Analyzing the urban forms in relation to sustainability in the capital city, Bhopal

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Abstract

Considering the present scenario, it is quite evident that cities are dealing with abrupt expansion and population outgrowth. Our needs are contradictory to our want, resulting in imbalance between economy and ecology. Hence, there is a sudden need to come up with infrastructure solutions which give sustainable future a strong foundation and at the same time bear the shock of the circumstances future changes might bring. Urban forms can be seen as that "micro entity" which eventually determines the urban morphology of a city. This paper is an attempt to understand the overall impact, of different urban forms on sustainability of a city keeping in mind the day to day activities of residents. To study this, three urban forms of Bhopal (a two tier city) were studied considering waste, transport and public spaces as the variables to be assessed on the basis of economic, social and environmental sustainability. The primary source of data collection include, on ground study of urban forms of habitation i.e. mixed use houses, mid-rise apartments and an urban sprawl. The data for the case study is collected by on-site survey, visiting government offices like ward offices, solid waste treatment plant, etc. On further analysis it was observed that mid-rise urban form stands firm on the ground of sustainability and urban resilience of a city.

Keywords —Urban Form, urban resilience, sustainable city, Bhopal, mid-rise, mixed use development, urban sprawl

I. INTRODUCTION

If we call the 20th century the age of urbanization and urban life – this is because never before in the history of mankind urbanization grew so fast – the new century has experienced us people with packages of rural life who live in an urbanized world. Transition is complex phenomenon that includes important technological, economic, social and political aspects. The process of economic globalization today is having profound impacts on national and urban economies and patterns of spatial development in most regions of the world. If we look deep into the city development and expansion over the past few decades, we will realize how cities are expanding in unplanned way leading to densely populated areas, uneven crowd distribution which increases traffic, pollution and exploit the resources. Keeping in mind the current rate of expansion and population growth it is clear that the cities are going to grow dramatically in the near future. The consequences which impacts directly or indirectly on other phenomena, such as-

- Planet's deforestation with loss of wildlife habitat, as well as other natural resources.
- Progressive expansion of the land occupation, for agricultural and dwelling purposes.
- CO_2 emissions increment.
- Air, Land and water quality deterioration.

Hence it is a major concern of the city planners, social scientists and policy makers to come up with solutions which can accommodate the growing population in a way that creates better living standards for people and can evenly distribute the resources, giving sustainable living a strong foundation. Architects and urban planners now perceive the role and function of urban space and also understand the dramatic consequences for how urban forms are planned and designed.

II. WHAT IS AN URBAN FORM

Urban form is the physical characteristics that make up built-up areas, including the shape, size, density and configuration of settlements. It can be considered at different scales: from regional, to urban, neighborhood, 'block' and street. Evolving continually in response to social, environmental, economic and technological developments, governed and restricted by byelaws and city development norms. The connectivity within different settlement in the city is through road on which cars and buses run. This becomes the major determinant in defining the urban morphology of any given area.

Other than these parameters within a settlement, a number of historically laid morphological forms are present including-

- dense settlement
- irregular medieval street patterns
- planned radial and grid structures
- curvilinear suburban layouts

These are macroscopic factor responsible for defining the urban form of any settlements. In any urban morphology urban form becomes the physical entity determining the shape and volume of that space, well knitting together to form the urban fabric. This paper focuses on the urban forms in a city to further deduce the opportunity of establishing foundation of sustainable living in the cities to harmonize the urban living with nature, as that in villages.

