“I will tell the story as I go along of small cities no less than of great. Most of those that were great once are small today; and those which in my own lifetime have grown to greatness, were small enough in the old days.”

- Herodotus

(The introductory quote in Jacobs, 1969)
Urbanisation in Bangalore

H. S. Sudhira
Overview

- What is Urbanisation?
- Looking at Cities as Complex Social Systems
- Bangalore
  - An Overview of the City
  - Analysing Change for Bangalore City
  - Development Characteristics across Bangalore
- Policies, Planning and Programs
- Points to ponder
What is Urbanisation?

- Evolution of Humans against other life forms
- Organization of social systems – 3 levels
  - 1st Level: Hunter – Gatherer
  - 2nd Level: Initial Settlements – River Valleys
  - 3rd Level: Urban Areas / Towns and Cities
- Changing patterns of activity
  - 1st Level: Hunting, Collection of fruits, etc.
  - 2nd Level: Agriculture – Growing crops, harvesting…
  - 3rd Level: Industrialization – Fossil-fuel based
# Tracing Human Evolution

## Prehistory

<table>
<thead>
<tr>
<th>Event</th>
<th>Time (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earliest finds of modern man (Africa)</td>
<td>150,000</td>
</tr>
<tr>
<td>Fossils found in Natal (S'Africa)</td>
<td>100,000</td>
</tr>
<tr>
<td>Arrival of modern man in Europe</td>
<td>50,000</td>
</tr>
<tr>
<td>First Civilizations</td>
<td>10,000</td>
</tr>
</tbody>
</table>

- **Homo sapiens sapiens (early man)**
- **Ice-Age**
- **Cro-Magnon**

### Hominids (Africa)

<table>
<thead>
<tr>
<th>Species</th>
<th>Time (million years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australopithecus</td>
<td>4</td>
</tr>
<tr>
<td>Homo habilis</td>
<td>3.5</td>
</tr>
<tr>
<td>Australopithecus afarensis</td>
<td>3</td>
</tr>
<tr>
<td>A. africanus</td>
<td>2.5</td>
</tr>
<tr>
<td>A. robustus</td>
<td>2</td>
</tr>
<tr>
<td>Homo erectus</td>
<td>1.5</td>
</tr>
<tr>
<td>Homo sapiens</td>
<td>1</td>
</tr>
<tr>
<td>Neanderthal</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Human Species

- **Use of tools**
- **Use of fire**
- **Ice-Ages**

### To Text:
- Australopithecus
- Homo habilis

**Source:** [http://www.hyperhistory.com/](http://www.hyperhistory.com/)
What is Urbanisation?

- 3rd Level – Post Industrialization
- Humans colonizing in large settlements
- Supported by surplus food made possible by advances in agriculture
- Post 18th Century, transformation of human population from largely Rural-Agrarian to Urban-Non-Agrarian
- Currently moving towards Urban ~ Service-oriented economies from Industrial and Manufacturing centers
What is Urbanization?

- Urbanization characterized by the proportional change in urban to total population
- Typically characterized by large scale migration from rural-urban
- India is experiencing Urbanization only since last 60 – 70 years
- North America and North-Western Europe are 80 % urbanized and no scope for further urbanization
- Currently India is urbanizing at 3 – 4 % than avg. population growth of 1 – 2 %
- India is about 27.2 % urbanized, while Karnataka is about 34 %; according to 2001 Census
What is Urbanization?

- A causal phenomenon of Human Design and Evolutionary Emergence
- Human Design & Evolutionary Emergence
Evolutionary Emergence & Human Design

Photos: Sudhira and BMP
Evolutionary Emergence & Human Design

Photos: Sudhira
Cities as Complex Social Systems

- Urbanization and *Evolutionary Emergence*!
- Towns and Cities – as forms of Human Social Organization
- Towns and Cities depict strange pattern!
- Scaling in urban systems – Zipf’s Law
- Rank-size of towns and cities fit a power law – depicting hierarchy and urban primacy
- Towns and cities of Karnataka and India fit Power law for last 100 years
- Essentially Bangalore ranked 1 in population 100 years ago and continues to do so
The Idea of Emergence

