell-digging spree, Times of India.*

[12] *Singh, Mamata R., V. Upadhyay, and Atul K. Mittal. 2010. Addressing Sustainability in Benchmarking Framework for Indian Urban Water Utilities. Journal of Infrastructure Systems (March):81-92.*

[13] *BS Reporter. "Mumbai Facing Power Shortage." Business Standard (17 October, 2006).*

[14] *"Looking to Power the State Forward." Report. DNA (Daily News & Analysis) 5 July 2010.*

[15] *Rediff News. "Can Mumbai Escape Power Cuts?" Rediff News (**Business Standard) 03 April 2007.***

# Infrastructure

**Solid Waste Management:**

- Most of collected solid waste (7,025 MT/D) is disposed of as mere dumping and levelling at the landfill sites [9]
- landfill sites have almost outlived their carrying capacity [9]
- Allotted site likely to be inadequate for the projected solid waste generation [9]


**Drainage:**

- flooding and water logging during heavy rains and high tides[9]
- discharge of large amount of untreated sewage into creeks[9], resulting in degradation of coastal water quality, contamination of the adjoining beaches and seafronts [16]
- dilapidated condition resulting in leaks and contamination of ground water and piped water supply[9]




***Reference:***

[16] *Kumar, Rakesh, Jayshree Subramaniam, and Dhanyakumar Patil. "Water Quality Modelling of Municipal Discharges from Sea Outfalls, Mumbai." Environmental Monitoring and Assessment 62 (2000): 119–32.*

[9] *MCGM. "Greater Mumbai City Development Plan." Mumbai, (2005 to 2025).*

# Infrastructure

**Food:**

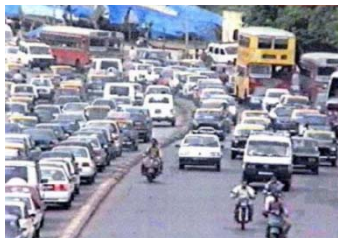
- reduced agricultural productivity [20] due to an increasing shortage of availability of productive land [16,9] and water for irrigation[21]
- transportation of food from outside the city and storage, requires considerable amount of energy and space

**Transport:**

- 85% of Mumbai's travel demand is still carried out through mass transport systems [32]

  - Trains : 53%  - Buses : 35%
- use of personalised vehicles has been rising[9]
- slow traffic and environmental pollution [18] linked to increasing respiratory problems [19] in the city
- more emphasis is given to infrastructure development that promotes use of private vehicles without due consideration to pedestrians [17]




***References:***

[9] *MCGM. "Greater Mumbai City Development Plan." Mumbai, (2005 to 2025).*

[16] *Bhaskar, RN. "Food Security - Ii: Why Food Prices Will Keep on Rising." DNA (Daily News & Analysis) 2 September 2010, sec. Money.*

[17] *Bombay First. Transportation. Strategy Paper*

[18] *Dhakras, B. S. (2004). Study of Parameters in the Development of Sustainable Transportation System : A Case Study of Mumbai, India. Master of Civil Engineering, The University of Toledo, Toledo*

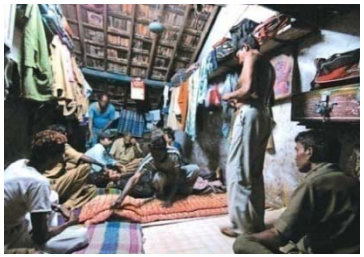
[19] *Lewis, Clara, and Malathy Iyer. 2010. Asthma is top killer of Maha women: Survey. Times of India, 28 March.*

[20] *Renton, Alex. "Food, Famine & Climate Change: India's Scorched Earth." The Observer (Observer Food Monthly).11 October (2009).*

[21] *Tiwari, P., & Kawakami, T. (2001). Modes of Commuting in Mumbai: A Discete Choice Analysis. Paper presented at the The Applied Regional Science Conference*

