Land Use Changes in India and its Impacts on Environment

Shashi Chawla

Department of Applied Chemistry and Environmental Sciences, Amity School of Engineering & Technology, New Delhi, India
E-Mail: shashichawla10@gmail.com

Abstract

Land use changes result from population growth and migration of poor rural people to urban areas for economic opportunities. Changes in land use directly influence the regional air quality, energy consumption and climate at global, regional and local scales. Controlled, coordinated and planned urbanization is a gift to the human society. However, unplanned urbanization can be a disaster. Urban sprawl refers to some types of uncoordinated land use resulting from lack of integrated and holistic approach in regional planning. Information related to the rate of growth, pattern and extent of sprawl is required by urban planners to provide basic amenities such as water, sanitation, electricity, etc. Urban sprawl increases traffic problems, depletes local resources and destroys open space. Thus, it is very important to examine causes of urban spread out, its associated problems and possible solutions in India. This paper provides a valuable basis to understand the major issues faced by urban citizens in India as a consequence of land use changes. The suggested solutions are very helpful for the strategic planning in future.

Keywords: Land Use Changes, India, Environmental Impact, Pollution

1. Introduction

Agriculture, industry, energy production, urban development, grazing, logging, mining and other land uses relate to human activity or economic function associated with a specific piece of land. Generally land use is constrained by soil characteristics, topography, vegetation, climate, and other such environmental factors. But it also reflects the importance of land as a crucial and finite resource for most human activities. Land use is a product of interactions between cultural backgrounds, state and physical needs of the society with the natural potential of land (Karwariya & Goyal, 2011).

Often improper land use is responsible for various forms of environmental degradation. It is essential to know the natural characteristics, extent and location, its quality, productivity, suitability and limitations of various land uses for sustainable utilization of the land ecosystems. The need for new housing, schools, industries, transportation and other civic amenities increases with increase in population. Earlier this was considered as a development, advancement or urbanization. However, urban dispersion processes in various Indian cities have led to patterns of uncontrolled suburbanization. Sprawl is defined as “the uncontrolled spreading out of a given city and its suburbs over more and more semi-rural land at the periphery of an urban area. The sprawling process of expansion is disordered, unplanned, leading often to inefficient and unsustainable urban expansion patterns (Travisi and Camagni, 2005).

Urban sprawl is characterized by four dimensions i.e. widely dispersed population in low-density development; sharply separated homes, stores, and
workplaces; poorly connected network of roads, marked huge superblocks and lack of well-defined activity centres and downtowns (Camagni et al, 2002 and Wright, 2005).

Sprawl can be measured by using an integrated sprawl index containing configuration (density and scatter) as well as composition (mixed land use). The following indicators are used for measurement of sprawl (Frenkel & Ashkenazi, 2005):

- Growth rates are measured by the ratio between the growth rate of built-up areas and the population growth rate (sprawl quotients).
- Urban activity is residential units, number of residents and employees.
- Density is ratio between a certain urban activity and the area in which it exists.
- Spatial geometry is measured using leapfrog and continuity to quantify scattering and fragmentation of the urban landscape.
- Accessibility is measured using road length, road areas and travelling times of households. In general, the condition of poor accessibility is followed by the higher use of private vehicles.
- Aesthetic measures are difficult to measure as sprawl is a boring, homogenous form of development.

Consequences of urban sprawl can be positive and negative. Increased satisfaction of housing preferences, the convenience of car travel, the filling in of leapfrogging land, lower crime rates and better public spaces in suburban local governments are some of the positive effects of sprawl. However, a shortage of functional open space, car and its polluting effects, air and water pollution, loss of farmland, tax money spent on duplicative infrastructure, concentrated poverty, racial and economic segregation, a shortage of employment accessibility etc. are some of the negative effects of sprawl (Wassmer, 2005).

Urban sprawl lead to shift towards more personal vehicle use and is thus responsible for more pollution, higher road accidents and an ever-increasing demand for petroleum. Auto-catalysts in catalytic converter play a key role in automotive emissions control because of their extraordinary and sometimes exclusive properties. Thus, they play an important role in building a more sustainable society (Christian, 2011).

2. DPSIR Framework for Urban Sprawl

In Section 2, DPSIR framework is presented. The driving forces of environmental change; pressures on the environment; the state of the environment; impacts on the population; and the response of the society is described in this conceptual framework.

2.1. Driving Forces (D)

Income, wealth and car use provide the framework for land consumption of households, companies, and public spaces such as parks. However location choices are made based on the comparison of costs and utility effects (Siedentop, 2005). The lack of consistent and coherent urban development policy, faulty and improper urban planning, poor implementation and inefficient regulation are some of the important causes of urban sprawl in India (MHUPA, 2011).

