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IMPLICATIONS OF SPRAWLED AND COMPACT DEVELOPMENT ON MOBILITY PATTERNS: A CASE-STUDY OF BHOPAL, INDIA

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Abstract
Cities across the world are witness to increasing phenomenon of urban sprawl. The paper contends that sprawl affects mobility in terms of increased dependence on private motor vehicle which is high in energy use and carbon emissions. The study is based on primary investigation of three neighbourhoods in Bhopal city (India), the first two lying within the city in varying contexts and the third outside the present city limits which can be classified as a sprawl. The analysis throws significant light on the changes in mobility pattern in areas with more compact development vis-à-vis those that have sprawled with relatively lower densities. It shows that densely populated areas having mixed use has higher share of walk trips and that the average trip length is higher in lower density areas in sprawls. The study further examines the role of land use planning, zoning regulations and urban form in encouraging sustainable mobility.

Keyword: Urban sprawl, Sustainable mobility, Land Use planning, Zoning regulation, Travel behaviour

INTRODUCTION
The world is experiencing tremendous urbanization, especially in the developing world. In the global context, India's urbanization is expected to take place at a massive scale with about 590 million people living in cities by 2030. Further, it is predicted that the number of cities with a million plus population will increase from the current 42 to 68 by 2030 (McKinsey, 2010). Existing and new cities need to add additional spaces to accommodate this growing urban population. This phenomenon of urbanization often leads to sporadic development in the outer peripheries and beyond the city boundaries in peri-urban areas or fringes of agglomerations, thereby creating pressure on natural resources and environment. A lot of agriculturally and ecologically productive land is thus making way for unmindful urban expansion. Already, large cities are witnessing the fallouts of rapid urbanization, in terms of haphazard and sporadic development, resource depletion, unsustainable mobility patterns and increasing levels of pollution. Tremendously growing urban population and urban areas reflects reduction in per capita amount of land which has come down to 67% from 1951(0.48Ha) to 2008(0.16 Ha) in India. Thus, the way these cities grow in the coming decade are bound to have profound implications on the natural resources, ecologically fragile and agriculturally productive areas, environment and social sustainability and also long-term economic prosperity of

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these cities. In this era of resource scarcity, where food security and depletion of resources is an area of concern, and the world needs to produce more food to feed 9 billion people by 2050, it is imperative to address and control sprawls.

ZONING REGULATIONS AS A CAUSE OF SPRAWLED DEVELOPMENT

It is important to understand the causes of sprawl development if we need to address the solutions effectively. Studies list a multitude of causes out of which planning and zoning regulations is cited as an important one. Siedentop (2005) identifies two major causes of urban sprawl, one of which is regulation controls. A study for measuring compactness through various parameters and dimensions of measurement of compactness by Kotharkar (2014) found density and FAR plays important role in spatial expansion of city. These studies indicate that sprawls in city takes place due to proposing regulation not specific to city structure and to the direction of development like density variation based on potential of the area, FAR, and skewed landuse distribution. Factors such as low density leading to more consumption of land by households, single use zoning or spatial segregation of different type of landuse, leapfrog development and no centralised ownership of land or planning of development abet formation of sprawls. A Habitat (2013) report claims that the pace of sprawl and mobility impact is major function of zoning regulation i.e. urban form – emerging either from a haphazard process of locating settlements and activities, or from strategically planned intervention it makes a big difference in mobility systems.

One of the reasons that cause Indian cities to expand outwards spatially is low permissible FAR in central locations. Bertaud (2002) found that Indian cities have lower densities and floor area ratio (FAR) of approximately 1.6 as compared to other cities of Asia which have values ranging from 5 to 15 in centrally located areas.

Crane and Chatman's (2003) suggest for zoning regulation such as proposed landuse, density and FAR to be designed in such a way so as to reduce distance and transportation needs and focus on bringing people and places together. Similarly other scholars emphasise on intensity of mixed landuse as it increases opportunity for walkable destinations (Chapman and Frank, 2004, Kuzmyak, 2009; Pushkar et al., 2000).

EFFECTS OF SPRAWLED DEVELOPMENT ON MOBILITY

Sprawls are characterized by structure and form attributes of a settlement system. Literature on sprawl typifies them as essentially low density, single use, and fragmented development. It is understood as an urban form building process that transforms a former monocentric compact structure into a discontinuous, polycentric and disperse settlement structure (Galster et al. 2000, Torrens, Alberti 2000, et al.). There exists a plethora of research indicating that due to their very nature of development, sprawls tend to disperse activities and subsequently increase vehicle travel (Litman, 2015). These in turn impose various economic costs in terms of increase in motorized trips ultimately contributing to increased energy consumption and pollution levels, less walk and cycle trips, loss of agricultural land and productivity, lack of employment accessibility, increased cost on infrastructure and increased cost on travel. This is further corroborated by Ewing et al. (2002), who observed that metropolitan sprawl bore correlation with higher rates of driving and vehicle ownership, increased levels of ozone depletion, greater risks of fatal

