Flexible and Environment Responsive Mass Housing in Bangalore, India

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ABSTRACT

Bangalore is one of the fastest urbanizing cities in India due to rapid increase in population and migration of people from varied and distinct cultural backgrounds. This has resulted in rapid development of high density housing characterized by towers of repetitive units. Most modern housing developments are focused on the repetition of units suitable for an average dweller, without taking into consideration the diverse and dynamic needs and wants of individuals and society.

What is ironic is that for centuries now, most societies have produced housing it requires, naturally and indigenously. The traditional vernacular architecture has always been in empathy with the environment.

This project develops options for a prototype housing unit and tests it by an analysis using the TAS software package for achieving flexibility without compromising on natural ventilation. It then develops a residential cluster which can be used as a model for future developments in Bangalore.

INTRODUCTION

India is urbanizing at an unprecedented rate due to an immense increase in population and migration of people from distinct cultural backgrounds and traditions from the suburbs and villages into cities. This has resulted in rapid high density housing development in the city resulting in towers of repetitive units. Migration has given rise to more mixed-cultural societies. These residents from varied cultural backgrounds and traditions, therefore, require residential areas or spatial configurations of apartments to be adaptable, comfortable and culture friendly for a better living. This cultural heterogeneity demands a different approach to housing. Also, the current housing industry is very limited when it comes to catering for long term social needs. It is crucial to take into consideration the different needs and patterns of individuals or each family.

While traditionally most buildings fundamentally responded to the climate, in the recent times, the dependence on mechanical heating and cooling devices has increased immensely, bringing about a change in the housing form and also the lifestyle of the people. Energy consumption in the building sector alone is more than one-third of the national energy use in India (Plea, 2013).

In architect Charles Correa’s words:

“In a third world country like India, we simply cannot afford to squander the kind of resources required to air-condition a glass-tower under a tropical sun.” (Correa, 2012, p.21)

India being home to diverse climatic conditions and energy availability being scarce it is important that buildings use passive means rather than mechanical air conditioning and heating. The term 'passive' refers to those design techniques which, in order to enhance thermal comfort, utilize the favourable and

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minimize the unfavourable elements of the local climate.

This project aims at developing a prototype for urban high-density mass housing to accommodate passive design features while providing flexibility in design to cater to the varying cultural backgrounds of the migrant population in Bangalore and assessing it using TAS software package.

The objective is to develop a flexible unit to suit the demographics and the changing family needs. The current housing industry is very limited when it comes to catering for long term social needs. It is crucial to take into consideration the different needs and patterns of individuals or each family. Currently most mass housing in the city are being taken up by commercial real estate developers resulting in high rise structures with repetitive units.

CONTEXT

Bangalore, situated in the south of India, is the third most populous city in the country with a population of 8.4 million. It is located at 12.97°N 77.56°E with an average elevation of 920m on the Deccan Plateau.

The climate of the district is classed as the seasonally dry tropical savanna climate. Bangalore experiences a pleasant climatic condition, with occasional heat waves during the summer. In summer the temperature goes up to 38°C during the day and falls to 20°C at night. In winter the maximum temperature goes up to 27°C during the day and goes below 17°C during the night (Pib, 2008). The primary wind direction in Bangalore is south-west. During the months between January and March and October and December the wind direction is from north-east to south –west and between April and September it is from south-west to north-east.

The design criteria in this zone are to reduce heat gain by providing shading, and to promote heat loss by ventilation. Bangalore being located on a relatively higher altitude experiences a pleasant climate and does not require mechanical cooling for most part of the year. Effective ventilation and air circulation can cut down the energy needs in the city.

The city, earlier, known as the “Pensioner’s paradise” is now India’s Silicon Valley with the unprecedented rapid growth caused by the boom of the Information Technology sector. Also, various MNCs have set up their R&D centres in Bangalore, attracting young professionals in search of career or entrepreneurship (Forbes India, 2014).

As a result of the migration from other cities and town, the demand for housing has really gone up in the city, mostly in the rental market. Bangalore witnessed the launch of 35,000 residential units in the year 2012 and nearly 8,100 in the first quarter of the year 2013 (The Hindu, 2013). However, the current housing developments follow a trend of “cloning”, where the developments are focused on the repetition of units suitable for an average dweller, without taking into consideration the diverse and dynamic needs and wants of individuals and society.