# Density

- Population of Mumbai = about 12 million[9]
- Developable land = 63% of 438 sq km (total area)
  = about 275 sq km[9]
- Population density = 43,700/sq km[9]
- Built-up area = 265 sq km[9]
- Developable land remaining = 10 sq km[9]
- This suggests congested living conditions and constrained land availability for further development and growth.
- Households in Mumbai consume an average of 2.9 square meter of floor space per person which is one of the lowest residential floor areas per person in the world[42]
- It has a negative effect on the health of the inhabitants and the city should aim at least doubling it[22]
- Compared to crowding within dwellings, higher household/population density has fewer negative impacts[23]




***Reference:***

*[22] Bertaud, A. (June 2004). Mumbai FSI conundrum: The perfect storm: the four factors restricting the construction of new floor space in Mumbai. Retrieved from http://alain-bertaud.com*

*[23] Dave, S. (2010). High Urban Densities in Developing Countries: A Sustainable Solution? Built Environment, Vol 36, No 1(The Compact City Revisited), 9-27.*

*[9] MCGM. "Greater Mumbai City Development Plan." Mumbai, (2005 to 2025).*

# Potential for future development


**Island City**

- Increasing the availability of land by [9]
  - increasing Floor Space Index (FSI) and
  - linking it to redevelopment program,
  - opening up mill and port lands,
  - relaxing Coastal Regulation Zones (CRZ) II and III for Mumbai,
  - building the trans-harbor link
- MHADA identified 19642 old and dilapidated buildings, called “Cessed Buildings”, in the Island City[9]

***References:***

*[9] MCGM. "Greater Mumbai City Development Plan." Mumbai, (2005 to 2025).*

*[24] MCGM. (2007). Development Control Regulations for Greater Bombay,1991. Mumbai: Government Central Press.*

# Potential for future development


**Island City**

- In addition to FSI required to rehabilitate the existing occupiers[24]
  - **Individual** redevelopment of plots: **50% incentive** FSI
  - **Composite** redevelopment of
    - **2-5 plots** : **60% incentive** FSI
    - **6 or more : 70% incentive** FSI

- Proposal is architecturally based and promote the demolition of large areas of low rise development in the city in favour of high rise development with open area around them [25]

***References:***

*[24] MCGM. (2007). Development Control Regulations for Greater Bombay,1991. Mumbai: Government Central Press.*

*[25] Nandy, M. (2010, 7 September). Real estate funds seek to tap urban redevelopment segment, livemint.com, p. 6. Retrieved from http://www.livemint.com/2010/09/06204311/Real-estate-funds-seek-to-tap.html?atype=tp*

# *Objectives of the research*

- Analyse the problems faced by mega cities in the developing countries of the tropics, particularly Mumbai
- Analyse the options currently existing for accommodating future population
- Derive optimum densities based on infrastructure, urban planning principles and the needs of the city
- Identify areas with high redevelopment potential
- Derive optimum mix of uses
- Derive the correct built-form
- Derive the architectural/planning interventions needed for a sustainable built environment

