CHAPTER - II

ACCESSIBILITY – URBAN STRUCTURE INTERFACE:
THEORETICAL FRAMEWORK

2.0. OVERVIEW OF THE CHAPTER

This chapter reviews the literature available for accessibility measures, urban structure models and relationships tested between the two. Clarity about concepts and definitions, parameters, approaches of measurement and models have been done to facilitate selection of parameters and approaches of measurement for the present research. Appreciation of relationships between accessibility indices and urban structure parameters has been done to theorize the base of relationships.

2.1. TRANSPORTATION AND URBAN STRUCTURE

Human settlements are conscious creations of man’s creative urges. Inter and intra city connections and interactions between physical, socio-cultural and political forces have overwhelming effects on the structure of a city. Some of the most significant factors that affect the urban structure include rapid and massive growth, economic forces and the changing form of transportation. Doxiadis [1970, pp. 393-404] after analyzing the growth of few cities has concluded that even if cities are initially conceived with a very definite structure and form, invariably change when they grow. That is why cities are known to be dynamic entities and their land use patterns and land economics keep on changing with time and space. Consequently, new form, pattern and structure of a city emerge.

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Cities not only expand spatially in all directions but land use pattern, densities, FARs, land values, rent structure, etc. are also effected directly, which in turn reciprocate to affect each other. The basic components of the city (the nodes) i.e. work, residential, educational and recreational places cannot function individually. They have to interact for growth and development. In this process, urban transportation provisions not only bind these elements/indices together but also profoundly control their arrangements and functions.

Meier as cited by F. Stuart Chapin Jr. [1964] conceptualized the city in terms of systems of interaction prompted by man's urge to maintain communications (in the general sense) with his fellow men. At the present stage in man's state of development, transportation and communications technology supply the principle media of interaction. He holds that "-----transportation overloads are imposing limiting conditions on opportunities for interacting through transportation system."[pp.51-52] Similarly, The physical structure of a city, its size and sprawl, its way of life and character are dependent upon the nature and quality of its public transport system.

Therefore, it can be said that transportation facilities determine the form, shape, and structure of settlements. That is why the emphasis of transportation planning has changed from easing congestion to accessibility provisions. It is because of the fact that accessibility should be provided to all sections of the society to enable them to take part in activities and enrich the development of society like employment, education, shopping, recreation, medical, etc. Thus, accessibility becomes a function of landuse pattern and performance of the transportation system. Under the process different physical and economic indicators of urban structure are affected varyingly due to varying accessibility levels.

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2.2. ACCESSIBILITY

The ever increasing transportation problems in urban areas have transferred the emphasis of transport planning from minimization of travel demand to integrated landuse – transport plans. In this context accessibility provision is an explicit objective of transport planning. The planners are interested in reduction of travel demand through proper reshuffling of activities. It is in this context that accessibility is often discussed in contrast to mobility. Mobility emphasizes the transportation system, while accessibility also accounts for landuse patterns.\(^4\) Thus, accessibility is a function of landuse pattern and performance of transportation system. Access is an end rather than an impact on transport planning. Karlqvist [1975, p.71] as cited by G. H. Pirie [1979]\(^5\) rightly observed that "Accessibility has become a key concept for characterizing a fundamental principle of human activity: maximum contacts through minimum activity."

Accessibility is a general term used differently in different disciplines. It is believed that no single definition can encompass the meaning of accessibility, as it contextually varies [Raju, 1996].\(^6\) There is no consensus on an operational definition of the term ‘accessibility’ and hence has been defined in different ways by different researchers as per their requirements and convenience. Gould [1969, p.64] as cited by D. R. Ingram [1971]\(^7\) rightly pointed, "Accessibility ---- is a slippery notion ---- one of those common terms that everyone uses until faced with the problem of defining and measuring it".


According to Ayeni [1979] and cited by E. Cater [1983], “Accessibility per se is one of the most frequently used and yet little defined terms in urban studies”. However, researchers believe that it cannot remain clouded in concepts; it must be clearly defined and, if possible, measurable quantitatively in order to facilitate the determination of accessibility needs.

2.2.a Concept and Definition of Accessibility

Accessibility is a concept that has become central to physical planning during the last fifty years. The term was first occasionally used in the 1920s in location theory and regional planning, becoming important once transport planning began [Batty, 2009]. In general, accessibility means the ability or the ease with which one could go from place to place. But it is applied in varying forms in urban systems including transportation system. In spatial planning it is used to explain spatial variations of the phenomena under study, be it growth of towns; the location of facilities and functions; and the juxtaposition of land uses, etc. It is one of the most commonly applied terms in transportation discipline to study planning and operational mechanisms of transport systems and other perceptual frameworks. In a comprehensive urban planning context, accessibility is viewed as a dynamic element in urban development and is a function of three factors: the transport system, location, and the social attitudes of urban population.

Thus, accessibility is viewed as a paradox; neither travel time nor location fully explains its concept [Raju, 1996]. Different authors have defined the term ‘accessibility’ as per their perceptions and requirements. Following are


9 Batty, Michael (2009), Notes on accessibility in search of a unified theory, in Daniel Koch, Lars Marcus and Jesper Steen (Eds.), Proceedings of the 7th international space syntax symposium, Stockholm: KTH, 2009.

some of the quotes of authors while defining accessibility.

The credit of defining the term ‘accessibility’ goes to Hansen [1959]\(^ {11}\). He defined accessibility “as the potential of opportunities for interaction”. More specifically, it is a measure of the intensity of the possibility of interaction rather than just a measure of the ease of interaction. In general terms, accessibility is a measurement of the spatial distribution of activities about a point, adjusted for the ability and the desire of people or firms to overcome spatial separation. Defined in this manner, accessibility is a generalization of the population over distance relationship.

Wingo, Jr. [1961]\(^ {12}\) states, "In technical sense, accessibility is a relative quality accruing to a parcel of land by virtue of its relationship to a transportation system operating at some specified level of service. ----- the level of service of a transportation system is a reflection of the quantity of transportation services supplied by the system and the volume of demand that is asserted in it : it is, in short, a measure of system's efficiency, its `output' per unit of cost."

As per Ingram [1971]\(^ {13}\), "Accessibility may loosely be defined as the inherent characteristics (or advantages) of a place with respect to overcoming some form of spatially operating source of friction (for example, time and/or distance)." In one sense the word `accessibility' means capable of being reached, thus, implying a measure of the proximity between two points. Alternatively, `accessibility' is related to the ability of a transportation system to provide a low cost and/or quick method of overcoming the distance between two locations. Ingram introduced two subsidiary notions of accessibility i.e. `relative accessibility' and `integral accessibility'.


\(^{12}\) Wingo, L (Jr.), (1961), *Transportation and urban land resources for the future*, Inc., Washington, DC.

`Relative accessibility` is defined as "the degree to which two places (or points) on the same surface are connected" (refer figure 2.1.).

![Figure 2.1. Relative Accessibility of Two Nodes](image)

In other words, relative accessibility defines connectivity of two nodes by a link as explained in figure 2.a. where nodes ‘A’ and ‘B’ are connected by a link.

Whereas `Integral accessibility` is defined “for a given point as the degree of interconnection with all other points on the same surface” (refer figure 2.2.).