accidents, declined rates of walking and transit ridership, and higher rates of obesity. These contribute towards negative impacts of sprawled development. At the same time, there also are evidences supporting the positive impacts of sprawls, and these are experienced by sprawl residents, in terms of increased satisfaction of housing preferences, better environment compared to dense city areas and increased convenience to travel by car. Nonetheless, they impose external costs to the city on the whole. A 2002 study in Chicago, Los Angeles and San Francisco demonstrated that families living in sprawl own three times as many cars and drive four times as much as families of same size and income living in location efficient neighborhoods. Similar research found that in case of a compact development in a city, every additional passenger-kilometers travelled on public transit translate into 8-10 kilometer reduction in citywide driving (Holtzclaw, 1994). The same study also concluded that the difference between 20 dwellings/acre (urban densities) and 5 dwellings/acre (suburban densities) was a 40% increase in travel. Another study by Wang (2013) concluded that vehicle travel is 9% lower for households that reside in mixed land use neighborhoods with good network connections.

It is quite evident that sprawled development has considerable amount of impact on mobility and environment, since the spread out pattern of development tends to increase the dependence on private automobile leading to increased carbon emissions. There is increasing recognition that density and design both play an important role in shaping city structure and growth pattern and landuse planning tool creates built environment along five core dimensions or the '5 Ds': density, diversity, design, destination accessibility and distance to transit entails paying attention to multiple scales of urban mobility. A number of studies have shown that design intervention through planning leads to an enhancement of economic and social value of a city. As a planner one thus needs to understand the urgent requirement of integrating landuse zoning regulation and mobility for sustainable growth of cities

Taking example of an Indian city Bhopal, this paper attempts to find out how zoning regulation in the city have impacted the mobility patterns. It also builds a relationship between the indicators of urban form and mobility so as to make clear the causes and consequences. The analysis throws significant light on how the mobility pattern changes with areas having more compact development vis-à-vis those which have developed as sprawls and with lower densities. One of the consequences of sprawled development is implication of zoning regulation on carbon emissions, and the paper tries to compare both areas close to city center and sprawls. The study has also critically analyzed the Masterplan of Bhopal which has earmarked extensive parcels of land in the peripheries with almost uniform density and FAR without considering potentials of certain areas to have higher densities and FAR.

BHOPAL URBAN SCENARIO

Bhopal is the capital of one of the states, Madhya Pradesh in India, thereby making it an administrative hub. According to the 2011 Census of India the population of the city is 17, 95,648 with a declining growth rate (25.33% in 2001-11). Figure 1 indicates that the population growth rate of the city increased tremendously in the earlier decades and then showed a sudden decline due to Bhopal gas tragedy in 1984 and further due to the state of Chhatisgarh being carved out and separated from Madhya Pradesh, prompting migration of many government employees to the newly formed state. Having 70 wards,

covering a gross area of 285 km^2 (Bhopal municipal limit) including the lakes and hills, the city is a low-density city of 50 persons per hectare (PPH). Even if the areas of steep hills and the lake area of 38 km^2 are discounted, the density on habitable land remains low at 80 PPH.

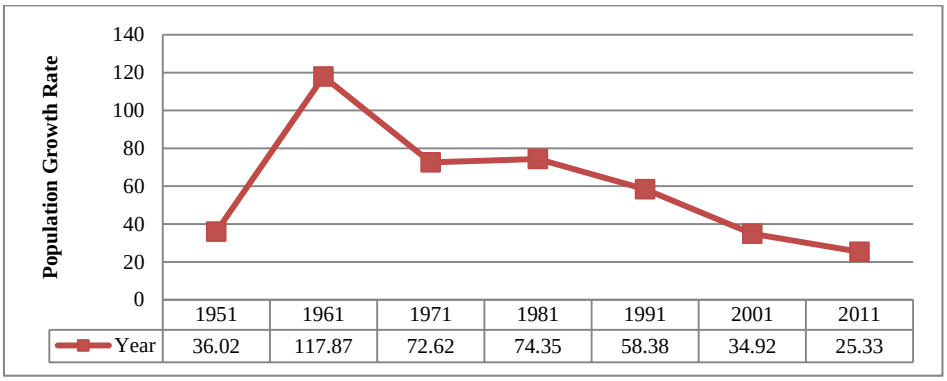

Figure 1: Decadal Growth Rate of Bhopal
Source: Census 2001, 2011, Bhopal Masterplan, 2005

SPATIAL GROWTH AND SPRAWL

Despite a declining population growth rate, the spatial expansion of Bhopal is high, which is an area of concern. The city has expanded almost three-folds from 1989 to 2012, as can be seen from Table 1, which is tremendous given the fact that this was the phase during which the population growth rate started declining.

