

# The Typologies of Urban Mixed Landuse: Their Characteristics, Geographical Applicability, Regulations and Prevalence in Pune, India

POULOMEE GHOSH\*  
PRATAP RAVAL\*\*

## ABSTRACT

*Mixed landuses are extensively promoted in the contemporary urban planning concepts and policies. In many cities like Pune, mixed landuse is a natural phenomenon existing without being a regulatory compulsion. The form and extent to which different uses mix can vary extensively, giving rise to various mixed landuse types. It gives the opportunity to observe and research the various types in which mixed landuses occur. This research, through literature review and field observations, has defined the mixed landuse typologies. The applicability of the typologies at various geographical scales is discussed. Observation in the three neighbourhoods of Pune, revealed that the vertical and horizontal mix is prevalent along with single-use. There is a certain amount of neighbourhood mix in all three neighbourhoods. Unplanned mixed landuse where originally designed spaces for residential use is being used for non-residential use is also dominant.*

**Keywords:** *Mixed Landuse Typology, Applicable Geographical Scale, Mixed Landuse Typology Prevalence, Planned and Unplanned Mixed Landuse*

## INTRODUCTION

Mixed landuse is a contemporary planning strategy promoted in many urban planning policies such as smart city, new urbanism,

---

\*Assistant Professor, National Institute of Construction Management and Research, Pune, India. Email: pghosh@nicmar.ac.in

\*\*Professor, Department of Civil Engineering, College of Engineering, Pune, India. Email: pmr.civil@coep.ac.in

compact city and 15-minutes city (Pisano, 2020; Zagorskas, 2016). The popularity is due to the mixed landuse character of co-locating various uses, thereby reducing travel distances and increasing social connection (Jacobs, 1961; Grant, 2002; Bahadure & Kotharkar, 2015). Cities have been traditionally mixed settlements with homes and workplaces located within walking distance. The segregated single-use zoning and planning practised since the industrial revolution to protect homes from the impoverished environment around factories prevented the natural and synergic mixing of uses and made the cities automobile-dependent (Herndon, 2011). Post-World War, as city cores declined, single-use zoning faced criticisms of being unsustainable and socially non-conducive (Grant, 2002). Jane Jacobs's book '*The Death and Life of Great American Cities*', published in 1961, portrayed the social relevance of mixed landuses and criticised single-use zoning. This book became the genesis of the revival of mixed landuse in urban planning practices. Since then, mixed landuse in the western world has been encouraged as urban infill, urban renewal, and improved neighbourhood quality strategy (Vreker, et al., 2004). Mixed landuse in this context can be defined as '*the extent of coexistence of non-residential uses with residential use in an integrated way within walking distances of homes*' (Hirt, 2007).

In Indian cities, the mixing of landuses is a natural phenomenon occurring without being a regulatory compulsion. The city's central core, developed before colonisation, is traditionally highly mixed with a high density of commerce and residences (Spodek, 2013). In contrast, areas developed during the British occupation, have very low density that now houses institutions. The plague in 1896 was associated with poor hygiene and overcrowding in the core areas of the cities, calling for decongestion and segregation. But, owing to the visit of Sir Patrick Geddes in 1914, the foundations of the present-day city planning in India were set, allowing natural mixing of uses (Guha, 2020). He deeply appreciated local culture, heritage and architectural form and advocated for careful restructuring of human habitat and life rather than *ad-hoc* redevelopment. Today's planning practice in Indian cities allows self-led development guided by liberal development plans (Dave, 2010). However, in recent times mixed landuse is being formally recognised in Indian city planning in its Smart City Mission (MoHUA, 2016) and Transit-Oriented-Development Policy (MoHUA, 2017). As it gets formally included in the planning process, the nature or typology of the existing mixed landuse that has naturally evolved must be understood and appropriately managed, promoted or controlled for effective development of implementation methods. The article fulfils the need to define mixed landuse typology and examine the laws

governing their predominance. The implementation of mixed landuses is influenced by many social, cultural, and historical facets of a city (Rowley, 1996). Mixed landuse is not the actual use of land but refers to mixing various other defined landuses. The types, proportions and forms of the different landuses are vital for mixed landuses. If the right balance in mixing the uses is not met, residents may have to suffer from lower housing affordability, noise, litter, privacy, etc. (Mouratidis, 2019; Moos, et al., 2018; Neuman, 2005). In India, in the absence of stringent regulations, the problems associated with mixed landuse can become more intense and diminish its benefits (Dave, 2010; Kotharkar, et al., 2012; Williams, 2004).

To have a conducive mixed landuse, it is essential to understand the various components of mixed landuses. Rowley (1996) and Hoppenbrouwer & Louw (2005) discuss the urban factors that influence mixed landuses such as density, grain, layout, permeability and public policy. Other components of mixed landuse discussed in the literature are – 1) the geographical scale of consideration (floor of a building, plot, street, block, neighbourhood, city or region) (Rodenburg & Nijkamp, 2004); 2) the quantifiable intensity of mixed landuses (Manaugh & Kreider, 2013; Gehrke & Clifton, 2016; Song, et al., 2013); 3) the actual uses and their subcategories that are mixed (multi-home apartment, single-family home, barber shop, stationery shop, school, manufacturing industry, etc); 4) The typology of mixed landuse (the design form in which different uses are integrated) (Hoppenbrouwer & Louw, 2005; Narvaez & Penn, 2016). Although there is considerable literature regarding components one and two, they are rarely used as legal implementation tools. The third component is extensively regulated across cities worldwide in the form of the zoning – landuse matrix. But, there is very little literature on defining the fourth component, the mixed landuse typology, in literature. This paper aims to fill this research gap by defining mixed landuse typologies, especially for developing nations like India.