The key determinants of an urban form are –

1. Density
2. Housing type
3. Layout
4. Land use
5. Transport infrastructure

Urban form directly affects energy consumption, correspondingly amount of carbon dioxide emissions from building, transportation and other sectors causing climate change. Waste generation, air, noise and water pollution levels are also dependent on the way an urban form is built. This directly affects the well being of a city. To combat urban expansions while addressing these problems policy maker are trying to find more resilient and sustainable urban forms which will reduce the impact of urbanization on nature and ecology. Considering the well being of the planet, there are three priorities for the development of sustainable urban form:

- "Transportation priorities: Extension of road and transit infrastructure.
- Economic priorities: Economies of Greenfield developments or redevelopment processes.
- Cultural priorities: Socio-cultural perception of urban space." (1)
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III. BHOPAL AND ILL EFFECTS OF URBANIZATION

(A) ABOUT BHOPAL

Bhopal is the capital of 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). Having 70 wards, covering a gross area of 285 km2 (Bhopal municipal limit) including the lakes and hills, the city is a low-density city of 50 persons per hectare (PPH). At this time the city had started to grow as a multi-nuclei city. *(3)*

(B) PRESENT ENVIRONMENTAL STATUS OF THE CITY

Bhopal has a hilly terrain with lakes and green cover. But over the years with the expansion of cities the green cover has reduced with considerable amount. The city, once placed among the greenest cities of India is fast losing its tag of green city. According to a study by researchers from IISc Bangalore, Bhopal lost its vegetative cover of 92% in 1977 to 21% in 2014. The study predicts degradation of the same to 11% by 2018 and to just 4% by 2030 if the city administration continues to work on the same policies.(2)

Because of lesser green cover and more vehicular load on roads the air is getting more polluted. The increased traffic also leads to congestion in peak hours.

The waste generation of the city has also increased by leaps and pounds. The landfill site at Bhanpur is causing respiratory illness among nearby residents. Because of emission of gases and raised temperature in summer, the use heaps of waste frequently catch fire. This continuous degradation of environment in the past few years is majorly because of no consideration of present problems and following norms of old master plan. Because of the absence of right mitigation measures, builders and colonizers took over and gated communities started sprouting in the periphery of the city, leading to loss of agricultural land and depletion of resources like water and soil.

IV. BHOPAL – A CASE STUDY IF ITS URBAN FORM

Bhopal comes in the category of 2 tier cities and two tier cities are maximum in the country ranging from 50,000 to 1, 00,000. In all these cities similar kind of urban forms have developed over the years. Most prominently in any city there is an area which carries the history of that city. With narrow lanes, densely populated old houses its urban morphology has been developed over many decades. With further rise in the population expansion of the city parameters led to bringing nearby villages and spaces in vicinity in to the city parameters, developing urban spaces with then built building norms and development plans, commonly known as the new city. The third kind of expansion is seen which is mushrooming in the recent decades with the sudden growth of population. This part of the city usually have row houses gated communities, apartments built by builders and illegal settlements of migrated laborers' and workers from nearby villages. Most of this development happens at the cost of green cover of the city or the agricultural land. This urban morphology is usually termed as urban sprawling.

To assess these urban forms and study the impact of the daily activity on the city as a whole in relation to three variables, namely-

1. Transport
2. Solid waste
3. Public spaces

The basic aim is to assess these activities in relation to the urban form being studied and its effects on sustainability on the basis of economical, social and environmental sustainability. Considering the above mentioned commonly seen three different types of urban morphology of any two tier city.Three areas where chosen for the study:-

1.) Ibrahimpura- part of old city
2.) South T.T. Nagar- part of new city
3.) Khajurikaln- part of urban sprawl

The most commonly found urban forms in these three areas are-

1. Ibrahimpura (part of old city) -Tightly packed houses with mixed use duplexes having shops in the ground floor and habitable spaces in the above floors. Traditionally build by then skilled craftsmen and artisans. These houses are average more than 50 years old with historical significance, but bad structural conditions.
2. South T.T. Nagar (part of new city) – this area mostly has government planned mid-rise housing apartments, 2-3 decades old.
3. Khajuri kaln (part of urban sprawl) – this area has gated society and kaccha pakka houses of migrant workers from nearby villages living in the city for work.

