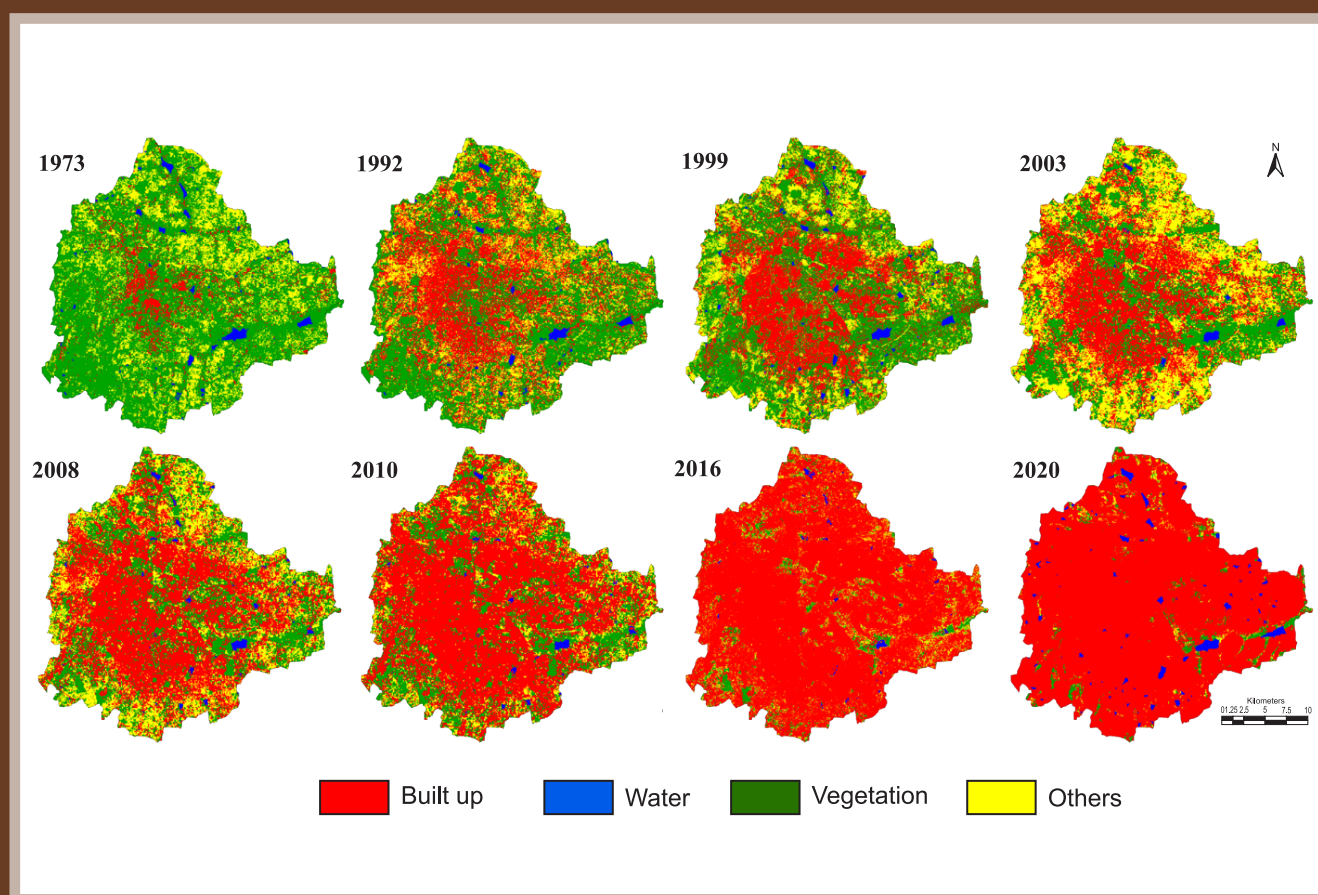


CURRENT SCIENCE

Volume 110 Number 12

25 June 2016



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Bengaluru's reality: towards unlivable status with unplanned urban trajectory

The origin of cities can be traced back to the river valley civilizations of Mesopotamia, Egypt, Indus Valley and China. Initially these settlements were largely dependent upon agriculture; however, with the growth in population the city size increased and economic activity transformed to trading (Ramachandra, T. V. *et al.*, *TEMA J. Land Use, Mobility Environ.*, 2014, 7(1), 83–100). The process of urbanization gained impetus with the Industrial Revolution 200 years ago and accelerated in the 1990s with globalization and consequent relaxation in market economy (Ramachandra, T. V. *et al.*, *Int. J. Appl. Earth Obs. Geoinf.*, 2012, 18, 329–343).