### **Methods and Materials**

First, the mixed landuse typologies mentioned in the literature were reviewed. Based on the literature, theoretical mixed landuse typology is defined. Second, the applicability of these typologies in different geographical scales was checked. Third, the mixed landuse typologies in the three selected neighbourhoods of Pune were mapped. Fourth, the prevalence of the mixed landuse typologies in the neighbourhoods was analysed. Lastly, the implication of the planning regulations on the typologies is discussed.

### **Literature on Mixed Landuse Typologies**

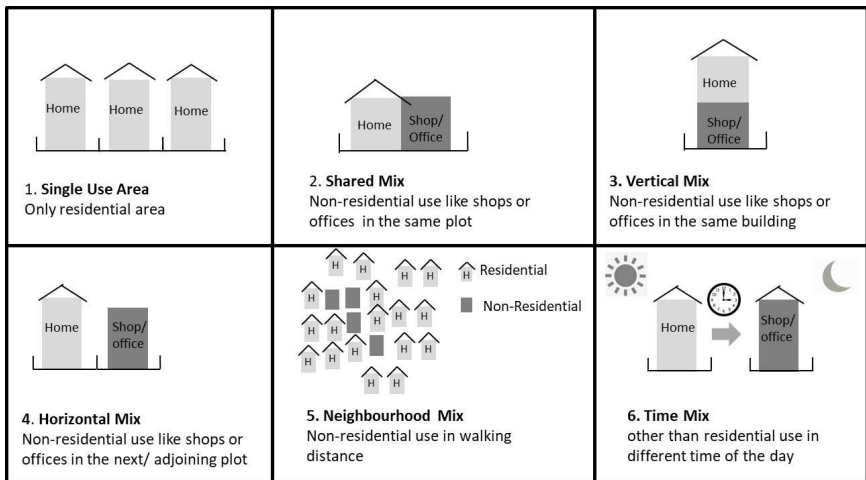
Hoppenbrouwer and Louw (2005) classify mixed landuse into shared, vertical, horizontal, and time mix. In this classification, it is assumed that one use is residential. A shared premise refers to sharing one single plot or premise for residential and work purposes. An example can be a doctor's residence with an outpatient clinic in the front room of his house. Vertical-mix refers to different uses on different floors of a building. Time-wise mix refers to those premises used as a residence and other use at different times of day, week, or month. Horizontal-mix refers to different uses among adjacent premises. Yinan (2009) has added a single function to the dimensions for better comparative understanding. Placemakers (2013) also added block level mixed-use apart from vertical, horizontal and time dimensions. A distinction is made between enterprises employing nearby residents and those run by outsiders. There are studies that look at mixed landuses from beyond the physical or spatial perspective and other dimensions. Evans & Foord (2007) have considered social mix (income, housing tenure, demography, visitors, lifestyles), economic-mix (activity, industry, scales (micro-large), consumption-production), physical land-use mix and temporal mix. Grant (2002) has also considered a mix of different types of housing as a kind of mixed landuse. Narvaez & Penn (2016) defined the typology based on the architectural characteristics based on the location and floor occupancy of uses in a building. For India, Raman & Roy (2019) showed that mixed landuses could be categorised as planned and unplanned. Self-led development of unplanned mixed landuse could be legal. However, there may also be unlawful mixed landuses like running offices in residential apartments without adequate infrastructures like parking or street vending. He has further categorised the legal mixed landuses as zonal, tonal (allowed addition of small proportion of another use to a principal use of a plot) and composite mixed landuses.

### **Mixed landuse typology in Indian City**

The term 'plot' needs some deliberation while defining the mixed landuse typology in the Indian context. A plot is a land parcel enclosed by defined boundaries (UDCPR, 2020), reflected in the legal land records or city survey documents. A plot can have individual or joint ownership of individuals, establishments, or associations. A single-family may have their house and business on the plot. In a housing society, the plot may have multiple apartment buildings where each family has a legal share of the plot. The plot may also have certain floors used for non-residential use or a few buildings dedicated to some non-residential use.

Based on the literature, the mixed landuse typology can be of six types as shown in Figure 1.

**Figure 1: Typologies of MLU**



Source: Prepared by authors based on literature (Hoppenbrouwer & Louw, 2005)

These types are from a resident's point of view and can be described as follows:

- 1. Single-use Area:** It is a purely residential area. Non-residential uses are not within walking distance. It is not mixed landuse but is necessary to include in the typology to perceive the other typologies.
- 2. Shared-mix:** Residential and non-residential uses share the premises of a plot even if individual buildings are single-use.
- 3. Vertical-mix:** Mix of uses on different floors of the same building.
- 4. Horizontal-mix:** Individual plots are single-use, but adjoining plots of different uses.
- 5. Neighbourhood-mix:** Non-residential landuses blended in residential neighbourhoods such that necessary non-residential uses are within walkable distances.
- 6. Time Mix:** Plots subjected to different uses at different times of the day/ week/ year.

