## Chapter 2
### Conceptual Models of Peri-Urbanization

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Introduction</td>
<td>34</td>
</tr>
<tr>
<td>2.2</td>
<td>Concept of Models in Urban Geography</td>
<td>37</td>
</tr>
<tr>
<td>2.3</td>
<td>Overview of Urban Models – Concentric Zone, Multiple Nuclei, Sector</td>
<td>38</td>
</tr>
<tr>
<td>2.4</td>
<td>Mathematical Models Related to Peri-Urbanization</td>
<td>43</td>
</tr>
<tr>
<td>2.5</td>
<td>Building Conceptual Models</td>
<td>44</td>
</tr>
<tr>
<td>2.6</td>
<td>Comparing Conceptual Model with Perceived Reality</td>
<td>47</td>
</tr>
<tr>
<td>2.7</td>
<td>Spatio-temporal growth of Bangalore City</td>
<td>49</td>
</tr>
<tr>
<td>2.8</td>
<td>Constructing Conceptual Model for the study Area</td>
<td>53</td>
</tr>
<tr>
<td>2.9</td>
<td>GIS Visualization in Building Conceptual Model</td>
<td>55</td>
</tr>
</tbody>
</table>
2.1 Introduction

Model has been defined as an idealized and structured representation of the real world. A number of definitions of models, have however, been given by geographers. In the opinion of Skilling (1964), a model is “a theory, a law, a hypothesis, or a structured idea. Most important from the geographical point of view, it can also include reasoning about the real world (physical and cultural landscape) by means of relation in space or time. It can be a role, a relation or an equation.

In the opinion of Ackoff, “: a model may be regarded as a formal presentation of a theory or law using the tools of logic, set theory and mathematics”.

According to Young and Petch, “any device or mechanism which generates a prediction is a model”. Accordingly, modeling, like experimentation and observation, is simply an activity which enables theories to be tested and examined critically.

Thus, most of the geographers of the post-second world war period have widely conceived models as idealized simplified representation of geographical reality (physical and cultural landscapes).

**Significance of Geographical Models:** Geography can be formally defined as the study of the earth’s surface within which the human population lives (Peter Haggett, 1990). The world is derived from the Greek geo, the earth, and graphein, to describe.

Geography is a discipline which deals with the interpretation of man-nature relationship. The earth—the real document of geographical studies—is, however, quite complex and cannot be comprehended easily. The surface of the earth has great physical and cultural diversity. In geography, we examine location, landforms, climate, natural vegetation, soils and minerals, their spatial distribution and utilization by mankind which leads to the development of cultural landscape. Moreover, geography is a dynamic subject as the geographical phenomena (created by nature and by man) change in space and time. The subject matter of geography, i.e., the complex relationship of man and environment, can be examined and studied scientifically by means of hypotheses, models and theories. This basic aim of all models is to simplify a complex situation.
and thus render it more amenable to investigations. In fact, models are that they are predictive devices.

**Utility of Modeling in Geography:** For the last few decades geographers have been increasingly concentrating on the development of models and theories (both in the physical geography and human geography) like that of in the physical, biological and other social sciences (Economics, Sociology, Psychology, etc.) Since models are a device of understanding the vast interacting system comprising all humanity and its natural environment on the surface of the document of the earth surface. Modeling in geography is therefore done to achieve the following objectives:

1. A model-based approach is often the only possible means for arriving at any kind of quantification or formal measurement of unobserved phenomena. Models help in estimations, forecasts, simulations, interpolations, and generalization of geographical data and information. For example, the future growth and density of population, use of land, intensity of cropping, migration pattern of workforce, industrialization, urbanization and growth of slums may be predicted with the help of models. Models are also very useful in the forecast of weather, change of climate, change in sea level, environmental pollution, soil erosion, forests depletion and evolution of landforms.

2. A model helps in describing, analyzing and simplifying a geographical system. Locational theories of industries, patterns of agricultural land use intensity, trends of population growth, patterns of migrations and stages of landforms development can be easily understood and predicted with the help of models.

3. Geographical data about the physical and cultural phenomena are enormous and every passing day geographical data is becoming more and more difficult to understand. Modeling is undertaken for structuring, exploring, organizing and analyzing the obtained data through discriminating pattern and correlation.

4. Alternate models can be used as ‘laboratories’ for surrogate observation of systems of interest, which cannot be observed directly, and also experimenting and estimating the effects and consequences of possible changes in particular components. These are also useful for generating future scenario of evolution.

