

High Density and its impact on City Infrastructure: Case of Old area of Pune city

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Abstract: *Increasing population is like a knock-on effect that affects every positive aspect of city's infrastructure. It leads to various problems like traffic congestion, poor housing, and degradation of urban environment. The old areas of city often attract population because of its good connectivity to employment centres as well as greater accessibility and mobility to other areas. In such areas, new high rise buildings are constructed replacing the traditional housing of ground and first floor structures on the plot area. This causes additional pressure of increased households on the existing services thereby leading to crowding in terms of per capita service used. Similar is the case of Prabhat road area, which is one of the oldest areas in the Pune city. It exhibits a changing character from low density traditional housing to high density high rise development. In this area, the service related issues have risen in recent years. Every service has a threshold, beyond which the systems will not function effectively unless they are expanded. It is thus necessary to assess the capacity of existing facilities and prevent its breakdown through provision of additional services or restricting uncontrolled growth.*

Keywords: *Population density, additional pressure, crowding, service threshold*

I. Introduction

The ability of a city or community to support and sustain its current population and anticipated growth is directly related to its infrastructure facilities. With increase in the urbanization rate, there is an increase in the population growth rate in the urban areas. This causes a necessity for provision of houses to the people. People prefer to stay in areas that are in vicinity to their work place, which is usually the central area of the city. The old areas of the city have better access to transportation and other significant facilities. They include a majority of old and dilapidated structures that were once occupied by single dwelling houses. Accessibility and availability of facilities are two important factors that influence the choice of housing for many people. (Ref iii) Due to increased demand of housing at this location, the old single storied structures are being replaced by high rise buildings without considering its effects on existing roads, water supply and other services. (Ref iv)

Need for study

As land is a scarce resource, high rise development is a favoured solution in the central areas to incorporate increasing population. This is reflected in the conversion of traditional housing typology to modern age tall buildings. Its construction is taken up as a redevelopment project with proper housing to the owner and incentive to the developer. The developer constructs the building without considerable setback as required for a high rise building. Moreover, the increased population density exerts additional burden on the

existing urban services that may lead to operational failure or complete breakdown.

The study area is majorly a residential area which was distinctly known for its traditional housing of single or two storied bungalow structures. These were located along both the sides of the road with plenty of open spaces, amenities and facilities sufficient for the residing population. But as the city grew, the demand for housing in this area also increased. The older residential structures were brought down for redevelopment purposes and high rise structures were constructed to accommodate the increased population. These structures were built on the same plot without the expansion of adjoining street or existing facilities. The width of the road remained same catering a population which is many times greater than what it was designed for. This extended the number of users depending on the use of existing facilities thereby contributing to problems related to transport, open spaces, utilities and services.

This paper discusses the effects of increasing density on transport infrastructure and water supply and sewerage facilities.

II. Growth of study area

The structural growth of Pune is brought about within a definite frame by variety of causes like geographical, political, social and economic factors. (Ref i) The changing conditions in the Deccan plateau have considerably influenced the growth of the city and today it is the product of both, the regional requirements and relations, and the growing needs of the city itself. By 1970s, Pune was divided into five morphological zones based on the emergent characteristics of the area: the old core, Cantonment Complex, outer residential extensions, industrial ribbon and the undeveloped area. (Ref ii) The study area is a part of the outer residential extension which includes Shivajinagar, Erandwane, (Prabhat road) and Karvenagar area. This zone developed after the introduction of the Town Planning (TP) schemes and so is better planned compared to other old areas. (Ref vi) Buildings with one or two stories with independent compounds were built post-independence. This building characteristic was predominantly prevalent till the last decade. Majority of the structures were bungalow type. The roads were planned with broad and straight access. There were ample of open spaces back then with low building and population density. The increase in population growth in the last years has decreased the open spaces in the area.

