Web-based Urban Metabolic Mapping for Bangalore, India

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www.urbanmetabolism.in/bump/

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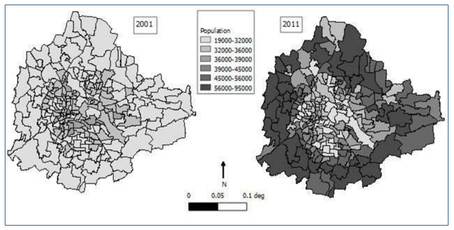
Problem

Rapid population and economic growth in Indian cities have overwhelmed their ecological base, leading to chronic shortages in electricity, water and road space, while polluting the environment. Bangalore city, India, is a case in point, with 3 million people added in the last decade.

Bangalore Population Growth

Year	Population (million)	Density (per sq km)	Built-up area (% urban footprint)
1971	1.65	9,465	20%
1981	2.92	7,990	26%
1991	4.13	9,997	39%
2001	5.7	11,545	69%
2011	~8.5	12142	*na*



Population growth is highest away from the historic center of the city; precisely in those areas which are least connected to water utility pipelines.

Goals

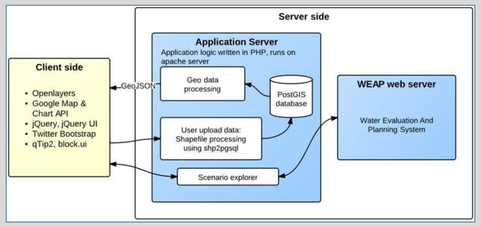
To use the framework of urban metabolism [1,2] for science-based comprehensive planning. Cities are like living entities, needing a continuous throughput of materials and energy for survival and growth, generating waste in the process.

The objectives of the web-based geoportal of the Bangalore Urban Metabolism Project (BUMP) are to develop:.

- *An interactive information communication and delivery platform*
- *An online planning platform*

The first phase focuses on population growth and residential water use.

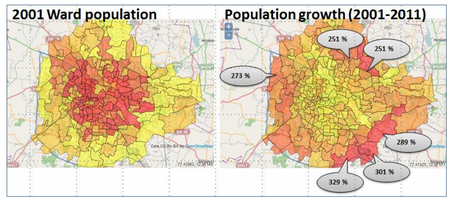
Design



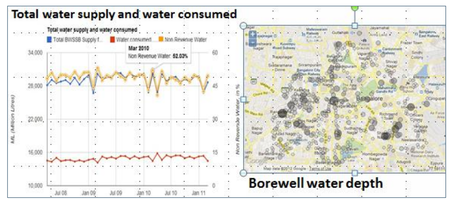
- The mapping service is built on a free/open source web GIS stack, with Postgis and Apache web server deployed on a 64-bit Ubuntu Linux server.
- The Scenario Explorer links to a water resources model built on the Water Evaluation And Planning system (www.weap21.org).
  - *Users can create scenarios of the city's growth, water demand and supply infrastructure.*
  - *Key results are returned to the browser.*
- The entire application is being deployed on the cloud, using Miscrosoft's Azure platform.

Mapping Features

Choice of Basemaps

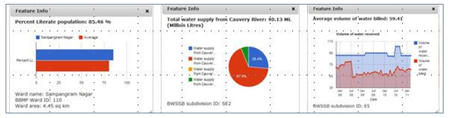


Thematic rendering: polygon data

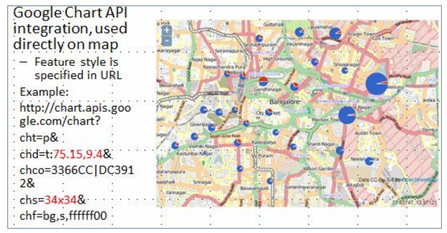


Thematic rendering: line and point data

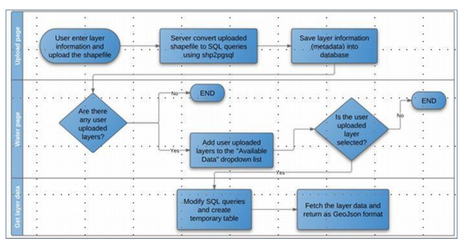
- **Basic mapping functions**: basemaps selection, thematic colouring, feature selection
- **Advanced functions**: Google Chart API and Places Autocomplete integration
- **Upload shapefile**