![Figure 2.2.: Integral Accessibility of Nodes](image)

Thus, interconnectivity of node ‘A’ with nodes ‘B’, ‘C’, and ‘D’ defines the integral accessibility of node ‘A’.

Muraco [1972]^{14} states, “Accessibility is associated with the geographic notion of situation, thus it is related to the elements of spatial relationships, interaction, and connectivity.”

Zakaria [1974]^{15} defines accessibility as “The travel performance and the quality of interaction between land use activities in the urban region. It shows the trip linkage between one zone and the other zone of a region and measures the locational advantages of that zone for various land


Haggerstrand [1974] as cited by M. J. Mosely et al [1977] states that, “Accessibility has at least two sides. One is the legal/social. Frequently an individual must fulfill certain requirements in terms of training, age, ability to pay, support from others and so on in order to be permitted to pass the barriers around the supply point he wants to reach. The other is the physical. He must be able to command the transportation facilities which are needed for reaching the supply point at suitable times”.

Dalvi and Martin [1976] state that there are several aspects implied in the term to be considered separately.

- individuals, their purpose, preferences and decision-making processes. The relative importance they attach to money costs, time, comforts and convenience should all enter into the construction of any meaningful measure.
- the opportunities themselves.
- the ability of transport system to provide low cost/or quick methods of overcoming distance between different locations.

While defining physical accessibility Daly [1977] states, “Physical accessibility is the ease with which people can reach distant but necessary services.”

According to Mitchell and Town as cited by Mosely et al [1977], “Accessibility is the ability of the people to reach destinations at which they can carry out a given activity.”

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19Ibid
According to Online TDM Encyclopedia [Victoria Transport Policy Institute, 2005, p.1][20], “Accessibility refers to the ability to reach desired goods, services, activities and destinations (together called opportunities”).

Conroy [1977] as cited by Pirie [1979][21] points out that “Accessibility is a property of the arrangement of activities and the level of service on the transportation system." In this statement the phrase ‘arrangement of activities’ is sufficiently broad to include the spatial, temporal, and functional arrangement of activities.

Hensher and Stopher [1977] as cited by Pirie [1979][22] states, “Accessibility is a property of people, opportunities and space, independent of trips actually made."

Leake and Huzayyin [1979][23] defines accessibility “to be the ease of traveling the origin and destination points of a trip. Ideally, ‘ease of travel' can be satisfied by using the safest, most convenient, and most comfortable means of travel, at minimum travel time and cost, and following the shortest (most direct) route."

Hence, ease of travel, or accessibility, is a function of the transport system. The latter is basically composed of two sub-systems, the transport network(s) & number of transport modes and it is the characteristics & the efficiency of these, which determines the physical meaning of accessibility. The efficiency of any transport system, and hence the accessibility of different places in an area, can be expressed by three major elements viz.,

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22 Ibid
the network structure i.e. how is it connected and to what extent it links different zones of the urban area.

- the travel resistance on different links of the network as reflected by travel distance, time and/or generalized costs.

- the level of service provided by public transport in terms of service frequency (bus/hour) and route coverage of the area.

According to Morris, Dumble and Wigan [1979]24, accessibility has generally been defined as some measure of spatial separation of human activities. Essentially, it denotes the ease with which activities may be reached from a given location using a particular transportation system.

They interpreted accessibility “as a property of individuals and space which is independent of actual trip making and which measures the potential or opportunity to travel to selected activities. Alternatively, it may be held that "proof of success" lies in the use of services and participation in activities, not simply in the presence of opportunities.”

Short [1984]25 states, “Accessibility is the ease with which a household can overcome the distances between the different centers of activity."

Pike and Vugioukas as cited by Short [1984]26 in their study define accessibility in terms of

- the disposition and attractiveness of land use; and

- characteristics of transport system and its ability to connect people with activity centres.


26 Ibid
Suryanarayan, Sarna and Malhotra [1986] interpreted accessibility “as an indicator of location of household or group of households in relation to the distribution of activities and to the transportation system which connects them.”

While conducting traffic survey in London Murthy [1989] designates ‘public transport accessibility’ in terms of the number of routes serving the zone, the frequency of the service on each route and the area of the zone.

Some studies consider additionally the characteristics of the population actually residing in the study area and define accessibility of an area as the average opportunity which the residents of the area possess to take part in a particular activity or a set of activities.

Gray as cited by Murthy [1989] defined ‘public transport accessibility’ as, "Adequacy of route distribution over the area served, vehicle capacity, service frequency and operating time span, identification of stops and vehicles and distribution; information on fares, schedules etc., as well as fare paying; and well spaced stops and terminals."

Johnston [1994] defined accessibility as the ease with which one place can be reached from another. It may be measured in terms of geodetic distance, topological distance, journey distance, journey time or monetary cost.

Firstly, general accessibility may be calculated from a single point to all

27 Suryanarayana, Y., A. C. Sarna and S. K. Malhotra (1986), Accessibility to employment in Delhi - a case study, Road Research Papers, No. 215, Central Road Research Institute, New Delhi, India.
28 Murthy, D. N. (1989), Public transport and accessibility, Unpublished Thesis, School of Planning and Architecture, New Delhi, India.
29 Ibid
30 Ibid
other points or areas in the study region. Secondly, accessibility may be related to the geographical content of other areas in the study: access to employment opportunities, population, educational or health facilities, etc. Thirdly, access to certain activities and facilities may be made less easy by barriers other than physical distance (e.g. the effect of income and social class) and attempt to incorporate these in measures of accessibility.

In all of these applications accessibility is seen to combine at least three elements: the location of a place within the study region (in general, centrally located places are more accessible); the form of the transport system; and the location within the study area of the activities to which access is being measured.

According to Sarkar and Crouch [1994]32, “Accessibility is concerned with the opportunities that an individual or a type of person, at a given location possesses to take part in particular activity or set of activities. It is a function of the mobility of the individual, of the spatial location of the opportunities relative to the starting point of the individual, of the time at which the individual is able to participate in the activity and of the times at which the activity is available”.

Bhat et al [2000a]33 defined accessibility ‘as a measure of the ease of an individual to pursue an activity of a desired type, at a desired location, by a desired mode, and at a desired time.’

It is clear from the above discussion that the researchers have based the definitions of accessibility primarily on three approaches viz.,

- Spatial separation approach;

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- Gravity approach; and
- Transport system approach

However, the usefulness of a particular definition depends on the objective of the study under consideration. All the three approaches have used following components to define accessibility.

- Node – location or origin & destination point
- Spatial separation – link/distance/time/cost /etc.
- Service of transport system –availability & choice, route network, frequency, etc.
- Ease and ability to travel - safe, convenient, comfortable, cheap means of travel
- Potential opportunities or activities - distribution/spatial separation

Litman [2003]\(^{34}\) defines accessibility as ‘the ability to reach desired goods, services, activities and destinations (together called opportunities). Accessibility depends on mobility, mobility substitutes and opportunities.

According to Handy [2004] as cited by Halden, Jones and Wixey [2005]\(^{35}\), accessibility may be defined as the ability to get what you need, ideally with a choice of destinations and using a choice of modes.