2.2. Pressures (P)

Car ownership numbers in families residing in the new dispersed suburbs are much higher than those residing in high density spaces. This is because separation and differentiation of land use intensifies mobility. Pressures in future will increase as projections suggest that India will have more than 700 million urban persons by the 2040s (MHUPA, 2011).

Slump has been criticized for eliminating permeable area. Increase in the paved area severely reduces the groundwater recharge potential, leading to situations which may truly be potential catastrophes (Farooq & Ahmed, 2008).

2.3. State (S)

In Delhi, India built-up area witnessed an overall increment of 16.86% of the total city area of 1490 km² during 1997 to 2008. This area mainly came from agriculture land, waste land, scrub-land, sandy areas and water bodies. In comparison the increment in forest cover of 0.5% is very small. Total area of water bodies has reduced by 52.9% in the same period. To increase the quality of life in an urban environment, it is essential to preserve and manage natural land use classes through appropriate urban planning (Manju et al, 2011).

Along the Mangalore-Udupi highway in India, it was found that the percentage change in built-up area over a period of nearly thirty years was 145.68% and by 2050 the built-up area in the region would rise to 127.7 km², which would be about 106% growth in the change in built-up area to the current sprawl of 61.7 km² over the region (Ramachandra et al, 2004).
Sprawls change in Salem city situated in Salem District of Tamilnadu, India was identified and quantified for 1973-2010. It was found that the Old Suramangalam Cluster or North West Cluster extends from Andipatti to Burns Colony. The Kalarampatti to NGGO Colony/ Chindra Kollapatti extensions is the Second Cluster which occupies in the north-eastern part of the corporation. This implies that by 2020 and 2050, the built-up area in the region would rise beyond the corporation limits and hence the corporation limit will be extended (Tamilenthi et al, 2011).

With the expansion of the urban expansion and the increasing population in Lucknow, India, there has been an excessive pressure on natural and built drainage systems and surface/subsurface hydrological storage units. Changes in land use and land cover were estimated with respect to urban sprawl and methodology is suggested during the design of the master plan with focus on surface and subsurface water integrity of Lucknow (Basavaraja et al, 2011).

Assessment of Raichur City located in the state of Karnataka, India, revealed that the city is under imminent threat from the rapid urbanization. As per the present trend, by 2021, nearly 27% of the agricultural land would be converted to settlements resulting in shortage of the surface and ground water resources which, in turn, would further impact agriculture (Basavaraja et al, 2011).

Urban sprawl is consuming agricultural land and threatening ecologically sensitive areas. It also significantly increases the cost of providing infrastructure (MHUPA, 2011).

In India, there were five cities with a population greater than 1 million and much of humans effectively lived in 0.56 million villages in 1951. There are, however, 53 cities with population greater than 1 million and 3 cities with population greater than 10 million in 2011. The census figures of 2011 reveal that the process of urbanization has accelerated from an increase from 25.5% to 27.8% to 31.2% of total population in decades ending in 1991, 2001, and 2011 respectively. Number of Rural and Urban Settlements and their Population in India are summarized in Table 1. Over the next 50 years, India will experience the second largest Urban transformation in history, involving approximately 5 mega-urban regions, seventy plus million cities and over 0.5 million villages across a diverse sub-continental landscape. India will thus make a historic transition from a largely rural and agricultural society to one that is predominantly urban (IIHS, 2012).

2.4. Impacts (I)

Shifting to a car-dependent lifestyle has caused an ever-increasing demand for petroleum. The higher rates of vehicle use lead to higher road accidents. Less walking and more usage of personal vehicles led to higher incidence of obesity and high blood pressures in owners. All the driveways, highways, parking lots associated with urban sprawl lead to a significant increase in runoff, resulting in increased flooding and erosion of stream banks. Water quality is degraded by the runoff of fertilizer, pesticides, oil that drips from engines, etc. In addition, sprawling development is also responsible for loss of agricultural land, landscapes and wildlife. Various Indian cities are suffering from untidy informal irregular growth, huge urban land shortages, growth of slums, chaotic transport, insufficient municipal finances, inefficient governance, water logging, damaging diseases, huge infrastructure and housing shortages (Figure 1) (MHUPA, 2011).

The agricultural space is used, connected agricultural land is destroyed, natural potential of soils is indirectly lost and the endangered animals and plants are eliminated (Ecological Impacts). Inhabitants of densely built cities have to bear lower traffic costs. As households and firms suburbanize, radial commuting to the city centre is more and more replaced by cross-commuting within the urban area. Even in a more decentralized structure, transportation costs may actually be lower with jobs nearby. The time cost of commuting would have increased even more without suburbanization (Traffic Impacts).