A. MID-RISE OF SOUTH T.T. NAGAR

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

The area studied comes under ward 22

Fig- 1, Mid-rise residential apartment

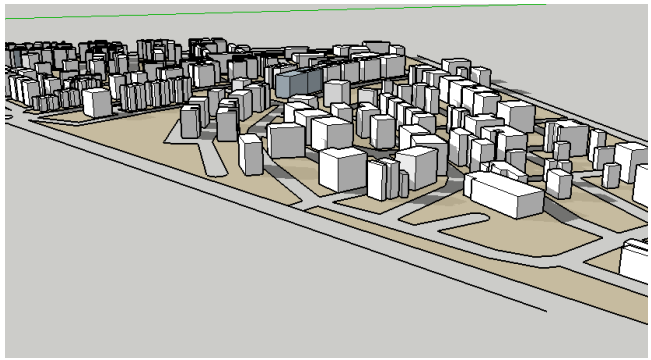


Fig. 2, Sketch depicting the volume and void created by mid-rise in T.T. Nagar

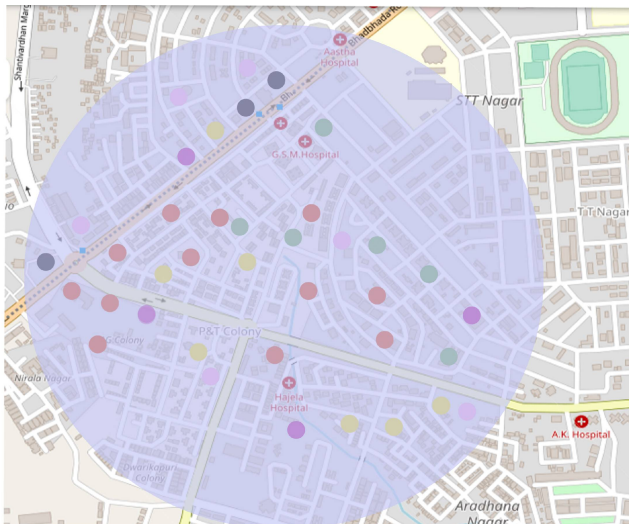


Fig- 3, Amenities available in the 1KM radius of STT Nagar

B. MIXED-USE HOUSES OF IBRAHIMPURA

The second case study is Ibrahimpura the walled city of Bhopal with Jama Masjid as its center and two perpendicular lines dividing it in four grids. Existing density of more than 500 PPH, predominant mixed land use (having residential, commercial, retail and public/semi-public land use) characterizes 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 the famous upper and lower lake re within 2-3 km radius making it very convenient to take a break in the parks and public spaces nearby.

Fig-4, Compact residential duplexes with shops in ground floor

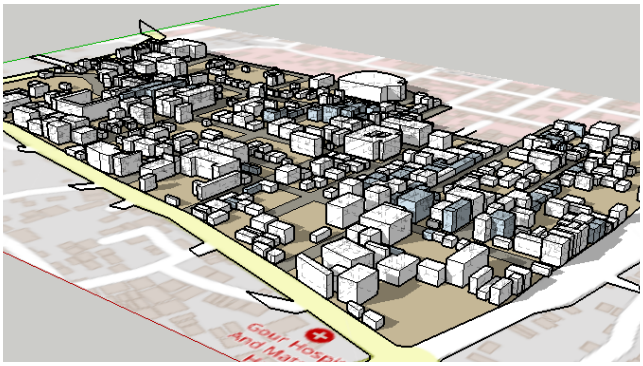


Fig-5, Sketch depicting the density of the place grown over the years because of population growth and market place inclusion in Ibrahimpura