Type 2 and 3 together are referred to as mixed-use plots where there are different use -occupancy in different portions of the building

or plot with one of the use as residential (UDCPR, 2020). These typologies can be further subdivided based on the number and type of non-residential use, housing typologies or ratio of residential to non-residential use. The population and built-up density of the plots and neighbourhoods and plot sizes would also drastically influence the final mixed landuse form. They could be used to further sub-categorise the typologies. However, discussions on these subcategories are out of the scope of this article.

### Applicability of Mixed Landuse Typology at Geographical Scales

Individuals can identify the mixed landuse typology for their residence based on the typology defined in the previous section. However, the context of the typologies differs with geographic scale, and it is necessary to clearly state the applicability of the identified typologies at different urban geographic scale. The geographic scales considered are individual apartment (self-enclosed tenement/ flat/ dwelling unit/ premise which is a part of a building or plot with other units), building, plot, street/ block, neighbourhood, district, City (Hoppenbrouwer & Louw, 2005; Rodenburg & Nijkamp, 2004; UDCPR, 2020). The matrix indicating the applicability of the typologies at different geographical scales is indicated in Table 1. It is based on the experience of mapping mixed landuse typology for three neighbourhoods that are discussed later. The attempt had been to classify every plot into one of the typologies. The possibility of categorising a plot in one of the typologies and for a lower and higher geographical scale was checked.

TABLE 1: APPLICABILITY OF THE TYPOLOGY AT GEOGRAPHICAL SCALES

		<i>Urban Geographical Scale</i>					
		<i>Individual apartment*</i>	<i>Building</i>	<i>Plot</i>	<i>Street/ Block</i>	<i>Neighbourhood</i>	<i>City</i>
Mixed Landuse Typology	Single-Use	✓	✓	✓	✓	✓	
	Shared-Mix	✓	✓	✓			
	Vertical-Mix		✓	✓			
	Horizontal-Mix			✓	✓		
	Neighbourhood-Mix					✓	✓
	Time-Mix	✓	✓	✓			

\*applicable only for multi-family, multistorey building.

Source: Prepared by authors.

The typologies at various geographical scales is elaborated as follows:

**Individual Apartment Level:** Consider a family living in an apartment of a building. It could be completely residential, or a family member could have his painting studio in one room, making the premise a shared-mix. If the apartment has only one room and kitchen and the family uses the room for making handicrafts during the day and the same room for sleeping at night, then the premise would be a time-mix.

**Building Level:** Consider the same apartment building, which has commercial shops on the ground floor, making it a vertical-mix. If there is no formal non-residential use in the building, but there are families carrying out certain home-based businesses like tailoring or tutoring it would be converted shared-mix. A two-storey building that has an eatery in the front, but the backside is used as residential quarters will be shared-mix. Dead non-residential usage such as parking or storage or even amenity space for the residents like clubhouse need not account for a mix. If there is a school building where the classrooms are used for sleeping at night by occasional group visitors or the homeless or serves as a disaster refuge centre, it can be called a time-mix.

**Plot Level:** A shared-mix would be a residential apartment building and one commercial building in a plot. If there are multiple buildings with non-residential on the ground floor and residential above, such a plot can be categorised under vertical-mix. If the buildings in the plot are completely residential, but the adjacent plot has some non-residential use, then such plots would be a horizontal-mix. The time-mix for a plot is similar to that of the building level.

**Street/Block Level:** A street or block may be completely single-use. Plots and buildings in the street or block may have shared or vertical-mix or have a few adjacent residential and non-residential plots (horizontal mix). Time-mix is bound to be present in every street or block, making it unnecessary as a typology at this level.

**Neighbourhood Mix:** A neighbourhood may be completely residential (single-use). There may be non-residential uses dispersed among residential uses in the form of complete non-residential plots or vertical/ shared mix. It may also have one block or street which is entirely non-residential, and the rest are residential. In both scenarios, non-residential uses are accessible to the residents within walking distance (neighbourhood-mix). Categorising neighbourhoods into a simple yes or no for neighbourhood mix is not relevant. Quantification of neighbourhood-mix in the intensity of mixing is more useful. Several methods of measuring mixed landuse intensity at neighbourhood level

are used in literature, such as Entropy Index, Herfindahl–Hirschman Index and Shannon’s Diversity Index MLU (Manaugh & Kreider, 2013; Song, et al., 2013; Wo, 2019; Zagorskas, 2016).

**City Level:** For the city level, the entire city cannot be considered as one unit for typology. Instead, the distribution of mixed landuses or intensities is more relevant. One way to do so could be mapping the neighbourhood mix in the form of mixed landuse intensity for all neighbourhoods in the city. The typologies described in this study thus do not directly apply to the city level.