- How systems grow and evolve
- Biological Evolution
- Cities and Evolution – Urban Evolution
- Puzzles!!
  - Size of a city and rank – correlated!
    - Popular as Zipf’s law / Pareto law
  - Size of a city and growth – uncorrelated!
    - Gibrat’s law
- Why?
  - Historical path dependence and lock in
Scaling and Urban Systems

- Evolution of towns and cities since about 8000 years
- Persistence of scaling behaviour in urban systems
- Are the scaling effects observed in urban systems produced by the **hierarchical organization of societies**?
- Are they **emergent properties** linked with the **historical process of urbanization**?
- Could they **disappear** after the **end of the urban transition**?
Emergence of Urban Systems

- Implications from Scaling behaviour
- Organization of human societies in structurally similar pattern as observed in different places irrespective of
  - Geographic boundaries,
  - Political boundaries and
  - Political economies
- New Towns and Larger Urban Agglomerations
Evolution of Towns and Cities in Karnataka

- Dynamics of City-Size Distributions
  - Verifying for Zipf’s law for Karnataka from 1901 – 2001
  - Verifying for Zipf’s law for India – 2001
Verifying Zipf’s law as applied to cities in Karnataka for 2001

\[ y = 3 \times 10^6 x^{-1.0393} \]

\[ R^2 = 0.9396 \]
Zipf’s law as applied to cities in Karnataka

Log Rank vs Log Size

- Log-Population vs Log Rank
Verifying Zipf’s law as applied to cities in India

$y = 6 \times 10^7 x^{-1.2067}$

$R^2 = 0.9583$
Zipf’s law as applied to cities in India

Log Rank vs Log Population
Evolution of Towns and Cities in Karnataka from 1901 - 2001
Evolution of $\alpha$ parameter from 1901 - 2001

Evolution of alpha parameter

- 1901
- 1911
- 1921
- 1931
- 1941
- 1951
- 1961
- 1971
- 1981
- 1991
- 2001

- 0.8
- 0.85
- 0.9
- 0.95
- 1
- 1.05
- 1.1
## Evolution of $\alpha$ parameter

<table>
<thead>
<tr>
<th>Year</th>
<th>$\alpha$ (alpha)</th>
<th>$R^2$</th>
<th>$P_k$</th>
<th>$P_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1901</td>
<td>0.8307</td>
<td>0.9341</td>
<td>177976</td>
<td>163091</td>
</tr>
<tr>
<td>1911</td>
<td>0.8455</td>
<td>0.9212</td>
<td>181396</td>
<td>189485</td>
</tr>
<tr>
<td>1921</td>
<td>0.8503</td>
<td>0.9491</td>
<td>209419</td>
<td>240054</td>
</tr>
<tr>
<td>1931</td>
<td>0.8456</td>
<td>0.9562</td>
<td>243477</td>
<td>309785</td>
</tr>
<tr>
<td>1941</td>
<td>0.8838</td>
<td>0.9528</td>
<td>333558</td>
<td>410967</td>
</tr>
<tr>
<td>1951</td>
<td>0.8719</td>
<td>0.9669</td>
<td>462989</td>
<td>786343</td>
</tr>
<tr>
<td>1961</td>
<td>0.8973</td>
<td>0.9651</td>
<td>619737</td>
<td>1206961</td>
</tr>
<tr>
<td>1971</td>
<td>0.9199</td>
<td>0.9441</td>
<td>895520</td>
<td>1664208</td>
</tr>
<tr>
<td>1981</td>
<td>0.9306</td>
<td>0.9801</td>
<td>1294733</td>
<td>2921751</td>
</tr>
<tr>
<td>1991</td>
<td>0.9628</td>
<td>0.9784</td>
<td>1812023</td>
<td>4130288</td>
</tr>
<tr>
<td>2001</td>
<td>1.0393</td>
<td>0.9396</td>
<td>3002970</td>
<td>5686844</td>
</tr>
</tbody>
</table>
In the case of urban systems, scaling effects could be studied by relating either cities population size, their occupied surface, density of activities, speed of transports, income levels and/or accessibility in transportation systems...

