

Cataloguing Wards of Delhi for effective Local Area Planning using Geographical Information Systems



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Abstract: Increased urbanization in an unprecedented manner has resulted in the splitting of urban areas into small divisions for the administrative convenience and effective planning purpose. In India, ward is the smallest administrative unit and has been in attention since 74th Constitutional Amendment Act. This act provided for autonomy to the ULBs to be responsible for the planning, implementation and operation of municipal services at local level. As per the Master Plan of Delhi 2021, all the wards shall have a Local Area Plan (LAP) to meet the needs and aspiration of the local people. The LAP is deciphered at the individual ward level in case of Delhi. There are 272 wards in Delhi and the population of these wards varies from 5000 to 200000. Hence, it is gathered that one approach or framework for urban management at local level may not be suitable for all wards of Delhi and also it is technically not achievable to have 272 individual LAP in the light of both financial and material resources shortage. With this background, the study is conducted and authors have attempted to list the criteria for spatial categorization of wards through literature review with the view to catalogue the wards in Delhi. This will enable planners to formulate strategies suitable for various wards catalogued under one category leading to effective utilization of common resources. As a pilot study three important planning criteria - population density, building density and development pattern - were identified from literature studies and Geographical Information System (GIS) application and correlation analysis statistical used over these three criteria to catalogue the wards in Delhi. Consequently, 272 wards of Delhi were catalogued under 9 different categories. The findings are suggestive that physical planning attributes are important tools to define the vast spatial built areas into categories that are more conducive for local planning in comparison to the administrative boundaries delineated on the basis of population only. This may give stimulus to the operative planning at local level and shall enable policy makers and planners to design the strategies which are more efficient in terms of resources, time and are more effective and implementable at ward level. The originality of the study is in the fact that no such study has been conducted in the Indian context that attempts to catalogue built and unbuilt spaces based on physical planning attributes.

Keywords: Governance, Local Area Planning, Geographical Information System, Cataloguing

I. INTRODUCTION

The existing planning tools i.e. Master plans, Zonal plans and other development plans accommodate the needs and requirements of the urban population in the form of spatial plans but have failed to address the issues and aspirations of the people at the ground level. Urban Local Bodies (ULBs) - Municipal Corporations and Municipalities in many parts of India have been unsuccessful to keep up with the demands of the unprecedented and increasing population in the absence of institutionalized processes and participatory governance. Decentralized urban management seems to be the innovative solution, where the smallest unit of administration is a ward. A ward is a local geographical area that is typically formulated as the smallest urban administrative unit for the electoral purposes. These wards are either numbered or named to give an identity to each unit. This administrative level became important after the 74th Constitutional Amendment Act (CAA), which provided for autonomy to the ULBs to be responsible for the planning, implementation and operation of local services at local level. Adding a rung to the existing planning hierarchy, Ministry of Urban Development, Government of India proposed the concept of Local Area Plans (LAP), where the local areas are defined as smaller areas with unique and uniform character and concerns. In respect to this development, the concept of local area planning is introduced in the Master Plan of Delhi (MPD)-2021 in order to achieve the objectives of people participation as mentioned in the 74th CAA.

LAP refers to the plan of a ward; it is a qualitative and quantitative tool of assessment of public participation and satisfaction in the planning process, as envisioned by the MPD 2021. LAP is bound to state the strategy for the effective planning and sustainable development of a local area. Delhi Municipal Corporation, the ULB, is the pioneer organization to introduce LAPs in the Indian planning machinery. INDO-USAID FIRE (D) Project, 2005 prepared guidelines for LAP preparation for enhanced local participation in urban governance. Nonetheless, these guidelines failed implementation. According to the experts of the field, the prime reason is the complex issues and concerns in different wards with varied characteristics and spatial differences.

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Wards in Delhi area primarily divided on the basis of population for the purpose of administration. Population is one of the many criteria that define the characteristics of the ward. Defining boundaries of the wards for the administrative purposes is justified but not at all suitable for effective planning at a local level.

Ward plans or LAPs are mandated to be formulated for each of the 272 wards in Delhi. This is indicative that one approach or framework for urban management at local level may not be suitable for all wards of Delhi. Literature suggests that there exists numerous attributes which affect spatial micro level planning and are being used to delineate boundaries of the planning zones/ areas at the local level globally.