### **Mapping of Mixed Landuse Typology in Case Study Neighbourhoods**

#### *Background of Pune and Neighbourhood Selection*

The city of Pune in the western state of Maharashtra, India, has a population of 3.13 million residing in the 331.26 sq km (Pune Municipal Corporation, 2020). The city can be divided into core area, old limit and extended area. The core area of the city developed under the *Maratha Empire* between 1595 and 1817 AD, with segregation based on trade, profession, and social status rather than landuses (Mundhe & Jaybhaye, 2017; Diddee & Gupta, 2013). The core area now is a thriving market serving the entire city and beyond, an important centre of religious destination, traditional craft and industries and a very dense residential population. Low rise, high density built-up with indistinguishable plots due to high ground coverage and vertical mixed-use are the dominant characteristics of the core area. During the British colonisation between 1918 and 1947 AD, some areas were added to the core area for the local population and cantonment areas outside the core area were established. After Independence, the 20 years – Development Plans govern land development. The area covered by the development plan of 1987- 2007 is considered the old limit. Some of the areas in the old limit were developed using town planning schemes (land pooling mechanism). But mostly, the development was self-led. The old limit can be characterised by mid-rise stand-alone apartments and clear plot boundaries. A separate development plan is prepared for the areas added to the municipal corporation between 1997 and 2007. This is the extended area characterised by large gated housing societies with multiple apartment buildings, adjoining but independent commercial complexes or planned mixed landuses.

One neighbourhood from each of the three areas is taken for this study. The purpose of studying the neighbourhood is to validate the theoretical typologies identified. Narayan Peth neighbourhood has



existed since 1773 AD and has a residential population density of 35448 people per square kilometre (Mundhe & Jaybhaye, 2017; Pune Municipal Corporation, 2020). According to the Development Plan of 2007-2027, most of the Narayan Peth area is under the residential zone, and only the portion adjoining the main road is under the commercial zone. Model Colony neighbourhood was developed through a town planning scheme in 1966 and now has a residential population density of 14,395 people per square kilometre. It is under the residential zone but is located near a major commercial street. Kondhwa Budruk was included in Pune Limit after 2001 and has a residential population density of 4497 people per sq km. It is adjoining a dense village settlement as well as an industrial zone. A small portion of the neighbourhood is in an industrial zone. The results and discussion section explain how the mixed landuse typologies are affected under different zones of the development plan.

### **Neighbourhood Survey and Data Collection**

Base maps showing plot boundaries and landuse are based on the development plan maps and other literature sources (Ghosh & Raval, 2021). The neighbourhoods were surveyed during August and September 2019. The mixed landuse typology, if mixed-use, whether it is planned or unplanned, average building age and height were marked for each plot. Figure 2 illustrates the selected neighbourhoods.

Figure 2 indicates the typologies that can be defined at the plot level of the urban geographical scale. For the neighbourhood scale, the mixed landuse intensity index is computed. Time-mix was observed in a few plots in all the neighbourhoods. Some examples observed are restaurants where the staff uses some space by moving furniture for sleeping at night. There were a few household industries where family members make homemade items, and the same place is used at night for sleeping. Similarly, some of the residents ran tuition and other classes from their homes. However, they existed in the same plot with dominant other typologies such as vertical mix; hence, they were not included in the map.

### **Method for Computing Neighbourhood-Mix**

Shannon's Diversity Index is used to compute the mixed landuse intensity or the prevalence of mixed landuse at the neighbourhood level. The index quantifies the diversity based on two components – the number of different patch types and the proportional area distribution among patch types. Adjoining plots that have the same use in the landuse map are grouped together as one patch. The index is calculated by adding the proportion of area covered by each patch, multiplied by

**Figure 2: Landuse and Mixed Landuse Typology Maps of the Neighbourhoods**



Source: Landuse based on the development plan and Ghosh & Raval (2021); Mixed landuse typologies and photographs documented through the primary survey.  
 Note: The mixed-use category in landuse plans indicate vertical or shared mix in plots according to the development control regulations of Pune.

that proportion expressed in natural logarithm (Kajtazi, 2007; Huang & Tsai, 2013; Lu, et al., 2009; Yue, et al., 2017). It can be expressed through the following equation:

$$m = \text{total number of patches, } P_i = \text{proportion of area covered by patch } i. \quad \dots(1)$$

The larger the index, the more is the intensity of mixed landuse or neighbourhood-mix.

RESULTS AND DISCUSSION

**Prevalence of Mixed Landuse Typology**

Table 2 indicates the proportion of the total number of plots under each mixed landuse typology in the neighbourhoods. The neighbourhood mix is computed using equation (1).

TABLE 2: PREVALENCE OF MIXED LANDUSE TYPOLOGY IN THE SELECTED NEIGHBOURHOODS

	<i>Narayan Peth</i>	<i>Model Colony</i>	<i>Kondhwa</i>
Total No. of Plots:	347	318	215
Area of Neighbourhood ((Square Kilometre	0.2	0.48	0.58
<b>*Mixed Landuse Typology</b>			
Single use Residential	1%	46%	8%
Single use non-residential	15%	20%	66%
Vertical Mix	63%	12%	10%
Shared Mix	1%	2%	3%
Horizontal Mix	20%	20%	14%
Neighbourhood Mix	1.02	1.04	0.77

Source: Prepared by authors.

\*The cell figures indicate the per cent of the total number of plots under a mixed landuse typology.

