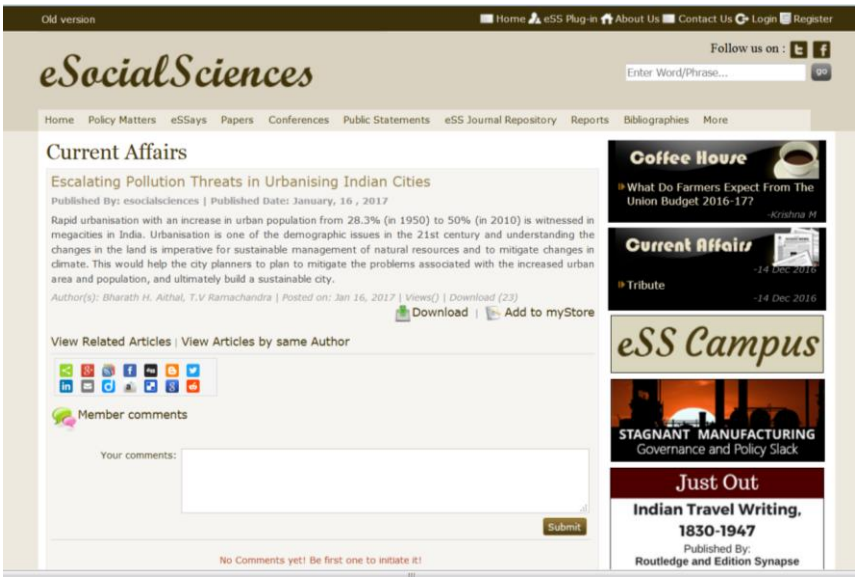

Union Budget 2017-18: Outlook

Escalating Pollution Threats in Urbanising Indian Cities

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Rapid urbanisation with an increase in urban population from 28.3% (in 1950) to 50% (in 2010) is witnessed in megacities in India. Urbanisation is one of the demographic issues in the 21st century and understanding the changes in the land is imperative for sustainable management of natural resources and to mitigate changes in climate. This would help the city planners to plan to mitigate the problems associated with the increased urban area and population, and ultimately build a sustainable city.

Concentration of greenhouse gases (GHG) in the atmosphere has been increasing rapidly during the last century due to ever increasing anthropogenic activities with rapid urbanisation resulting in significant increases in the temperature of the Earth causing global warming. Major sources of GHG are forests (deforestation), power generation (burning of fossil fuels), transportation (burning fossil fuel), agriculture (livestock, farming, rice cultivation and burning of crop residues), water bodies (wetlands), industry and urban activities (building, construction, transportation, solid and liquid waste disposal). Aggregation of GHG (CO2 and non-CO2 gases), in terms of Carbon dioxide equivalent (CO2e), indicate the GHG footprint. GHG footprint is thus a measure of the impact of human activities on the environment in terms of the amount of greenhouse gases produced. Urban dynamics associated with the haphazard and dispersed growth has been posing serious challenges to the urban planners.

The sprawl regions lack basic amenities such as treated water supply, sanitation, etc. In order to provide basic infrastructure and amenities, planners require information related to the extent and dynamics of sprawl. This necessitates regular monitoring and understanding of the rate of urban

development in order to visualize the likely sprawl pockets to provide basic amenities. The rate of change of land use and extent of urban sprawl can effectively be visualized and modeled with the help of geo-informatics using temporal spatial data acquired through space borne sensors. The knowledge of urban area, especially the growth magnitude, shape geometry, and spatial pattern is essential to understand the growth and characteristics of urbanization process. This communication quantifies the urbanisation and associated environmental consequences in Delhi, Capital of India.

This study focuses on accounting of the amount of three important greenhouses gases namely carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) and thereby developing GHG footprint of Delhi. Spatial data of four decades were analysed to understand land use dynamics, which indicate that the area under built-up has increased from 3.6 (1977) to 25.06% (2010). Vegetation decreased phenomenally from 41% (in 1973) to 31% (in 2010) with an increase in urban impervious layer. This is significant as this alters the environmental parameters such as ground water recharge, micro-climate, etc. The current study estimates GHG footprint or GHG emissions (in terms of CO2 equivalent) for Indian major cities and explores the linkages with the population and GDP. GHG footprint (Aggregation of Carbon dioxide equivalent emissions of GHG's) of Delhi is found to be 38633.2 Gg, CO2 eq. The major contributors sectors are transportation sector (contributing 32%), domestic sector (contributing 30.26%) and industrial sector (contributing 7.9%,) of the total emissions in Delhi.