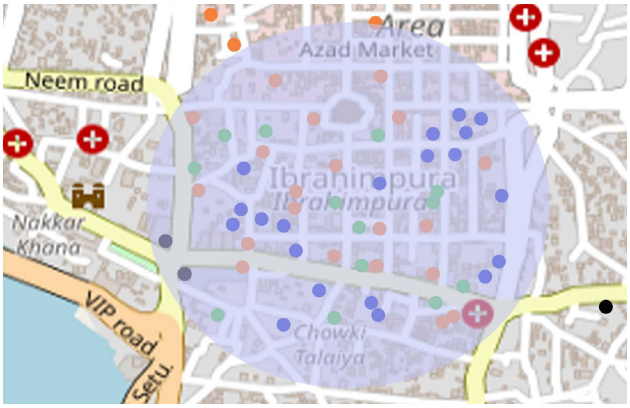


Fig-6, Amenities available in the 1KM radius of Ibrahimpura

URBAN SPRAWL IN KHAJURIKALN

The third case area, Khajuri kaln (10kms from the city center) characterized as sprawl with a density of about 136 PPH is of predominantly residential use. Residential 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 residential development along the main road. The work centers are located far from this area because of which it lacks job-housing balance. The residing population is majorly the migrant workers from nearby places and villagers who have been living from generations now. The houses are a mix of kuccha and pukka houses, covered with agricultural land. Further, the area has no mixed land use and recreational spaces.

Fig-7, kuccha and pukka houses in Khajurikaln

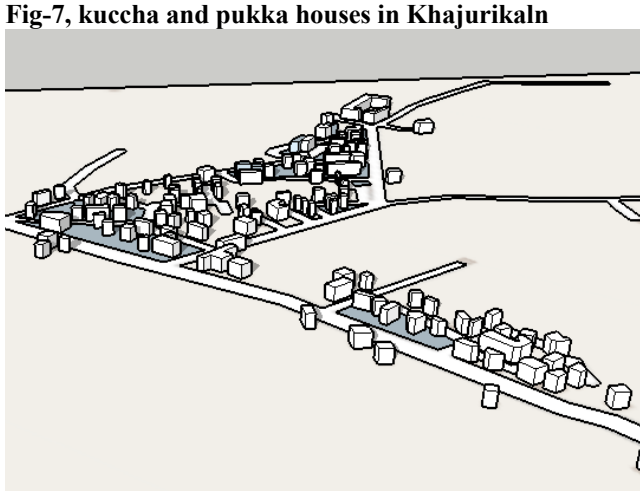


Fig- 8, One or two storied houses built in an unplanned way along the main road

Fig- 9, Amenities available in the 1KM radius of Khajuri kaln

Titles	Ibrahimpura	South TT Nagar	Khajuri kaln
Ward	20	32	59
Zone	4	7	10
Total area of study	18.1 hectare	18.9 hectare	14.3 hectare
Area of green patch	1.5 hectare	6.6 hectare	9.2 hectare
Population	30,104	23,000	9399
Density	500PPH	255PPH	236PPH
Road area	4.6 hectare	2.7 hectare	2.5 hectare
ATM/ bank	8	6	NA
Bus stop	3	4	NA
School	13	3	2
Super market	6	6	NA
Hospital	2	6	NA
Religious	12	17	5
Height	6-9M	18M	3-6M
Housing typology	Mixed use housing Duplex	Residential Mid-rise	Kaccha/pakka house
Land-use	Residential/ Commercial	Residential	Agricultural
Places for entertainment	5	10	0
Proximity from			
Railway Station	3.5 KM	6.8KM	12.2 KM
Center of city	9KM	6KM	15KM
Waste segregation area	8KM	11KM	11KM
FAR	1.25-1.75	2.5	1.25
Housing typology plotted development	Central core area have unplanned old built-up, plotted development exceeds ground coverage with almost 80-90%	This area was planned and designed by government as LIG'S. The planning of the area has lesser built-up area and more left out land for green cover.	Private housing, randomly developed not plotted, urban sprawl with kuccha and pukka houses
Water supply	Kolar	Kolar	Narmada
Water logging	Observed	Not observed	Observed
Sewage treatment	myodarman oxidation pond2.36MLD	Mata madir tricking filter13.6MLD	No Treatment

Table 1, Details gathered about the three urban forms

From the table- 1 it is quite evident that the basic amenities like ATM, School, Super market etc are in proximity in South T.T. Nagar area, hence it reduces the vehicular movement and making easier access for the resident. Because of government involvement in the development of this land, the bye laws are strictly followed which leads to lesser built-up space. The green cover is also maximum in the area leading to proper percolation of water; hence no water clogging was observed.