The growth of this area is linked to the establishment of the Deccan Gymkhana Club. The Deccan Gymkhana Housing Society was subsequently established around the club in 1926 to help develop the surrounding areas. Around 180 plots were part of this residential colony. (Ref x) People were reluctant to move out of the city to this locality and at first it was only the elite who constructed houses here. With the area offering a

sports club, a vegetable market and civic amenities, it soon became a much sought after residential locality. It was the great flood of 1961 when the Panshet dam burst that led the growth of this locality. The spread of the plague epidemic in the 20th century led to migration of people from the core areas to suburbs of Bhamburda and Erandwane.(Refi) After the First World War, a number of schemes concerned with basic urban amenities were taken up. This era marked development of the city through introduction of underground drainage scheme, electricity and construction of important arterial roads. The TP schemes were introduced for the first time in the city in these areas in 1930.(Refi, vi) The enforcement of strict rules and regulations made possible the growth of a really good residential locality. The TP schemes in these areas ensured laying down of a regular plan. This area gave the idea of space with a network of broad and straight roads which were designed based on the then population density of the area. Till the late 1980s the Deccan Gymkhana area was a serene, peaceful neighborhood with stately old bungalows along verdant avenues and plenty of open spaces. Once, considered as the heart of the cultural district with minimal activities, it is now abuzzing locality with numerous institutional and residential buildings, cafes, offices, hospitals, entertainment areas, restaurants and shops.

III. Area profile & Data Collection

The study area falls under the jurisdiction of the Ghole administrative ward which is geographically located between 18°N latitude and 73°E longitude. It is a part of Deccan Gymkhana area and the delineated area lies within the intersection of four main roads viz., Prabhat road, Law college road, Bhandarkar road and F.C road. The total area delineated for the study is 70.73 ha (7,07,354.67 sq.m). This area is similar to the core areas of Pune city in the context of traditional building types, accessibility and is on the verge of transforming into a high density area. It was developed as purely residential colony, but is now a prime location for commercial activities with various offices and shops emerging in the area. Though it is one of the planned areas, the effect of increasing density is reflected through the various issues. The data required for the present study was collected from the secondary and primary sources. The secondary sources included the government reports, news articles and expert opinions while the primary data included surveys like field mapping, road inventory, building typology, resident opinion survey and land use survey. For the resident opinion survey, a sample size of 200 residents was selected. The sampling technique used was stratified random sampling. The sample was divided into four groups based on the duration of person's residence in the study area. The stratum formed for the same were viz., residents staying for less than five years, five to ten years, 10 to 20 years and more than 20 years.

IV. Demographics, Land Use analysis

The population of Pune city has been growing tremendously in the last 20 years. The birth rate is high with a high immigration rate due to availability of opportunities like education, work, business, etc. With a hike in city population, there was increase in no. of households in the Ghole road administrative ward also as per 2011 census. The study area falls under Sector III as per Draft Development Plan of Pune-2007-2027. It is a non-congested area with moderate density.(Refvi) The total area of the study area is 70.73 ha. As per the data from draft DP, the gross density of this sector as defined for 2017 is 209 persons per Ha.(Refvi) The population

of the study area is 14,782. The total residential BUA is 63.79 Ha (6,37,932.47 sq.m) and residential FSI is 1.56.

Table for Land Use Classification

Sr. No	Land Use	Area (sq.m)	%
1	Residential	321556	44.19
2	Commercial	32781.98	4.52
3	Mixed Use	85778.86	12.06
4	Public Semi-public	50413.14	6.93
5	Recreational	87268.1	11.99
6	Vacant Land	2146.29	0.29
7	Transport	145601	20.01
Total Area		707354.7	100

From the above table, it is observed that the predominant land use in the area is residential (44.19%) followed by mixed use (12.06%). The recreational spaces like Kamala Nehru Park, Deccan Gymkhana and PYC ground are located in the central part of the study areas shown in figure 1 constituting to 11.99%. These attract traffic from the nearby areas thereby adding up to the existing traffic and leading to congestion during peak hours. The commercial use contributes to 4.52% of the study area which is observed along F.C road and Bhandarkar road. Important institutes like National Film Archive of India, Vimlabai Garware College, Symbiosis School and similar other educational institutes constitute to 6.93% of the total study area. It is to be noted that the land under transport use is 20.01% with every plot being accessible by more than one road.