# Methodology

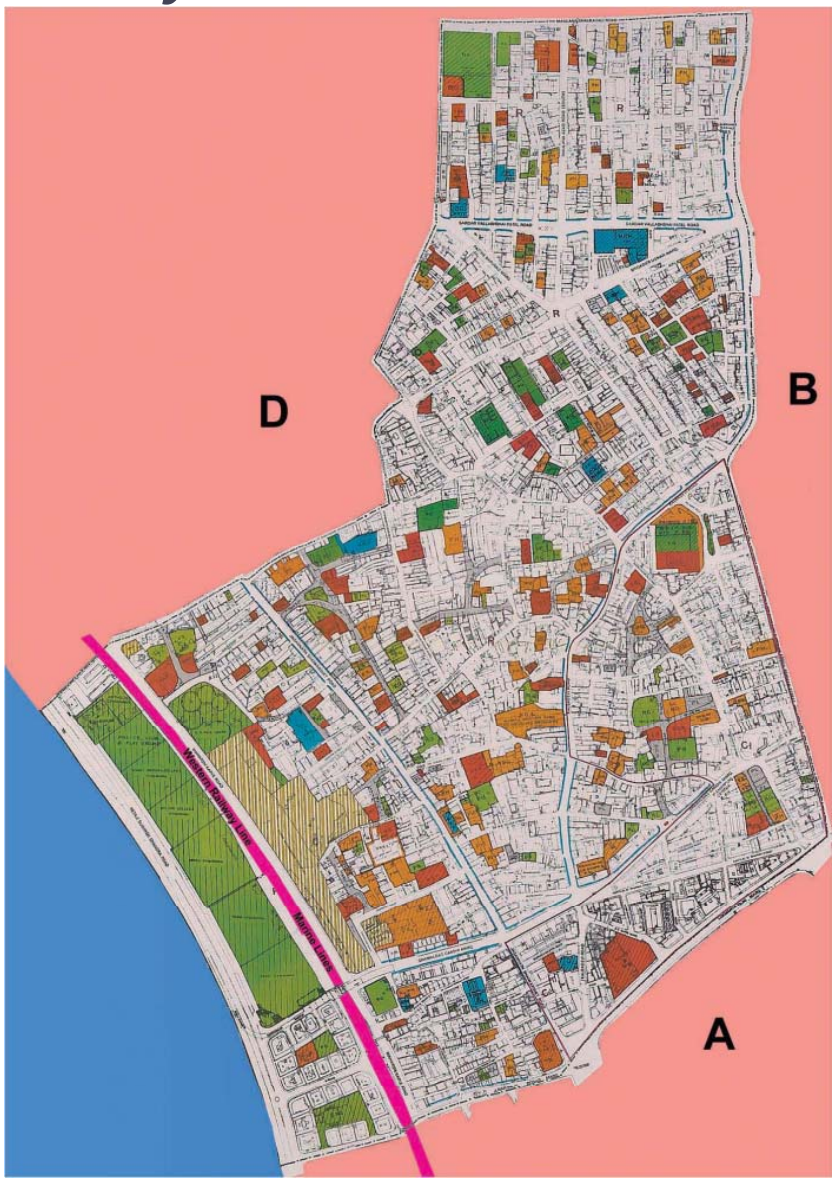
- **Comparative Ecological Footprint Analysis**: energy and land required for the production of energy (for transportation and various residential uses), collection of water, disposal wastes, in addition to the land required for the physical development, will be measured in KWhr/$m^2$ and hectares and expressed in land area equivalent per household per year.

- Derived from PhD thesis of Sumita Ghosh (2004)[37] which analysed four residential zones of Auckland

***Reference:***

*[37] Ghosh, S. (2004). Simple sustainability indicators for residential areas of New Zealand. Thesis (PhD, Architecture)--University of Auckland, 2004.*

# *Study Area*




**C-Ward**

- **C-ward :**

- one of the oldest urbanised areas of Mumbai
- highest population density in the city
- maximum number of dilapidated building
- failing infrastructure