It is observed that there is some degree of mixed landuse present in all the selected neighbourhoods even though they were not specifically planned for it. More than half the plots in all three neighbourhoods fall under one of the mixed use typologies. The distribution of plots among single-use, vertical-mix and horizontal mix varies among the neighbourhood. The prevalence of shared-mix and time-mix at the plot level is low in the selected neighbourhoods.

Shannon’s Diversity Index for neighbourhood mix needs to be cautiously interpreted. The index computation is based on two-dimensional distributions of landuses in the neighbourhood. Accordingly, Kondhwa has the lowest neighbourhood mix and model colony has the highest neighbourhood mix among the three neighbourhoods. This is despite Model Colony having the highest single-use residential plots, Narayan Peth with huge dominance of vertical mix and Kondhwa with many single-use plots. As the areas of the patches are used for computation, the plot sizes are not considered. Among the three neighbourhoods, Kondhwa has the largest area but the least number

of plots indicating that the plot sizes are large. Kondhwa being in the newly developed extended area, has a character of large residential gated societies. It also had many under-construction and vacant plots, which were considered non-residential single-use for mixed landuse typology, leading to a higher per cent. As these features generated large patches, the index value is low, reflecting the true nature of the neighbourhood mix. Narayan Peth has the smallest area with the maximum number of plots indicating smaller plot sizes. The prevalence of vertical mixed landuses in most of its plot generated a large patch. However, the index treats it as any other patch and does not incorporate the true essence of mixing in that patch. Therefore the neighbourhood mix of Narayan Peth is likely to be higher than what the index indicates. In Model Colony, the residential and non-residential uses are distributed evenly, generating smaller and many patches giving a higher index value.

### **Existing Regulations Regarding the Typologies**

Pune follows the state's uniform development control regulations, liberal toward mixed landuses (UDCPR, 2020). The associated Development Plan indicates the dominant landuse zones for the city. It also indicates the areas reserved for public utilities and amenities. A plot's use and building regulations vary depending upon its location in a zone and local circumstances such as plot size and adjoining road width. The sub-zones are defined based on the width of the roads and the existing characteristics, creating small clusters within the neighbourhoods instead of large zones.

The amount of built-up allowed in a plot is governed by Floor Space Index (FSI). FSI for a plot varies based on the width of the adjoining road. The minimum plot area required for various uses is also prescribed with a minimum of 30 square metres for residential. Table 3 describes the regulations related to the typologies.

The regulations support the mixing of landuses in almost all parts of the city as seen in Table 3. The dynamics of city growth and change alter the demand for landuses in a particular location over the years.

Like Pune, many Development Plans and Regulations of Indian cities like Bangalore, Ahmedabad and Nagpur do not have any dedicated mixed land use zone. Mixed landuses are generally permitted in most of the landuse zones to different extents but are not compulsory. Segregated landuse planning was practised in Delhi until 2001 when mixed land uses were introduced. It has now adopted a differentiated approach towards allowing non-residential uses in residential colonies based on the characteristics of the colony. Certain streets have been proposed to be converted into mixed land uses due to the potential

TABLE 3: REGULATIONS FOR MIXED LANDUSE TYPOLOGIES IN PUNE, INDIA

	<i>Residential Zone 1 (Road width less than 12 metres)</i>	<i>Residential Zone 2 (Road width more than 12 metres)</i>	<i>Commercial Zone</i>	<i>Industrial Zone</i>
Single-Use	Single-use residential allowed	Single-use residential allowed; Single-use non-residential use in an independent building, including listed non-residential uses are allowed	All uses of residential zones are allowed. Single-use large commercial use like office parks are allowed	Residential hostels are allowed. Residential and commercial use is allowed with special permissions. Segregating distance from obnoxious industries is mentioned.
Shared Mix	Specific listed non-residential use of limited size like creche allowed but need not be in a separate building	Mixing of non-residential uses as per list without floor restrictions	Allowed	No specific mention except residential hostels within the premise of industries is allowed with additional regulations.
Vertical Mix	Shops only on the ground floor. Professional offices and home-based industries on any floor, Nursing homes on any floor with separate entry. Public library on the ground or first floor. Other listed non-residential uses are allowed.			
Horizontal Mix	Allowed – The zone names are indicative, and there is no minimum or maximum per cent necessary for particular use in a zone.			
Neighbourhood Mix	Allowed			
Time Mix	No specific mention			

Source: Prepared by authors based on 'The unified Development Control and Promotion Regulations (DCPR or DCR) for Maharashtra.

and prevalence of mixed landuses there. These practices are starkly different from the western world which implement a landuse zoning matrix and then encourage mixed landuses only in the identified zone (Ghosh & Raval, 2018).