Table 1: Developed area, Bhopal

Year	Area (in Km^2)
1989	53.30
1994	63.9
1999	95.1
2005	125.70
2012	140

Source: Calculated and compiled by author through various sources Draft Bhopal Masterplan 2021, Bhopal

Table 2 also indicates that although the rate of spatial expansion in the last decade has shown decline from 89.09% to 34.04 %, it is still high when compared to other cities in the country which are similar to Bhopal in terms of either population or spatial structure, such as Lucknow (23.58%) and Nagpur (23.8%).

Table 2: Spatial Growth Rate (in %age) of Bhopal, Lucknow and Nagpur

Year	Bhopal	Lucknow	Nagpur
1991	-	57.7	-
2001	89.09	23.2	20.47
2011	34.04	23.58	23.8

Source: Draft Master Plan of Bhopal 2021; Regional Remote sensing service centre, Nagpur; Siddiqui, 2012

Figure 2 shows the spatial growth of the city over the last two and a half decades. It can be seen that most of the new residential areas are sprawling towards south-east and south west directions i.e. Kolar and Hoshangabad areas unlike the proposed Master plan (as indicated in Figure 3) which has proposals of residential pockets in each of the direction.

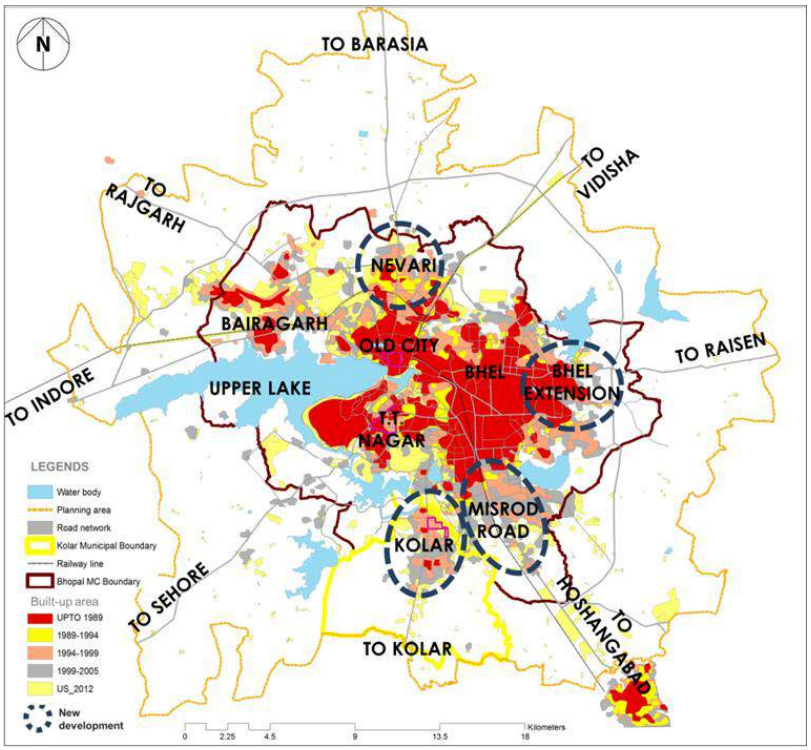

Figure 2: Spatial growth of Bhopal from 1989 to 2012

Till date, three development plans for Bhopal have been prepared out of which the Bhopal Development Plan (BDP) 2021 was rejected and at present a new draft is under process for the horizon year 2031. The first Development Plan for Bhopal i.e. BDP 1991 was prepared in 1973-75. It focused on the efficient and judicious utilization of land, compact city development, hierarchical city structure in terms of self contained units and

effective and direct linkages between the work centers and living areas, minimizing travel distances. In 1994, the second Development Plan for Bhopal (which is followed till date) was prepared in accordance to the implementation of the previous plan. At this time the city had started to grow as a multi nuclei city. So the objectives for the plan were undertaken as 'Multi Nuclei Compact City development', environmental conservation, conservation of cultural assets, efficient utilization of land, providing infrastructure and facilities and proposal for participation in land allotment and infrastructure development. Although the Bhopal Master Plan 2005 envisaged a 'Multi- Nuclei Compact City Development', its vision appears farfetched given the current way the city has expanded. There are efforts to redensify certain parts of the city, but it is quite insignificant as the proposed area for redensification comprises of only 1.74% of the total proposed residential use. The proposed residential area as per the Master Plan itself is more than double the existing residential area i.e. 36.6 Km^2 to 81.9 Km^2. Further, the master plan proposes a uniform residential density of 250 PPH (with 25 PPH in areas having physical constraints) in all directions, as can be seen in Figure 3, without considering transit corridors and activity hubs which could have been addressed through TOD concept so as to have varied density and more efficient utilization of land resources.