The Bureau of Transportation Statistics states that accessibility is “fundamentally concerned with the opportunity that an individual at a given location possesses to participate in a particular activity or set of activities.” This concise statement captures the broad concept of accessibility, which incorporates the underlying notions of accessibility as well access afforded

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by socio-demographic characteristics. Accessibility measures in transportation are concerned with distance/travel time and cost [Maidment, 2011].

As per Batty [2009], a well defined form of accessibility index associates some measure of an opportunity at a place with the cost of actually realizing that opportunity. In its early form, increased accessibility of a place with respect to some fixed location was assumed to vary directly with a measure of the size of the opportunity at some other place or location and to vary inversely with the distance or time taken to access the opportunities between the two places in question. This is a measure of inter-zonal accessibility from one place to another, but the usual form is to produce a composite index of total accessibility from one place or zone to all others, which gives a measure of how easy or difficult it is to realise all these opportunities from the place (zone) in question.

To generalize, accessibility can be defined as the ease of travel by which the potential opportunities or activities at different nodal points are overcome by some spatially operating source of friction, be it distance, cost, time, the quality of transport service, etc.

### 2.2.b. Parameters and Indicators of Accessibility

While examining the impact of accessibility on different aspects of urban structure/system different researchers have used various factors that affect accessibility measurement. According to Wachs [1978] as cited by Batty [2009] Accessibility indicators provide possibly the most useful and appropriate means of summarizing a great deal of information on the

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38 Ibid
location of households in relation to the distribution of urban activities and the transport system that connects them.

According to Morris, Dumble and Wigan [1979]\textsuperscript{39} four general guidelines may be identified to assist the selection of accessibility indicators for evaluation viz,

1. The indicator should incorporate an element of spatial separation which is responsive to changes in the performance of the transport system;
2. The measure should have sound behavioural foundation;
3. The indicator should be technically feasible and operationally simple; and
4. The measure should be easy to interpret and preferably be intelligible to the layman.

Keeping note of the requirements of a good accessibility measure some of the important parameters suggested by the researchers are listed below.

According to Zakaria [1974]\textsuperscript{40}, in order to account for interaction between the transportation system and land use activities, the accessibility measures should consider the following factors:

- The geographic distribution and intensity of land use activities.
- The mode and quality of the transportation service. This includes speed, cost, comfort, and convenience.
- The socio-economic characteristics of travelers (such as income and car ownership).

According to Leake and Huzayyin [1979]\textsuperscript{41} the accessibility of a place

\begin{thebibliography}{99}
\bibitem{39} Morris, J. M., P. L. Dumble and M. R. Wigan (1979), Accessibility indicators for transport planning, Transportation Research, Vol.13A, PP.91-109.\textsuperscript{Ibid}
\bibitem{41} Leake, G. R. and A. S. Huzayyin (1979), Accessibility measures and their suitability for use in trip generation models, Traffic Engineering and Control, 20,
depends on its location, the travel mode being considered and the time of travel.

- **Place**
  - District (represented by its centroid)
  - Zone (represented by its centroid)
  - Household location (place of residence)

- **Mode**
  - Private
  - Public
  - All modes (public plus private)

- **Time period**
  - Peak hours (weekday)
  - Off-peak (weekday)
  - Average daily (weekday)
  - Average daily (weekday)

Murthy [1989] identified following factors affecting accessibility.

- **Demographic characteristics**
  - Density of the zone
  - Participation ratio (work force/employment)

- **Socio-economic characteristics**
  - Household income
  - Vehicle ownership

- **Transport network characteristics**
  - Land use pattern and intensity
  - Location of bus stand in relation to activity area

- **System's (public transport) characteristics**

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• Fare structure
• Route network system
• Frequency of bus service
• Spacing of bus stops along the route

• User's characteristics
  • Trip rate
  • Trip purpose
  • Mode of travel
  • Trip length
  • Travel time
  • Age/sex/physically handicapped, etc.

Thus, while defining accessibility researches have defined it on the basis of network links, transport provisions, travel time & cost measures and some gravitational attributes such as population, workforce, FAR, etc. Depending upon research requirements the relevant parameter is considered for assessing the accessibility of a point or node.

2.2.c. Approaches to Measure Accessibility

Different researchers have measured accessibility based on different parameters. Broadly, these methods can be categorized into following

♦ Spatial Separation Approach;
♦ Cumulative-Opportunity Measure;
♦ Activity-Interaction Approach;
♦ Utility Measure;
♦ Travel-Space Measure; and
♦ Transport Mode Measure
2.2.c.i. **Spatial Separation Approach**

The early interpretations of accessibility are based on spatial separation measurements. It is based on theory of networking or graph, which defines accessibility on the basis of nodes and vertices (links). It interprets accessibility as the ‘relative nearness’ between different nodes on the transport network. More explicitly, it is a measure of the spatial relationship between a given element of the network (e.g. a point of intersection between two links) and the remainder of the network [Leake and Huzayyin, 1979]. In urban context, nodes may be considered as the activity areas (work places, market places, residential areas, etc.) and roads/rail links are the linking propositions to these nodes. Spatial separation approach evaluates accessibility in a number of ways, as below.

- Leake and Huzayyin Measures;
- Shimble’s Index;
- Kansky’s Measure;
- Ingram’s Accessibility Index; and
- Alan Hay’s Accessibility Measure.

Leake and Huzayyin [1979] approach used connectivity approach and measured accessibility in terms of ‘Associated Number’ and ‘Degree of Node’.

**Associated number** is the number of links in the shortest path from a particular node to its remotest node. The lower the associated number of a node, the more accessible is that node. The concept of ‘associated number’ measures the relative accessibility of a node. For example, in figure 2.c. the nodes ‘c’ and ‘b’ are at the same surface level and the

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44 Ibid
farthest node from them is 'k'. The node 'b' is more accessible to 'k' than 'c' because the associated number is lower i.e. 3.

**Degree of node** defines the number of links converging to each node. It is obtained by the sum total of the row/column values in the n x n matrix and explains the integral accessibility of the node. Values 0 and 1 are used for non-existence and existence of a direct link between two nodes respectively. The nodes characterized with larger sum of number of links are more accessible than those having few linkages. In matrix 1, the node `d' is the most accessible node (see figure 2.3 and matrix 1).

![Figure 2.3: Link and Node Diagram](image)

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**Matrix 1**

Leak and Huzzain’s measures are based on existence or non-existence of direct links but they do not present true picture of accessibility of a node.
The total length and actual distance traveled on the shortest path between the nodes gives a better dimension of the accessibility measure.

Shimble’s [1953]\(^{45}\) accessibility approach as cited by Leake and Huzayyin [1979] suggested a graphical technique to measure integral accessibility of different nodes. Shimble's measure took into account all possible destinations for each node.

\[
A_i = \sum_{j=1}^{n} l_{ij}
\]

where

- \(A_i\) = accessibility of node \(i\) with respect to all other nodes in the network.
- \(l_{ij}\) = distance (i.e. the number of links in the path containing least number of links) between node \(i\) and \(j\).
- \(n\) = the number of nodes in the network.

As per Shimble’s index, lower sum of the row total will mean a higher accessibility index and vice versa. To measure the Shimble's accessibility index each link in the network is assigned a value as ‘1’ and a N x N matrix is formed by summing the number of links between two nodes. Shimble's accessibility index as derived from figure 2.3. can be presented in matrix form (matrix 2). In the matrix 2, node ‘f’ is the most accessible point in the network.