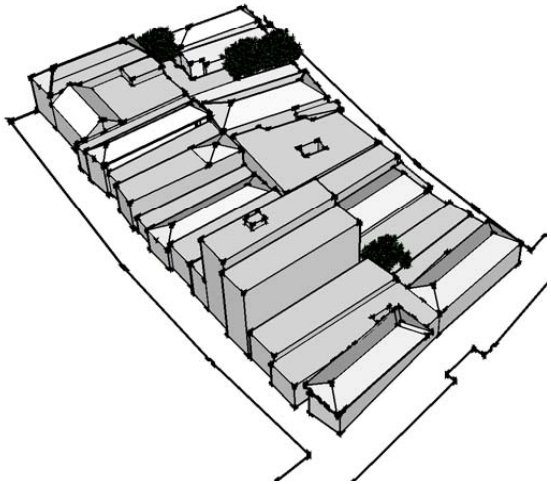




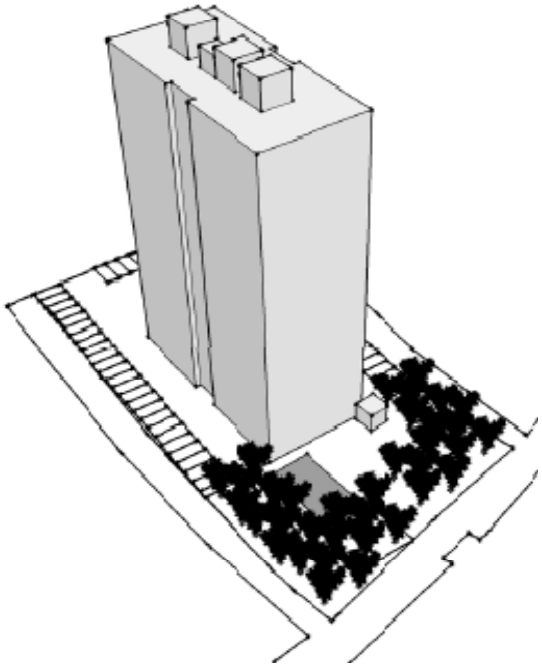

# Preliminary Study - 1

- Selection of typical cluster based on the detail of data already collected for its built form and density
- Bulk of hypothetical building designed based on the requirements and Development Control Rules of Mumbai

| | Existing | Potential |
|---|---|---|
| Land Area | 3725 sq m | 3725 sq m |
| FSI | 1.705 | 4.34 |
| Built-up Area | 6349.365 sq m | 16181.88 sq m[1] |
| | - | 155% increase |
| Avg. Tenement Size | 13 sq m (140 sq ft) | 27.8 sq m (300 sq ft) |
| | | 47 sq m (500 sq ft) |
| | | 75 sq m (750 sq ft) |
| Population (approx) | 1030 people[2] | 1305 people[3] |
| | - | 27% increase |
| No. Of Storeys | 2-6 | 30 |



**Existing development**



**Proposed development**

***Notes:***

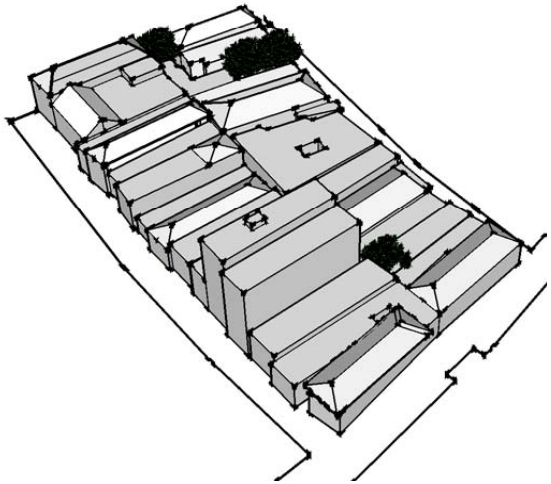
*[1] Considering incentive of 55% on built-up area required to rehabilitate existing users*

*[2] Considering an average tenement size to be 140 sq ft (13 sq m) and average household density to be 4.5 persons*

*[3] Considering an average tenement size for rehabilitation to be 27.8 sq m, and additional built –up area used for tenement sizes of 47 sq m and 70 sq m; average household density to be 4.5 person*

# Preliminary Study - 1

| | Existing | Potential |
|---|---|---|
| Car Parking | < 10 | 35 - 80 (approx) |
| Estimated $CO_2$ produced by Cars | >2340 Kg/year | 8190 – 18720 Kg/year |
| | - | 71% - 88% increase |
| Amenity Open Space | None | 930 sq m |
| Roof Area | 3375 sq m | 385 sq m |
| | - | 88.5% reduction |
| Energy Consumption | - | 50% increase[4] |
| Water Use | - | 80% increase[5] |
| RWH potential | - | 90% decrease[6] |
| Trees | 3-5 | 47[7] |
| $CO_2$ Sequestering Potential | 69–115 Kg/year | 1081 Kg/year |
| | 95-97 % deficit | 87-94% deficit |
| Food consumption | - | 27% increase |