5. Models help in improving the understanding of causal mechanism, relationships between micro and macro properties of a system and the environment.
6. Models provide framework within which theoretical statement can be formally presented and their empirical validity then put under scrutiny.

7. Modeling provides linguistic economy to geographers and social scientists who understand their language.

8. Models help in the testing hypothesis, and building of theories, and laws.

Features of a Model: The salient features of a model are as under:

1. The geographical reality of the earth’s surface and man-environment relationship are quite complex. Models are the selective picture of the world or part of it. In other words, a model does not include all the physical and cultural attributes of a macro or micro region. In fact, model is highly selective attitude to information to geographical information.

2. Models give more prominence to some features and obscure and distort some others.

3. Models contain suggestions for generalization. As stated above, predictions can be made about the real world with the help of model.

4. Models are analogies as they are different from the real world. In other words, models are different from the geographical reality or the real document of the earth.

5. Models tempt us to formulate hypothesis and help in generalization and theory building.

6. Models show only some features of the real world in a more familiar, simplified, observable, accessible, easily formulated or controllable form, from which logical inferences and conclusions can be drawn.

7. Models help in squeezing out the maximum amount of information from the available geographical data.

8. Models provide a framework wherein information may be defined, collected, tabulated, processed and arranged.

9. Models help to explain how a particular phenomenon comes into existence.

10. Models also help to compare some geographical phenomena with the more familiar ones.

11. Models causes a group of phenomena to be visualized and comprehended which otherwise could not be understood because of its magnitude and complexity.

12. Models form the stepping stones to the building of theories and laws-both the general and particular.
2.2 Concept of Models in Urban Geography

The origin of urban places has been a point of great controversy and the experts of urban geography are not unanimous in their opinions on this issue. There are, however, four broad explanations which have been advocated about the origin of urban settlements. These are described below:

1. The Ecological Models: The ecological models typically associates urbanism with the production and concentration of a ‘surplus’ of some kind through, in particular, the commencing of large-scale irrigation schemes. In the irrigated areas, there was surplus production. In fact, an agrarian society based on large-scale hydraulic constructions, typically irrigation systems, was having surplus production. The effective management of these irrigation works involves an organizational web which covers either the whole, or at least the dynamic core, of the country's population. In consequence, those who control this network are uniquely prepared to wield supreme political power. The result, Wittfogel contended, was that the state “occupied an unrivaled position of operational leadership and organization control”. It mobilized labour (forced labour raised on a temporary but recurrent, because seasonal, basis) and enforced such an inordinately powerful control over its subject population that it was, in effect, a state stronger than society. The state apparatus, thus, took the form of a hydraulic bureaucracy. Wittfogel thesis has been used to account for urban origins precisely because it is supposed to provide a rationale for centralization and concentration.

2. Economic Models: The economic models, typically focus on changing forms of economic integration and, in particular, on the transition from reciprocity to redistribution are especially concerned with ways in which such systems of exchange are ‘embedded’ in non-economic institutions. Most of these models are indebted to Polanyi’s substantivist anthropology.

3. Cultural Models: These models typically examine the formative influence of religion on urban genesis. “The religious component is almost alone”, Wheatley (1971) argues, “in having left in several of the realms of nuclear urbanism, a more or less continuous success of surviving material traces through… to fully evolved urban life”. In this view, the earliest foci of power and authority took the form of ceremonial centre’s, with religious symbolism imprinted deeply on their physiognomy and their operation in the evolution of town or iconography of ancient city, which projected images of the cosmic
order or iconography of ancient city, which projected images of the cosmic order on to the plane of human experience, where they could provided a framework for social action.

4. Politico-military Models: These models typically conceive of the first city as both fortress and refuge. Many of these models are, of course, compatible with the arguments of previous paragraphs-the supposed conjunction between ‘hydraulic society’ and ‘Oriental Despotism’, for example, or the centering of “political and military power … first in theocratic and later in monarchical control” (Giddens, 1981, 1985), but they usually go beyond those claims to emphasize the decisive importance of military power through a grid of cities for the creation of empires.