But Shimble's accessibility index also faces the same problem as that Leake and Huzayyin’s i.e. measuring the shortest path with number of links. There is every possibility that the links may be of different lengths that may affect the accessibility index of the nodes to a large extent.

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Kansky\textsuperscript{46} as cited by Hay [1977] used a set of nodes and links (or using graph terminology vertices and edges) to represent accessibility from a network.

Let

\begin{itemize}
  \item $e$ the number of edges (links)
  \item $v$ the number of vertices (nodes and terminals)
  \item $p$ the number of separate (i.e. completely unconnected) networks to which can be added a fourth
  \item $m$ the total network length
\end{itemize}

There are large number of ways in which these can be used to describe networks viz.,

\[
B = \frac{e}{v} \quad \text{-------- (I)}
\]

`B` is in fact 1/2 of the average number of links serving each node. Values above 1 indicate an increasing complexity.

\[
G = \frac{(e-v+p)}{2v-5} \quad \text{-------- (II)}
\]

\textsuperscript{46} Hay, Alan (1977), \textit{Transport networks}, Coes The Printers Limited, Great Britain, PP. 18-37.
This compares the number of closed circuits (loops) in a network \((e-v+p)\) against the maximum possible number of circuits which it might have \((2v-5)\). The range of the index is, thus, from zero to one, with the highest value of \(G\) indicating the greatest level of connectivity. Thus, this index introduces some notice of geographic scale.

\[
Q = \frac{m}{e} \quad \text{(III)}
\]

Clearly, the more densely a network is packed into a region and the greater the number of junctions the shorter will edge lengths become. ‘\(Q\)’, therefore, may be expected to be high in ill-developed nets and low in well-developed nets.

In some networks it is possible for links to cross each other without intersecting (or without any possibility of traffic exchange): these networks are non-planer. Under such situations following equation is used.

\[
G = \frac{e-v+p}{\frac{v(v-1)}{2} - (v-1)} \quad \text{(IV)}
\]

As an improvement to the criticism of earlier approaches Ingram [1971]\(^{47}\) used distance as measure of accessibility to measure relative and integral accessibility as under.

**Relative accessibility measure**

\[
A_{ij} = d_{ij}
\]

where

\(A_{ij} = \text{accessibility from zone } i \text{ to zone } j\)

\(d_{ij} = \text{separation between zones } i \text{ to } j \text{ measured by time, distance, cost, etc.}\)

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Integral accessibility measure

\[ A_i = \frac{\sum_{j=1}^{n} d_{ij}}{n} \]

where

- \( A_i \) = accessibility index for zone i
- \( d_{ij} \) = separation between zones i & j measured by time, distance, cost, etc.
- \( n \) = number of zones

Lower the value of \( A_i \) higher is the accessibility index of node i.

The effect of network (route or air) has an important role in the structuring of the nodes. Hay [1977]\(^{48}\) measured accessibility by using route distance, geodetic distance (crow-flies), route factor. Whereas route distance is an important indicator in urban studies, geodetic distance and route factor are quite significant to explain the pattern and entropy of nodes at the regional level.

Route Distance or Cell Value Measure

It uses Shimble's formulation with the difference that instead of number of links the actual distance is measured for each node viz.,

\[ A_i = \sum_{j=1}^{n} d_{ij} \]

Where

- \( A_i \) = the accessibility of node i with respect to all other nodes
- \( d_{ij} \) = the route distance between node i and j

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\[ n = \text{the number of nodes in the network} \]

Lower the value of the row sum higher is the accessibility and vice versa.

**Geodetic Distance (Crow-Flies) Measure**

The formula used to calculate accessibility is same as that of route distance with the difference that instead of route distance crow fly distance between the nodes is taken. Since perfectly direct distances are measured, therefore, it shows the relative locational accessibility of the places. A lower geodetic distance will mean high accessibility.

**Route Factor Measure**

The effect of the network is reflected by the route factor. Route factor, infact, explains that the nodes, which are more accessible, may not be better served because there may be large residual between route distance and geodetic distance. Route factor is calculated by dividing the route distance by geodetic distance viz.,

\[
\text{Route Factor} = \frac{\text{Route Distance}}{\text{Geodetic Distance}}
\]

The value of the route factor will be equal to or more than 1. Nodes with route factor nearing 1 will mean better accessibility and better served by the network.

As a result of application of various accessibility measures using graphical technique different dimensions have been added to achieve a better formulation of the accessibility index. The criticisms of different approaches have directed the researchers to use different parameters (distance, cost, time, etc.) to indicate separation between two nodes. But the level of accessibility is a function of the activities, which are processed by different nodes. It is the activity concentration at a point that demands accessibility.
measurement. As a consequence, different researchers have measured accessibility to various opportunities at different locations.

2.2.c.ii. Cumulative Opportunities Measure

The simplest accessibility measure that takes account of both distance and the objective of a trip is the cumulative–opportunity measure. This measure defines a travel time or distance threshold and uses the number of potential activities within that threshold as the accessibility for that spatial unit.

\[ A_t = \sum_{t} O_t \]

Where

- \( t \) = the threshold
- \( O_t \) = an opportunity that can be reached within that threshold.

Often, several time or distance increments are used to create an isochronic map. The only information needed for this measure is the location of all the destinations within the desired threshold (e.g., jobs or hospital). Researchers have investigated different ways of characterizing the parameters for this type of measure. This measure is used to monitor changes in accessibility due to changes in land use, the transportation system, or growth in general.

2.2.c.iii. Activity-Interaction Approach

Hansen [1959]\(^{49}\) introduced the activity-interaction approach in 1959. He introduced the activity potential to measure the accessibility index, in addition to the ease of interaction. His approach follows the gravity model and he defines accessibility as the potential of opportunities for interaction. Defined in this manner accessibility is a generalization of the population-

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over-distance relationship. In general terms, accessibility is taken as a measurement of the spatial distribution of activities about a point, adjusted for the ability and the desire of people or firms to overcome spatial separation.

Hansen proposed that the accessibility of zone $i$ is measured as,

$$A_i = \sum_{j=1}^{n} \frac{(S_j)}{(d_{ij})^a}$$

where

$A_i$ = measure of accessibility of zone $i$ to activities located within remaining zones of the area

$S_j$ = size of opportunity at zone $j$ i.e. number of jobs, people, etc.

$d_{ij}$ = travel time or distance from zone $i$ to zone $j$.

$a$ = an exponent to describe the effect of travel time between zones.

The distance $d_{ij}$ is not necessarily the best measure of travel difficulty and the deterrent effect of this difficulty could be measured by other functions proposed.

As more and more jobs are located nearer to the node $j$, the accessibility to employment at point $i$ will be high.

To know the comparative positioning of accessibility indices of a node with respect to an activity in the regional context, it is important to normalize the Hansen measure. The normalized Hansen measure can be described as

$$A_i = \frac{\sum_{j=1}^{n} (S_j f(d_{ij}))}{(\sum_{j=1}^{n} S_j)}$$

Where

$f(d_{ij}) = 1/ (d_{ij})^a$
Instead of using absolute number of opportunities, it uses the proportion of the opportunities in the entire study area, namely,

\[ \frac{S_j}{\sum_{j=1}^{n} S_j} \]

The exponent 'a' may form a utility function to describe the effects of various constraints on the network and other policy matters. But there is a prior need to calibrate a 'gravity type' trip distribution model in order to determine the power of the travel resistance term.