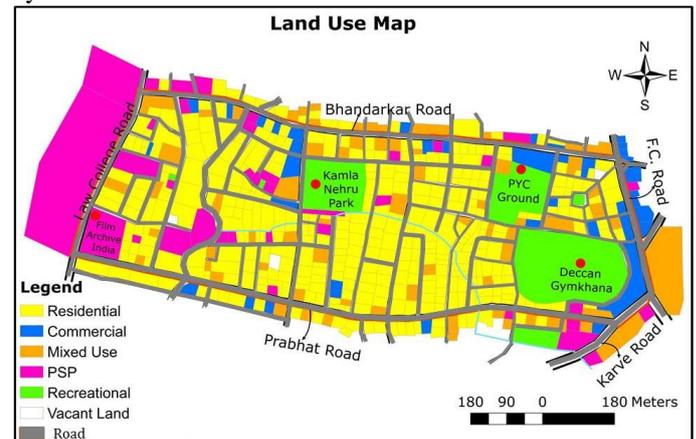


Figure 1 Land use map of study area

The accessibility to necessary amenities and facilities, recreational places, educational buildings and commercial spaces together make this area an ideal location for housing.

V. Crowding in terms of FSI

Societies at different levels of prosperity have different standards of consumption. This applies not only to commodities but also to something like floor space. Poorer societies manage with floor areas per person that would not be tolerated in a wealthier society. In order to measure and compare this variation in floor space consumption from one area to another, a metric called "Crowding" is used.(Ref ii) It is an inversion of the residential space taken up per capita. The important terms related to crowding include: Indoor Crowding (IC) = Persons/Built-up area, Street Crowding (SC) = Persons/Street Area, Plot Factor (PF) = Plot Area/Street Area.(Ref ii) Here, street area refers to the public, shared space, used for circulation of pedestrians. It excludes the area taken up by arterial traffic and on-street parking as it is not

available for local circulation. The calculated street area for the study area is 11.54 Ha (1,15,477.1sq.m)A significant relationship between the above mentioned terms can be established:(Ref ii)

$$SC = IC \times FSI \times PF$$

$$\frac{Population}{Street\ area} = \frac{Population}{Built\ up\ area} * \frac{Built\ up}{Plot\ area} * \frac{Plot\ area}{Street\ area}$$

The following is the relation between street crowding, FSI and plot density for the study area:

Indoor crowding(IC) = Population/BUA = **232 ppH**

Street crowding (SC) = Population/Street Area= **1280 ppH**

FSI=BUA/ Plot Area= **1.56**

Plot Factor (PF) = Plot Area/Street Area= **3.54**

Plot Density (PD)=IC X FSI = **361 ppH**

It can be observed that the indoor crowding is 232 ppH, which means 232 persons can be occupied in 1 ha=10,000 sq.m. This implies one person occupies 43 sq.m of the BUA. Keeping the indoor crowding same, if the FSI is increased to say 2, then the plot density will increase from 361 ppH to 464 ppH leading to an increase in persons per plot area. If the street layout remains the same, i.e if the roads are not widened or if no alternate road is proposed with no change in plot factor then SC increases to 1643 ppH. Accommodating more people on a plot (by raising its FSI) means there should be provision for more road space for these people and more area for other facilities. The higher the FSI, the higher the proportion of land needed for public use. We should choose an optimum density for the city, not too crowded and comfortable to live in and accordingly the facilities should be expanded. Increasing FSI alone, without enlarging road systems and public facilities, will only diminish the facilities. It worsens living conditions, with no long-term gain.

VI. Building survey & analysis

Due to the outward movement of the people who preferred to have bungalows in the outskirts of the city (today's Erandwane, Shivajinagar and Parvati area), the percentage of large and spacious houses having more than five rooms increased. The height of the buildings decreased from the old core with two-three storied buildings to one story and ground floor structures in the newly developed areas. The building conditions in the old areas was unsound while in these newly planned areas, the condition of buildings with reference to sanitation, ventilation and congestion was satisfactory as they were provided as per the population needs.

In order to understand the present building characteristics, building survey was carried out in the study area. The type of structure, their age and height was noted. It was observed that 33% of the residential structures along Prabhat road are old traditional bungalows that keep intact the peculiarity of the area. Majority (50%) of the buildings fall under the category of medium aged structures which are constructed in RCC unlike the old structures where stones were used extensively. These are observed mostly along Bhandarkar road. 16% of the buildings are newly constructed and 1% are under construction.