2.3 Overview of Urban Models – Concentric Zone, Multiple Nuclei, Sector

Although each city is unique in respect of detailed pattern of its internal land use, there is nevertheless a considerable degree of repetition in the broad geographical arrangement of the various categories of urban land use from one city to another. As a result, a number of theories have been formulated which attempt to describe and explain the patterns involved. About the internal structures of cities, three popular models, based on empirical studies in different cultural settings, are important. These theoretical structures are referred as

1. The concentric zone model by E. W. Burgess
2. The wedge or sectoral model by Homer Hoyt and M. R. Davis
3. The multiple Nuclei model by C.D Harris and E. I. Ullman.

The concentric Model:

The concentric zone model of urban land use was first proposed by E. W. Burgess (1924, 1927). This is also known as the ecological theory of city structure. Burgess main research interest was the determinants of urban social problems such as vice and crime, and his mapping of their occurrence within Chicago indicated a concentration in certain type areas only, but was later seen to have more universal application. Burgess model is based on the idea that the growth of the city takes place outwards from its central area to form a series of concentric zone. Burgess identified a system of five concentric zones, each characterized by a particular type of land use.

Zone I (central Business District- CBD): CBD occupies the central place and it is the focus of city’s commercial, social and civic life. This part is most readily accessible part of city as
all routes radiate here. The heart of all these is known as down town. It contains departmental stores, smart shops, office buildings, financial institutions, banks, insurance offices, real estate offices, hotels, restaurants wholesale trades, theatres, recreation places, and head quarters of economic, social, civic and political organizations. The land value and rent of the spaces are very high in the CBD.

**Zone II** (Zone in transition): this zone surrounds the CBD and it is the zone of residential deterioration. There is invasion of business in this area which led to decline in residential desirability. Some slums may also develop in this area. There may be some light industries in the inner part of this zone. The owners of property in this zone are not interested in improving the quality of buildings. This area is occupied by lower income groups. They live close to the place of work as they cannot afford high cost of transport.

**Zone III** (Zone of Independent Workmen’s home): this zone is made up largely of homes of factory workers and laborers and these are the people who often moved out of zone 2. In India, generally, this area has planned flats. The density and occupancy of this zone is always high.

![Diagram 2.1: Concentric Model by E. W. Burgess](image-url)
Zone IV (Zone of Better Residence): In this zone the majority of the middle and upper-middle class people reside. Small businessmen, professional people, better paid government employees and salesmen reside in this zone. This area is dominated by single families.

Zone V (Commuter’s Zone): Beyond the city proper are located a small number of small towns which are mostly dormitory towns in that most of the people living here commute to the city every day for work. Most of the people living here work in the CBD. Here are large spacious houses usually having their own lawns etc. and are built at some distance from each other. The cost of land is comparatively low.

As stated above, each of the city zone, according to Burgess, has a tendency to expand outward.

Criticism

1. The Burgess model suggests a circular shape of CBD. The CBDs are generally either square, rectangular or linear and not necessarily circular in shape.
2. There is over emphasis on commerce and trade activity and complete neglect of industrial land use.
3. The outward expansion of the Zone II into Zone III has not been explained. In fact, how the lower income group people can encroach the outer space of Zone III occupied by rich people.
4. The effect of major transport has been ignored. People prefer to stay close to the roads. Consequently, the space along the roads has high valuation and high rent value.
5. The topographical factors have also been ignored. Concentric zones are not possible in the areas of undulating topography and the cities located near lakes, rivers and other water bodies.

The Wedge or Sectoral model:

The wedge or sectoral model of urban structure was propounded by Homer Hoyt and M. R. Davis in 1939. It was based on the study of 64 American cities. According to this theory, patterns of urban land use are conditioned by the arrangement of routes radiating out from the city centre which create a sectoral pattern of land and rental values which in turn influences the urban land use pattern.
According to the proponents of this theory, a high-rent residential district in one sector of the city will migrate outwards by the addition of new belts of housing along its outer arc. Similarly, low-rent housing might expand outwards in a different direction. In other words, once contrasts in land use have developed near the city centre, these differences will be perpetuated as the city expands. This idea of sector-like expansion is an improvement on the earlier concentric model in that it takes into account both (i) the distance and direction of expansion, and (ii) acknowledges the importance of transport routes on the growth of the city.