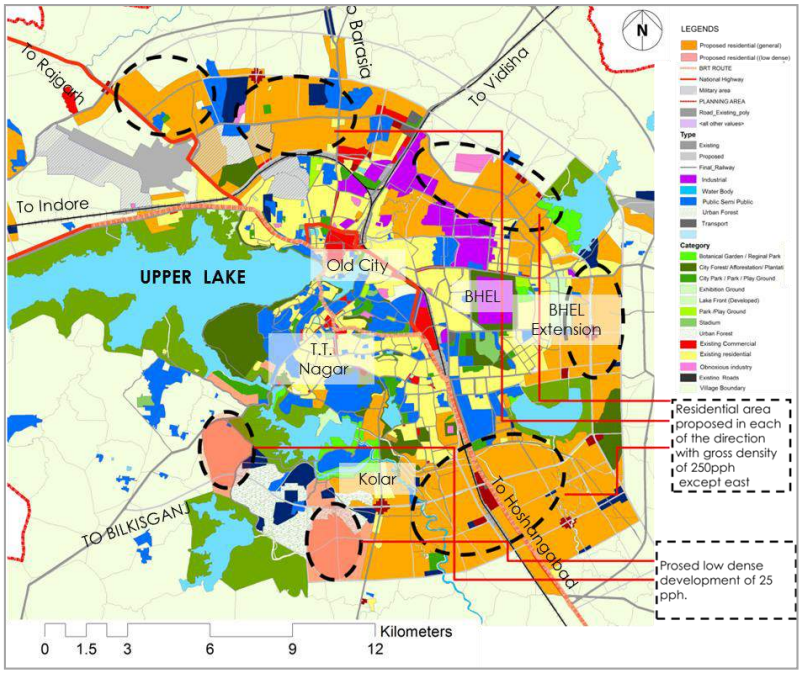

Figure 3: Proposed Landuse 2005
Source: Bhopal Masterplan 2005

ZONING REGULATION

Proposed housing density and FAR have been prescribed in Bhopal Master plan 2005 which are being followed till date. The proposed densities (gross residential density) vary

from 50 PPH to 250 PPH. Only one small area in the city (T.T. Nagar area) proposed for redensification has a proposed density of 675 PPH. The FAR vary from 0.15 (mainly west of Kolar due to topographical constraints) to 1.25, in all the new development. The proposed redensification area is permitted to have a higher FAR of 2.5 as per group housing development control regulation.

MOBILITY

The mobility pattern of Bhopal city overall shows that average trip length (ATL) has increased over the years i.e. from 3.1 km to 5.4 km which indicates that the average distance from home to other activities have increased; indicative of low density and sprawled development. The draft City Mobility Plan of Bhopal estimated ATL of commuters on buses and intermediate public transport (IPT) as 7.4 km. Majority of trips are within the range of 2-5 km and 7-10 km; this also indicates that there is requirement to address the need of sustainable mobility as the trips are becoming gradually longer. The modal share in the city on an average shows that maximum trips by commuters are taken up by walk, two wheeler and public transport (Refer Table 3), indicating that the mobility issues are not that critical and with apposite interventions, the trend of increasing trip lengths and changing modal split can be reversed towards a more sustainable direction. Because of the constant rise in the number of motorized vehicles the city felt the need to wean people away from private vehicles and persuade them to use public transport and consequently introduced a bus rapid transit system (BRTS). A Metro rail is also proposed having 6 routes.

Table 3: Modal Share, Bhopal

Mode	Percentage
Walk	43
Cycle	3
Two wheeler	25
Public Transport	20
Car	6
IPT	1

Source: Draft Report on Comprehensive Mobility Plan for Bhopal, 2012

DATA AND RESEARCH DESIGN

In order to understand and develop relationship between zoning regulation and its implications on mobility pattern, the study is based on primary investigation of three case areas (neighborhoods) in Bhopal city in varying contexts. The areas have been identified based on parameters such as proposed density, applicable floor area ratio (FAR), period of development, distance from city center and availability of public transport.

The first area is located in the Old city (in the core area of the city) having a density of 518 PPH (high density) and is an organic development having mixed use; the second area is South T.T. Nagar having a density of 255 PPH (medium density) and located near major activity centres; and the third area is East of Kolar having density of 136 PPH located outside municipal limits and can be classified as sprawl. The total areas of the 3 case study areas are 53 Ha, 90 Ha, and 83 Ha respectively. Master plan 2005 proposes, for old city to retain the existing density as it is highly dense with very narrow streets.

South T.T. Nagar area is proposed for redensification with a new proposed density of 675 PPH and permissible FAR of 2.5. The density for Kolar is proposed to be increased upto 255 PPH with 1.25 FAR.