Whereas in Ibrahimpura the high density leads to a lot of problem like, water clogging, poor air quality, lesser privacy. The major reason behind congestion in this area is also because of old planning and integration of market places with residential space, leading to a lot of traffic, noise, exaggerated waste generation. Hence the municipal corporation vehicle for waste collection also takes three round i.e. morning, afternoon and night to collect the waste produced due today to day activity in a market place. The old area of Ibrahimpura was built in grid iron pattern hence the roads intersect at 90 degrees. There is a need for renovation in almost all houses, but neither there is care of old houses nor the authorities are taking in consideration the hazardous impact failure in any of these structures can cause. There is an urgent need to depopulate the area to make it function better.

Khajuri-kaln is a village with people working in farms becoming part of agricultural practices. With the urbanization many villagers from the nearby villages migrated in search of job and in search of cheaper place to stay and settled in this area far from city. Hence the urban sprawl came into existence and is now expanding. Because of this condition, sometimes it leads to dispute over land and other resources. There is no waste management system, as this area does not come in municipal area of monitoring. And the sullage also goes to the agriculture fields. All the amenities are quiet far away, with bus stand also 7km with no connecting vehicle.

V. TRANSPORT

A.*MOBILITY PATTERN OF THE CITY*

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. It is evident (taking reference from Table-1) that the urban sprawl in Khajurikaln lies way ahead of the average trip estimate of the city, which leads to more petrol consumption, long hours of travel and more carbon emission. Others two urban forms i.e. Ibrahimpura and South T.T. Nagar lie in the range of ATL.

B. PUBLIC TRANSPORT

Launched on 27th Sept 2013, 24 Km BRT Corridor connects 03 Railway Stations and 03 Bus Stations. 77 BRT Bus Stop integrated with Automatic Fare Collection System. 41 Bus Stops are now integrated with AFC system. BRT was able to integrate city bus services due to proper design in respect of integrated study. BRT AC buses, Non AC Low Floor and Midi Buses are able to ply inside & outside of BRTS. (4)

Fig- 10, Map showing routes and stops of BRTS buses

Fig-11, Separate lanes in BRTS buses in between the two lanes

The BRTS lanes have turned out to be the most comfortable mode of public transport till now in the city and the ticket collection process is easier and cheaper comparatively. The bus stops are safe and maximum distance is of 25m in between the two stations, which makes it easier for the residents to walk to the bus stand from their home. The bus stop near S.T.T. Nagar and Ibrahimpura is in very close proximity (refer table -1).
But because of narrow lanes and traffic congestion
(because of high population density and mixed use), the movement of huge BRTS buses create a lot of trouble and difficulty in vehicular movement. It is also dangerous for any kind casualty or accidents.

C. INTERNAL ROAD NETWORK

The internal road network of the selected area of study in STT Nagar is safe and in good condition. The average road width is 6m and ample footpath space is provided for vehicular parking and pedestrian movement. Minimum area is covered with concrete and natural vegetation is growing in the vacant spaces between built-up and roads, allowing a lot of area for percolation in rainy season.

Fig- 12, typical street in STT Nagar

The internal roads of Ibrahimpura are approximately 3-6 m wide. Because of traffic congestion and narrow roads the space for parking is a serious issue, causing inconvenience to the residents there. The constant traffic also causes noise and air pollution in the area which may lead to health problems. The houses are placed next to each other with no consideration of MOS, because of which there is no open space and greenery to be seen in the vicinity. Water clogging is a major issue in rainy season.

Fig-13, Typical street of Ibrahimpura

The housing settlement of Khajurikaln is based alon side the main road. The main road is 6m wide with ample open space for vehicular parking and pedestrian movement. Because earlier it was all farm land there is ample amount of greenery in the vicinity, with good air quality.