India is the finest example to showcase spatial, social, economic, cultural and technological heterogeneity spread over geography. It is the seventh-largest country by area, the second-most populous country, and the most populous democracy in the world. To administer that large base of population, the existing planning machinery establishes population as the most acceptable criteria for demarcating the areas for planning. As a result, the urban centers in India are divided into numerous wards for the administrative convenience, using the same criteria. Ironically, these wards may be different in terms of population but could be homogenous in terms of demographic, social and spatial characteristics. With this understanding and question in mind, the researchers realized that the wards possibly could be catalogued under different categories to best suit the characteristics, issues and aspirations of the people at ward level and thereafter, strategies can be made for each category of wards instead distinct approach for each and every ward in specific. This shall save the stressed resources and time and shall lead to effective and implementable local level planning. Therefore, with this context, authors have attempted to list the criteria or attributes for spatial categorization of wards through literature review. Thereafter, three criteria are chosen to catalogue the wards in Delhi, as a pilot study, to seek adaptability of the approach. The literature to identify spatial indicators for categorization of wards has been reviewed and is explicated in the preceding section of the paper.

II. IDENTIFICATION OF CRITERIA THROUGH LITERATURE REVIEW

Throughout history, settlements have been delineated on the basis of geography and physical features to support administrative, political and economic activities. Geography underlies the political, socio economic and environmental characteristics of the area. Many studies promoted that the delineation of urban boundary and its further divisions is done by portioning geographical space into small units and each unit is characterized as a node within a geographical frame. An appropriate community detection algorithm is used many a times to partition the network and associated geographical space based on the strength of human interactions between the nodes (Lancichinetti and Fortunato 2009). This indicator is further linked to another parameter i.e. Environment. Recent studies shows the urban environment is a subject of interest and concern including a variety of shareholders acting at different spatial scales (Guerrero, Mcallister, & Wilson, 2014) such as, global, regional, or even local. This indicator includes delineation of planning areas based on environmental issues in terms of floodplain recession, land

degrading, aquifer depletion, air or noise pollution etc. Environment as an indicator is important but often lead to soft boundaries with overlapping concerns and issues (Hoffman, Varady., Flessa, & Balvanera, 2009). On the contrary, population is considered to be the quantitative indicator for demarcation of boundaries for administrative purposes.

A high degree of heterogeneity and spatial disparities is a basic feature of the urban population in a city. In the urban planning framework, physical density has been defined in two contexts i.e. people or population density and building density. The former is defined as the number of people or household per given area and is often perceived as the indicator of quality of life, levels of income and standards of living (Plane, David A., and Peter A. Rogerson. 1994). In India, density of population is one the indicators used for a human settlement to qualify as an urban entity as defined by the Census of India. Olsun (1996) noticed that there is a positive and statistically significant relationship between population density and per capita income. Residential population is the most important feature that occupies the largest fraction of a city's land, and residents and their living conditions are the prime concerns of the city plans. Development Authorities attempt to manage disproportions among the city population in residential areas by earmarking residential land for four categories: high income, middle income, low income and economically weaker sections. This is indicative that the residential densities increase with decreasing income level with highest densities being reported among the economically weaker sections and vice versa (Parikh, K. 2015). Malthus (1798) has also strongly supported that fact that population increases at a geometrically whereas resources grows only at an arithmetic pace. Because of the disproportionate balance, there are bound to have instances of hunger, disease and survival. This view strongly supports the fact that population density and economic status are the important indicator that affects growth and development of people in their local contexts.

It is perceived that denser the population in a geographic unit, greater will be the effects on environment quality, since the open areas in a locality are inversely related to the density of population of that area. As the area under buildings increases, the open areas shrink. This phenomenon is defined by technical concept of Building Density. Building Density is defined as the ratio of area under building structures to an area unit. Higher building densities result in overcrowding that further leads to efficiency losses (Owusu, Richard Kofi, 2012). These losses are attributed to the infrastructural inefficiencies, in the urban context. Overexploitation of the limited resources are unable able to satisfy consumption needs effectively, which often results in poor living conditions. Subsequently, this hampers overall development of the local areas. The literature further supports that since 1970's, the affluent and plush population moved from the densely built-up and congested areas to the less built-up areas to ensure pleasant living conditions, cleaner and healthier environment. (Péter István Balogh, Dániel TAKÁCS, 2011). This clearly shows that the built environment is another important parameter that affects the general wellbeing of the populace at the local level.

Local areas strive primarily on its social and economic characteristics. It is anticipated to have strong interdependent social and economic linkages between the constituent units of the area. People with similar or interdependent economic activities and economic status opt to live in proximity. Whole concept of spatial economics is based on this fact. Spatial economics is about distribution of resources over space and the location of economic activity.

The first spatial theory of economics model is described by J. von Thünen in “The Isolated State in Relation to Agriculture and Political Economy” (Thünen, 1826). Though his theory was related to agriculture markets but many urban theories are developed based on economic characteristics of the zones. In addition, level of services and satisfaction of preferences of citizens and efficiency of provision of local public goods and services is studied as an determinant. Often people with similar preferences live together in an area (Oates, 1972). Another aspect of the territorial division defines the technical scope of economies of scale when determining the issues of provision of public goods or services (Ebel and Vaillancourt, 2007). This can be used as an indicator for territorial divisions.