### **Planned and Unplanned Mixed Landuse in the Neighbourhoods**

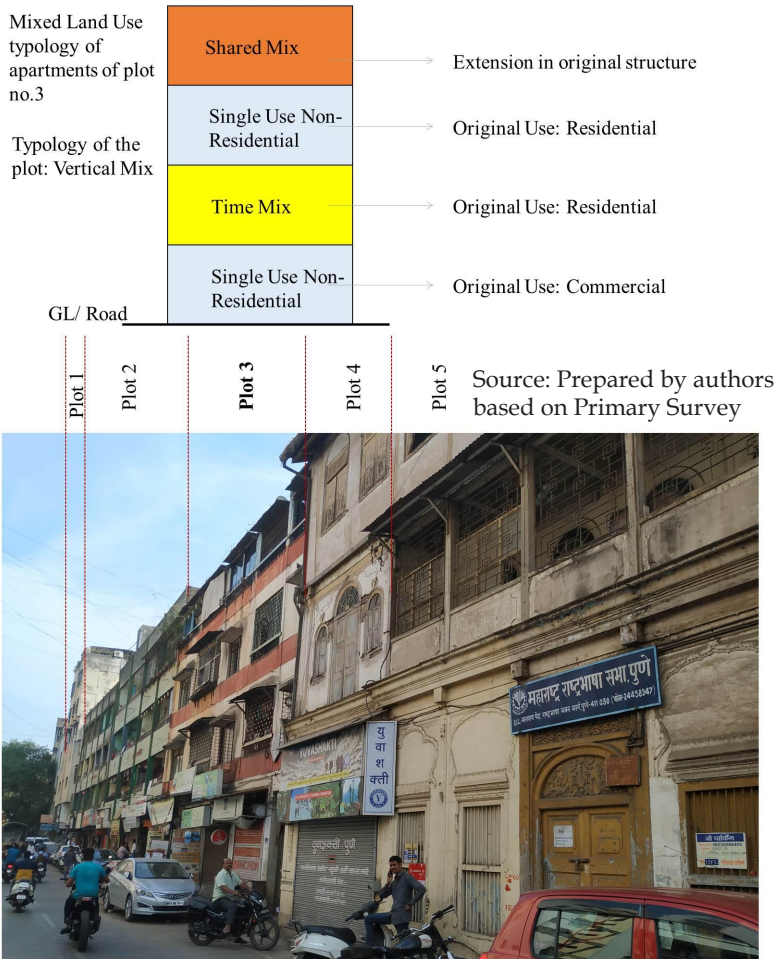
One alluring feature of mixed landuse typology observed in all three neighbourhoods is the non-residential uses in premises originally designed as a residence. The conversion from residential to non-residential use may be due to commercialisation pressure. Very few unused planned commercial spaces were observed, and none were being used for residential purposes, confirming the pressure of commercialisation. The reason could be the higher population density creates the opportunity for businesses to meet their threshold subsistence demand (Vreeker, et al., 2004). The sustenance of mixed landuses is associated with population densities (Mashhoodi & Pont, 2011). The cost of renting or buying a residential property is cheaper than commercial properties leading to small businesses finding it affordable to operate from residential properties. Moreover, property owners may find it financially more beneficial to rent to non-residential uses with a longer contract period and higher rent. There is a tax difference between residential and commercial properties.

Sub-categorisation of mixed landuse typologies into planned and unplanned may be essential in some cases as it does impact external factors such as parking, safety of remaining residents, structural requirements, fire hazard, etc. The same is elaborated through some examples.

**Narayan Peth:** Major places of commerce surround Narayan Peth. The real estate demand increased in the area, with many plots being redeveloped as vertical mix. As the locational importance for commercial establishments in Narayan Peth became overpowering, many residential apartments are used for non-residential purposes. In the 2007 Development Plan, some areas adjoining the main road were rezoned as commercial, due to which the redeveloped buildings that are now coming up are purely for commercial use.

Figure 3 demonstrates the mixed landuse typology classification of the apartments in a vertical-mix building in Narayan Peth. In the shown example, the building occupies 100 per cent of the plot area and shares common walls with the adjacent plots. The ground floor of the building has planned shops. The first and second floor was planned as residences. While one is occupied by a family who has a home-based business, the other is now an office. The third floor is an unplanned extension, which has a residence and a small office.

**Figure 3: Sub-Categorisation of a Vertical Mix Building from Narayan Peth**



As observed here, the variety of usage of built spaces is wide, making it tedious to keep official records of the real uses in every apartment, floor, and building.

**Model Colony:** As Model Colony was planned through Town Planning Scheme for residential purposes, it has ample recreational and public spaces. Being centrally located near Commercial Street with no crowding and parking problems, it is very attractive for small establishments like service centres and professional offices. This has led to the conversion of residential properties for office and commercial use. Figure 4 is an example of a building designed with shops on the ground floor and residences above. However, the first and second floor

is being used by computer service centres while the apartments on the third floor are entirely residential.

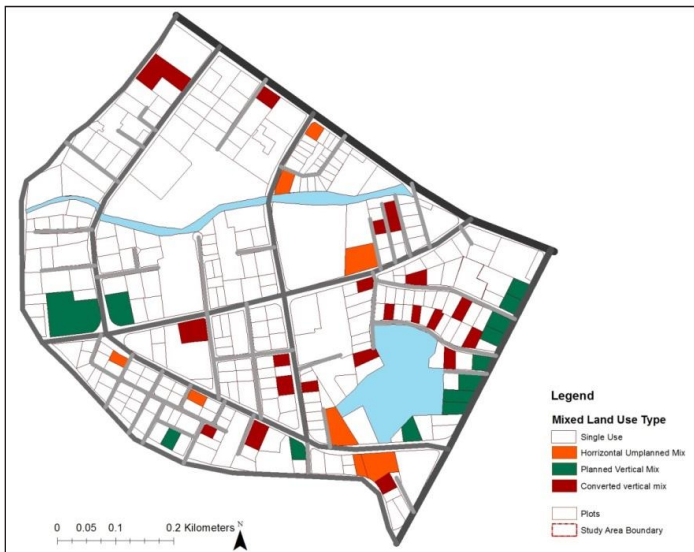
**Figure 4: Unplanned Vertical Mix in Model Colony**



Source: Authors

Figure 5 maps the planned and unplanned mixed-use typology at the plot level in Model Colony. While the plots adjoining the commercial streets are planned for vertical mix-use, those in the internal areas are converted.