Many researchers have explored the appropriate nature of the impedance factor of the gravity equation. Searching for an appropriate form and value of the impedance function they find it appropriate to have different parameter values for different kinds of attractions.

There are three main components of gravity model i.e. zone’s attractiveness, impedance measure between zones (e.g., time or distance), and the form of impedance function. The attractiveness of a zone can be modeled as number of jobs in a zone while assessing accessibility to employment; number of retail positions or square footage devoted to retail sales to assess accessibility to shopping. Spatial separation or impedance function can be characterized by euclidean distance, actual distance, travel time, combined measure, and perceived distance or cost. The most common form of impedance measure is the exponential form and many researchers use values ranging 0 – 1 for ‘a’. Some researchers use empirical data to determine a value that best describes the area under consideration.

2.2.c.iv. Utility Measure

Utility measure is based on an individual's perceived utility for different travel choices. The most general form of this measure is:

\[ A_n = \sum_{i = C} \left( \text{Max } U_{in} \right) = \ln \sum_{i = C} \exp \left( V_{in} \right) \]
That is, for individual n, accessibility is defined as the expected value of maximum of the utilities over all alternative spatial destinations i in choice set c.

2.2.c.v. Time - Space Measure

Time–space measures add another dimension to the conceptual framework of accessibility corresponding to the time constraints of individuals under considerations. Haggerstrand [1974] as cited by Mosely et al [1977] conducted early work in this area. He used a three-dimensional prism of the space and time available to an individual for partaking in activities. The motivation behind this approach to accessibility is that individuals have only limited time periods during which to undertake activities. As travel times increase, the size of their prisms shrinks. The space dimension of this measure is calculated with the accessibility measures described in the previous sections. Constraints on time are generally divided into three classes viz.,

- capability constraints – related to the limits of human performance (e.g., people need to sleep every day);
- coupling constraints – when an individual needs to be at a particular location at a particular time (e.g. work); and
- authority constraints – higher authorities that inhibit movement or activities (e.g., park curfews).

In reorganizing the time-space accessibility of individuals, trip chaining can be better evaluated.

2.2.c.vi. Transport Mode Accessibility Measure

Shindler and Ferrari as cited by Leake and Huzayyin [1979] used the ratio of the Hansen measure of access to employment by public transport to that

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by private transport to evaluate the effectiveness of the public transport system.

\[
A_i = \frac{\sum_{j=1}^{n} B_j f(C_{ij})}{\sum_{j=1}^{n} B_j f(C_{ij})}
\]

where

\begin{align*}
B_j &= \text{the attractiveness of zone j for employment.} \\
C_{ij} &\text{& } C_{ij} &= \text{the travel cost by public and private transport from zone i to j respectively.}
\end{align*}

Higher value of \(A_i\) reveals lower level of accessibility to employment by public transport mode and vice versa.

Shindler and Ferreri defined a measure of accessibility that involved a trip attraction term,

\[
A_j = \sum_{j=1}^{n} \frac{(W_j)}{(t_{ij})^2}
\]

where

\begin{align*}
A_j &= \text{the accessibility of zone i} \\
W_j &= \text{trip attractions at zone j} \\
t_{ij} &= \text{travel time between zone i and zone j}
\end{align*}

They suggested that different powers of travel time should be used for different trip purposes.

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Baltimore Metropolitan Area Transport Study\textsuperscript{52} used two measures of accessibility in the trip generation stage. These measures were termed as ‘accessibility index’ and ‘transit service index’.

\[
A_{1i} = \frac{1}{\sum_{j=1}^{n} t_{ij}}
\]

\[
A_{2i} = \sum_{j} f_i
\]

where

\(A_{1i}\) = accessibility index of zone \(i\) expressing the highway service
\(A_{2i}\) = transit service index, or transit accessibility measure of zone \(i\)
\(t_{ij}\) = minimum travel time, by private modes, between zone \(i\) and \(j\)
\(f_i\) = transit service frequency available at zone \(i\)
\(n\) = number of zones

London Traffic Survey\textsuperscript{53} used the following approach to measure public transport accessibility of a zone.

\[
A_i = \sum_{r} \left( \frac{\sqrt{N_{ri}}}{a_i} \right)
\]

where

\(A_i\) = bus accessibility of zone \(i\)
\(N_{ri}\) = off-peak frequency of buses on route \(r\) and passing through zone \(i\)
\(a_i\) = the area of zone \(i\) in square miles

By taking the square root of \(N_{ri}\), this measure placed greater emphasis on the number of services in the zone rather than on frequency of service. The

\textsuperscript{52} Leake, G. R. and A. S. Huzayyin (1979), \textit{Accessibility measures and their suitability for use in trip generation models}, Traffic Engineering and Control, 20, 12, December, PP. 566-572.

\textsuperscript{53} Ibid
The square root of the area was adopted in order to compensate for the unequal size of the zones.

Leake and Huzayyin [1979] suggested measures for private transport and public transport accessibility as under.

Private transport accessibility measure

\[ \text{Accessibility of zone } i \text{ by mode } m = \sum_{j=1}^{n} (TR_{ij})^m \]

or

\[ \text{Relative accessibility of zone } i \text{ by mode } m = \frac{\sum_{j=1}^{n} (TR_{ij})^m}{\sum_{i=1}^{n} \sum_{j=1}^{n} (TR_{ij})^m} \]

where

\[(TR_{ij})^m = \text{the travel resistance between the centroids of zone } i \text{ and } j \]

for mode \( m \).

\( n = \text{the number of zones in the study area.} \)

Travel resistance may be expressed in terms of the shortest travel distance, minimum travel time, or generalized costs, i.e.,

\[ D_{1i} = \sum_{j=1}^{n} d_{ij} \]

\[ T_{1i} = \sum_{j=1}^{n} t_{ij} \]

where

\( D_{1i} = \text{accessibility of zone } i \text{ based on travel distance}. \)

\( T_{1i} = \text{accessibility of zone } i \text{ based on travel time}. \)

\[ d_{ij} = \text{shortest route travel distance (Km.) between centroids of zone i and zone j.} \]
\[ t_{ij} = \text{minimum total travel time (min.) between the centroids of zone i and zone j.} \]
\[ n = \text{number of zones.} \]

Another measure of accessibility based on travel time is

\[ T_{1i} = 1 / \sum_{j=1}^{n} t_{ij} \]

The main difference between \( T_{2i} \) and \( T_{1i} \) is that, with \( T_{2i} \) increased accessibility is associated with a higher value of the accessibility measure.