Sprawl leads to an erosion of functioning urban cores. This results in reduction in degree of social interactions and cultural diversity (Social and health impacts) (Siedentrop, 2005).

The rapid growth of population has brought about extensive land-use changes in the Himalayas, mainly through the extension of cultivation and large-scale deforestation. The irrational land transformation process has not only disrupted the ecological balance of the Himalayan watersheds through reduced groundwater recharge, increased run-off and soil erosion, but has also adversely affected the economy and ecology of the adjoining Indo-Gangetic plains by frequent floods and reduced irrigation potential (Tiwari, 2000). The agro-ecosystems of Central Himalayan villages are under enormous pressure due to industrialization and commercialization of agriculture. The production and sustainable management of resources is necessary to save these natural ecosystems from further decline (Chandra et al, 2011).

As the number of cars on the road increases, a number of harmful pollutants are emitted as vehicular exhausts. These pollutants include carbon monoxide gas, nitric oxide, hydrocarbons and particulates. Carbon monoxide (CO) reduces the capacity of the blood to carry oxygen and extended exposure to CO can contribute to heart disease. Nitric oxide product is precursor for atmospheric
generation of nitric acid—one of the constituents of acid rain and is also an essential component in photochemical smog formation which intensifies breathing problems. Hydrocarbons have an unpleasant smell and they are also involved in the formation of smog. Particulate matter interferes with normal respiratory functions and is associated with emphysema, asthma and bronchitis (VanLoon & Duffy, 2011).

A pioneering program by New Delhi, India’s 2003 conversion of 90,000 buses, taxis and auto-rickshaws to compressed natural gas (CNG) has not significantly improved harmful vehicle emissions. The study finds that as much as one third of CNG is not properly burned in two-stroke engines, producing high emissions of methane that contributes to climate change. CNG use also produced substantial emissions of high particulate matter from unburned lubricating oil (UBC, 2011).

Particulate matter: Fine, ultrafine and black carbon particles are associated with respiratory, heart diseases and premature death. Their concentrations in Delhi auto-rickshaws are about 2-10 times higher than measured in other megacities around the world. Pollution is 35-55% less in AC cars with windows closed. Short-term peak concentrations in auto-rickshaws are about 6-50 times higher than ambient levels. Thus it is crucial to reduce emissions of vehicle fleet (Apte et al, 2011).

Vehicular pollution is increasing in Indian cities and has a deleterious effect on various systems of the body. This was found through a study in two areas of Delhi (India); one highly polluted and the other low polluted area (Bhattacharya et al, 2007).

As roadways choke on traffic, researchers suspect that the tailpipe exhaust from trucks and cars—especially tiny carbon particles already implicated in cancer, respiratory ailments and heart disease—may also injure brain cells and synapses key to learning and memory (Robert, 2011).

Table 1. Number of Rural and Urban Settlements and their Population in India (IIHS, 2012)

<table>
<thead>
<tr>
<th>Year</th>
<th>Rural</th>
<th>Urban</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>634,321</td>
<td>3,351</td>
<td>74.5</td>
<td>25.5</td>
</tr>
<tr>
<td>2001</td>
<td>638,588</td>
<td>5,161</td>
<td>72.2</td>
<td>27.8</td>
</tr>
<tr>
<td>2011</td>
<td>640,867</td>
<td>7,935</td>
<td>68.8</td>
<td>31.2</td>
</tr>
</tbody>
</table>

Figure 1. DPSIR Framework for Urban Sprawl (Wright, 2005)
Air pollution due to road traffic is a serious health hazard and thus the persons, who are continuously exposed, like traffic policemen, are at an increased risk. The effect of pollution by vehicular exhausts may be responsible for impairment in lung function in traffic policemen (Gupta et al, 2011).

Levels of ambient air pollution uniformly exceed the recently revised WHO air quality guideline (AQG) levels across most cities in India, with almost 80 nonattainment cities and towns and 24 critically polluted hotspots identified by the Central Pollution Control Board (CPCB). An estimated 120,600 deaths are attributed to outdoor air pollution each year in India (Balakrishnan et al, 2011).

2.5. Responses (R)

Indian government is trying to control pollution by implementing strict emission control laws. Ministry of Housing and Urban Poverty Alleviation, Government of India has started Urban Strategic Planning for the 12th Five-Year Plan (MHUPA, 2011).