**Figure 5: Planned and unplanned mixed usage of plots in Model Colony**



Source: Plot boundaries based on the development Plan; Planned and unplanned mixed landuse type mapping by authors based on primary survey



**Kondhwa:** Kondhwa already had the presence of small and micro industrial units, a spillover of a larger industrial estate nearby, before it was included in the corporation limit. Once included in the corporation, the vacant and agricultural land started to develop as residential and planned mixed-use. Even the industrial units were redeveloped to house residential and office use. This may be due to an increase in real estate value far more than the industrial output value. The newer large gated residential society requires a no-objection certificate from the residents' committee for alternate use of the residential property to make the unplanned mix more acceptable and better managed.

### CONCLUSION

This research fulfils the main aim of defining mixed landuse typology for the Indian context. The following conclusions are made:

The mixed landuse can be categorised into typologies such as single-use, shared-mix, vertical-mix, horizontal-mix, neighbourhood-mix and time-mix.

The mixed landuse typologies are relevant to a specific geographical scale. For a particular geographical scale, some typologies are more relevant than others. The typologies defined in this study are most applicable at the plot level.

All the neighbourhoods studied in this reseach had some level of neighbourhood-mix. Other than single-use, the most prevailing typologies are vertical-mix and horizontal-mix at plot level. Time-mix and shared-mix are more noticeable in a smaller geographical scale of building or apartment.

The regulations allow all typologies in all major landuse zones. Mixed land-use is not compulsory anywhere, and there is no one particular mixed-use zone. Yet mixed landuses exist due to other external forces like density. Adjoining road width is the most crucial determinant of landuse and density in the regulations. The regulations specifically mention the uses which need to be compulsorily housed in an independent building.

Some of the causes for the diversification of the uses in the neighbourhoods are population density, a locational advantage for commercial, transportation ease and access, real estate value, commercial agglomeration and services offered in that area.

Unplanned mixed landuse where premises originally designed for residential purposes are used for non-residential use is observed in all three neighbourhoods. They are not illegal and need to be considered

as subcategories of mixed landuse typologies as they are relevant from structural, environmental, infrastructure and safety perspectives.

The establishment of the mixed landuse typologies that aid in comprehending landuse dynamics and developing mixed landuse strategies is the most significant application of this research. The study's main limitation is that subcategories of the typologies, such as plot size or housing category, are not explicitly discussed.

#### REFERENCES

1. Bahadure, S. and Kotharkar, R. (2015). Assessing sustainability of mixed use neighbourhoods through residents' travel behaviour and perception: The case of Nagpur India. *Sustainability*, pp. 12164-12189.
2. Dave, S. (2010). High urban densities in developing countries: A sustainable solution? *Built Environment - The Compact City Revisited*, 36(1), pp. 9-27.
3. Diddee, J. and Gupta, S. (2013). *Pune Queen of the Deccan*. Pune: Elephant Design Pvt. Ltd.
4. Evans, G. and Foord, J. (2007). The generation of diversity: Mixed-use and urban sustainability. In: *Urban sustainability through environmental design: Approaches to time-people-place*. s.l.:Taylor & Francis.
5. Gehrke, S. R. and Clifton, K. J. (2016). Toward a spatial-temporal measure of land-use mix. *The Journal of Transportation and Landuse*, 9(1), pp. 1721-186.
6. Ghosh, P. A. and Raval, P. M. (2021). Modelling urban mixed land-use prediction using influence parameters. *Geoscape*, 15(1), pp. 66-78.
7. Ghosh, P. and Raval, P. (2018). *Case Studies of Mixed Land use Policies*. Pune, Urban Infrastructure Development and Management, ICCRIP 2018, NICMAR, Pune.
8. Grant, J. (2002). Mixed use in theory and practice: Canadian experience with implementing a planning principle. *Journal of the American Planning Association*, 68(1), pp. 71-84.
9. Guha, R. (2020). Making Indian Cities Habitable-The Legacy of Patrick Geddes. *The India Forum*. [Online] Available at: <http://www.theindiaforum.in/articlemaking-indian-cities-habitable>
10. Herndon, J. D. (2011). Mixed-use development in theory and practice: Learning from Atlanta's mixed experiences. *Applied Research Paper*, pp. 1- 95.
11. Hirt, S. (2007). The Mixed-use Trend: Planning attitudes and practices in Northeast Ohio. *Journal of Architectural and Planning Research*, 24(3), pp. 224-244.
12. Hoppenbrouwer, E. and Louw, E. (2005). Mixed-use development: Theory and practice in Amsterdam's Eastern Docklands. *European Planning Studies*, 13(7), pp. 967-983.
13. Huang, S.-W. and Tsai, W.-J. (2013). The analysis of measurements and influence

factors of mixed landuse. *International Journal of Bioscience, Biochemistry and Bioinformatics*, 3(3), pp. 206-210.