The Multiple Nuclei Model:

According to C. D. Harris and E. L. Ullman, the concentric and sectoral models have the advantage of an essential simplicity, but actual patterns of land use are generally far more complex and varied, than either model would suggest. Consequently, in 1945, a less rigid model capable of application to a variety of urban patterns was proposed by Harris and Ullman. This was termed the multiple nuclei theory of urban structure.
It was suggested that land use patterns in most large cities develop around a number of discrete centers of nuclei rather than a single centre as described in concentric and sectoral models. The clustering of related land uses around these nuclei in the city creates a cellular structure, the pattern of which will be largely determined by the unique factors of site and history of any particular city. The multiple nuclei theory does not produce a simple model of urban structure appropriate to each and every city, but suggests a number of general principles which are relevant to the land use pattern of most cities. In this model the term ‘nucleus’ has been used to refer to any attracting element around which urban growth may take place.

The proponents of this theory emphasized that such multiple nuclei have been present right from the time of origin of cities, presenting as urban growth has filled around them. Metropolitan London is cited as one of the examples with the city and ‘west minister’ originating at separate points in the open country- one as a centre of finance and commerce, and the other a political centre. In fact, with the growth of city, the CBD loses its uniqueness- that it may become just of the many centers in the city. The high grade activities will abandon it for centers better located to serve the high income areas. The dominant nuclei are proliferating in this manner. Other centers will develop on a regional or specialized basis, thus strengthening the multiple nuclei generalization.
This model is considered to be more scientific which explains the present growth of urban centers both in the developing and the developed countries. This theory goes much farther than previous two in explaining the modern expanding cities where a number of nuclei, each specializing in particular functions, are evolving. In brief, none of the three models provides a true explanation of land use in urban areas. Each of the models, however, has some merits. It must be underscored that urban land use is a dynamic concept. The morphology of a city changes with the change in time and space. The development of transport is constantly changing the internal structure of the urban places.

2.4 Mathematical Models Related to Peri-Urbanization

The diversity of cities in various countries appears to defy analysis; some have a single centre, some no centre, and some several centers. However, the methods of mathematical geography make it possible to uncover regularities in the population distribution in cities and thus to obtain a more ordered picture of them. Such an ordering is of great practical importance both for geographical city studies and for urban planning. The Mathematical Method in Geography stressed the need for using theoretical probability structures in the study of various important problems of Mathematical Geography. Mathematical Geography uses many symbols and functions to calculate and simplify the problems.

Mathematical model-building is one of the new research methods used in Urban Geography particularly in modeling peri-urbanization. A model of a given dynamic system makes it possible to study the structure of the system and its relationship and to carry out experimentation, which is especially effective in the compilation of long-term forecasts. The functional relationship between elements of the model reproduces the actual relationship of the real elements of the system. Thus, by carrying out the theoretical and practical research with the model, one can also obtain information about the object that is being modeled. The functional interdependence between elements of the model is expressed in mathematical form, which makes it possible to interpret the quantitative aspects of phenomena and to obtain, on the basis of a quantitative analysis, new data of a qualitative character.

The construction of Conceptual models in Urban Geography is relatively a recent development. This method holds promise both for the study of individual cities and their
component elements and for systems of cities, but it still requires further development. The construction of models for the peri-urbanization is the latest trends in the geography. Constructing the models for urbanization using cellular automata model is a challenge for the urban geographers. Cellular automata model is based on the cell and the cell values relationship with the neighbour cells. Conceptual models provided the information to the reader related to the particular area, growth and distribution of the region, conceptual models based on the flow diagrams and algorithms and takes the help of the mathematical formulas and logics. Creating the models for the Peri-urbanization we have to take the help of the Mathematical models.

### 2.5 Building Conceptual Models

A conceptual model describes abstractly — in terms of tasks, not keystrokes, mouse-actions, or screen graphics — what users can do with the system and what concepts they need to be aware of. The idea is that by carefully crafting a conceptual model, then designing a user interface from that, the resulting application will be cleaner, simpler, and easier to understand. The goal is to keep the conceptual model:

1) As simple as possible, with as few concepts as are needed to provide the required functionality, and

2) As focused on the task-domain as possible, with few or no concepts for users to master that are not found in the application’s target task domain.

<table>
<thead>
<tr>
<th>Steps for building Conceptual Model</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearly state goals for developing the model</td>
<td>Some examples: to synthesize the understanding of ecosystem processes and stressors for a specific theme within a catchment. To identify gaps in knowledge about ecosystem processes for a specific theme within a catchment.</td>
</tr>
<tr>
<td>Identify the scope of what is under investigation</td>
<td>It is important to clearly identify the boundaries (spatial or temporal) or even whether the elements of an ecosystem or its pressures will be the main focus.</td>
</tr>
</tbody>
</table>
Identify key components of the model and pressures

This is where components may first be identified as a pressure, state or response to help construct the model. The team developing the model may consider in more detail how best to present the conceptual model, although this may change as the model is developed.