The potential occupants of the residences mostly being young professionals migrating from other cities, an ideal solution would be to incorporate flexibility in the planning to suit the different lifestyles and also provide for incremental growth in the housing. Also, the demand for rental properties being high, flexibility in the planning would help cater to a diverse crowd. For instance, the potential residents may vary from a group of individuals sharing a unit to a newly married couple or a growing family.

Living Arrangement in India

The living arrangement in India traditionally has been a multigenerational household where it is the duty of the child, especially the male, to provide parental support in their old age. Nowadays the shift in the demographics such as migration for employment has resulted in children leaving the residences shared with their parents and has resulted in many nuclear families in the city.

For instance, 73.6% of the household in this state are working couples and these young working populations mostly take up studio apartments as a temporary base and move out to a bigger place after a few years when the family expands or when the elderly parents move in with them.

Figure 1 Living Arrangement in India (Source: Authors)

In Bangalore, in the past few decades, it has mostly been plotted developments where people buy the land and develop their house according to their requirements.

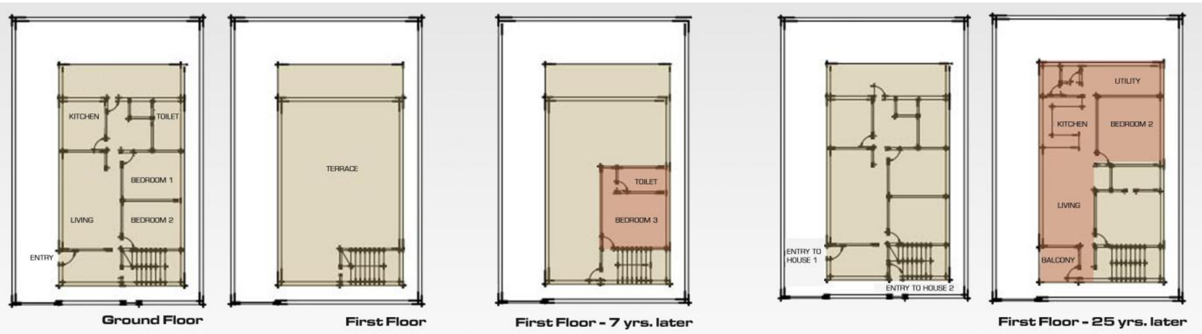

Figure 2 Example of a plotted development (Source: Authors)

Site

The site measures 1.6 acres and is located in South Bangalore, situated off Bannerghatta Main road, on Ranka Colony Road. Ranka Colony Road is developing to be one of the busiest roads, connecting Bannerghatta road to rest of South Bangalore.

Figure 3 Site Location and surroundings (Source: Authors)

DESIGN

Concept

The design attempts to bring together flexibility and passive design strategies in a prototype housing unit providing for expansion and division within a mass housing to suit the Indian living patterns. The design comprises of group housing with set defined boundaries for each housing unit.

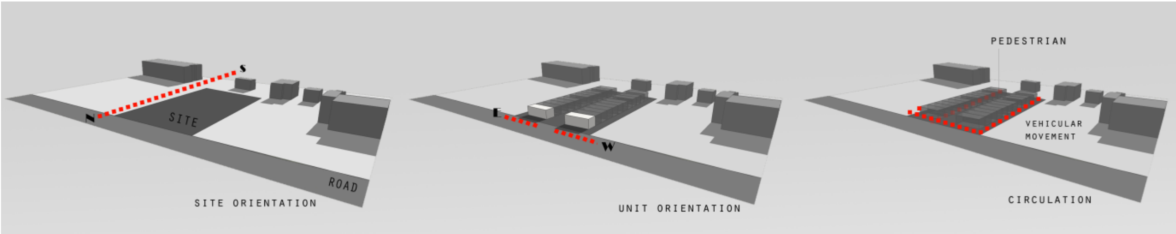

Figure 4 Orientation (Source: Authors)

The basic form was developed based on certain passive design strategies suitable for the tropical savanna climate of Bangalore.

- Orienting the longer façade in the North-South direction as east and west façade receive higher intensity of solar radiation throughout the year.
- Shading the east and west façade by staggering the units.
- Facilitating stack effect, which is very effective in the Bangalore climate.
- Taking advantage of the predominant wind originating from the east and west direction by having more openings in that direction, maximizing cross ventilation
- Possibility for controlled adjustable shading on the east and west façade.