3. Discussion

3.1. Vehicular Pollution Control using Auto-Catalyst

The chemistry of platinum group metals (pgms), namely, platinum, palladium, rhodium, iridium, ruthenium and osmium, is dominated by the catalytic properties of the metals. Diesel Oxidation Catalyst (DOC) uses a Platinum Group Metal (PGM) catalyst. Diesel Particulate Filter (DPF) may also be catalysed by pgms to aid regeneration. Oxides of nitrogen (NO\textsubscript{x}) absorbers based on pgm, hold NO\textsubscript{x} until the downstream Selective Catalytic Reduction (SCR) or NO\textsubscript{x} trap catalysts are warm enough to remove NO\textsubscript{x}. Reformer catalyst containing rhodium converts some of the fuel into CO, CO\textsubscript{2} and H\textsubscript{2} in reforming process. This H\textsubscript{2} is introduced into the engine alongside the fuel. This helps combustion and can also reduce emissions of NO\textsubscript{x} and particulate matter (PM). Three-way catalyst (TWC), combination of platinum, palladium and rhodium, removes hydrocarbons, CO and NO\textsubscript{x} and help in deodorisation of the exhaust gases in motor vehicles (Millington & York, 2012).

Exhaust Gas Recirculation (EGR) works by recirculating some of the exhaust gas back into the engine. This reduces the amount of NO\textsubscript{x} formed by lowering the temperature of combustion. Various technologies used in India for controlling pollution are summarized in Table 2 (Kapoor, 2012)

Thus, the platinum group metals are increasingly important as auto-catalysts for pollution control. They reduce the pollutants in diesel exhaust by converting 30 to 40% of particulates and 90% of hydrocarbons and carbon monoxide into carbon dioxide and water vapour respectively. They also convert over 90% of carbon monoxide and oxides of nitrogen and hydrocarbons from gasoline engines into less harmful carbon dioxide, nitrogen and water vapour (VanLoon & Duffy, 2011).

Indian Government continues to apply increasingly stricter emissions standards to cut in pollution per vehicle which is needed to keep improving air quality. India has already implemented Bharat IV emission standards in thirteen cities and the number of cities will increase in future. Clean air legislation results in catalytic converters being fitted to petrol and diesel cars and heavy trucks. This has and will continue to drive greater use of the catalytic converter (Kapoor, 2012).

3.2. Smart Growth

The continued use of more and more cars by rapidly increasing urban population is not sustainable given the combination of environmental consequences of fossil-fuel usage, congestion caused by use of more cars, potential disruptions to fuel supplies etc (Chin, 2010).

To be more responsive to the changing needs and demands of the citizens, the urban planning process must combine environmental planning, transportation planning with land use and spatial planning with socio-economic and financial planning. Planning should concentrate growth in selective city centres to avoid urban sprawl. Smart growth advocates compact, transit-oriented, walk-to-work, bicycle-friendly land use to the extent possible, including neighbourhood schools, streets and amenities that are suitable for everyone. Planning as per smart growth principle

<table>
<thead>
<tr>
<th>Diesel Commercial Vehicle Class</th>
<th>Size (Tones)</th>
<th>EGR</th>
<th>EGR+DOC</th>
<th>EGR+DOC+DPF</th>
<th>SCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>3.5 to 7.5</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>Medium</td>
<td>7.5 to 12</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Heavy</td>
<td>&gt;12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
</tr>
</tbody>
</table>
advocates mixed-use development with a range of housing choices and focus on public transport. Such compact cities are more efficient and sustainable than cities that are sprawled over large areas (MHUPA, 2011).

4. Conclusions

This paper has reviewed the key policy and governance challenge in India originated as a result of land use changes resulting in urban sprawl. Air legislation standards are getting stricter day by day to cut in pollution resulted from urban spread out. As automobiles will be driven by an increasing number of users who live in urban areas, so stricter emission standards will increase the demand of auto-catalysts used in catalytic converter. In summary, this paper provides an important insight into possible solutions for various problems resulting from the urban sprawl.

Acknowledgements

Author is greatly indebted to Dr Ashok K Chauhan, founder President, Prof. B.P.Singh, Senior Director and Prof. Rekha Agarwal, Director; Amity School of Engineering & Technology for their continued guidance and encouragement. He is thankful to Dr. Alok Saklani, Prof. and Director of Apeejay School of Management for his valuable guidance during the faculty development course. He is also thankful to Ms Rachana Nagal and Ms Neera Bhutani for language corrections. A draft of this paper has been significantly re-written and updated based on valuable reports from unspecified referees, and their comments are gratefully acknowledged.

References


Manju, M., Subhan, K.P., Kolli, N., Anurag, K., and Sucheta, P. (2011) Dynamics of urbanization and its...