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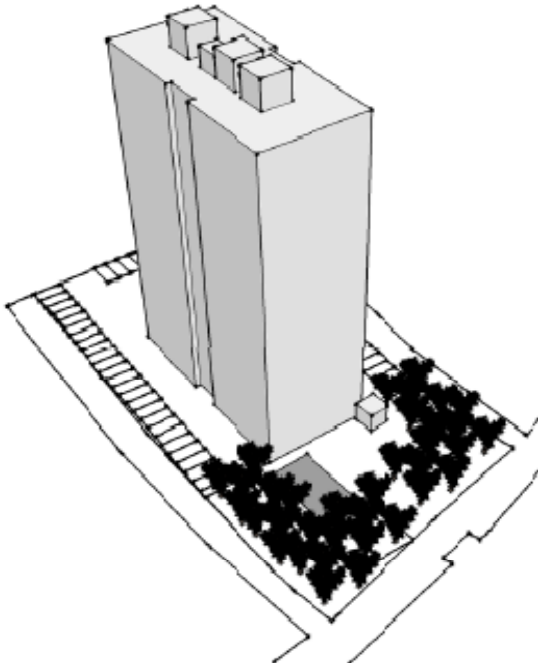


**Proposed development**

***Notes:***

*[4] Excluding Air conditioning, which is expected to increase (uptake in the existing clusters is approx. 10% of households)*

*[5] Due to a combination of an assumed 'take-back' (increased use of water due to improved bathing facilities), watering of trees and other landscaped areas and for washing the increased number of cars*

*[6] Due to significantly reduced roof area*

*[7] At the rate of 5 tree per 100 sq m or part thereof of the said recreational space to be grown within the entire plot (as per DCR for Greater Mumbai, 2007)*

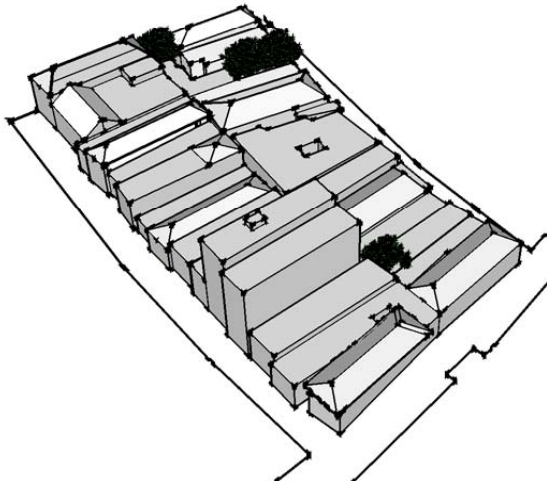
# *Preliminary Study - 1*

***Observations:***

- A typical development with increased density (27%) would mean
  - more than double the energy consumption,
  - double the use of water,
  - reduce the amount of rainwater that could be collected or returned to the ground and
  - reduce the scope for collecting solar energy,

  causing further strain on the already overloaded infrastructure

- Encourage a increase in the number of private vehicles, without providing an opportunity to increase road width



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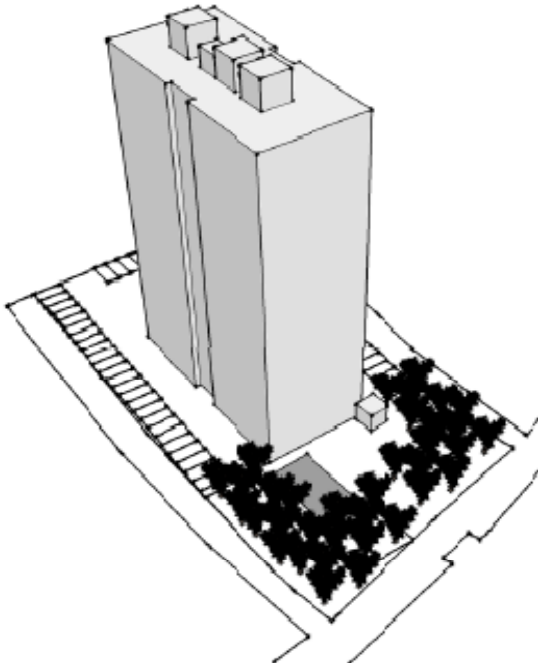
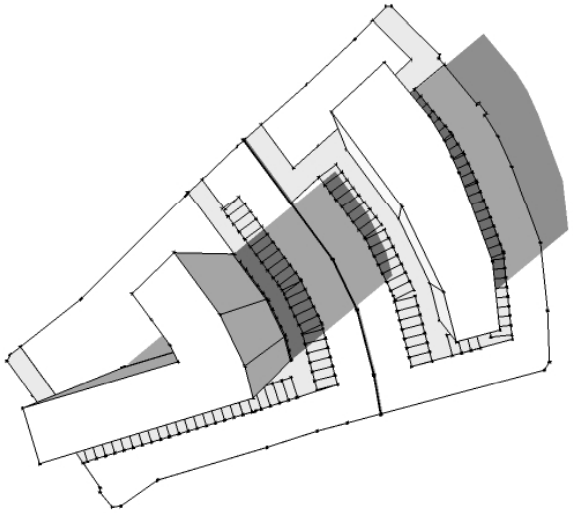