To consider the question of urban spatial expansion at two scales of analysis, trying to understand two contrasting processes:

- at the level of the city, slower growth in surface than in population, increasing urban densities, then rapid urban sprawl with a larger increase in surface than in population during the last decades, inside a general model of spatial distribution characterized by a rather steep but recently decreasing density gradient from the centre to the periphery; and
- growth in size and number of cities but with increasing size inequalities (and local concentrations) at the scale of the interurban processes (national or regional territories)
In both cases, the controlling parameters could be the **means of transportation, with varying speeds over time**, and their typical **spatial range** that is different when adapting to the daily urban system or to the **connection within networks of cities**.

But perhaps other social (economic) or physical processes have to be included to provide a consistent model at both scales.
Bendakaaluru - Bangalore - Bengalooru

Courtesy: Google Inc. and HyperCam
Bangalore: An overview of the City

- Origins and History
  - Etymology and Historical Accounts
- Climate, Geography and Environment
- Growth in Bangalore
- Governance and Administration
- City Economy and Land use
- Mobility
- Land use and Transportation
- Development Characteristics across Bangalore
GROWTH OF BANGALORE CITY

Maps: Directorate of Census Operations and BMP
Bangalore City Corporation limits over the years

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Year</th>
<th>Area (sq. km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1949</td>
<td>69</td>
</tr>
<tr>
<td>2.</td>
<td>1963-64</td>
<td>112</td>
</tr>
<tr>
<td>3.</td>
<td>1969</td>
<td>134</td>
</tr>
<tr>
<td>4.</td>
<td>1979</td>
<td>161</td>
</tr>
<tr>
<td>5.</td>
<td>1995</td>
<td>226</td>
</tr>
<tr>
<td>6.</td>
<td>2006</td>
<td>696</td>
</tr>
</tbody>
</table>
Population Growth of Bangalore City during 1871 - 2005

Year

Population
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0

Population Growth...
Climate, Geography and Environment

- 12 – 35° C
- 12.59° N and 77.57° E
- 875 m to 940 m above msl – Undulating terrain
- Ridge dividing 3 watersheds
- Strengthened by Chain of Tanks
- As per recent satellite imagery, only 34 lakes are visible, out of which only about 18 exist in some shape while another 20 show some signs of existence
- Green spaces harbouring Flora and Fauna
- Most recently, Bangalore also witnessed a new ‘ant’ species, *Dilobocondyla bangalorica*, described from the city (Varghese, 2006)
Bangalore Lakes

Governance and Administration
- Multitude of organisations – coordination and changing mandates
- Common Geographic Unit / Boundary
- Hence no information to interpret across domains

City Economy and Land Use
- Core City Functions – Jobs
- Moving jobs on the periphery – inducing mobility to the outskirts
- What can Bangalore say as its own?
<table>
<thead>
<tr>
<th>No.</th>
<th>Organisations</th>
<th>Functional Areas (Scope of Work)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bangalore Mahanagara Palike (BMP)</td>
<td>Urban local body responsible for overall delivery of services - Roads and road maintenance including asphalting, pavements and street lighting; solid waste management, education and health in all wards, storm water drains, construction of few Ring roads, flyovers and grade separators</td>
</tr>
<tr>
<td>2</td>
<td>Bangalore Development Authority (BDA)</td>
<td>Land use zoning, planning and regulation within Bangalore Metropolitan Area; Construction of few Ring roads, flyovers and grade separators</td>
</tr>
<tr>
<td>3</td>
<td>Bangalore Metropolitan Region Development Authority (BMRDA)</td>
<td>Planning, co-ordinating and supervising the proper and orderly development of the areas within the Bangalore Metropolitan Region, which comprises Bangalore urban district, Bangalore rural district and Malur taluk of Kolar district. BDA’s boundary is a subset of BMRDA’s boundary</td>
</tr>
<tr>
<td>4</td>
<td>Bangalore Water Supply and Sewerage Board (BWSSB)</td>
<td>Drinking water – pumping and distribution, sewage collection, water and waste water treatment and disposal</td>
</tr>
<tr>
<td>5</td>
<td>Bangalore City Police</td>
<td>Enforcement of overall law and order; Traffic Police: Manning of traffic islands; Enforcement of traffic laws; Regulation on Right of Ways (One-ways)</td>
</tr>
<tr>
<td>6</td>
<td>Bangalore Metropolitan Transport Corporation (BMTC)</td>
<td>Public transport system – Bus-based</td>
</tr>
<tr>
<td>7</td>
<td>Bangalore Metro Rail Corporation Ltd (BMRC)</td>
<td>Public transport system – Rail-based (Proposed)</td>
</tr>
<tr>
<td>8</td>
<td>Regional Transport Office (RTO)</td>
<td>Motor vehicle tax; Issue of licenses to vehicles</td>
</tr>
<tr>
<td>9</td>
<td>Bangalore Electricity Supply Company (BESCOM)</td>
<td>Responsible for power distribution</td>
</tr>
<tr>
<td>10</td>
<td>Lake Development Authority (LDA)</td>
<td>Regeneration and conservation of lakes in Bangalore urban district</td>
</tr>
</tbody>
</table>
City Economy and Land Use