Figure 14, The main road of Kajuri kaln with housing development in both the sides of road

VI. WASTE

A. SOLID WASTE MANAGEMENT

In order to maintain the proper sanitation system of Bhopal, which has an area of 648.24 square kilo meters, has been divided into 19 zones (85 wards) and cleaning works are being split into the health inspector in each zone / Swachcta in-charge is also placed. Health supervisor in each ward level, Sub-Sanitary Inspector set no. of sanitary employees are also kept. Everyday Health Department conducts sanitation works in two shifts 7:00 am to 10:00 am and from 2.30 pm to pm. On a regular basis garbage collection, sweeping, lifting garbage from the container through the sanitary workers and shifting them to trenching ground located in Bhanpur khanti is done through 169 vehicles. Each and every zone is supplied with 10 JCB, 14 Dumper, for lifting of garbage. Approximately 550 tons of trash a day from Bhopal is generated every day is brought to Bhanpur khanti.(4)

"Bhanpur khanti" is widespread in the area of approximately 75 acres of land situated in Bhanpur village located 11 km away from the Bhopal city. It was a primary municipal dumping site of the capital city "Bhopal" till 2018. (5)

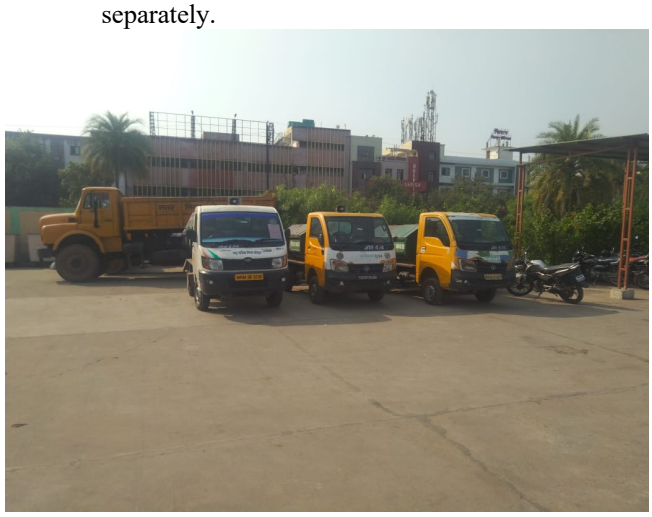
Earlier on the problem of solid waste management was a serious issue, because no one paid attention to the heaps of garbage getting accumulated in Khanti every day. Some other reasons are listed below -

- Poor public participation in waste segregation.
- Poor efficiency of waste collection.
- Inadequate maintenance of transport fleet, including underutilization of capacity.
- Inadequate sitting and mismanagement of landfills – not properly covered, no ring fencing to prevent entry by people and animals.
- Lack of financial resources for hiring adequate manpower, upgrading vehicle fleet, and adopting recycling technology.
- Illegal dumping of industrial waste at landfill sites in Bhopal.

IMPACT OF SWACCHA BHARAT MISSION

But after the Swaccha Bharat mission, intermediate waste segregation and compressing units were introduced in different parts of the city. Hence following steps were added to properly manage the waste and efficiently use it for recycling.

1. The door to door waste collection is done by vehicles which collect wet and dry waste separately.



2. The vehicle then comes to the waste segregation station nearest to their place.

3. The vehicles are first weighed in the below shown machine

4. The dry waste is then dumped into the compressor capsules and again the weight of the vehicle is noted to

calculate the amount of wet waste. The wet waste is sent into the third capsule from where it is sent to the manure making company.

5. Any other kind of waste which can be reused or recycled such as metal, shoes, plastics etc.

6. The compressed dry waste is then taken to khanti.

This process has reduced the amount of waste reaching Khanti and has increases the opportunity of recycling of waste. Many NGO's have also joined hands in the program.

URBAN FORM AND SOLID WASTE MANAGEMENT

Figure 2, Truck collecting agricultural waste from Khajurikaln

The waste generation in Ibrahimpura area is tedious because of the high amount of waste generated from the market place. The litter can be seen spilled over in the nearby spaces. Because urban sprawl of khajuri kaln does not come under any municipality, the door to door waste collection and disposal does not take place.

VII. PUBLIC SPACES

The public space like parks, culverts, congregation spaces are well built in STT Nagar stadium because of the ration of open to built-up spaces. In Ibrahimpura area the congestion does not allow peaceful congregation of people. Even in occasions of festivals the pandals are erected blocking the roads making congested spaces more congested. The khajurikaln area is not developed by nagar nigum hence there is no such park or gathering space, aside then a temple which is half built.