Identify relationships b/w components of the model

An understanding of the linkage between these components will either come from collaborators’ technical knowledge and experience or from the literature. The best models are those that stay simple. If the detail is too complex, consider breaking the model into smaller components.

Documentation

It is not only important to document sources of evidence that have been used to formulate the model but also any key questions, assumptions or limitations. This will ensure knowledge is not lost over time, when the model is reviewed or used at a later stage as part of the evaluation.

Review and refine the model

When first developed, the model will be based on best-available knowledge. As new knowledge becomes available, the model may need to be reviewed and any management decisions implemented.

Six Benefits of Conceptual Models

Starting a design by devising a conceptual model has several benefits:

1. By laying out the objects and operations of the task-domain, it allows designers to notice operations that are shared by many things or criteria’s. Common operations across objects make the UI simpler for users to learn and remember.

2. Even ignoring the simplification that can result from noticing shared operations, devising a user-model forces designers to consider the relative importance of concepts, the relevance of concepts to the task domain (as opposed to the computer domain), the type hierarchy of objects, and the containment hierarchy of objects. Having thought about these things greatly facilitates designing a user-interface.
3. A conceptual model provides a seed or starting point for the development of a region, which will be used to identify each of the objects and operations embodied in the software. This helps in ensuring that terms are used consistently throughout the research work and the planning and management.

4. Once Researcher has a conceptual model for his research work, they can write scenarios depicting people using the app to perform tasks, using only concepts from the conceptual model and terms from the vocabulary. A conceptual-level scenario for the calendar application might vary from user to user. Every place will not be used by all the users, in the same way, all the user will not use the same place. Such scenarios (which can be separated into use-cases), help to validate the design in functional reviews. They can also be included in product documentation and training. Conceptual scenarios describe tasks and goals without revealing the UI-level user interactions required to achieve those goals, so they can be used as task descriptions in usability tests.

5. A conceptual model provides first cut information to the researcher. Using that, researcher can easily assume the growth and development of the region or area. Afterwards he can implement the same region using the earlier experience.

6. An actively-maintained conceptual model supports a better development process. It can insure that all user-visible aspects of an application are consistent. Both of these also reduce development resources by reducing rework.

A conceptual model represents the minimum necessary set of activities, at a particular level of detail or resolution [Wilson, 1984]. To gain a better understanding of the systems or sub-systems, the system modelling can be taken to a higher level of resolution. It is also important to check the adequacy and validity of the conceptual model. To test for internal inconsistencies, the model has to fulfill the criteria of “3Es” (Efficacy – do the means work, Efficiency – amount if input divided by amount of resources used, and Effectiveness – is the transformation meeting the longer term aim.)
Chart 2.1 Shows the processes involved in building conceptual activity models.

It is a matter of judgment to determine whether the conceptual modeling has been completed. Once the decision is taken that the model is complete, it can be compared with what exists in the real world and what is suggested by the conceptual model. It is not necessary every time the conceptual model should be right, because of the local circumstances and the factors affected to the model leads to the false result. After finalizing the Conceptual model the researcher can apply the same to the Study area as well as in general and specifically.

2.6 Comparing Conceptual Model with Perceived Reality

The conceptual models are compared to the real world with the objective of having a well-structured and logical debate about how to improve the perceived problem situation. That discussion is structured around the models in order to inquire into the perceptions of the circumstances of the situation. The comparison should be done together with participants of the
problem situation that wishes to make the improvements happen, and who also have the authority to do so.

The method of comparison most commonly used is called formal questioning, where the conceptual models are used as a foundation for inquiring into the real world. Answering those questions encourage discussion about improvements in the problem situation. The discussion may be performed by a group of people in one, or by interviewing a single person over a period of time. The comparison will be done formally through a tabular display, a matrix, that for each activity in a model indicate whether it exists or not, and if it does exists – in what form. The matrix should also include how these activities are linked together. An example of such a matrix for formal questioning when performing the comparison between the conceptual models and reality is demonstrated in the below table, it explains us in what way the conceptual models is suitable for the real world situations.