Bangalore FCC IRS LISS-III - 1999

Bangalore FCC ASTER - 2003
Land Use Classification - Bangalore 2000 (Landsat ETM+ )

- Openland: Yellow
- Vegetation: Green
- Waterbodies: Blue
- Built-up: Red

North

deg

0.08
Bangalore and Mobility

- **Mobility**
  - Systems Analysis for Mobility
  - Presence of Braess Paradox for transportation networks
  - Stakeholders involved
  - Multitude of organisations and no information

- **Systems Analysis – Systems Thinking**
  - Represented by Causal Loop Diagrams
Corridor development in light of BRAESS Paradox

- Originally presented by Braess in 1968.
- It consists of a phenomenon which contradicts the common sense:
  - in a congested traffic network, when a new link connecting two points (e.g. origin and destination) is constructed,
  - it is possible that there is no reduction regarding the time necessary to commute from the origin to the destination.
  - Actually, frequently this time increases and so the costs for the commuters
- Changing land use patterns... out growth of urban areas
  - The percentage of parks and open spaces including lakes and tanks is around 2.5 to 3% down from 4.4% in 2002
  - The built-up was 16% in 2000 and is currently estimated to be around 23-24%
- Creation of ring road – Sinks of sprawl
  - Legitimizing/demarcating the extent of outgrowth
Migration as a factor for Urban Growth

Why Migration?
- Livelihood
- Irregular rainfall and failing crops

Decision to Migrate, if
- Expected real income in Urban > Expected real income in Rural
- Probability of finding a job in Urban > 0
Migration as a factor for Urban Growth

- Analysis of Migration in Bangalore Urban Agglomeration:
  - Place of last residence
    - In Karnataka or outside Karnataka
    - In Rural or Urban
  - Reason for Migration
    - Work / Employment
    - Moved with household
    - Moved after birth
    - Education
    - Marriage
    - Business
    - Others
  - Duration of Residence
    - Less than one year
    - 1 – 5 years
    - 5 – 9 years
    - Greater than 10 years
Migrants in all Duration of Residence and the Reasons for Migration

- Work/employment Persons
- Business Persons
- Education Persons
- Marriage Persons
- Moved after birth Persons
- Moved with household Persons
- Others Persons

All
Urban
Rural

0
100,000
200,000
300,000
400,000
500,000
600,000
Migrants, their place of residence and reason for migration – all durations

- Work/employment
- Business
- Education
- Others
- Moved with household
- Moved after birth
- Marriage
- Last Residence elsewhere in India - Rural
- Last Residence elsewhere in India - Urban
- Within the state of enumeration but outside the place - Rural
- States in India beyond the state of enumeration - Urban
- Within the state of enumeration but outside the place - Urban
- States in India beyond the state of enumeration - Rural
Migrants, their place of residence and reason for migration – 10+ years

- Work/employment
- Business
- Education
- Last Residence elsewhere in India - Rural
- Last Residence elsewhere in India - Urban
- Within the state of enumeration but outside the place - Rural
- States in India beyond the state of enumeration - Urban
- Within the state of enumeration but outside the place - Urban
- States in India beyond the state of enumeration - Rural

- Moved with household
- Moved after birth
- Marriage
- Others

180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Migrants, their place of residence and reason for migration – 5-9 years

- Work/employment
- Business
- Education
- Others
- Moved after birth
- Married
- Moved with household
- Last Residence elsewhere in India - Rural
- Last Residence elsewhere in India - Urban
- Within the state of enumeration but outside the place - Rural
- States in India beyond the state of enumeration - Urban
- Within the state of enumeration but outside the place - Urban
- States in India beyond the state of enumeration - Rural
Migrants, their place of residence and reason for migration – less than 1 year