Google Chart API Integration

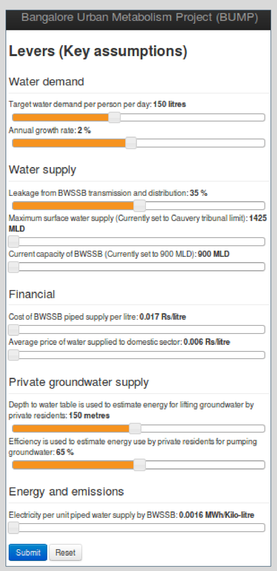


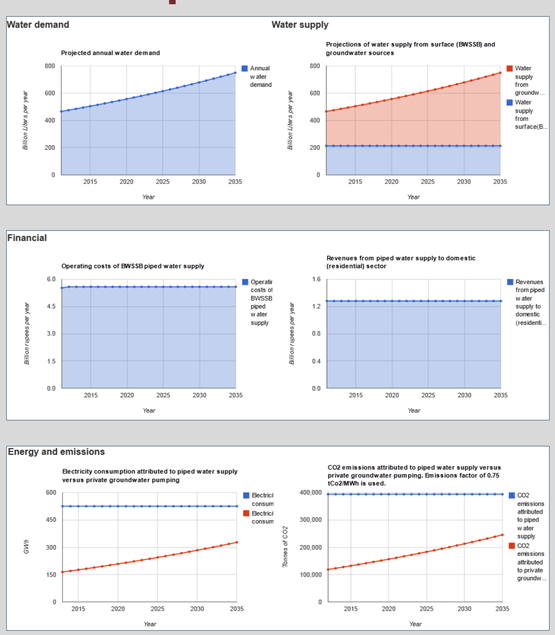
e.g. Surface vs Groundwater use



Upload your own shapefile: users can upload a shapefile and thematically render numeric attribute columns

Scenario Explorer





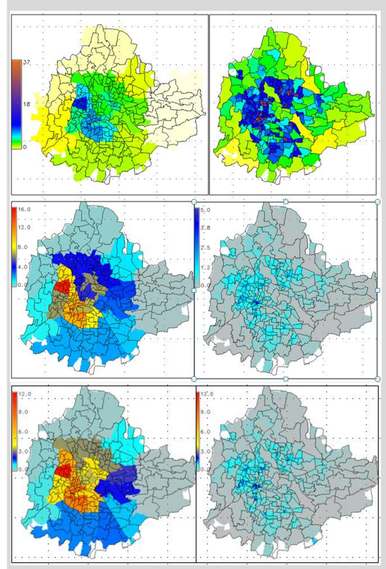
Screenshots from the Scenario Explorer. www.urbanmetabolism.in/bump/scenario.php

Key Challenges

- Water for each sector is consumed from various sources, because utility supplied water is insufficient. There is no systematic knowledge of actual water consumption by source and sector, for any Indian city [3].
- There is no knowledge of the groundwater surface at adequate spatial resolution. A very small number of long-term groundwater monitoring stations exist, whereas the number of groundwater extraction wells may number between 200,000-400,000.
- Science-based water policy and management is severely hampered by these knowledge gaps..

Ongoing Research

- A household water consumption survey will produce the first water demand function for the city.
- Distributed groundwater models are being implemented using GRASS GIS tools [4].
- Crowdsourcing and citizen science initiatives will be explored to fill critical data gaps.
- Water-energy nexus of residential water supply, from *public* (left) and private (*right*) sources, estimated below:



Water consumption, million liters/year

Electricity consumption, MWh/year

CO2 emissions, tonnes/year

Electricity and emissions from private pumping are very sensitive to water table depth. These results emphasize the need for data-driven, coupled social-ecological modeling of cities as living systems.

Acknowledgements

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References

[1] Rolf Peter Sieferle. "Cultural evolution and social metabolism", *Geografiska Annaler: Series B, Human Geography*, 93 (4):315–324, 2011.

[2] E.H. Decker, S. Elliott, F.A. Smith, D.R. Blake, and F.S. Rowland, "Energy and material flow through the urban ecosystem", *Annual Review of Energy and the Environment*, 25 (1):685-740, 2000.

[3] Sunita Narain, *Excreta Matters: How urban India is soaking up water, polluting rivers and drowning in its own waste. (Volume-1)*. Centre for Science and Environment, 2012.

[4] M. Neteler and H. Mitasova, *Open source GIS: A Grass GIS Approach*. 2008. .