<table>
<thead>
<tr>
<th>Conceptual Model Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity in Conceptual Model</td>
</tr>
<tr>
<td>1...........</td>
</tr>
<tr>
<td>2...........</td>
</tr>
<tr>
<td>3...........</td>
</tr>
</tbody>
</table>

**Performance criteria for evaluating Conceptual Model:**

- **E1: Efficacy** - Measured by asking ‘Does the system work?’ (yes/no/partly)
- **E2: Efficiency** - Measure by asking ‘Does the result justify the amount of resources used?’ (yes/no/partly)
- **E3: Effectiveness** - Measure by asking ‘Does the system meet both the short and long-term goals?’ (yes/no/partly)

**Table 2.2 The Matrix as a Technique for Comparing a Conceptual Model with a Real World Situation**

First the name of the conceptual model should be filled in the matrix. Since every conceptual model is to be compared to reality, it might be quite confusing and difficult to connect the answer to the correct model if it were not named correctly. A left-hand column lists all activities in the model. The following record the real-world manifestations, if they exist and under what circumstances. A third column adds value assessment about the activities in the real world, and how it presently being done. The last column is for describing what kinds of
improvements are necessary for performing any plans and developmental activities. The last column is for any comments on the way that things are being done. There should be room for anything that might concern the present ‘how’. This is all written in a language that is suitable for the situation and consists of the proposed changes together with the real-world evidence that support the recommended changes. It is this last column which is the source for the ideas about desirable and feasible changes to the problem situation. Lastly the relationships between the activities should be listed. This would entail all possible relationships, and preferably with a short description as to under what circumstances these links occur. The comparison of the conceptual model with reality is used to define systemically desirable and culturally feasible changes in the real-world.

2.7 Spatio-temporal growth of Bangalore City

Hiriya Kempe Gowda was son of Kempananje Gowda who had ruled Yelhankanadu for more than 70 years, supposed to have shown leadership skills during his childhood and was educated at Gurukula in Aivarukandapura (Aigondapura), a village near Hesaraghatta, for nine years. It is said that Kempe Gowda got the vision of building a big futuristic city during a hunting expedition near Shivasamudra (near Hesaraghatta) near Bangalore. He envisioned the city to have a fort, a cantonment, tanks (water reservoirs), temples and people of all trades and professions to live in it. He conquered Sivaganga principality, 30 miles from Bangalore on Bangalore-Poona Highway. Next he annexed Domlur which is on the road from Bangalore to the old Bangalore Airport. Within this vast forest area, with the necessary Imperial permission of the Vijayanagar Emperor, Achyutharaya (Dasarahalli record dated 1532) he built the Bangalore fort and the town in 1537 A.D. and moved his capital from Yelahanka to the new Bangalore.

Kempe Gowda built a red fort in centre of Bangalore with eight gates with moat surrounding it. Inside the fort two wide roads ran from North to South and East to West. The other roads were made parallel or perpendicular to them. On a supposedly auspicious moment fixed by an astrologer, Kempe Gowda harnessed the bullocks to the ploughs at the central Doddapete square, at the junction of Doddapete (Avenue Road) and Chikkapete, got the ground ploughed and worked the four main streets running in four directions. One ran from Halasoor (Ulsoor) Gate to Sondekoppa Road from East to West, and another from Yelahanka Gate to the Fort running from North to South. These roads are the present Nagarthapete, Chikkapete and Doddapete respectively. The streets and the Blocks were demarcated for the purpose they were
meant, like for business or residences etc. Streets of Doddapete, Chikkapete, Nagarthapete were for marketing of general merchandise, Aralepete (Cotton pet), Tharagupete, Akkipete, Ragipete, Balepete etc. were for marketing of commodities like cotton, grain, rice, ragi, and bangles respectively: kurubarapete, Kumbarapete, Ganigarapete, Upparapete etc. were for trades and crafts, and residences of Kuruba, Kumbara, Ganiga, Uppara castes respectively and similar petes' (Blocks). Halasoorpete, Manavartepepete, Mutyalapete (Ballapurapete) etc. were meant for other groups of the society. The Agraharas were for the priests and learned classes. He got skilled artisans and craftsmen from the neighboring as well as far off places and got them settled so that they could pursue their avocations.