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Rural–urban or peri-urban regions are prone to sprawl with the concentrated growth of cities. The peri-urban regions with dispersed growth are devoid of basic amenities and are normally left out on most of the civic governing body facilities. Urban sprawl is considered to be one of the major reasons for rural push and spreading of city towards outskirts. The sprawl takes place at the urban fringes resulted in radial development of the urban areas or development along the highways results in the elongated development of urban forms. Urban Sprawl further affects the urban core areas by phenomena such as massive congestion, insufficient public transportation and infrastructure, lack of proper sanitation and many other basic amenities. This is also associated with extreme socioeconomic disparities, vulnerability to natural and manmade risks.

Urbanization process in Delhi has the major impact on the India's urban development. The rapid increase of urbanization resulted in the increased population density. In this backdrop, the objectives of this communication is towards understanding the urban dynamics through land cover

and land use analysis, ii) understand the local level changes that takes place in the region using directional density gradients, and iii) GHG footprint assessment.

Land use analyses for the period 1977 to 2010 indicate that the area under built-up has increased from 3.6 (1977) to 25.06% (2010). Vegetation decreased phenomenally from 41% (in 1973) to 31% (in 2010) with an increase in urban impervious layer (Ramachandra et al., 2015a). This is significant as this alters the environmental parameters such as ground water recharge, micro-climate, etc. Figure 1 depicts the growth of urban area in the study region in past 4 decades.

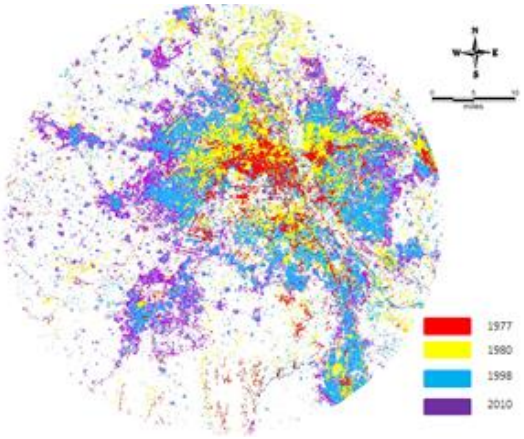

Figure 1: Urban dynamics in Delhi during 1977- 2010

India is currently second most populous country in the world and one of the major greenhouse gas emitter contributing about 5.3% of the total global emissions (Ramachandra et al., 2015b). Countries such as India which is one of the fast growing economies in the world, with higher energy consumption for various activities with increase in transport sector emissions with scale of rapid and uncontrolled urbansiation and quest of higher living standards (with emerging higher consumption behavior) are eventually the causes of GHG emissions in todays' scenario. The quality of air in the major Indian cities which affects the climatic conditions as well as health of the community is a major environmental concern (Ramachandra and Shwetmala, 2009). Higher levels of energy consumption have contributed to the degradation of the environment. CO2 equivalent emissions (GHG footprint) from Delhi, is 38633.2 Gg and the major share is by the transportation sector (Figure 2). Transportation sector is a major source of emissions when city level studies are carried out. Emissions from CNG vehicles in few of the cities are calculated along with the fuel consumption for navigation in the port cities. Lesser polluting fuels like LPG and

CNG can be made compulsory in major cities, phasing out older and inefficient vehicles and extensive public transport helps in reducing pollution. Domestic sector resulted in emissions of 11690.43 Gg of CO2 equivalents (~30% of the total emissions) in Delhi which is the highest among all the cities (Ramachandra et al., 2015b). Management and treatment of solid and liquid waste in cities results in emissions. This sector shares 3-9% of total emissions resulting from the cities. Delhi emits 2232 Gg of CO2 equivalents and is higher when compared with other cities. This showed that waste sector accounts for considerable amount of greenhouse gas emissions.