They suggested that closer the existing shortest travel distance routes between zone centroids to the airline distances, the more efficient the structure of the road network.

\[ D_{2i} = (1/ n - 1) \sum_{j=1}^{n} (d_{ij} - a_{ij}) \]
\[ D_{3i} = (1/ n - 1) \sum_{j=1}^{n} (a_{ij} / d_{ij}) \]

where

\[ D_{2i} \text{ & } D_{3i} = \text{measure of accessibility of the zone i} \]
\[ n \text{ and } d_{ij} = \text{the same as earlier} \]
\[ a = \text{the airline distance (Km.) between the centroids of zone i and zone j.} \]

Low value of \( D_{2} \) and higher value of \( D_{3} \) are associated with high zonal accessibility.
**Public transport accessibility measure**

They suggested the following measure

\[
B_{1i} = \sum_{m=1}^{k} \left( \sum_{r=1}^{h} \left( f_{rm} \right)^i \right) \left( l_{rm} \right)^i \text{ (veh. Km./h)}
\]

where

- \( B_{1i} \) = public transport accessibility measure for zone i.
- \( (f_{rm})^i \) = frequency of public transport mode m (veh/h), operating over route r in zone i
- \( (l_{rm})^i \) = length of route r (Km.) for public transport mode m passing through zone i.
- \( h \) = number of public transport service routes passing through zone i.
- \( k \) = number of public transport modes serving zone i.

\[
(f_{rm})^i = \left( \frac{(N_{rm})^i}{(T_{rm})} \right) (Z_{rm})
\]

\[
Z_{rm} = \left( \frac{(T_{rm})}{T_{max}} \right) \times 100
\]

where

- \( N_{rm} \) = number of public transport mode m operating over route r in zone i.
- \( T_{rm} \) = operating time of the bus service on route r on a weekday (hours) i.e. (last public transport mode departure time - first public transport mode departure time)
- \( T_{max} \) = longest operation time (hours) on a weekday, among all public transport mode service operating in the study area.

Another form of determining public transport mode accessibility is

\[
B_{2i} = \frac{B_{1i}}{A_i}
\]


where

\[ A_i = \text{the area of zone } i \text{ (Km}^2\text{)} \]

In addition, there should be some limits to the distance walked to the bus stop that the average traveller would consider acceptable. Therefore, the following form is useful:

\[ B3_i = B1_i \times L_i \]

where

\[ L_i = \frac{1}{n} \sum_{r=1}^{n} \frac{(a_r)^i}{(A_i)} \times 100 \]

\[ (a_r)^i = 2b \times (L_r)^i \]

\[ (a_r)^i = \text{the area served by route } r \text{ in zone (Km}^2\text{)} \]

\[ (L_r)^i = \text{length of route } r \text{ (Kms.) of the bus service passing through zone } i. \]

\[ b = \text{average walk distance (Km.) relevant to average walking speed } v_w \text{ (Km./hr) to join route } r \text{ after walking time } t_w \text{ (min.)} \]

Lower value will indicate lower accessibility to that zone.

Short [1984]\(^{55}\) suggested the following measure

\[ A_{oi} = \sum S_i / (t_{ij})^b \]

where

\[ A_{oi} = \text{access opportunity of zone } i. \]

\[ S_i = \text{size of facility (employee hours or some other measure) in zone } j. \]

\[ t_{ij} = \text{distance and/or time taken to travel from zone } i \text{ to } j. \]

\[ b = \text{an exponent.} \]

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Erie Transport Study\textsuperscript{56} adopted the following model to measure accessibility.

\[
Q_i = \sum_{j=1}^{n} (A_j F_{ij})
\]

\[
F_{ij} = 1 / (\text{door to door travel time})^b
\]

Where
\[
Q_i = \text{accessibility index for zone } i \text{ to the other zones.}
\]
\[
A_j = \text{attraction in zone } j.
\]
\[
F_{ij} = \text{travel time friction factor for travel from zone } i \text{ to } j \text{ on a particular transport mode.}
\]
\[
n = \text{number of zones.}
\]
\[
b = \text{varies with travel time.}
\]

Accessibility Friction Factor\textsuperscript{57} is a measure of mobility provided to the people of zone by a specific public transit facility.

\[
\text{AFF}_i = \left(\frac{K_i}{K}\right) \times \left(\frac{N}{N_i}\right)
\]

where
\[
\text{AFF}_i = \text{accessibility friction factor for zone } i.
\]
\[
K_i = \text{total bus trips in a day to zone } i.
\]
\[
K = \text{total bus trips in the whole city.}
\]
\[
N_i = \text{total mass transit person trips generated from zone } i.
\]
\[
N = \text{total mass transit trips performed in the whole city.}
\]

Higher value of \text{AFF}_i to a zone will indicate higher accessibility of that zone.

\textsuperscript{56} \text{Ahmed, M. I. (1980), Urban Travel Models, Unpublished Thesis, School of Planning and Architecture, New Delhi, India.}

\textsuperscript{57} \text{Ibid}
Martin and Dalvi's [1976][58] used the following measure to calculate accessibility.

\[
(A_i)_k^k = \left( \sum_{j=1}^{n} (W_j e^{-c_{ij}}) \right) / \sum_{j=1}^{n} W_j
\]

where

\( (A_i)_k^k \) = accessibility afforded by mode K to household residents in zone i.

\( W_j \) = measure of attractiveness of zone j.

\( c_{ij}^k \) = cost of travel from zone i to zone j by mode k.

Lower value of \( A_i \) gives higher level of accessibility.

Thus, accessibility measures established the basis to determine the accessibility indices of different nodes on a two dimensional surface. The geographical approach is more useful to determine the physical accessibility of the node whereas activity-interaction approach establishes the functional base to accessibility to determine the interaction levels between the nodes. The accessibility assessment approach stands as a useful indicator in urban and regional planning studies. The selection of a particular approach to be adopted is largely dependent on the objective of the study and the type of constraints that exist on the network.

2.3. STUDIES IN ACCESSIBILITY

Ingram in his study on "the concept of accessibility: a search for an operational form" has measured accessibility in the city of Hamilton, Ontario. He used distance as a measure of accessibility. Both straight line and rectangular distances were measured. A significant correlation between the two methods of calculating integral accessibility was found.

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Martin and Dalvi's analyzed the pattern of accessibility by public and private transport in Inner London by using modified Hansen measure. Four measures of areal attractiveness viz. total employment, retail employment (convenient goods), retail employment (durable goods), and population were used to measure accessibility. Correlation coefficients between different public transport indices were calculated. The following results were found;

- Highest correlations are between the measures using total and retail employment (between 0.7 and 0.9) as the attractor variable.

- The correlation of each of these measures with population as the attractor variable is somewhat lower (between 0.2 and 0.4), reflecting differing spatial distribution of total employment retail employment. Whereas the convenience goods shopping facilities follow more closely the distribution of population.

- Accessibility based on total employment is closely related to distance (-0.79); whilst accessibility based on population showed very little correlation (-0.07).

- Total employment accessibility showed strong negative correlation both with distance and public transport travel time from the centre reflecting relatively high concentration of job opportunities in the central area.

- Population accessibility showed an irregular pattern of relationship with distance from the centre for public transport.

- The spatial variations in public transit accessibility based on population are considerably less than for public transport accessibility based on employment.

Suryanarayan, Sarna and Malhotra in their study on `accessibility to
employment in Delhi used normalized Hansen's measure to study accessibility to employment. Cycle, public transport, scooter/motor cycle and car were the modes taken for the study. The study laid the following inferences.

1. Accessibility to government employment is generally better than to the total employment in case of all the zones for various modes.

2. All the opportunities can be reached by car in case of govt. jobs in 50 minutes and in case of total employment in 60 minutes.