16% of the structures are more than 40 years old. 34% structures are 10-20 years old while 25% of total structures are newly constructed in the last 10 years predominantly seen along Prabhat road.

Only 1% of the total buildings are ground floor structures that mostly include bungalows and row houses. G+ 1 structure

constitute to 30% while G+2& G+3 structures contribute 22% each respectively and are observed along Bhandarkar road. 15% comprise more than four story structures that are constructed in the last 10 years.

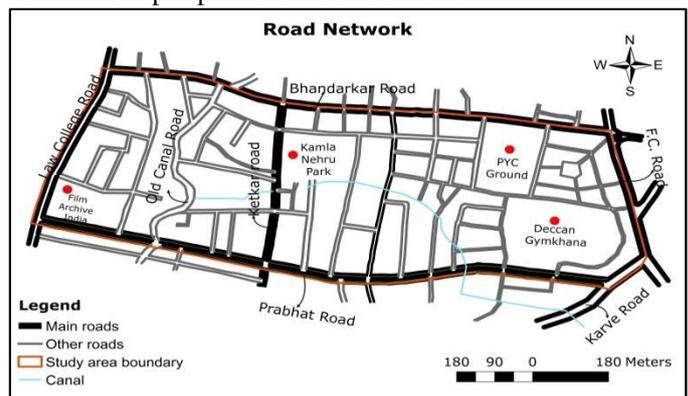
Thus, it can be inferred that structures on Prabhat road depict the early style construction which is gradually being replaced by new buildings. Also, as the old structures are being brought down, the percentage of redeveloped structures is increasing. The changing height of the structures helps in understanding the modifying skyline and the new development of high rise buildings. The recent structures are higher buildings means increasing density on the same plot of land.

Details	Journey speed (kmph)	V/C ratio & LOS
Prabhat Road	15-25	0.9, LOS E
Bhandarkar Road	10-20	>1, LOS F
Ketkar road	20-25	0.6, LOS C
F.C road	10-20	>1, LOS F
Law College road	10-20	0.9, LOS E

VII. Review of transport infrastructure and utilities & services

Road Transport

With increase in population and urban functions, there is a corresponding increase in the volume of traffic and the vehicles carrying them. Presently, the routes that pass through study area are through roads that connect two different parts of the city. In the past, the road system was designed to meet the demands of pedestrian traffic and lesser vehicles. Thus, increasing traffic pressure on the roads is observed which results in congestion. The volume as well as the character of traffic has out-grown the capacity of the road system. It is thus not able to cope up with the modern rush of the traffic.



Map of road network in study area

The traffic composition on all the routes includes two-wheeler, four-wheeler, autos, public transport and school buses except Ketkar road which does not carry any heavy traffic. The footpath is present on both the sides for all roads except Ketkar road as it is an internal road with abutting residential use. However, parking on either side of the road reduces the effective width of carriageway. Encroachment due to vendors and vehicular parking on footpaths further reduces its width. All the roads are two way except FC road which is one way. The following table gives details on inventory, Volume/Capacity Ratio (V/C), Level of Service (LoS) based on primary data:

*Footpath width- each on both sides

**Parking-only on one side of road

From the opinion survey, it is observed that traffic congestion during peak hours is the major issue. The reasons include: on-street parking, parking of school buses on the main road and adjacent lanes as well as through traffic moving on the main roads. One of the associated issues to traffic congestion is pollution which is the major concern of residents near the Kamala Nehru Park area.

Inferences from traffic & transport study:

- Narrow width of Prabhat road and Bhandarkar road as compared to its function.
- On-street parking of vehicles by residents as well as other heavy vehicles.
- Lack of dedicated parking facility for Kamala Nehru Park leading to haphazard parking.
- Non-uniform width of footpath along the main roads.
- Misuse of footpath due to encroachment by vendors and vehicular parking.
- Increase in pollution levels near Kamala Nehru park.