14. Jacobs, J. (1961). *The Death and Life of Great American Cities*. New York: Random House.
15. Kajtazi, B. (2007). *Measuring multifunctionality of urban area*, Enschede, Netherlands: International Institute for Geo-Information Science and Earth Observation.
16. Kotharkar, R., Bahadure, P. N. and Vyas, A. (2012). *Compact city concept: It's Relevance and applicability for planning of Indian cities*. Lima, Perú, PLEA2012 - 28th Conference.
17. Lu, S., Huang, Y., Shi, C. and Yang, X. (2009). Exploring the Associations Between Urban Form and Neighborhood Vibrancy: A Case Study of Chengdu, China. *International Journal of Geo-Information*, 8(4).
18. Manaugh, K. and Kreider, T. (2013). What is mixed use? Presenting an interaction method for measuring landuse mix. *The Journal of Transport and Landuse*, 6(1), p. 63 - 72.
19. Mashhoodi, B. and Pont, M. B. (2011). *Studying land-use distribution and mixed-use patterns in relation to density accessibility and urban form*. s.l., s.n.
20. MoHUA (2016). *Smart City Features*. [Online] Available at: <http://smartcities.gov.in/content/innerpage/smart-city-features.php> [Accessed 2020].
21. MoHUA (2017). *National Transit Oriented Development (NTOD) Policy*, s.l.: Ministry of Housing and Urban Affairs, Government of India.
22. Moos, M., Vinodrai, T., Revington, N. and Seasons, M. (2018). Planning for mixed use: Affordable for whom?. *Journal of the American Planning Association*, 84(1), pp. 7-20.
23. Mouratidis, K. (2019). Compact city, urban sprawl, and subjective well-being. *Cities*, Volume 92, pp. 261-272.
24. Mundhe, N. N. and Jaybhaye, R. G. (2017). Chronological development of Pune from 758-2014 AD. *International Journal of Environment, Ecology, Family and Urban Studies*, 7(5).
25. Narvaez, L. and Penn, A. (2016). THE architecture of mixed uses. *The Journal of Space Syntax*, 7(1), pp. 107-316.
26. Neuman, M. (2005). The compact city fallacy. *Journal of Planning Education and Research*, Volume 25, pp. 11-26.
27. Pisano, C. (2020). Strategies for post-COVID cities: An insight to Paris En Commun and Milano 2020. *Sustainability*, 12(5883), pp. 1-16.
28. Placemakers (2013). *Don't Get Mixed Up on Mixed-Use*. [Online] Available at: <http://www.placemakers.com/2013/04/04/mixed-up-on-mixed-use/>
29. Pune Municipal Corporation (2018). *Development Plans*. [Online] Available at:

- <https://pmc.gov.in/en/draft-development-plan-old-pmc-limit-2007-2027-published-us-311-mrtp-act-1966> [Accessed 2018].
30. Pune Municipal Corporation (2020). *Census data*. [Online] Available at: <https://pmc.gov.in/en/census>
  31. Raman, R. and Roy, U. K. (2019). Taxonomy of urban mixed landuse planning. *Landuse Policy*, Volume 88.
  32. Rodenburg, C. and Nijkamp, P. (2004). Multifunctional landuse in the city: A typological overview. *Built Environment*, 30(4), pp. 274-288.
  33. Rowley, A. (1996). Mixed-use development: Ambiguous concept, simplistic analysis and wishful thinking?. *Planning Practice & Research*, 11(1), pp. 85-97.
  34. Song, Y., Merlin, L. and Rodriguez, D. (2013). Comparing measures of urban landuse mix. *Computers, Environment and Urban Systems*, Volume 42, pp. 1-13.
  35. Spodek, H. (2013). City Planning in India under British Rule. *Economic and Political Weekly*, 48(4), pp. 53-61.
  36. UDCPR (2020). *Unified Development Control and Promotion Regulations for Maharashtra State*, s.l.: Government of Maharashtra, Urban Development Department.
  37. Vreeker, R., de Groot, H. and Verhoef, E. (2004). Urban multifunctional landuse: theoretical and empirical insights on economies of scale, scope and diversity. *Built Environment*, 30(4), pp. 289-307.
  38. Williams, K. (2004). Can urban intensification contribute to sustainable cities? An international perspective. *City Matters; Official Electronic Journal of Urbanicity*.
  39. Wo, J. C. (2019). Mixed landuse and neighborhood crime. *Social Science Research*, Volume 78, pp. 170-186.
  40. Yinan, Z. (2009). *Intensity control in mixed-used new urban area: a case study of the waterfront in Xiasha, Hangzhou*. Amsterdam, The 4th International Conference of the International Forum on Urbanism (IFoU), pp. 1395-1404.
  41. Yue, Y. et al. (2017). Measurements of POI-based mixed use and their relationships with neighbourhood vibrancy. *International Journal of Geographical Information Science*, 31(4), p. 658-675.
  42. Zagorskas, J. (2016). GIS-based modelling and estimation of landuse mix in urban environment. *International Journal of Environmental Science*, Volume 1.