3. In case of short distances or travel time of 50 minutes, more opportunities can be reached by cycle than bus though the difference is marginal. For longer distance (travel time) the bus serves better.

Muraco studied intra-urban accessibility for Indianapolis, Indiana, Columbus and Ohio for 1954 to 1965 with respect to the relative nearness either in the sense of a direct linkage (finite graph theory) or a minimum expenditure to travel cost or time (network accessibility).

The analysis showed a reduction in accessibility outwards from the centre of the said cities for both the periods. The analysis also identified the location of high accessibility regions by employing principal component analysis. The analysis showed that the Columbus is characterized by a greater degree of centrality and corridor development compared to the Indianapolis surface, which exhibits generally a more uniform accessibility pattern.

Dallal's accessibility study on Inner London was studied with the following objectives;

- to produce a plan showing areas of varying overall household accessibility to public transport in the Borough to be used as an
input to decisions on land-use.

- to help identify those geographical areas within the Borough and groups within the community which are most in need of improvements in public transport.

- to provide an objective means of testing the effects of changes in the routing and frequency of public transport services.

Frequency of the transport service and maximum walk time were used to measure accessibility. The following results were drawn;

- There is a tendency in the Borough for high-income households to live in areas of high accessibility and for low-income households to live in areas of low accessibility. This contrasts with the situation in outer metropolitan areas where high-income households tend to be located in outer (poor public transport) areas. The percentage of people in the employer/manager/professional social groups was also found to be higher in high accessibility areas.

- Generally, higher incomes found amongst residents of high accessibility areas were not reflected in higher levels of car ownership. This is somewhat unusual and tends to suggest that having good access to public transport services may act as a disincentive to running a car.

- The greater use of bus/underground public transport in areas of high public transport accessibility is accompanied mainly by lesser use of walk mode.

2.4. URBAN STRUCTURE

Land use and transportation interaction is a dynamic process that involves changes over spatial and temporal dimensions between the two systems. Evolutions in transportation system create new accessibility levels that
encourage changes in land use patterns. There have been many studies to identify interaction between the two systems in terms of a time lag, the magnitude of impact, and the spatial relationship. Property value change has been popularly used in the regression model as an indication of land use change as well as increased development. Time series analysis of study conducted for Miami-Dade County, Florida showed that transportation improvements impacted land uses at varying rates and intensities [Chung and Zhoo, 2004].

As the cities get larger, an urban form that diverges from a monocentric city to a rather more complex spatial pattern of clusters would be expected.

According to Quinn as cited in Sehgal [2000], urban area is characterized by five qualities of population – density, size, mobility, permanence and heterogeneity. An urban area is something more than a large dense aggregation of people, buildings, and non-agricultural occupations and is not merely an area characterized by complex, impersonal social relations. It may be viewed as an internally organized community with spatial and social aspects. Spatially, an urban area contains several kinds of sub-areas: a central shopping district, secondary commercial areas of different sizes, wholesale areas, areas of light and heavy industry, and a considerable variety of residential areas. Each of these sub-areas has important relations with each other and is connected with others by lines of transportation and communications. Socially, the urban area includes a variety of segmentations of personal life, become organized bodies into an inclusive social unit and into a number of distinctive little social worlds. Generally, the institutions formed within an urban area become functionally integrated in such a manner that most residents obtain locally the

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satisfaction of their basic needs.

2.4.a. Concept and Definition of Urban Structure

The word “structure” comes from Latin word “struere”, which means to build, to arrange, and contains the notion of an organized thing. Spatial structures exist, because geographical space is not constituted by a set of unique places, occupying random locations. A spatial structure is completely described only if, beyond the form taken by the arrangement of objects, it is possible to figure out the inter-dependencies among the latter.

While defining urban structure Reif [1973] states that it is “the outcome of a process which allocates population activities to sites”. Thus, it explains spatial distribution of activities that population of an urban area enjoys or uses. Loosely defining, at times, it is equated with the word spatial structure of an urban area.

Chapin, Jr. [1975, pp. 144-163] stated that urban spatial structure is concerned with the order and relationship among the key physical elements of urban areas as they evolve and pass through transformations in time and space. In other words, it is concerned with activities of people and their institutional entities and the interactions these activities create.

Implied is a causal relationship between two pairs of concepts. One pair focuses on human behaviour: (1) place-related patterns of interactions (activities), and (2) patterns of interaction among different place activities (movements or, more broadly, communications). The other pair focuses on physical structure or form: (1) space adopted for activity use, and (2) channels developed for movements and other forms of communication.

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62  Reif, Benjamin (1973), Models in urban and regional planning, Leonard Hill Books, Aylesbury, Bucks.
Thus, the physical and spatial manifestation of development in all its related and inter-related angles is the settlement structure. In other words, by structure is meant the mutual relations of the constituent parts or elements of a whole as determining the particular nature or character. Various mutually related and dependent components are the social, economic, geographic, administrative and political forces which have played their vital role in molding and shaping the physical form of the settlements for satisfying particular functions of life

Salim, 1967.

In the words of Moral [1980], "Structuring is the manner in which the component parts of a complex whole are arranged and inter-related to make an entity."

Storrie as cited by Moral [1980] states, “The term structure is used to mean the social, economic and physical system of an area and includes such matters as distribution and the relationship between them. Patterns of land use and development together with communications and the system of utility services."

Spatial structure should not be interpreted only in a geometric or morphologic sense. A spatial structure is completely described only if it is possible to figure out the inter-dependencies among the latter. If geographical space is considered as a set of interacting elements, spatial structure must be understood as the principle of organization of the geographical entity under study, which is materialized under a form.

Bunge as cited by Moral [1980] proposed a theoretical geography predicated on a dualism between ‘social process’ and ‘spatial structure’,

66 Ibid
67 Ibid
that is to say, between ‘movements over the earth’s surface’ and ‘the resulting arrangement of phenomena on the earth’s surface’. In doing so, Bunge strongly agreed with Schaefer that spatial structure could be defined ‘most sharply by interpreting “structure” as “geographical”, from which it followed, so he said, that ‘the science of space [geography] a sharp tool’. Later, explanations of spatial structure were typically sought within the primarily spatial human and social sciences, most commonly psychology, cultural anthropology, political economy and sociology. \(^{68}\)

In physical planning this is used to explain the spatial structure of the settlement. Urban structure is the underlying basic skeletal system around which different parts of an urban area are bonded together. This system comprises of physical, functional, social, economic and perceptual components that are instrumental in determining the nature of the character of the area. In general, city structure means the size and shape of the city and the spatial distribution of homes, jobs, and other land use activities within its geographical area.

Johnston et al [1981] \(^{69}\) defined spatial structure as “the mode in which SPACE is organized by and implicated in the operation and outcome of social and/ or natural processes”.

Lohani [1986] \(^{70}\) commented, “Urban structure refers to location, arrangement and inter-relationship between social, economic and physical elements in the urban space displaying a degree of internal organization. This inter-relationship is most frequently described by regularities in land use pattern which summarizes the distribution of urban activities. Urban activities refer to people, their activities, pattern in space. The activity

\(^{68}\) Ibid
pattern depends upon the characteristics of people, their level of income, health, educational level, and above all their culture and historical evolution.” In a way, urban structure refers to the detailed description of all the areas of an urban settlement.