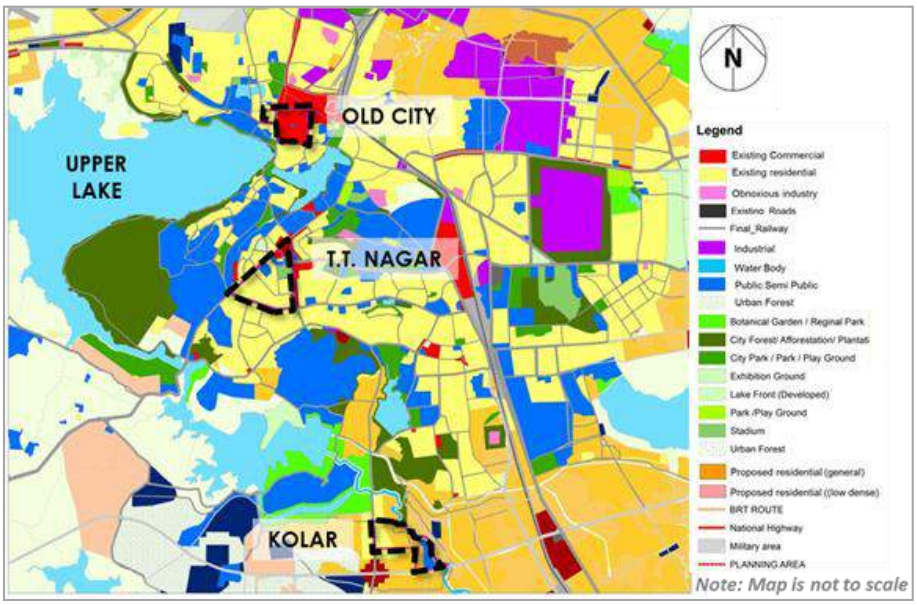

Figure 4: Map showing three case study areas in Bhopal City

The indicators identified for analyzing the case areas included broadly two aspects, one of them is urban form and the other one is mobility. Household survey was conducted in the three selected case areas to capture the trip characteristics of residents. A total of 150 households (50 households from each case study area) were surveyed. The population frame consisted of approximately 11,100 households.

Based on different researches carried out in the field, the indicators of urban form considered for this study are taken as density, FAR and landuse; and mobility indicators to assess the impact of urban form are modal share, average trip length (ATL) by mode, average trip length (ATL) by purpose, modal share by trip purpose, per capita trip rate (PCTR), vehicle ownership pattern and access to public transport.

SPATIAL AND MOBILITY CHARACTERISTICS IN THE THREE CASE STUDY AREAS

Spatial Characteristics of Case Study Areas

The three case study areas that are Old city, South T.T. Nagar, East of Kolar. Old city is the walled city of Bhopal with Jama Majid as its centre and two perpendicular lines dividing it in four grids. Existing density of more than 500 PPH, predominant mixed landuse (having residential, commercial, retail and public/semi public landuses) characterize this area. The mixed use is about 39% and uniformly distributed in all of the

area, followed by residential use (34%), commercial area (10%) and PSP (5%) which includes heritage building, religious building and educational centers. The area lacks in neighborhood recreational spaces, but is close to Upper Lake recreational area (city level).

The second case area South T.T. Nagar with a density of 255 PPH is a planned development and is close to the important work centres in the city. It has a mix of government and private housing (54%), an important city-level commercial facility (New Market) (11%), city-level recreational area (T.T. Nagar stadium) (8%) and public semi public area (10%).

The third case area, East of Kolar (13kms from the city centre) characterized as sprawl with a density of about 136 PPH is of predominantly residential use. Commercial areas can be observed along the main access road which is not conforming to the proposed master plan. This area is now a part of Bhopal urban agglomeration. Major transformation visible in this area is commercial development along the main road. The work centres are located far from this area because of which it lacks job-housing balance. Further, the area has no mixed landuse and recreational spaces.

Zoning regulation and mobility

The following section discusses the parameters of urban form and mobility and their correlation. The applicable regulation in the three study areas are indicated in Table 4.

Table 4: Spatial characteristics and zoning regulation of case study areas

Study area	Old city	South T.T. Nagar	East of Kolar
Area	53 Ha	90 Ha	83 Ha
Population	30,104	23,000	9,399
Existing Density	518PPH	255PPH	136PPH
Proposed Density	To retain existing density	675 PPH (as per redensification scheme)	Upto 250 PPH
FAR Permissible and ground coverage	Residential- 1.25 to 1.75	Residential - 2.5	Residential - 1.25
	Commercial- 2.5	Commercial- 2.5	Commercial - 2
	Ground coverage- 80 %	Ground coverage - 30 %	Plotted development ground coverage ranges from 30% to 60%
		Existing residential FAR - 1.25	Existing FAR - less than 1.25
Housing Typology- Plotted development	Central core area have Unplanned old built up, plotted development	Government Housing - mainly plotted development for F, G, H and I type , on the southern most part - Private housing plotted development	Private housing and townships, Plotted development as well as group housing, maximum area have plotted development
		Plot size range- 50 m^2 to 2000 m^2	Plot ranges from 50 m^2 to 1500 m^2
	Exceeds Ground coverage with almost 80-90 %		Ground coverage is as per the range of DCR

Housing Typology- Group Housing	Group housing includes commercial shops in ground floor and residential use in above floors	Apartments by housing board one such project - Platinum Plaza providing housing for MIG and HIG, FAR achieved in that project 2.5, G+9 storied building; private housing for MIG as well as LIG on western part of south T.T.Nagar	No of floors in apartment ranges from G+4 to G+5, Along the road G+3 commercial complex, Majorly plotted development single family housing. While moving away from road, near to drain, newly developed apartments.