Urbanization refers to the growth of towns and cities due to large proportion of the population living in urban areas and its suburbs at the expense of rural areas (*op. cit.*). In most of the countries, the total population living in urban regions has extensively accelerated since the Second World War. Rapid urbanization is evident from the increase in global urban population from 13% (220 million) in 1900 to 49% (3.2 billion) in 2005, and is expected to increase to 60% (4.9 billion) by 2030 (*op. cit.*). Current global population is 7.4 billion and urban population has been increasing three times faster than the rural population, mainly due to migration in most parts of the world. People migrate to urban areas with the hope of better living, considering relatively better infrastructural facilities (education, recreation, health centres, banking, transport and communication), and higher per capita income. Unplanned urbanization leads to the large-scale land-use changes affecting the sustenance of local natural resources. Rapid unplanned urbanization in most cities in India has led to serious problems in urban areas due to higher pollution (Ramachandra, T. V. *et al.*, *Renew. Sustain. Energy Rev.*, 2015, 44, 473–495) (air, water, land, noise), inequitable distribution of natural resources, traffic congestion, spread of slums, unemployment, increased reliance on fossil fuels, and uncontrolled outgrowth or sprawl in the periphery. Understanding spatial patterns of urban growth and visualization is imperative for sustainable management of natural resources and to mitigate changes in climate. This would help the city planners to mitigate the problems associated with the increased urban area and population, and ultimately build sustainable cities.

Bengaluru is experiencing unprecedented rapid urbanization and sprawl in recent times due to unrealistic concentrated developmental activities with impetus on industrialization for the economic development of the region. This has led to large-scale land-cover changes with serious environmental degradation, posing serious challenges to the decision makers in the city planning and management process, such as climate change, enhanced emissions of greenhouse gases (GHGs), lack of appropriate infrastructure, traffic congestion, and lack of basic amenities (electricity, water and sanitation) in many localities. Apart from these, major implications of urbanization are the following.

Urbanization and loss of natural resources (wetlands and green spaces): Urbanization during 1973–2016 (100% concretization or increase of paved surface) has had a telling influence on the natural resources, such as decline in green spaces (88% decline in vegetation), wetlands (79% decline), higher air pollutants and sharp decline in groundwater table. Figure (see Cover Page of this issue) depicts the unrealistic urban growth during the last four decades. Quantification of the number of trees in the region using remote sensing data with field census reveals that there are only 1.5 million trees to support Bengaluru's population of 9.5 million, indicating one tree for every seven persons in the city (Ramachandra, T. V. *et al.*, *ENVIS Technical Report 75*, IISc, 2014, p. 75). This is insufficient even to sequester respiratory carbon (ranges from 540 to 900 g per person per day). Geovisualization of likely land uses in 2020 through multi-criteria decision-making techniques (Fuzzy-AHP) reveals a calamitous picture of 93% of Bengaluru's landscape being filled with paved surfaces (urban cover), and drastic reduction in open spaces and green cover. This would make the region GHG-rich, water-scarce, non-resilient and unlivable, depriving the city-dwellers of clean air, water and environment.

Field studies during 2015–16 of 105 lakes revealed that 98% of the lakes have been encroached for illegal buildings (high-rise apartments, commercial buildings, slums, etc.) and 90% of the lakes are sewage-fed. Also, lake catchments are being used as dumping yards for either municipal solid waste or building debris. Indiscriminate disposal of solid and liquid waste (rich in organic nutri-

ent) has enriched nitrate levels in the surrounding groundwater resources, threatening the health of residents (such as kidney failure, cancer, etc.). Washing, household activities, vegetable cultivation and even fishing was observed in few contaminated lakes. Unauthorized construction in valley zones, lakebeds and storm water drains highlight the apathy of decision-makers, while mirroring weak and fragmented governance. This is correlated with the increase in unauthorized constructions violating town planning norms (city development plan), which has severely affected open spaces and water bodies in particular.