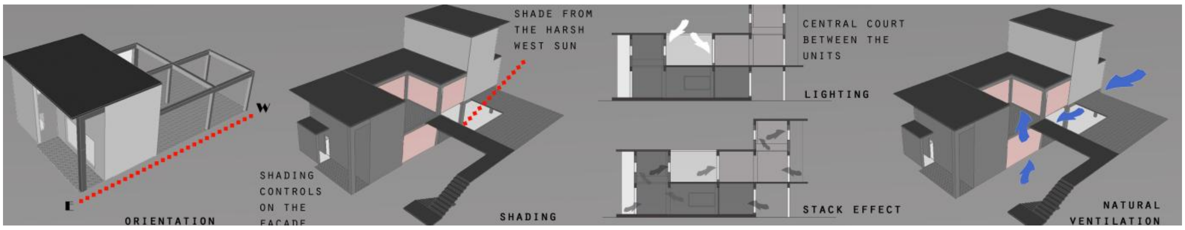

Figure 5 Passive Design Strategies (Source: Authors)

The concept of flexibility has been worked upon based on the ideology of providing a framework and giving indication to the possibilities of spatial arrangements. Initially, all units have the same basic essential form along with a steel frame structure for future expansion. The frame structure sets the boundary of the unit and gives the occupants the freedom to expand at their convenience and also to decide the materials for the infill. When it is just a basic unit, the open spaces enclosed by the frame, serve as a garden space or a backyard for the house. The framed structure forms a grid plan allowing the occupants to construct anywhere along the grid forming arrangements to suit their requirements. The planning has been done in such a way that each unit has its own court and once the unit is fully expanded, it encloses the court.

Also, two units have been interlocked together to develop a pattern of massing to achieve high density housing. At the same time, the upper unit shades the lower one from the harsh west sun. Also, the arrangement provides for unblocked cross ventilation as shown in figure 5.

In the case of a contraction in the family size, there is the possibility of dividing a single unit into two small units which can be used as an office space or a studio apartment.

The frame structure defines the boundary for each unit providing three grids for future expansion with the fourth grid serving as an open court all throughout.

Also, the units have fixed entries, even upon division.

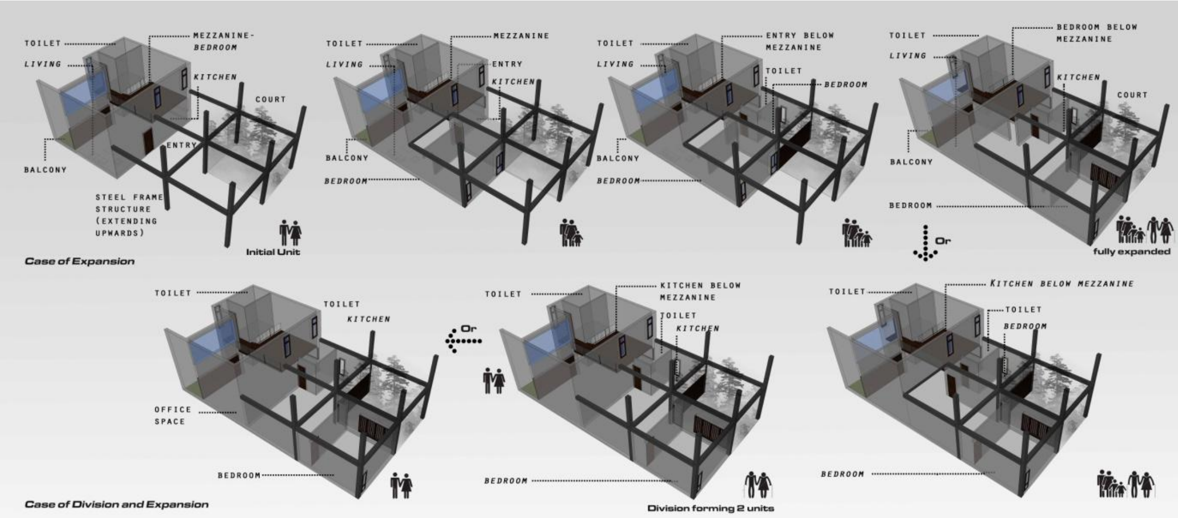

Figure 6 Cases of Expansion and Division (Source: Authors)

The above image shows the possibilities of arrangement as the unit expands. The first is the basic unit with a kitchenette space and a toilet and a mezzanine space which can be used as a bedroom. This would suit a single occupant or a couple.