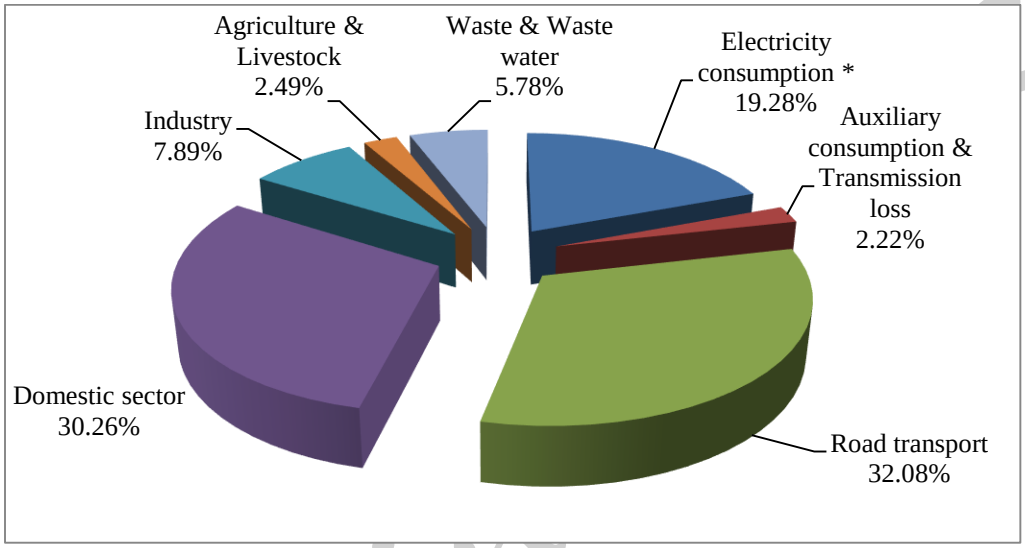

Figure 2: GHG footprint (Carbon dioxide equivalent emissions, Gg) of Delhi

Government needs to play a pivotal role in planning sustainable cities with the healthy urban environment and sustenance of natural resources (vegetation, water bodies and open spaces). The results of the current analyses highlight of the significant changes in land cover with the decline in vegetation, water bodies, crop and fallow land. This necessitates an integrated approaches in urban planning to ensure the sustenance of water, moderation of micro climate, etc. Conservative urban planning would take into account the sustenance of natural resources and people's livelihood aspects. Ensuring at least 33% of landscape with open spaces (lakes and native vegetation) would help in enhancing the landscape's capability to retain water. The current demand of water as per the recent estimates of Delhi Development authority, is about 1511billion liters with the shortfall of about 450 billion liters. The annual rain water harvesting potential is about 900 billion liters. Further augmentation of resources is possible through the revival of water bodies and greening of

the catchment with native vegetation helps in recharging ground water aquifers. Ground water contributes substantially in newly developed localities in Delhi due to insufficient supply of water from Yamuna River. In order to ensure groundwater recharge, the government authorities need to maintain minimum vegetation cover in the region apart from recharge through percolation pits and rain water harvesting. A green belt or native vegetation on either side of banks help in arresting the soil erosion, remediation, minimisation of salinity and improvements in water quality. This entails holistic approaches in urban development to appropriately preserve the areas of various land-use classes considering the ecological and environmental services for maintaining the inter-generational equity.

Countries such as India which is one of the fast growing economies in the world, with higher energy consumption for various activities with increase in transport sector emissions with scale of rapid and uncontrolled urbansiation and quest of higher living standards are eventually the causes of GHG emissions in todays' scenario. The quality of air in the major Indian cities which affects the climatic conditions as well as health of the community is a major environmental concern. Higher levels of energy consumption have contributed to the degradation of the environment. The data regarding emissions from different sector helps the policy makers and city planners to devise mitigation strategies focusing on the particular sector which helps in improving the environmental conditions within the city. Implementation of emission reduction strategies in cities also helps in gaining carbon credits in the global markets, which has been an outcome of increased awareness about greenhouse gas emissions. Mitigation strategies include:

Transportation Setor

- Improvements in public transport system (with apt share of commuter trains and user friendly buses. Automation of public transport system to reduce idle time and improve commute efficiency.
- Transport demand: integration of land use and mobility planning targeting land use, improvement of load factors and changes in patterns and scale of transport demand, where appropriate;
- Reduce emissions from vehicles, including prescription of emissions targets for new vehicles;
- Avoid ad-hoc or reactionary approach to mitigate emissions through approaches such as odd-even schemes (i.e odd registration number of vehicles on odd days, etc.). This has only helped the elites while posing serious hurdles to mid class families. Elites have managed to have two vehicle per person per family and succeeded in getting odd and even registration numbers for the respective vehicles. This only helped the bureaucrats in amassing wealth than helping common citizen of Delhi free of pollutants.
- Appropriate transportation strategy to reduce heavy duty vehicle fuel consumption and CO_2 emissions;
- a target to reduce the greenhouse gas intensity of fuels;