Temples of Vinayaka and Anjaneya were built at the Northern Yelahanka Gate of the fort (near the present head office of state bank of Mysore). Dodda Basavannanagudi (The Bull Temple) and in its neighborhood, Dodda Vinayaka and Dodda Anjaneya and Veerabhadhara temples, were also built outside the fort on the Southern side.

Tanks were built for the water supply to the town, to the moat around the fort and for the irrigation of crops. Inside the fort, a big pond enclosed by masonry of dressed granite stones was dug and built (on the South-Western corner of the present Sri Krishnarajendra Market). Dharmambudhi tank, which supplied water to the town (present Subhashnagar, Bangalore Transport Service (BTS) and Karnataka State Road Transport Services (KSRTC) bus stands, in front of the city Railway Station), Kempambudhi tank (named after Ranabhaiere Gowda's family Goddess, Dodamma or Kempamma), in Gavi-pura Guttahalli (recently dried up) and Sampigambudhi tank (named after one of the daughters-in-law: present Kanteerava Stadium), which were meant for irrigation, were also built. Irrigational facilities gave much impetus to agriculture and horticulture and also encouraged laying of gardens and raising groves of fruit crops. The Emperor of Vijayanagar pleased with his activities bestowed him with near-by villages of Halasooru (Ulsoor), Begur, Varthur, Jigani, Thalagattapura, Kumbalgodu, Kengeri and Banavara.
Modeling Peri-Urbanization of Bangalore Metropolitan City – A Geoinformatic Approach

Map 2.1: Growth of Bangalore City 1537 to 2009

Map 2.2: Growth of Bangalore City with Study Area 1537 to 2009
After the period of Kempegowda and Vijayanagar, Bangalore City grew like anything in the period of British Rule. In the mid of 18th century Tasker Town, Rusel Market, Shivajinagar, Cox town, Frazer Town, Cantonment Railway station area grew and they were the residential places of British officers.

In the first of the 20th century Bangalore grew little bigger than the British period. The major areas join the Bangalore city are ITC, Cleverland town, Richmond Road, Austin Town, Nilasandra Sonehalli, Wilson Garden, Shanthi Nagar, Basavanagudi, N R Colony, Hanumantha Nagar, Mysore Road Timeryard, Guddadahalli, Binni Mills, Okalipuram, Sheshadripuram, Rajbhavan, Jayamahal, Malleshwaram, Gayathrinagaram, Sri Ramapura, Domalur, Indiranagar, and Binmangala.

After the Independence when the Karnataka state formed in between the period of 1947-1971, Bangalore was considered as the capital town of Karnataka State. Some of the important areas joining the Bangalore city are Jayanagar area, Vijayanagara, Hosakere halli, Ramachandrapuram, Rajaji Nagar Industrial Area, Yeshwanthapuram, Goraguntepalya, Mattikere, Gangenahalli, Lingarajapuram, Vimanagaram, Belur, Yamalur, K R Puram, Marathahalli, Doodanekundi and others.

The real growth started after 1981 to 2001. In this duration many areas joined the Bangalore City those are: Challaghatta, Agara, Jakkasandra, Tavarekere, Koramangala Extension, Saraki, Puteenahalli, Arkeri, Hulimavu, Banashankari, Katraguppe, Channasandra, Srinivasanagar, Chandralayout, Nagarabhavi, Kengeri, Nagadevanahalli, Mariyapanapalya, Malathahalli, Papareddy Palya, Kotegepalya, Sunkadakatte, Henganhalli, Laggeri, Nandini Layout, Kanterava Nagar, Mallasandra, Bagalakunte, Jalahalli, Yelahanka, Byatarayanapura, Hebbala, Nagavara, Kammanahalli, Kacharakanahalli, Banasawadi, Narayanapura, Mahadevapura, Basavanapura, Hudi, Whitefield, Nallurahalli and Garudacharapallya.

After 2001, BBMP twice demarcated the administration boundary and added some more areas to the Bangalore city and named as Bruhat Bangalore Mahanagara Palike. Those major areas are Ramauthy Nagar, Horamavu, Bairathi, Belisivali, Tanisandra, Kogilu, Jakkuru, Thirumanahalli, Chikkabettahalli, Abbigere, Chikkabanavara, Hirohalli, Sonnenahalli, Gotigerepallya, Uttarahalli, Begur, Bellandur, Varthur and Kadagodi.
2.8 Constructing Conceptual Model for the study Area

Constructing Conceptual Model for the Bangalore City is based on the base information and the survey information. Some features of the conceptual model of Bangalore City are near to the Multiple Nuclei Model created by the C D Harris and E L Ullman.