Large-scale fish mortality in recent months further highlights the level of contamination and irresponsible management of water bodies. Sustained inflow of untreated sewage has increased the organic content beyond the threshold of remediation capability of the respective water bodies. Increasing temperatures (34–35°C) with the onset of summer, enhanced the biological activities (evident from higher ammonia and biochemical oxygen demand) that lowered dissolved oxygen levels leading to fish death due to asphyxiation.

Floods: Conversion of wetlands to residential and commercial layouts has compounded the problem by removing the interconnectivities in an undulating terrain. Encroachment of natural drains, alteration of topography involving the construction of high-rise buildings, removal of vegetation cover, and reclamation of wetlands are the prime reasons for frequent flooding even during normal rainfall post 2000.

Decline in groundwater table: The water table has declined to 300 m from 28 m, and 400–500 m in intensely urbanized area such as Whitefield, over a period of 20 years.

Heat island: Surface and atmospheric temperatures have increased due to the loss of natural cover (trees and water bodies) with an increase in artificial materials having high heat conductivities. Temperature has increased by ~2–2.5°C during the past three decades, highlights the implications of explosive urban growth on local climate, necessitating appropriate mitigation strategies.

Increased carbon footprint: Drastic increase in electricity consumption has been observed in certain corporation wards due to adoption of inappropriate building architecture in tropical climate. Per capita electricity consumption in the zones dominated by high-rise building with glass facades ranges from 14,000 to 17,000 units (kWh) per year compared to zones with eco-friendly buildings (1300–1500 units/person/yr)³.

Emissions from the transport sector is about 43.83% (in Greater Bengaluru) on account of large-scale usage of private vehicles, and mobility related to job accounts for 60% of total emissions due to lack of appropriate public transport system and haphazard growth with unplanned urbanization. Majority commute longer distances with private vehicles, thus contributing to emissions. Apart from these, mismanagement of solid and liquid waste has aggravated the situation with emission of GHGs (methane, CO₂, etc.)

Unplanned cities thus not only contribute to global climate change by emitting the majority of anthropogenic GHGs but are also particularly vulnerable to the effects of climate change and extreme weather. This emphasizes the need to improve urban sustainability through innovations while addressing technical, ecological, economic, behavioural and political challenges to create cities that are low-carbon, resilient and livable.

The 'Smart Cities Mission' launched by the Government of India recently (June 2015) envisages developing physical, institutional and social infrastructure in select cities with central assistance targeted at improving the quality of life as well as economic visibility of the respective urban centres (<http://smartcities.gov.in/> (last accessed on 20 May 2016)). Four strategic components are: (i) green field development through smart townships by adopting holistic land management; (ii) pan-city development through adoption of smart applications like transport, reuse and recycle of wastewater, smart metering, recovering energy from solid waste, etc. (iii) retrofitting to make existing areas more efficient and livable by reducing GHG footprint, improving power and treated water supply, improving communication and infrastructure connectivity and security, and (iv) re-development of existing built-up area, creation of new layouts through mixed land use, adoption of appropriate floor area index considering the level of existing, and scope for improvement of infrastructure and basic amenities, which helps in keeping the city's growth within the region's carrying capacity, and also urban infrastructure becomes inclusive. This entails efficient decision-making through (i) integrated land-use planning according to the city's requirements; (ii) enhancement of the functional capacity through user-friendly and economic public transport support; (iii) development of mass rapid-transport systems, and (iv) effective use of ICTs as enabling technologies. These measures have to be implemented quickly as most cities are in a civic and financial disarray because of senseless unplanned rapid urbanization.

Environmentally sound urban centres with essential basic amenities and advanced infrastructure (such as sensors, electronic devices and networks) would stimulate sustainable economic growth and improvements in citizen services. The effective and coordinated governance supports social and urban growth through improved economy and active participation of citizens. Indian cities, while exhibiting technological innovations and connectedness, should also focus on increased living comfort through adequate infrastructure, green spaces and essential basic amenities to every citizen.

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