- rolling resistance limits and tyre labelling requirements with mandatory tyre pressure monitoring;
- legislation encouraging hybrid and electric vehicles; and,
- Accounting life time energy use and CO_2 emissions while procuring vehicles (mandatory disclosure in vehicles information brochure).
- Appropriate taxation regime to discourage private vehicles, phasing out out-dated inefficient vehicles,
- Mode share: measures facilitating less GHG intensive modes such as public transport and non-motorised transport (like Namma cycle in Bangalore). Public transport needs to be user friendly and economically competitive; train services for cargo and commuter movement.
- Innovations in vehicle design – smaller and light vehicles (for example in public transport) to reduce fuel consumption and improve use efficiency
- Fuel choice: measures aiding the development and dissemination of technologies for alternative fuels (hybrid, electric); and
- Fuel efficiency: development and dissemination of technologies for vehicles (including test cycle measures for vehicle components and accessories) and traffic management, traffic congestion abatement measures, eco-driving, awareness among public about implications of increases in GHG's, etc.
- Mandatory environment education at all levels to ensure future decision makers are sensible and environmentally literate.

Energy Sector: Appropriate policy incentives might help in the large scale deployment of solar devices at household levels. There is a need to focus on energy efficient decentralized electricity generation technologies with micro grid and smart grid architecture, which would go long way in meeting the energy demand. Solar energy based generation seems promising and environmental friendly option to meet the growing demands. India is blessed with the good solar potential and harvesting this potential would minimize the environmental implications associated with the fossil fuels. Solar Photovoltaic (SPV) technology has the potential to meet the domestic and irrigation demands in the decentralized way. In this regard, suggestions are:

1. Electricity generation using SPV (solar photovoltaic) and CSP (concentrated solar power) technologies would bridge the demand supply gap as India receives abundant solar energy of more than 5 kWh/m^2/day for about 300-330 days in a year. The adequate potential with mature technologies and apt policy incentives would help in meeting the electricity demand in a region.
2. Roof top based SPV would help in meeting the household energy demand in rural as well as urban households. Rural household require about 70-100 kWh per month and to meet this requirement 5-6 m^2 rooftop is adequate (at η=10%, and insolation of 5 kWh/m^2/day) and the average rooftop in rural locations in Karnataka is about 110 m^2 and about 155 m^2 in urban localities.

3. Adequate barren /waste land is available in Karnataka as the available waste land is about 7% of the total geographical area less than 1% area is sufficient to generate electricity required for irrigation and domestic sector through SPV installation.
4. Decentralized generation of electricity through renewable energy resources (solar, wind, bioenergy) SPV would help in meeting the respective household's electricity demand apart from the removal of T&D losses. Generation based incentives (GBI) would herald the decentralized electricity generation, which would help in boosting the regional economy. Considering the current level of T & D losses in centralized system, inefficient and unreliable electricity supply, it is necessary to promote decentralized energy generation. Small capacity systems are efficient, economical and more importantly would meet the local electricity demand.
5. Promotion of high energy efficient appliances in households, mainly by replacing conventional heaters and coolers with high energy efficient ones. Government need to improve the end use energy efficiency by providing improved cook stoves, Piped Natural Gas (PNG) usage instead of LPG, CFL/LED lamps, which will help in reducing the significant amount of energy and CO_2 emission from the household sector
6. Using clean energy such as electricity for low-end energy inefficient activities such as water heating (for bathing) necessitates the energy auditing in household sector and also the extent of penetration of energy efficient devices including solar water heaters.
7. To minimize electricity consumption per person, promotion of appropriate architecture for buildings in tropical region. Recent study reveals that adoption of architecture with glass facades have led to the tenfold increase in per capita consumption of electricity (14000-17000 units/person/year compared to the residents 750-1300 units/person/year - residing in building with region specific architecture). This would help in reducing carbon footprint in the domestic sector.
8. Impetus to energy research through generous funding for the R and D activities to ensure further improvements in the grid, technologies, two way communication energy meters (to connect rooftop generation with existing grid), efficient luminaries' production, low cost wiring, switchgears, appliances, etc.
9. Energy education (focusing mainly on renewable energy technologies, end-use energy efficiency improvements, energy conservation) at all levels. School curriculum shall include renewable energy (RE) concepts.
10. Capacity building of youth through technical education for installation and servicing of SPV panels.
11. Mandatory one week capacity building / training programmes to all bureaucrats and energy professionals at the initial stages of the career. This is essential as lack of awareness/knowledge among the bureaucrats is the major hurdle for successful dissemination of renewable energy technologies in India

This further highlights the need for research and innovations focussing on mitigation and adaptation mechanisms to reduce GHG emissions in transport sector.

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