Figure 3, open spaces in Ibrahimpura are covered with temporary shops

Figure 4, Temple with stage and gathering space for festivals, parties and gatherings

Figure 5, Unbuilt temple in Khajurikaln

Figure 6, The building covered in green becasue of the lesser built up space and well planned buildings

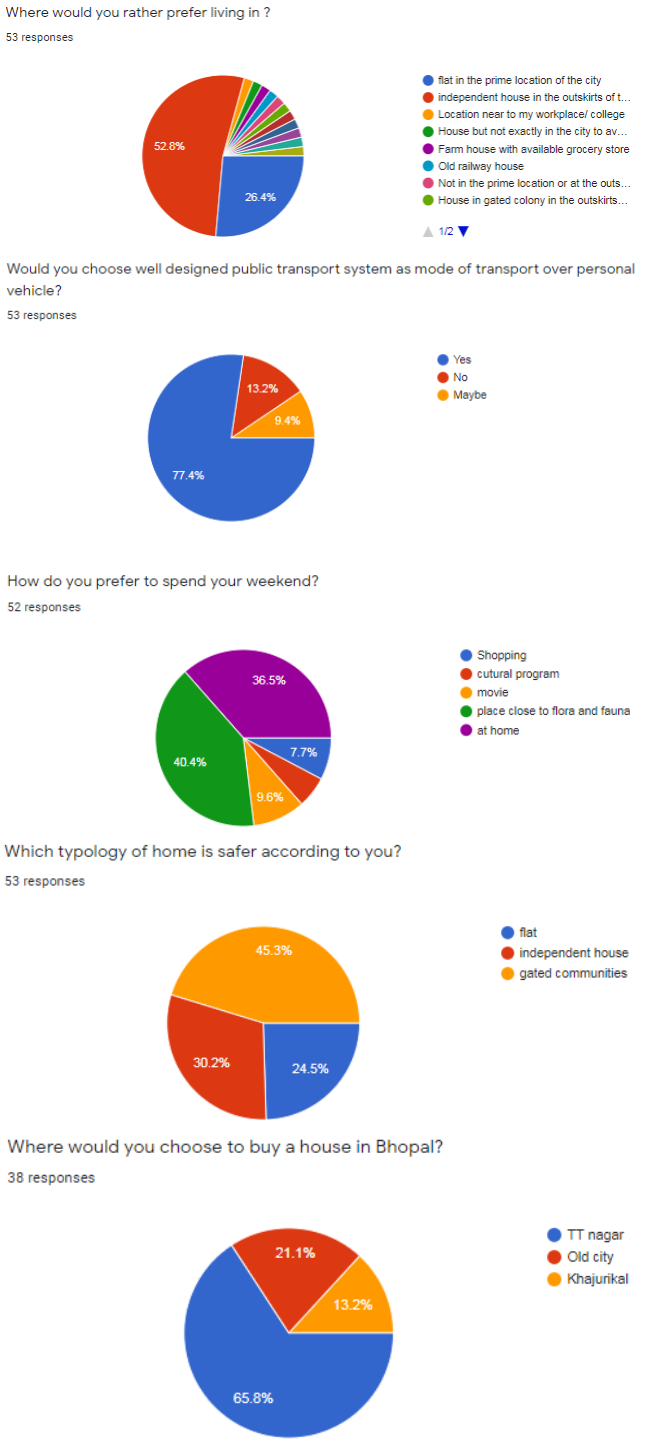
These photographs suggest that for the same occupancy of people, mid rise urban form, has a potential of lesser exploitation of land and more space for the greenery to take over if planned efficiently. STT nagar also has space for children to play freely and ample car parking space, which is seen absent in other two urban forms.

Figure 7, play area for kids in STT Nagar

Figure 8, agricultural land in the vicinity of houses, Khajurikaln

Figure 9, Pooja pandal blocking half road in Ibrahimpura

VII. PUBLIC OPINION



Taking reference from the online questionnaire done it can be observed that general public prefers STT Nagar to live over the other two areas and maximum public can reside in flats given the chance to stay in the center of the city. On their day of maximum people prefer to stay in the vicinity of greenery and open spaces. And using public transport as their regulars convince is acceptable to maximum population given the condition of public transport is up to date.