As the family expands and requires more space, the unit can be expanded by constructing along the grid as seen in the second, third and fourth case where the unit can be transformed from a studio apartment to a three bedroom housing unit.

However, if the family contracts, for instance, the children move out and the elderly parents are the only occupants of the unit and they do not require so much of space, the unit can then be divided into two. This can be done by constructing a wall between the basic unit and the expanded wing forming two units with separate entries.

Massing

The massing in this context has been worked out along a central pedestrian pathway with the interlocking housing units on either side, while the vehicular movement has been restricted to the periphery. Also, the units on either sides of the central path have been staggered to maintain privacy in all the units.

The central pedestrian route opens up to several shared courts which lead on to the private courts of the housing units.

The prototype units can be arranged to form different types of massing ranging from row housing to low-rise apartments and high rise apartments where there is a space constraint.

PASSIVE DESIGN STRATEGIES AND ANALYSIS

TAS software

The software is split into three main programs, the 3d Modeller, Building Simulator and Results Viewer. As the first step, the 3d modeller is used to create the building model for simulation. Here, the different spaces are assigned different zones.

Next, the model created is exported to the building simulator. In this program, the building components are assigned its materials. Using this program, one can choose which apertures are open, when and by how much. The internal conditions are assigned for the different zones depending on the number of people occupying the space and considering factors such as lighting, etc.

Once all the information has been entered, the model is exported to the result viewer. Here, any number of parameters such as relative humidity, dry bulb temperature, etc. from any number of zones or surfaces can be displayed and compared in a tabular and graphical format.

Parameters considered:

Materials

External and Internal wall – Brick wall
Floor Slab – Concrete
Window frame – wood 50mm width

Aperture type and schedule

The stack windows in the double height space were considered to be open all through the day. The windows in the main living room were kept open during the day from 7:00 to 10:00 and in the evening from 17:00 to 19:00. The bedroom windows were considered to be open during the night from 18:00 to 07:00.

Finally, in the Result Viewer the dry bulb temperature for all the zones were compared to study if it was within the comfort range. This was repeated for the different stages of flexibility.

Comfort Range

For all climate and building types, the National Building Code of India specifies the use of two narrow ranges of temperature: summer (23–26 °C) and winter (21–23 °C), (BEE, 2005). These standards are based on ASHRAE standards, which are not validated through empirical studies on local subjects. However, India experiences diverse climates, thus it is not proper to define a single comfortable temperature for the entire country, as it would vary region wise.

Based upon a comfort survey conducted all over the world, a relation has been derived between comfort temperature (Tc) and outdoor temperature (T0) [3] as

$Tc = 12.1+0.53T0$.

Another relation was obtained for Pakistan which has almost similar climatic conditions as in India as

$Tc = 17.0+0.38T0$.

Where,

Tc is comfort temperature and T0, mean monthly maximum and minimum external temperature. (Chandel and Aggarwal, 2012)

Based on this relation, the comfort range for Bangalore for the month of May was calculated to be 26°C - 29°C and 24°C - 28°C for December.

The analysis has been carried out based on both the comfort ranges, the one based on the ASHRAE standards and the one derived from the equation.