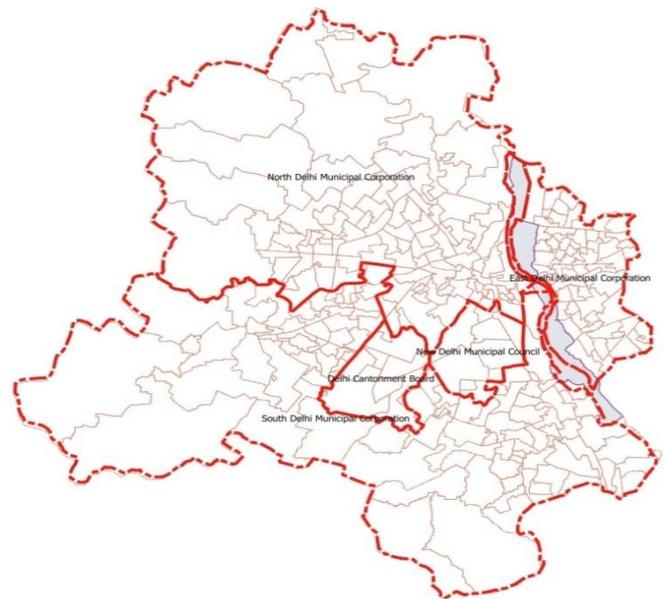
Another indicator that affects the local area is the development pattern. According to the Delhi Development Authority Act 1957, planned colonies are referred to as “approved” colonies. These settlements are part of the land which is demarcated as “development area” in the Master Plan of Delhi and/or the Zonal Plan. These colonies comply with the planning norms and are fully serviced with infrastructure like water pipelines and sewerage systems. The housing constructed or approved by the Delhi Development Authority (DDA) makes part of this category of settlement. In the era of unprecedented urbanization, most development takes place without the plan and therefore has negative impacts on existing environment, people’s health, and community, at large. Unplanned urbanization takes place in the absence of physical and social infrastructure, resulting in haphazard development and overcrowding. In Master Plan of Delhi 2021, unplanned areas include urban villages; unauthorized colonies; regularized colonies; resettlement colonies and JJ clusters. Moreover, there is a category called outlying areas, often defined as urban extensions (urbanizable areas). These areas are not planned yet but are demarcated as areas for future development. MPD 2021 proposes to accommodate 48 lakh additional population is to be accommodated in the future urban extensions. Thus, pattern of development is also an important proxy to determine issues, problems and aspirations of people at local level.

The authors have attempted to identify and synthesize the relevant attributes in Indian context. Therefore, the three critical physical indicators that affect local area planning are population density, building density and development pattern and are therefore considered as criteria for cataloguing wards of Delhi, where ward is a unit for preparing Local Area Plans.

III. STUDY AREA

Delhi, the capital of India, is selected as the study area. Delhi is spread over an area of 1483 sq. kilometres. It stands as a primate city in its regional setting with satellite towns like Faridabad, Gurgaon and Noida making it National Capital Region. According to 2011 census, Delhi’s city population was about 16 million, the second highest in India

after Mumbai, while the whole National Capital Region population is about 16.8 million, making it the world’s 3rd largest city in terms of population. The National Capital Territory of Delhi comprises 9 districts, 27 tehsils, 59 census towns and 300 villages. Delhi is divided into the New Delhi Municipal Committee (NDMC), the Municipal Corporation of Delhi (MCD) and the Delhi Cantonment Board (DCB). Owing to the high population densities of the wards and for administrative convenience, on 13 January 2012, the Municipal Corporation of Delhi was ‘trifurcated’ into three smaller municipal corporations. The new North Delhi Municipal Corporation and South Delhi Municipal Corporation each contain 104 municipal wards, the smaller East Delhi Municipal Corporation contains 64 wards, making it a total of 272 wards in Delhi, as shown in Figure 1.