VIII. MEASURES TO ACCESS SUSTAINABILTY AND URBAN RESILIENCE OF AN URBAN FORM

A successful urban form is seen as the solution to housing the world's growing urban population in a way that protects productive and environmentally important land, reduces sprawl, minimizes travel (and thus emissions), and accrues the benefits of efficiencies of scale in providing housing, public services, and infrastructure. The main constituent subsystems, which affect the urban morphology, as well as total energy balance of the city

- Urban volume (built-up mass layer)
- Urban voids (open spaces, streets and etc.)
- Functional layer (land use layer)
- Transportation layer

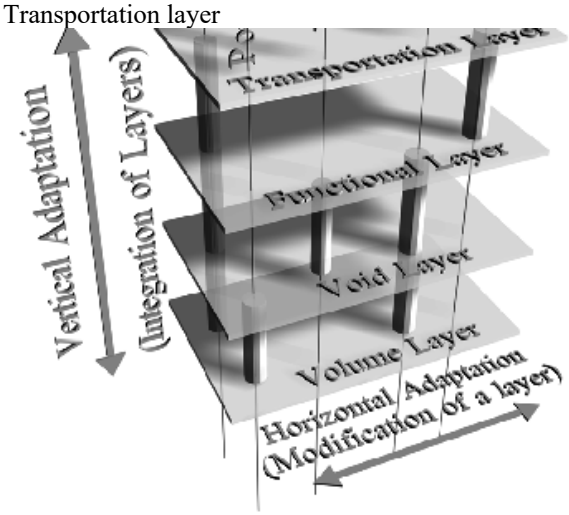


Figure 10, Schematic diagram visually representing determinants of an urban form (1)

KHAJURI-KALN

LAYERS	VOLUME	VOID	FUNCTION	TRANSPORT
VOLUME		POROSITY		
VOID				
FUNCTION				

SOUTH T.T. NAGAR

LAYERS	VOLUME	VOID	FUNCTION	TRANSPORT
VOLUME		POROSITY	PROXIMITY	EFFICIENCY
VOID			DIVERSITY	INTERFACE
FUNCTION				ACCESSIBILITY

IBRAHIMPURA

LAYERS	VOLUME	VOID	FUNCTION	TRANS PORT
VOLUME		PROXIMITY	EFFICIENCY	
VOID				
FUNCTION			ACCESSIBILITY	

IX. CONCLUSION

It is quite clear from the inferences drawn from that mid-rise buildings turn out to be better urban forms in terms of residential housing considering the three cases chosen. Primarily considering environmental factor, - we got to observe that solid waste management is easier in high rise if one has to propose an intervention for better management of waste because of a collective society, also because of ample amount of open space nearby treatment plants can be placed in the society. Secondly, if we consider transportation, because of location and nearby bus stand with good road network. It leads to lesser consumption of energy and because of convenient distance of travel; wellbeing of the person also improves. - Considering public spaces, because of comparatively lesser built-up area, there is a scope of creating interactive green spaces around the building which will increase the social wellbeing of people and reduce the pollution levels in the nearby spaces. It also has the scope to reduce urban heat island effect. If we consider the economical parameter of sustainability in terms of - Transport an affordable transport becomes a necessity for a larger group hence a nearby bus stand can be easily planned because it also increases the profits for bus services. And similar situations were observed in the high-rise patch of Bhopal. - Solid waste management is a lot easier in high-rise type urban form because cost of maintenance will not be high as more number of households will be involved. - Public access spaces are easier to build because of the availability of spaces nearby hence it becomes economical. If we consider the social parameter of sustainability in terms of - Transport and public access has a scope of lot of improvement in high-rise in comparison to other two urban forms - Solid waste management need a separate improvement structure irrespective of the land form, because social parameter majorly depends on the treatment process which has no relation to the urban form.

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