- Work/employment
- Business
- Education
- Others
- Moved with household
- Moved after birth
- Marriage
- Last Residence elsewhere in India - Rural
- Last Residence elsewhere in India - Urban
- Within the state of enumeration but outside the place - Rural
- States in India beyond the state of enumeration - Urban
- Within the state of enumeration but outside the place - Urban
- States in India beyond the state of enumeration - Rural
## Development Characteristics across Bangalore

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Characteristics</th>
<th>Development Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Zone 1</td>
</tr>
<tr>
<td>1.</td>
<td>Authority</td>
<td>Bangalore City Corporation</td>
</tr>
<tr>
<td>2.</td>
<td>Urban Status</td>
<td>Core city</td>
</tr>
<tr>
<td>3.</td>
<td>Infrastructure Services</td>
<td>Present, but nearly choked, needs augmenting of existing infrastructure</td>
</tr>
<tr>
<td>4.</td>
<td>Impact of growth</td>
<td>No scope for new growth but calls for urban renewal to ease congestion</td>
</tr>
<tr>
<td>5.</td>
<td>Planning, Development and Regulation Controls</td>
<td>Planning not vested with urban local bodies, while local bodies control for building regulations</td>
</tr>
</tbody>
</table>
Policies, Planning and Programs

- Policies and Planning
  - Information & Indicators
  - Dynamics and Models
  - Evaluation of Policies
- Capturing the multitude of processes in urban systems
- Programs
  - State govt. initiatives
  - JnNURM
Planning trends

- Multiple Agencies and Plans
  - Comprehensive Development Plans – BDA
  - City Development Plans – BMP
  - Infrastructure Development and Investment Plan – KUIDFC
  - Comprehensive Traffic and Transportation Plan – Rites
- Coordination?
- Planning for Life, with Philosophy, Culture, Tradition, and Resources
- Spatial Planning Support Systems?
  - Prototype Simulations...
Patchiness or Number of Different Classes
Points to ponder

- Does evolution of new cities follow any underlying principle?
- Does emergence of large cities irrespective of the international / national / regional economic / political boundary follow Zipf’s law?
- Alright, if they are following Zipf’s law what do they suggest?
- Are urban systems and hence urban evolution self-organizing?
- If rank-size distribution is the accepted, what do deviations at the end suggest?
Central questions are:
- When do we know / ascribe the emergence of new cities?
- When do we know / ascribe the decline of large cities?
- And when does these large cities collapse? (recall Herodotus quote)
- Any possible ways to detect at least half-life of these cities?
Points to ponder…

- Is Bangalore’s growth self-organizing?
- How long will Bangalore retain its rank in Karnataka?
- Does ‘planning’ aid in addressing cities at different scales?
  - Near-to-Short term / Immediate: Requires Operational Planning
  - Short-to-Medium: 5-10 years
  - Long-term: 10+ years
- What will be the fate of cities beyond the fossil fuel regime?
More Questions, than Answers!!

Where do we go!??

Thanks very much!
Originally, **Zipf's law** stated that, in a corpus of natural language utterances, the frequency of any word is roughly inversely proportional to its rank in the frequency table.

So, the most frequent word will occur approximately twice as often as the second most frequent word, which occurs twice as often as the fourth most frequent word, etc.

The term has come to be used to refer to any of a family of related power law probability distributions.

- Zipf's law is most easily observed by scatter plotting the data, with the axes being log (rank order) and log (frequency).
- For example, "the" as described above would appear at $x = \log(1)$, $y = \log(69971)$.
- If the points are close to a single straight line, the distribution follows Zipf's law.

Zipf’s rank-size rule

- Zipf had expressed such a regularity as an inverse geometric progression between the population Pi of a city and its rank Ri in a national set of towns and cities, giving an approximate size of one half of the largest city population for the population of the second city and one third for the third one, and so on...

- This “rank size-rule” formulated as $P_i = P_1 / R_i$ has been generalized as a Pareto-type distribution of the number of cities according to their size,
  - $P_i = K / R_i^\alpha$,
  - where the parameter $K$ has a value close to $P_1$ and $\alpha$ is around 1