Source: Authors

Figure 1: Map of Delhi showing wards under their Municipal Jurisdiction

IV. METHODOLOGY

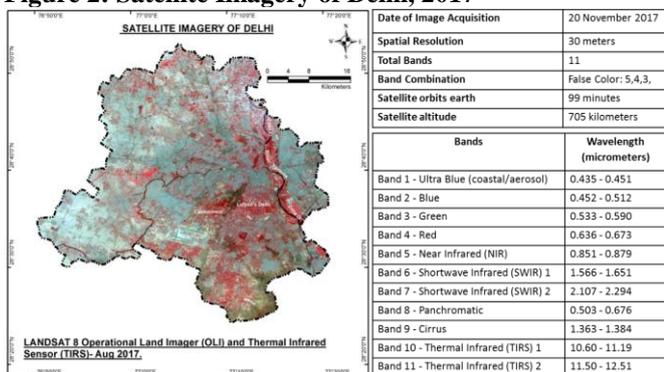
Geographic Information Systems (GIS) and Remote Sensing (RS), have proved to be useful tools for assessing spatial characteristics (Hathout, 2002 & Md. Inzamal H. et al). In India, an integrated remote sensing and GIS based methodology has been developed by many cities and have ended up by generating an up to date digital database platform (P Thirumalai et al, 2016). There are many studies available to support the importance of GIS and remote sensing in this context but the authors could not find an instance where GIS is used as a tool to identify spatial characteristics for the purpose of cataloguing wards in the city. In this paper, authors have used Geographical information System (GIS) to form the basis for cataloguing the wards of Delhi. The methodology is based on the two-staged approach. The paper uses data on remote sensing platform, received from the United States Geological Survey Earth Explorer. The details of the satellite imagery are provided in the Figure 2. Three softwares are used for this research viz; ERDAS Imagine (version 2014) software has been used for processing of the data (satellite imagery),

image enhancements and classifications. ArcGIS (version 9.3) has been used for processing of the data, analysis and to compliment the display (layout).

Microsoft office is used for the producing the bar graph, pie graph, analysis etc., post analysis to facilitate discussions.

Image enhancement is the process of adjusting digital images to make them more suitable for display and to facilitate image analysis. This includes noise removal, sharpening, or brightening an image, making it easier to identify key features. Histogram equalization technique is used for adjusting image intensities to enhance contrast. In case of multiband or multispectral imager, individual bands or their combinations can be used to identify different features on the ground. The authors have selected specific bands from a multispectral satellite image to create color pictures that are tailored to facilitate the identification of the features of interest like built-up, vegetation etc.

Figure 2: Satellite Imagery of Delhi, 2017



Source: United States Geological Survey Earth Explorer, August 2017

These images were then used to prepare maps for Delhi using supervised classification scheme, based on three identified criteria i.e., built density, population density and development pattern. A Supervised classification method was carried out using sample areas and test data for accurateness assessment. Maximum Likelihood Algorithm was used to detect the land cover types in ERDAS Imagine followed by accuracy assessment of data.

Further, to determine the co-relation between different attributes, spatial overlapping is done to understand the relation between them. The analysis for the three selected attributes has been done at zonal level and subsequently at ward level to facilitate cataloguing of wards under different categories.

V. DATA PRESENTATION AND ANALYSIS

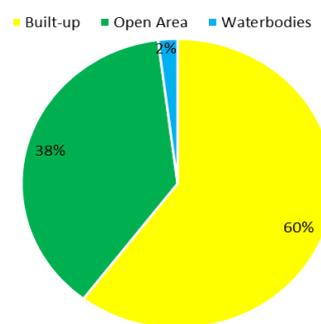
This section explains the approach to the paper in recognizing wards under the three identified spatial indicators that are building density, population density and development pattern in the first instance and subsequently overlapping the same to catalogue the 272 wards of Delhi.

a. BUILDING Density

Building Density is the ratio of area under building structures to an area unit. Here, area under building refers to any land on which buildings and/or non- building structures are present as part of a larger developed environment such as developed land by land owning agencies (MCD, DDA, Delhi Urban Shelter Improvement Board, and Railways etc.), rural and urban villages, unauthorized settlements including slums and

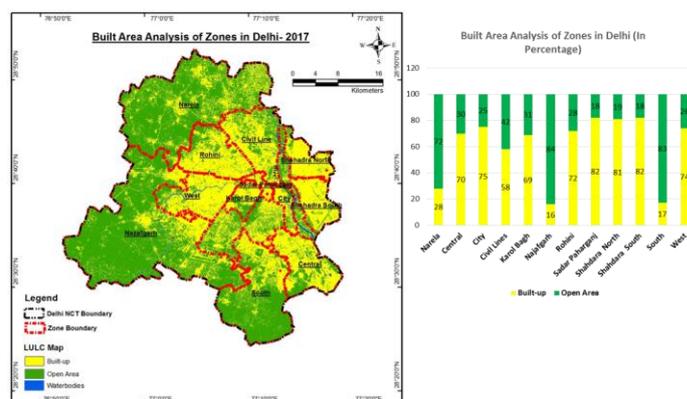
squatters etc. On the contrary, natural vegetation, reserved forested, barren/waste land, river and its floodplains, cultivated land, recreational parks, ground, multipurpose grounds etc. form the part of open land. The Analysis shows that 60.3% of the total land in Delhi is built. Presence of open areas like Cantonment, Lutyen’s Delhi, Airport, reserved forests of Asola and Jasola etc. reduces the built load in the core of the city. Pie chart shows ratio of open vs built areas in Delhi (Figure 3). Figure 6 shows the Built area in Delhi with respect to the zones. The analysis shows that the Periphery Zones of Delhi i.e. Najafgarh and Narela have less built character unlike the core zones. South Zone is comparatively less built due to presence of reserved forests and many heritage precincts. Further, built area mapping is done at ward level. An example of zone Narela is shown in figure 4. Subsequently, built area is calculated for all zones and then wards of Delhi.