![Map 2.3: Conceptual Model for Bangalore City](image)

The Conceptual Model created for the Bangalore City having 8 classes those are Central Business District, Industries, I T Industries, Industrial Suburb, Low Class Residential Area, Middle Class Residential Area, High Class Residential Area and Residential Suburb.
Central Business District - considered as the Center point for the city, Akkipet, K G Road, Cubbonpet, Chikkapet, Kempapuram Agrahara, Gandhinagar, Sheshadri Puram, Rajbhavan Road, Tasker Town, Infantry Road, Rusel Market, Brigade Road, M G Road, Richmond Road, Shanthi Nagar, Kalasipalyam, Mavali are the areas coming under the Central Business District.

Low Class Residential Area – Okalipuram, Lakshminarayana Puram, Prakashnagar, Guddadahalli, Avalahalli, Kotegepalya, Kamakshipallya, Sunkadhatte, some stages of Bhanashankari, Tanisandra, Jakkuru, Byatarayanapura, Chikkabetahalli, Jalahally Village are the important Low class Residential areas.

Middle Class Residential Area – Nagarabhavi, R P C Layout, Papareddypalya, Hanumantha Nagar, V V Puram, N R Colony, Madivala, Tavarekere, Audgodi, Wilson Garden, Nilasandra, Ashok Nagar, Langford Road, Ramamurthy Nagar, K R Puram, Basavanapura, Kammanahalli, Kacharakanahalli, I T C, Cooktown, Cleverland Town, Biyyapanahalli, Matthikere, Malleshwaram and Vijayanagara are some of the areas coming within the Middle Class Residential Area.

High Class Residential Area – The Important High Class Residential Areas are Shadhashiva Nagar, Guttahalli Palace, Vyalikaval, Indiranagar, Domlur, Kormangala, Tippancandra, C V Raman Nagar, Vignyananagar, Jayanagara, J P Nagar and Yadiyur.

Residential Suburb – Yelahanka and Yelahanka Satellite town, Kengeri, Vasanthanagara, Gottigerepalya, Bellandur, Devarabisanahalli, Dodda Kanahalli, Gunjur and Gunjur palya are the major areas coming under the Residential suburb area.

Industrial Area – The Major Area and Industrial belts are Peenya, Yeshwanthapura, Jalahalli, Rajajinagar Industrial Suburb, Kethumaranahalli, Dasarahalli and Kamakshipalya.

Industrial Suburb – Begur, Hulimau, Kotnur, Puttenahalli, Saraki and Kudlu are the major places which developed the industries outside the city to bring down the burden of the Industrial located in the city.
I T Industries – Bangalore is known for the IT Industries because it is called as the Silicon Valley. The major IT Industries located areas are IPTL, C M H Road, C V Raman Nagar, Mahadevapura, Marathahalli, Garudacharapalya, Nallurahalli, Doddanekundi, Chanasandra, Yalamuru, Belur, Viman Nagar, Booke Field, Hagadur, Kadagodi, Nagavara, Hennur, Hebbala and Manyatha Tech Park.

2.9 GIS Visualization in Building Conceptual Model

The questions of whether GIS can lead to improved urban models can be answered only by examining the impact that GIS methodologies can have on the various components that make up an operational urban model. We distinguish three components:

1. Data: one of the most important but often unrecognized components of urban model, they are needed for both calibrating and running the models.
2. Mathematical equations: the core of the model.
3. Software engineering: the user interface, the ease of running the model, the ability to interpret and visualize the results, etc.

There is an increasing emphasis on providing models with map visualization capabilities. Multimedia is another feature which could be added to a system. Animation could be used to show how a city evolves over time. These features might have a more immediate impact on policy made than tables or diagrams. It is often said that a thematic map is worth one hundred tables with numbers or that GIS based systems can sell a proposition.

Although the judicious use of visualization and animation can enhance the acceptance of models, there is also the danger that they might lead to an overshadowing of the substantive content of the model. Urban models are often considered as complicated and difficult to comprehend by practitioners. When models are used for forecasting, they are frequently seen as black boxes which generate voluminous data sets. Irrespective of dazzling visualization features of urban models, their core will always remain the mathematical model and the theory on which they are based.