The study reveals that these three areas having different zoning regulation and type of development show different mobility patterns. Figure 5 indicates the ATL with respect to the purpose of trips, in the case study areas. Through close examination of the collected sample, it is clear that the ATL has a direct correlation with the density of the areas: 3.1 km in high density area, 4.1 km in medium density area and 7.7 km in low density sprawls.

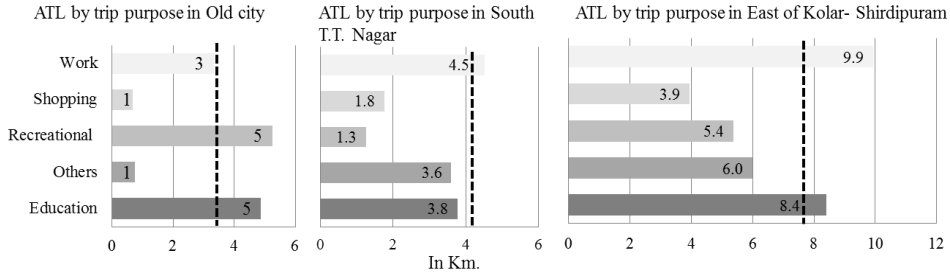

Figure 5: Average Trip Lengths (in Kms) by Purpose of Trips
Source: Primary Survey, 2015

It is further interesting to note that in old city area where workplaces are close to residences, ATL for work trips (which is a more regular trip) is the lowest (3 km); the ATL for work trips is exceedingly high in sprawl area (9.9 km). ATL for educational purposes also increases from 5 km to 8.4 km from dense compact areas to sprawled areas. Increased intensity of landuse mix and proportional distribution has positive impact on mobility, as it is inversely related to ATL. ATL for shopping purpose also increase significantly as we move from compact development to sprawls.

The study also reveals that walk trips are not only maximum in high density area with mixed landuse (39% in Old city area) they are also longer in these areas, i.e.0.8 km in Old city and 1.2 km in South T.T. Nagar area in comparison to sprawled area where commuters tend to make shorter walk trips (0.6 km).

The modal share (as illustrated in Figure 6) in high density mixed use area (Old city) is indicative of a more sustainable mobility pattern, where walk trips are as high as 52 %. Thus density and mixed landuse have positive relation with walk trips, whereas this is just the reverse in low dense area (Kolar) where 51% trips are undertaken by private motorized modes (car and two wheeler). This is reflective of the fact that households prefer to walk when facilities and work places are nearer to their residence which is supported by high density and mixed landuse. Even medium density area having

proportional distribution of landuse and better availability of public transport increases trips by public transport (32% in South T.T. Nagar).

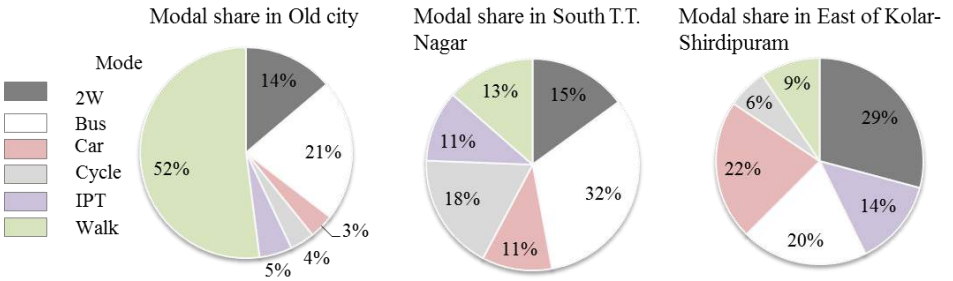

Figure 6: Modal Share (in Percentage)
Source: Primary Survey, 2015

For daily trips, such as work and education higher percentage is covered by walking in Old City (14% and 21% respectively); less than 5% of these trips are made by car. In contrast in the sprawled area a higher percentage of the corresponding trips are covered by private mode (13% and 14% respectively). The areas close to city centre have higher accessibility to public transport: Old city is served by both BRTS and IPT (Tata Magic) unlike sprawled areas where there is limited accessibility to public transport.

The investigation also throws light on vehicle ownership in case study areas: it shows some amount of relation on location (proximity to CBD) and type of development (compact or sprawl), although this cannot be taken as conclusive since the socio-economic characteristics of the three areas are not similar. It was evident that in sprawled areas households dependence on private mode increases and as subsequently the ownership also increases (81 % of households own private vehicle; 47% owns car and 34 % owns two wheeler) as they find walking, cycling or using public transport difficult and prefer private mode for better convenience. Thus, absence of policies like smart growth, transit oriented development (TOD), new urbanism at zonal or area level through zoning regulation tends to create unsustainable mobility.