Figure 3: Open versus Built ratio in Delhi



Source: Authors

For the ease of analysis, the wards are divided under 3 categories as less, moderate and highly built area. Wards which lay 25% on either side of the average built area of the wards are considered to be moderate. Wards lying in the range less than that are considered to be less and more than that are considered to be high on the scale for built area analysis. The Zones and respective wards that occupy core are highly built whereas those at periphery are less built and therefore are planned to accommodate future development.



Source: Generated by authors using ArcGIS (version 9.3)

Figure 4: Building Density of Zones in Delhi

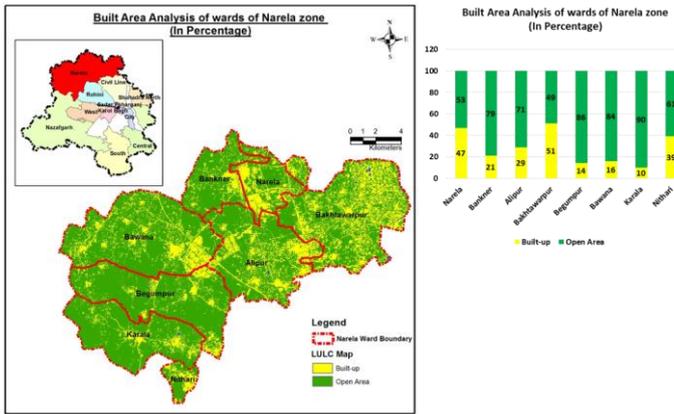
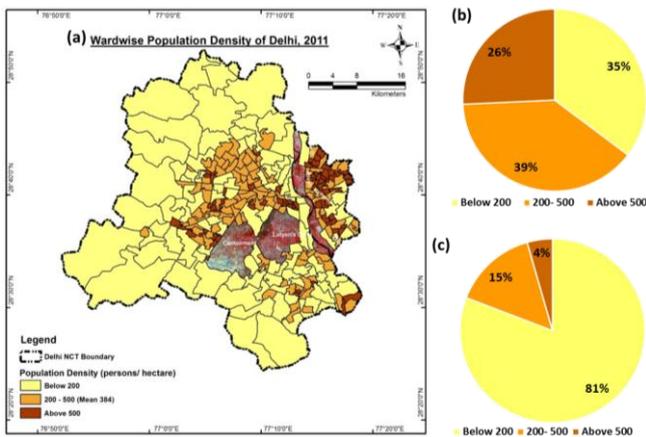


Figure 5: Building Density of wards in Delhi

Source: Generated by authors using ArcGIS (version 9.3)

Figure 6: (a) Ward-wise Population Density of Delhi 2021, (b) Number of wards in each population density category, (c) Area of wards in each Population Density category



Source: Generated by authors using ArcGIS (version 9.3)

b. Population Density

This indicator is calculated based on population of the wards as enumerated in the Census 2011. The data shows that though the numbers of wards in each category of population density seems to be fairly distributed because of the differential areas under each ward but while analyzing, it was discovered that 81% of area in Delhi has density below 200 and is planned for future growth (refer Figure 6). The area under this category is high because the wards at the periphery of the city are relatively larger in size. The density of population is high in core of the city and in the trans- Yamuna wards. Figure 5 shows the ward wise distribution of population density in Delhi.