Water Supply and Sewerage system

Water supply is a vital factor in the location and growth of a city. The water supply in the early stages of the city was from wells and rivers. Though there was no organized supply, it could cater the existing population. Scarcity of water was first felt during 18th century because of increase in population. But with construction of dams, these needs of water supply were met. The PMC presently provides piped water supply of about 1250MLD, covering almost the entire city. The water supply is made through the pipe network of about 2700 km. (Ref iii, ix) The average water supply at city level appears to be adequate. However, the spatial distribution is uneven, and in some areas below average. (Ref vi) The network in parts of the city is very old, and high leakages are prevalent. About 30% of the water distribution network (750 km) is more than 40 years old in the old areas of the city (Ref viii, ix) which includes the study area. These pipelines were designed for the then existing population and so the rapid increase in the last decades has put a pressure leading to various issues.

The Erandwane STP, which is located near Mhatre Bridge, has a capacity of 50 MLD and is functioning since 2004. The sewage from Erandwane, Kothrud, Warje, Karvenagar and Paud Road is treated in this plant. The total area served is about 26.15 sq. kms. (Ref ix) As per the secondary data, in the Ghole road administrative ward, all the houses/residential societies have 100% underground drainage connections. (Ref ix) But these lines have not been expanded in the recent years which have caused problems in certain areas. From the opinion survey, it is found that in some places, there are frequent repairs from channel blockage leading to foul odour. With increasing population in the area, there will be rise in the sewage generation leading to insufficiency or breakdown of existing capacity of the STP.

The water scarcity issue requires a long time to be addressed and thus gradual increase in population over many decades would then put pressure on existing water supply if not upgraded. Similar to water scarcity issues, the outburst of sewage pipelines and other problems are not immediate and require a long time to be addressed.

Inferences from water supply and sewage study:

- Water distribution network in the study area is older than 40 years causing frequent repairs and leakages.

Details	ROW (m)	Footpath*(m)	Parking* (m)	Carriageway (m)
Prabhat Road	13	1.5	2.5	7.5
Bhandarkar Road	14	1.5	2	9
Ketkar road	12	(One side)1	2	8
F.C road	21	2	2.5	14.5
Law College road	18	1.5	-	15

- High rate of water supply –resulting in higher sewage flows.
- No expansion in the existing pipelines or provision of alternate lines for water supply and sewage.

VIII. Findings from the study

- The study area is predominantly a residential area with educational institutions that attract population all over the city.
- Increase in plot density due to increase in FSI, reduces the per capita service use if the services are not expanded.
- With increase in FSI and no change in the street layout, the population per street area increases leading to street crowding.
- Out of the total structures, 16% are newly constructed buildings that define changing character and the modern aspect of high rise housing.
- The road network of the area was developed as part of TP schemes and thus every main road has a parallel road.
- The Prabhat road and Bhandarkar road function as primary roads and carry through traffic but are narrow in width.
- The on-street parking by the residents and other public vehicles reduces the width of the carriageway.
- Ineffective width of the footpath, encroachment by vendors and parked vehicles lead to disruption in pedestrian circulation.
- Repeated excavation of roads damaging the underground utilities and disturbed road level.
- The water distribution network in the old areas is old and requires frequent repairs.
- The present sewage system is not sufficient as it causes bursting and clogging of lines in certain areas of the study area.

IX. Conclusion & Recommendations

Density, land use, built-up and infrastructure status are key parameters which influence the urban physical structure of the area. (Ref vii) The increasing density has put a strain on existing road services which is beyond their threshold capacity. If sufficient infrastructure provision is not done with projected requirements, the existing system will quickly be overtaxed leading to subsequent high municipal costs.

Recommendations

- Planning for the basic services before allocation of houses to people can prove to be a 'right way of development' in shaping the urban landscape and managing cities effectively.
- Fixation of density norms should be based on carrying capacity analysis focusing on parameters - space/person, access to facilities, available services per capita, etc.
- The task should be settlement specific.
- The FSI in the study area is bound to increase in the recent years considering the housing demand. In this regard, the strategy to facilitate housing and infrastructure development should be of critical importance.
- Cluster development is one of the solutions to the required micro planning of areas. (Ref v)

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