IMPLICATION OF ZONING REGULATION ON MOBILITY, CARBON EMISSIONS AND SUSTAINABLE DEVELOPMENT

The study develops two alternative scenarios to understand the implications of different zoning regulations on sustainable mobility for the city. Scenario one is implications with revised zoning regulation and scenario two is observing status quo (that is, if redensification of T.T nagar does not happen). The revised zoning regulation (proposed as per zonal plan within the framework of Bhopal master plan 2005) in South T.T. Nagar area, stipulates the density to be 675 PPH (from the present 255) and FAR as 2.5 (from the present 1.5). In scenario one, the assumption are that modal share, average trip length(ATL), per capita trip rate are assumed to be same as that observed in the existing analysis of T.T.Nagar area for calculating vehicular km travel (VKT), consumption of fuel and carbon emissions. In scenario two which is status-quo it is assumed that when redensification doesn't take place, extra population which could have been accommodated within T.T. Nagar area will reside in any sprawl area in absence of

housing options close to city, and as such the trip characteristics are assumed to be similar to Kolar area (sprawled area). The emission standards per vehicle km are taken as 173 gm per vehicle km (Automotive Research Association of India, 2008). for car and 44 gm per vehicle km for two-wheeler (Michael Foley, 2013).

The analysis of both the scenario as shown in Figure 7 indicates that there can be reduction in total vehicle km travel by 46.5% if redensification takes place and people get opportunity to reside near city center unlike in Scenario 2 where vehicle km travel will get doubled as facilities and job opportunities will be far away from residence. This finding corroborates with Litman's (2015) study which identifies increase in per capita land development as sprawl's major resource impact, and by dispersing destinations, it increases total vehicle travel, which in turn have various economic costs. The cost of sprawl not only affects total travel but also cost on travel expenditure and fuel consumption which gets double in case of Bhopal if phenomenon of sprawl is left to continue at this pace. If redensification takes place, then both fuel consumption and expenditure on fuel will reduce by 58.3 %, which is quite high for households. Studies indicate that more compact development can provide substantial energy savings (Ewing, et al., 2009; UNEP 2011).

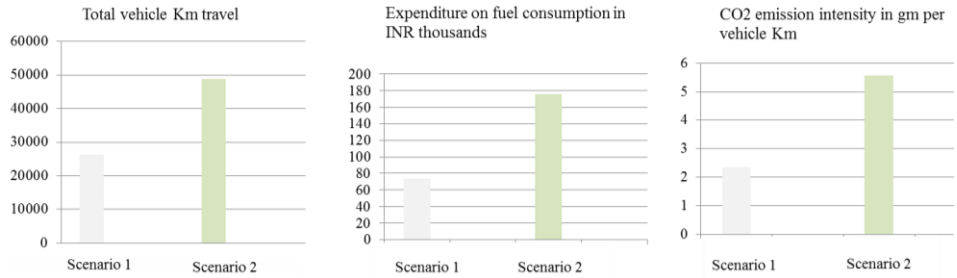

Figure 7: Reduction in vehicle Km travel, expenditure on fuel consumption (In INR thousands) and CO_2 emission intensity

A recent report (Environmental Defence, 2013) identified various external costs of sprawl including higher infrastructure costs, loss of open space and farmland, increased driving and related health problems, increased air pollution emissions, and reduced community cohesion (positive interactions among neighbors). For example, various studies at international level concluded that sprawling Atlanta produced six times more transport-related carbon emissions than relatively compact Barcelona. In case of Bhopal CO_2 emissions in Scenario 1 is 57 % lower than that of Scenario two where there is higher dependence on private low occupancy motorized trips with higher trip length. Implying improved zoning regulation at faster pace so that the mobility improves in terms of less travel, lesser consumption of fuel and lesser carbon emissions is question in today's context of planning where policies and plan should try to achieve sustainable mobility not only by providing facility but also framing regulation to achieve the vision.

PROPOSED STRATEGIES AND CONCLUSIONS

A revision in zoning regulation and relook towards the approach in proposing landuse zoning regulation is required so as to reduce sprawl and optimize expansion of the city.

Increase in city area and decline in average density eventually squeeze out public transport and non -motorized transport usage. These issues of sustainable mobility should be addressed at local level through revising zoning regulation. In order to reduce travel demand and negative externalities of transport, density of built-up area needs to be optimised and mixed landuse promoted, to enhance proximity of people's home to activities. It is also found that these conditions encourage walking habits and people are willing to walk longer distances. The study tried to establish the relationship between the components of urban form and mobility, and their importance in tackling the accrual problems caused due to unrestrained and sparse expansion of urban landscape. To attain sustainable mobility proactive approach towards integration of landuse and transport planning is required. The vision of compact development can be achieved only when New Master Plan of Bhopal for horizon of 2031 (in process) is prepared keeping in mind the need and essentials of multi nuclei compact development and environmental issues. Future development should not only focus on fulfilling infrastructure and housing requirements but also on ways and means through which the needs are met through reduced per capita consumption of land and other resources, even if it requires restriction on development of inexpensive urban-fringe land. This would also be in tune with the report of steering committee on Urbanization (12th Five Year Plan, 2012-2017), which recommends under planning strategies: *"Incentivise strategic densification: Strategic densification with mixed land use as a planning strategy needs to be pursued to accommodate future urbanization needs. In addition to this, mandating inclusionary zoning and providing higher Floor Space Index (FSI) with provision for amalgamation of plots to make the economics of affordable housing viable should be considered."*