c) Development pattern Analysis

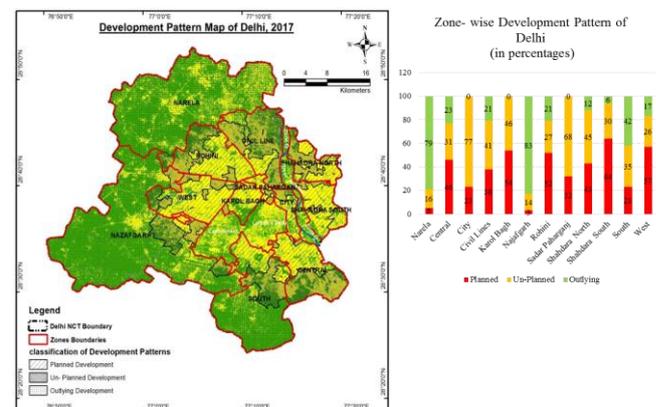
Development Pattern denotes to the collection and arrangement of the building masses in a city reflecting the spatial layout of spaces. This indicator included mapping of planned and unplanned areas of Delhi. Planned areas comprises of Planned colonies (which have approved layouts), Resettlement colonies (Slum & JJ Deptt. A MCD). Unplanned area includes urbanized villages (Urban Development Department GNCTD), Jhughi Jhompri Clusters (Slum & JJ Deptt. MCD), Slum Designated Areas (Slum & JJ Deptt. MCD) and unauthorised colonies (Slum & JJ Deptt. MCD) and regularised colonies (Urban Development Department GNCTD) of Delhi. Another category is added

under this category called “urban extensions”. These are outlying areas which are reserved to accommodate the future expansion the city. As of now, these areas are earmarked as the areas of agricultural use less density of population, which is limited to the villages in these zones. These areas are part of zones J to L, N & P (I & II). The mapping is done on the basis of review of government documents and wherever information was not available, the texture of the satellite imagery is referred as shown in the Figure 7.



Source: Google earth Pro, August 2019

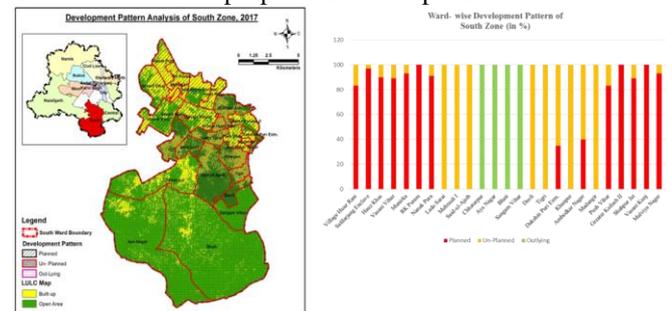
Figure 7: Aerial Views of types of Development in Delhi



Source: Generated by authors using ArcGIS (version 9.3)

Figure 1: Zone wise analysis of Development Pattern in Delhi

Figure 8 shows the Development Pattern in Delhi with respect to the zones. The analysis shows that Central, Karol Bagh, Rohini Zone houses more planned areas, as compared to other related old parts of the city. South Zone has fair distribution of planned and unplanned areas, owing to existence of posh colonies on one hand and large number of urban villages on the other. City Zone is largely occupied by the walled city and therefore has a large proportion of unplanned areas. Narela and Najafgarh Zone are part of the urban extensions and therefore has fewer proportions under planned areas.



Source: Generated by authors using ArcGIS (version 9.3)

Figure 9: Ward wise development pattern analysis of South Zone, Delhi

Further, development pattern analysis mapping is done at ward level. An example of South Zone is shown in figure 9. Subsequently, areas under the 3 categories are calculated for all wards of Delhi. Based on Bayesian statistics¹, if the ward has 70% or more than 70 % of area under a category, the ward is assumed to be of the same category. Likewise, all the wards are coded as planned, unplanned or urban extension. Therefore, all the wards are mapped according to the aforesaid three selected attributes for the purpose of analysis.

VI. DISCUSSION

In social science researches, correlation is an important statistical tool that talks about relationships and association between variables. This refers to the extent to which one variable changes (in quantity or quality) in response to change in another variable (Ibanga, U. A. 1992). The research progressed with calculation of correlation between 3 chosen criteria. 7 wards, out of 272 wards were not considered as the differential densities in these wards are the result of either physical features like river bed, ridge etc. or the floating population in wards with substantial commercial or industrial land uses. Examples-Chandni Chowk, Mehrauli etc.

Ironically, the analysis shows that there is a positive stronger correlation between development pattern and building density, as compared to correlation between population density and any other indicator, despite of the fact that this is the chosen criteria by the existing planning machinery. To assess the significance of the correlation between the two attributes, P value is calculated. P- Value is <3.32E-26, which is less than 0.05; there is a significant positive correlation between development pattern and building density.