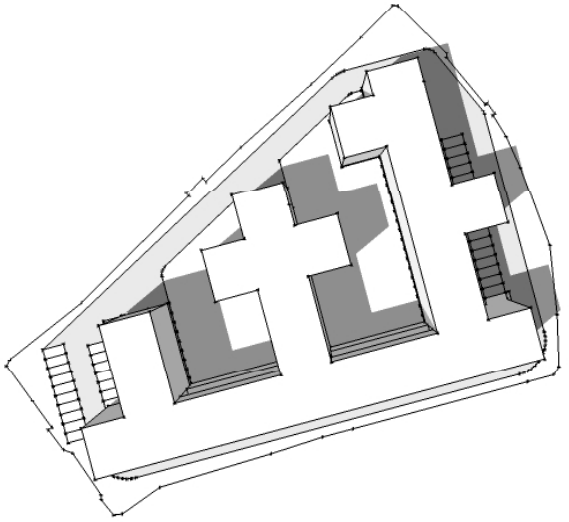
**Proposed development**

# Preliminary Study - 2

| | | | |
|---|---|---|---|
| Land Area | | 10,000 sq m | |
| Proposed Built-up Area | | 29750 sq m | |
| Open Space Required | | 1733 sq m (20%) | |
| Population (approx) | | 3814 persons | |
| Estimated Water Requirement | | 125,289 – 320,185 $m^3$ | |
| Car Parking | | 76 - 267 | |
| Estimated $CO_2$ produced by Cars | | 17,962 – 63,103Kg/year | |
| No. of Trees (min. required) | | 87 | |
| $CO_2$ Sequestering Potential | | 1993 Kg/year | |
| | | 11 – 0.5 % | |
| **Type of development** | | **Medium Rise** | **High Rise** |
| No. Of Storeys | | 10 | 25 |
| Roof Area | | 3264 sq m *(32.64%)* | 1311 sq m *(13.11%)* |
| Total Rain Water Harvested | | *5,587.6 $m^3$* | *1,845.6 $m^3$* |
| RWH potential | | 4.45 – 1.75% | 1.47 – 0.58% |
| Open Space | paved | 2884 sq m (28.84%) | 3208 sq m *(32.08%)* |
| | unpaved | 3852 sq m (38.52%) | 5460 sq m *(54.60%)* |



**High Rise Development**



**Medium Rise Development**

***Notes:***

[2] *Rainwater from roof top only has been collected for domestic use, whereas rainwater falling on paved areas can be used to recharge underground water. Total rainwater collected is the total of rainwater collected over the 12 months that is calculated using the formulae*

# Preliminary Study - 2

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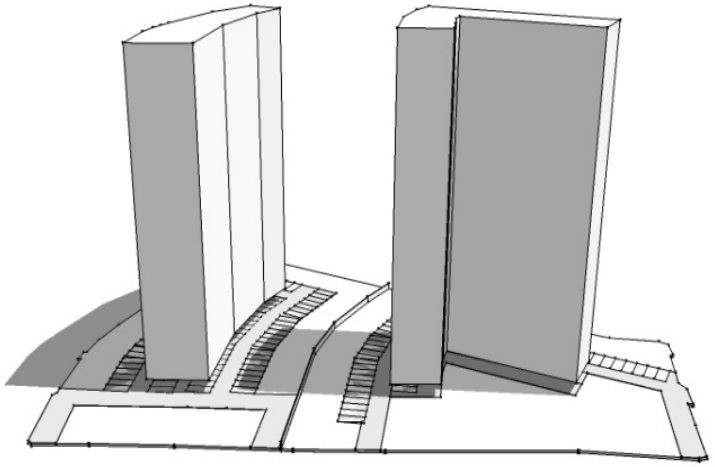