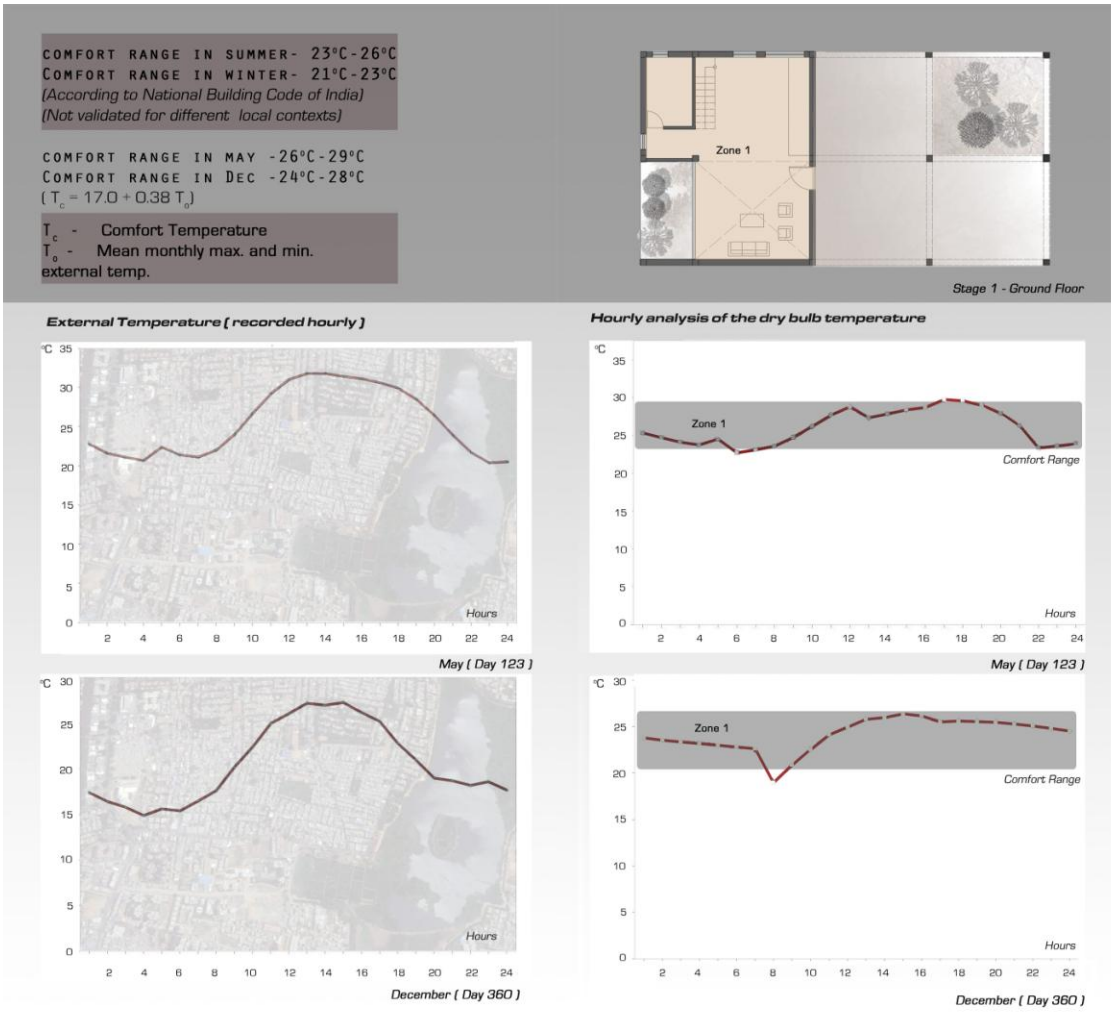

Figure 7 Variation in dry bulb temperature in a basic unit (Source: Authors)