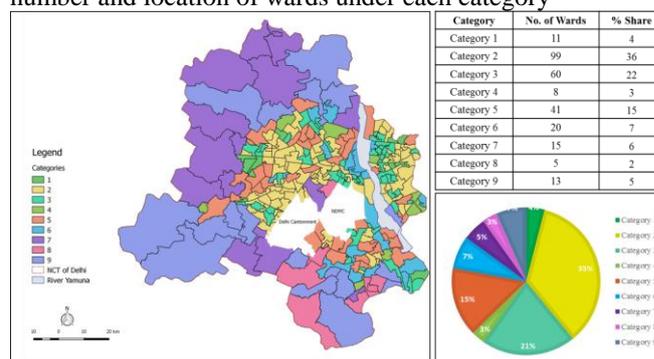
The relationship of the building density (Built vs. open) and development pattern is an important indicator while planning urban centres. However, the relationship between the two is not reasonably well developed and integrated into the urban planning processes in developing countries. As a result, not many studies have been undertaken with regard to density in relation to development patterns (Daniel Lirebo Sokido, 2016). Nevertheless, in case of Delhi, the two attributes, namely development pattern and building density is fairly correlated to each other and therefore can be taken up as criteria to catalogue the wards of Delhi. Table 1 shows distribution of 265 wards in 9 categories. The characteristics of the 9 categories have been described in the preceding section.

Table 1: Classification of wards in Delhi based on the Chosen Criteria

Built Ratio	Type of Development	Outlying	Planned	Unplanned
High		Category 1	Category 2	Category 3
Moderate		Category 4	Category 5	Category 6
Less		Category 7	Category 8	Category 9

Category 1 includes outlying wards with high building density. The analysis shows that 11 wards make a part of this category and accounts for 4% of the total wards in Delhi. It is found that most of these wards though lie in the outlying areas

but houses industrial estates and allied land uses. Few of them are Gokalpur, Jaitpur, Jhilmil, Nawada, Nangloi, Shahdara etc. Category 2 comprises of wards which are planned and have high density of buildings. The highest number of wards, around 35%, is recorded under this category. Most of these wards houses colonies that were made to resettle refugees in early 1950's by Ministry of Relief and Rehabilitation. Few of these wards are Model Town, Ashok Vihar, Lajpat Nagar, Adarsh Nagar, Janak Puri, Vikas Puri etc. Category 3 includes second largest number of wards. Wards under this category are characterized by high building density and unplanned development and house the old urban villages, unauthorized colonies, slums etc. interestingly, entire old Delhi falls under this category. Category 4 wards are outlying wards with moderate density. They are primarily peri-urban villages, which area extending beyond rural limits as a result of urbanization. These wards are large in size as they comprise of agricultural land which is yet to get urbanized fully. Dhirpur, Khichipur, Najafgarh etc. are few of the wards in this category. Category 5 houses the wards with planned and posh colonies of Delhi like Safdarjung Enclave, Vasant Vihar etc. on the one hand and wards that includes DDA housing schemes and DDA residential colony like Sarita Vihar, Rohini, Timarpur etc. on the other. Category 6 is a fascinating category since it comprises of unplanned areas with high density but compensated with adjacent large open areas either in terms of reserved forests, lakes or government acquired land for public good. Few of the examples are Badarpur ward comprising of large open land under NTPC water treatment plant, Bhalaswa with Landfill and Bhalaswa Lake, Lado Sarai adjacent Mehrauli Archeological Park, Majnu ka Tila near Reserved forest etc. Categories 7 encompass wards demarcated for future urban expansion and therefore these wards have less build density. Few of these wards are Nithari, Narela, Mundaka, Kapashera, Karala, Jharoda, Hastal, Deoli etc. Category 8 includes planned wards with less build density. Vasantkunj, Palam etc. makes part of this category. Lastly, category 9 combines 13 wards, characterized by less build density and unplanned areas like Chattarpur, Chhawala, Mehrauli etc. Figure 10 reveals the number and location of wards under each category



Source: Generated by authors using ArcGIS (version 9.3)

Figure 2: Map of Delhi showing Classification of wards

Interestingly, though category 7, 8 and 9 collectively includes less than 5% of the total no. of wards in Delhi but occupies about 40% of the area of the city. The categorization of wards in Delhi explicates the need for diverse planning strategies and development framework to ensure meaningful and indicative advancement of the capital city- Delhi.

¹ Bayesian statistics is a theory in the field of statistics based on the Bayesian interpretation of probability where probability expresses a degree of belief in an event.