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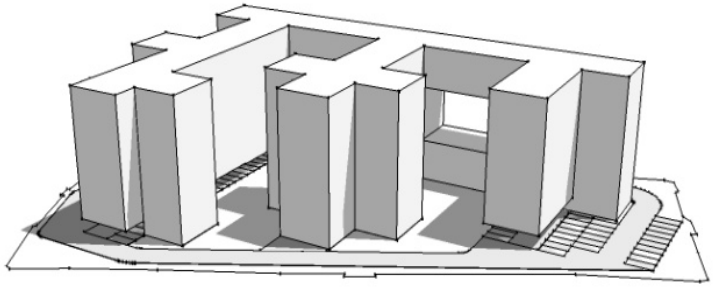

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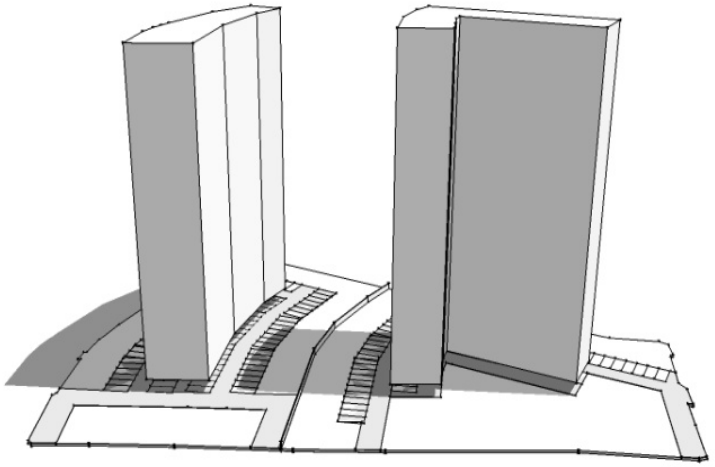
# *Preliminary Study - 2*

***Observations:***

- Medium rise development has greater potential for
  - rainwater harvesting,
  - electricity generation
  - shading open area

- High rise development has greater potential for
  - $CO_2$ sequestering
  - ground water recharge



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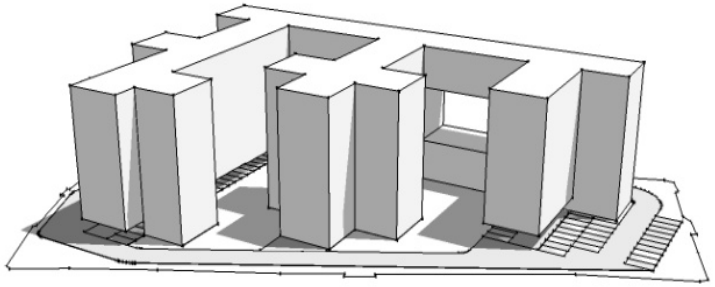

**Medium Rise Development**

# Methodological Concerns

- *"the main driver of environmental impact of human activity is the affluence, although increase in population also has a substantial impact on the environment through energy use and CO2 emissions"* [38]

- **Vehicular ownership**

Wider and better roads and more parking space, along with the growing affluence of the people is likely to increase the number of cars owned in the area, but it is difficult to predict the trend.

- **Air-conditioning**

The level of air-conditioning use in any new development can only be speculated at present but requires further research

- **Water consumption**

It is difficult to assess the increased use of water due to improved bathing facilities, watering of trees and other landscaped areas and for washing the increased number of cars.

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**Reference:**

[38] Ranjan, Alok. 2009. An empirical analysis of environmental impact. In Environmental concerns and sustainable development: Some perspectives from India edited by G. Somayaji and S. Somayaji. New Delhi: TERI Press

*Thank You*