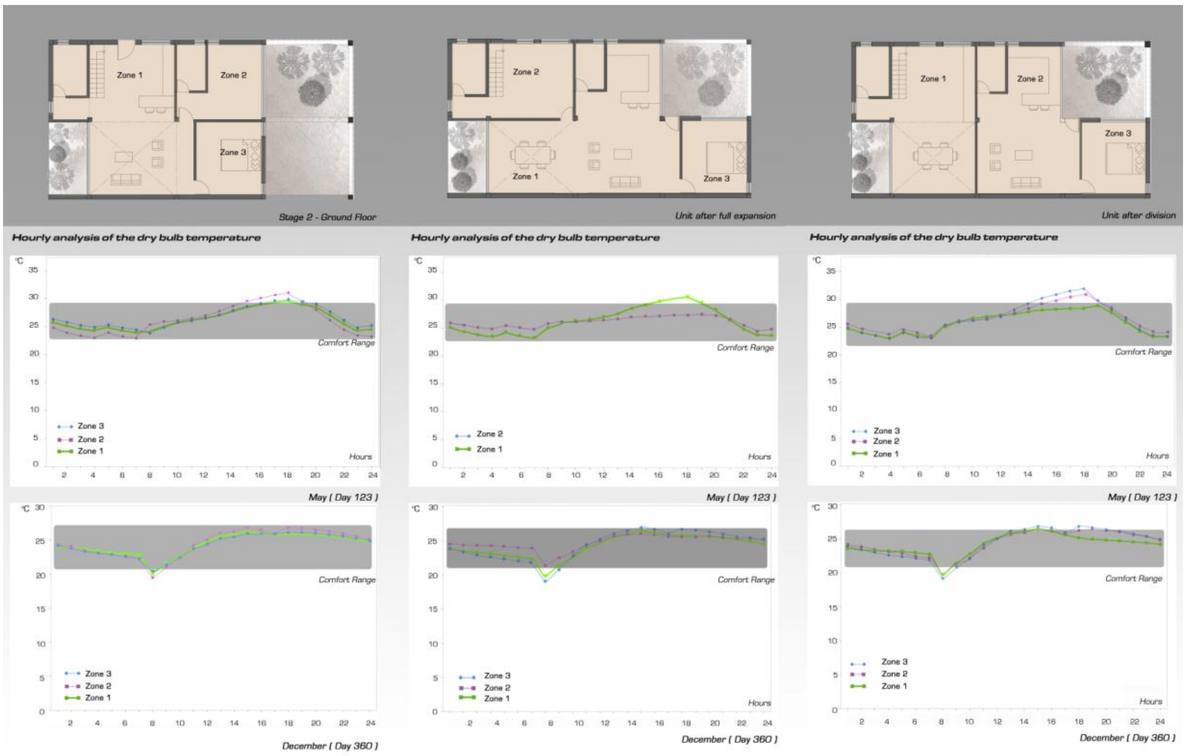

Figure 8 Variation in dry bulb temperature after expansion and division

Design iterations

First, the basic unit was simulated and it was observed that the double height space helped reduce the dry temperature within. However, it was more effective when the outlets where at the highest point and the inlets were narrow. From a comparison of the dry bulb temperature of the internal zones, it was observed that the temperature in the mezzanine was always maintained at a higher level making it an ideal zone for winter time.

Also, it was observed that the temperature within reduced with the addition of a covered balcony on the west façade. And as the housing unit expanded, the temperatures in the rooms were maintained within the comfort range when the central portion of the unit was left open with no partitions.

CONCLUSION

In a country like India, the cultural heterogeneity and the changing living patterns demands a flexible approach to housing. Also, energy consumption in the building sector alone is more than one-third of the national energy use in India. India being home to diverse climatic conditions and energy availability being scarce it is important that buildings use passive means rather than mechanical air conditioning and heating.

In terms of the factors contributing to the success of a flexible housing, most often a combination of both use and technology prove to be more effective as seen from the case studies. When the method of flexibility is just confined to the interior of an existing shell, the amount of choice and control of the occupants get limited. From the scale of a single housing unit to mass housing, with careful consideration of use and technology without much additional costs and over complicated technological systems, flexibility can be achieved successfully.

Coming down to the project, in a climate like Bangalore's with careful planning and by adopting climate responsive strategies, the energy use in the residential sector can be cut down drastically. It is evident from the TAS energy modelling analysis that the indoor temperature can be maintained to suit the comfort of the occupants without depending on mechanical cooling systems.

In terms of flexibility, the frame structure defines a boundary for each of the unit allowing it to expand or contract without affecting the neighbouring units much. Also the prototype design of the unit can be adopted to develop a variety of housing types such as row housing, high rise or even just a group of four houses.

REFERENCE

Chandel, S and Aggarwal, R. (2012). Thermal Comfort Temperature Standards in Cold Regions. Retreived from: http://www.omicsonline.com/open-access/thermal-comfort-temperature-standards-for-cold-regions-2090-5009-2-106.pdf.

Correa, C. (2012). A Place in the Shade: The New Landscape & Other Essays. Germany: Hatje Cantz

Forbes India. (2014). Mumbai vs. Bangalore. Retreived from: http://forbesindia.com/blog/beyond-the-numbers/mumbai-vs-bangalore/

Pib (2008) Climatic Zones and their Characteristics. Retreived from: http://pib.nic.in/newsite/erelease.aspx?relid=42191

Plea2014. (2013). Goals and Themes of PLEA 2014. Retreived from: http://www.plea2014.in/

The Hindu. (2013). Rental Housing market booming in Bangalore. Retrieved from: http://www.thehindu.com/todays-paper/tp-national/rental-housing-market-booming-in-bangalore/article4802302.ece