VII. CONCLUSION

The concept of decentralized urban management seems to be the recent inventive resolution to the existing urban issues at local level, where planning mechanisms are being developed at smallest administration unit i.e. ward. Despite of numerous efforts by the government, no planning strategy fitted best in identifying needs and aspirations of local people at each ward. This is primarily because wards have varied characteristics and need diverse treatment to address the needs of the public and therefore, a need to catalogue wards of Delhi under different categories to best suit the characteristics, issues and aspirations of the people at ward level is vital. Geographic Information Systems (GIS) and Remote Sensing (RS) have been proved to be the suitable tools for assessing spatial character. Thus, the authors have investigated the degree to which GIS and RS are fit to be used as tools for cataloging wards in Delhi. The three criteria identified from literature were population density, building density and development pattern. The study reveals a correlation between the latter two criteria, which finally became the basis of categorization of wards in Delhi. Despite of the established relationship between the two attributes, greatest hindrance is perhaps the absence of an adaptable theory in relation to the issues of spatial development and density paradox (Rådberg, 1996, 385). The study suggests that the wards at the core of the city, being highly built, needs a different planning mechanism and wards at the periphery, designated for future development necessities sensitive planning handling. Moreover, wards housing planned colonies and those with unplanned settlements need differential forecasting and management approach, despite of the fact that they may lie adjacent to each other. The planners needs to get sensitized towards decentralized and varied management and planning frameworks, which if formulated thoughtfully and considerately at the ward level would ensure, meaningful and implementable plans for effective urban development. The authors have categorized 272 wards of Delhi in 9 categories, based on the two chosen criteria, out of three. If the other important criteria, as discovered through literature, are also considered, one may end up with more categories, with more defined spatial and demographic characteristics. This may give impetus to the effective planning at local level, enabling policy makers and planners to design the strategies which are not only efficient in terms of resources and time but also be more effective and implementable at ward level.

REFERENCES

1. Daniel Lirebo Sokido, 2016, "Density in Relation to Patterns of Built-forms (Case Study: Addis Ababa, Ethiopia)" International Journal of Architecture and Urban Development Vol.6, No.3, Summer 2016
2. Ebel, Richard, Vaillancourt, Françoise. 2007. Intergovernmental Assignment of Expenditure Responsibility. In Ebel,
3. Guerrero, A. M., Mcallister, R. R., & Wilson, K. A. (2014). Achieving cross-scale collaboration for large scale conservation initiatives. Conservation Letters, 8(2), 107-117.
4. Hathout, S. (2002) 'The use of GIS for monitoring and predicting urban growth in East and West St Paul, Winnipeg, Manitoba, Canada', J. Environ. Manage. 66, p229-238.
5. Hoffman, L. L., Varady, R. G., Flessa, K. W., & Balvanera, P. (2009). Ecosystem services across borders: A framework for transboundary conservation policy. Frontiers in Ecology and the Environment, 8(2), 84-91. doi:10.1890/070216
6. Ibinga, U. A. (1992). Statistics for Social Sciences. Jos: Centre for Development Studies, University of Jos

7. Lancichinetti, A. and Fortunato, S., 2009. Community detection algorithms: A comparative analysis. Physical Review E, 80 (5), 56117.
8. Malthus, Thomas Robert (1798): "An Essay on the Principle of Population", Library of Economics and Liberty, Ed. 6, Chapter II
9. Md. Inzamal H. and Rony B.(2017), 'Land cover change detection using GIS and remote sensing techniques: A spatio-temporal study on Tanguar Haor, Sunamganj, Bangladesh', The Egyptian Journal of Remote Sensing and Space Science, Volume 20, Issue 2, Pg 251-263
10. Municipal Corporation of Delhi, 2005. Guidelines for local area plan preparation
11. Oates, Wallace. 1972. Fiscal Federalism. New York: Harcourt Brace Jovanovic.
12. Olson, Mancur, 1996 "Distinguished Lecture on Economics in Government: Big Bills Left on the Sidewalk: Why Some Nations are Rich, and Others Poor", Journal of Economic Perspectives, Vol 10, No 2, Pp. 3-24.
13. Owusu, Richard Kofi (2012): "Population density and Economic Growth Demography as a tool for growth", Masters. Roskilde University
14. P Thirumalai, P Priya, J Senthil and PH Anand (2016), "Land information system in a sample ward of Kumbakonam town using GIS for decision making", International Journal of Applied Research; 2(12): 770-774
15. Parikh, K. 2015, "Do the Smart Thing," Indian Express, February 02
16. Péter István BALOGH , Dániel TAKÁCS,2011 "The significance of urban open spaces and green areas in urban property developments", First International Conference "Horticulture and Landscape Architecture in Transylvania" Agriculture and Environment Supplement 110-121
17. Plane, David A., and Peter A. Rogerson. 1994. The Geographical Analysis of Population, with Applications to Planning and Business. New York: Wiley
18. Rådberg J. (1996). Towards a theory of sustainability and urban quality: A new Method of Typological Urban Classification in Gray M., (ed.). Evolving Environmental Ideals: Changing ways of life, Values and Design.
19. Thünen, J. (1826). Die Isolierte Staat in Beziehung auf Landwirtscha und Nationalökonomie – Berlin

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