For a sustainable and compact development, various policies and strategies like smart growth, new urbanism and transit oriented development have been adopted in developed countries to overcome the issues of mobility. Higher densities and better public transport access are traded off against the greater flexibility of the car. In some situations TODs can reduce car use per capita among their residents by half and save households around 20 percent of their income, as they have lower levels of car ownership which is concluded by Cervero (2008 cited Banister 2012, p.5). These strategies can also work in case of Bhopal. The recommendations for increasing sustainable mobility and reducing sprawls in Bhopal are discussed below.

a. Landuse and density proposed as per Masterplan 2005 should be revised in New Master Plan 2031, as demarcation for residential area is contradicting its "compact city development" vision. The vision cannot be achieved from top level; it is only possible when lower level planning is also aimed through compact neighborhood. For sustainable mobility, neighborhoods /zones can be developed within the scope of zonal plans as walkable units and as it is evident from the study- intensity of landuse mix decreases car ownership, the proposal should avoid single use zoning.
b. Redensification of other areas for reducing city expansion and increasing gross density of 60pph (As per Urban and Regional Development Plan Formulation and Implementation guidelines, the ideal density for metropolitan city is 125pph-175pph). Instead of drastically increasing land under residential use, density needs to be increased.
c. Revise zoning regulation to have high density and form based development (vertical) Height restriction and FAR should be relaxed to have efficient usage of

scarce land.

d. High density and mixed landuse zone should be provided along BRTS and Metro corridor after assessment of infrastructure. Masterplan should have a landuse category of mixed landuse. Considering potential of old city area for developing into walkable neighbourhood, more pedestrian friendly environment should be encouraged, so that people continue to make more walk trips. No vehicle zones should be identified so as to restrict vehicular movements in old city area. The area should not go beyond the existing density 518 PPH, as it would not be sustainable, given the high ground coverage and narrow street widths
e. South T.T. Nagar has also tremendous potential for walkable neighbourhood and its redensification provides scope for compact development sensitive to walking and cycling, to cut down the burden on increased parking requirements and other facilities. South T.T. Nagar area should be developed as a high density development with adequate social infrastructure and access to public transport with feeder service to enhance last mile connectivity.
f. Areas which are low dense should be developed as contiguous development through infilling; TOD along transit corridors should be explored. TOD can be developed along Hoshangabad road and infilling of the vacant areas between Hoshangabad road and Kolar road, and east of Hoshangabad road is required.
g. Development of work centers and social infrastructure within the city limits to cut down increased dependence on other areas and decrease trip length.

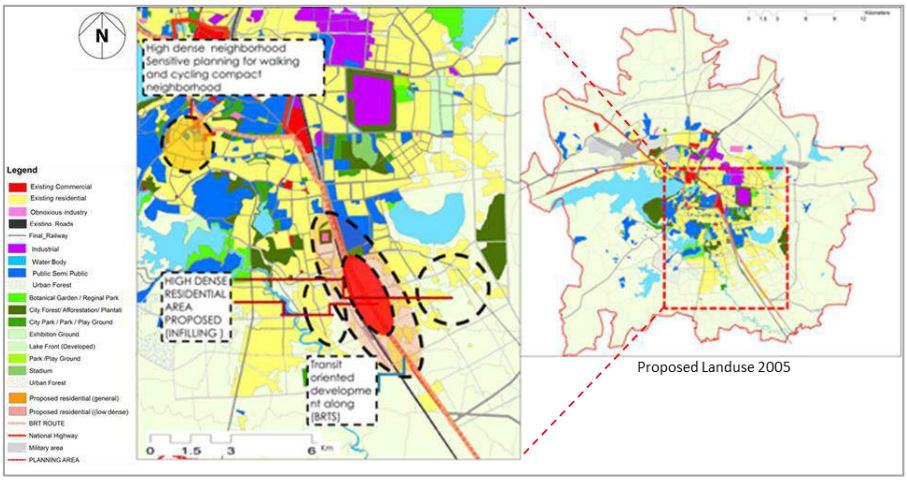

Figure 8: Proposed Strategies

Sprawl considerably suppresses sustainable mobility via affordable and environmentally friendly modes like walking, cycling and public transport. They not only shift the fulcrum towards ubiquitous private mode usage but also result in increased emissions. Policies and Master Plan should be made in such a way that it directs sustainable use of resources, thereby reducing the economic cost imposed by sprawls on the city and its residents. Sustainable densities at strategic locations with a combination of mixed uses are the likely panacea for cities so as to minimise transport sector footprint.

Reform in zoning regulations is thus the need of the hour and cannot be overlooked if cities have to grow sustainably.

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