Barry and Kasarda as cited by Aggarwal [1991] say about the urban structure that....

- The economic base of urban centres tends to act independently of other structural features and to the extent that there is geographic specialization based on locational factors other than market orientation. Each broad economic function will lead to its own distinctive economic town types.

- In every society the principal dimensions of socio-economic differentiation are those of social status age structure or stages in life cycle and to a large extent the urban structure of a town/city depends upon its relative accessibility to nearest metropolis.

- A culturally heterogeneous society will be characterized by separate ethnic or racial dimensions if the cultural groups are clustered in particular pockets and if the groups occupy different status lives and have different family structures, the cultural differences may override other socio-economic dimensions.

According to Aggarwal [1991], the form and structure of a town/ city is the result of numerous economic, social and cultural factors operating through long time. Some of the most significant of these include rapid and massive growth, a heterogeneous population and the changing form of urban transportation.

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72 Ibid
U.N. Publication [1992]\textsuperscript{73} defines urban structure “as the arrangement and relations of all elements forming the framework of the urban agglomeration.”

According to Balchin and Kieve as cited by Sehgal [2000]\textsuperscript{74} “The spatial structure of a city is a product of centripetal forces of attraction and congestion, centrifugal forces of decongestion, and forces of areal differentiation.”

Rodridge [2006]\textsuperscript{75} has defined urban structure as the set of relationships related to the urban form and its interactions of people, freight and information. According to him, even if the geographical setting of cities varies considerably, the urban form and its spatial structure relationships are articulated by two structural elements viz.:

- **Nodes**, which express the centrality of urban activities. This centrality can be related to the *spatial accumulation of economic activities* or to the *accessibility to elements of the transport system*.

- **Linkages**, which refer to the infrastructures supporting flows from, to and between nodes.

Thus, it may be concluded that urban structure can be defined in terms of extent and shape of built-up area, distribution of various landuses/functional zones, physio-socio-economic aspects of different functional zones. Hence, urban structure is composed of three components viz., activity, intensity, and network (transportation). The relationships and combinations of these components provide form and structure to an urban

\textsuperscript{73} UN Habitat (1992), *Multilingual glossary of human settlement terms*, United Nations Centre for Human Settlements (HABITAT), PO BOX 30030, Nairobi, Kenya.


settlement.

2.4.b. Parameters and Indicators of Urban Structure

John and Kasarda as cited by Aggarwal [1991]76 while defining urban structure suggested a set of independent dimensions to be treated as parameters of urban structure.

- Size of population;
- Quality of physical development;
- Age structure of population;
- Education level of population;
- Economic base of the town;
- Ethnic and/or religious orientation; and
- Geographical situation.

These parameters study the structure of an urban area at the broader level to reveal how a city or a town is responsive in the regional urban system.

While conducting a micro level study for Varanasi, India Aggarwal [1991]77 took physical aspect in her study measured urban structure as

- **Physical Aspects**
  - Linkage / accessibility
  - Land use
  - Network
  - Physiography
  - Population density
  - Social infrastructure

- **Employment pattern**
  - Work force participation rate
  - Tenure status
  - Income level

- **Social Aspects**
  - Demographic factors
    - Population trends

77 Ibid
• Urban form

- Sex ratio

- Migration pattern

- Social stratification

- Floating population

Economic Aspects

- Land value

- Economic base

Recognizing the role played by accessibility to urban structure Rodrigue [2006],\textsuperscript{78} states that all locations are relative to one another. However, locations are not constant as transportation developments change levels of accessibility, and thus the relations between locations. The following factors are particularly important in shaping the spatial structure:

• **Costs** - The spatial distribution of activities is related to factors of distance, namely its friction. Locational decisions are taken in an attempt to minimize costs, often related to transportation.

• **Accessibility** - All locations have a level of accessibility, but some are more accessible than others. Thus, because of transportation, some locations are perceived as more valuable than others.

• **Agglomeration** - There is a tendency for activities to agglomerate to take advantage of the value of specific locations. The more valuable a location, the more likely agglomeration will take place.

• **Physical Attributes**: Natural conditions can be modified and adapted to suit human uses, but they are a very difficult constraint to escape, notably for land transportation.

• **Historical Considerations** - New infrastructures generally reinforce historical patterns of exchange, notably at the regional level. At the urban level, the pattern of streets is often inherited from an older pattern, which itself may have been influenced by the pre-existing rural structure (lot pattern and rural roads).

\textsuperscript{78} Rodrigue, Jean-Paul, C. Comtois and B. Slack (2006), \textit{The geography of transport systems}, Routledge, New York.
A common myth tends to relate transportation solely as a force of dispersion, favoring the spread of activities in space. This is not always the case. In numerous instances, transportation is a force of concentration, notably for business activities. Automobile has favoured the concentration of several activities at specific places and in large volumes. Shopping centers are a relevant example of this process where central locations emerge in a dispersed setting.

According to him, accessibility is a good indicator of the underlying spatial structure since it takes into consideration location as well as the inequality conferred by distance. Since accessibility is dominantly the outcome of transportation activities, namely the capacity of infrastructures to support mobility, it presents the most significant influence of transportation on location. Hence, it appears that location (accessibility) and economic activities are intimately linked.

2.5. URBAN STRUCTURE APPROACHES AND MODELS

Although accessibility is an element inherent in all the physical organizations of space and movement systems, some models or approaches give more central role to it in building a theory. Much of the recent work on accessibility concepts has been primarily focused on transportation [Chapin Jr., 1964].

2.5.a. Guttenberg’s Approach

Guttenberg [1960] has developed a theoretical approach to urban structure and city growth which utilizes accessibility as an organizing concept what he calls "a community effort to overcome distance". He

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identifies three components. He subdivides the first into "distributed facilities" and "undistributed facilities", with these being a function of the third component, "transportation". The rationale states that if transportation is poor, the workplaces, trade centres, and community services will tend to assume a pattern of distributed facilities. If it is good, these activities will assume more concentrated patterns in the form of undistributed facilities. Thus, Guttenberg maintains that urban spatial structure is intimately tied up with the aggregate effort in the community to overcome distance.

He sees the spatial gradation of density outward from distributed and undistributed facilities as a function of access. He points out that his distributed centres of activity acquire a value in accordance with the substitutability of that place for the chief place, with the physical density gradient outward from these centres corresponding closely with, but not necessarily directly coincident with, the economic density gradient. In the context of his framework, therefore, the slope of the economic density gradient is closely related to transport efficiency as it enables outlying locations to substitute for more central locations.

In examining the implications of growth for his concept of urban structure, he points out that the transportation system holds the key to the way in which growth proceeds. The transportation decisions made from one year to another will result in a constantly changing urban structure, with the emphasis shifting along the continuum between the situation with highly distributed centres to the situation with one major undistributed facility. He implies that there is some limit in the ability of the undistributed facility continuing indefinitely to function as the only major center as compared to the capacity that distributed centres have for absorbing growth. As growth occurs, structural adjustments to overcome distance can take the form of either new centres or improved transportation facilities. Commonly both occur, with the enlarged scale and resulting changed relationships among home, work and various activity centres, population movements ensue.
With these shifts the areas which do offer the accessibility that people seek develop, and those which do not, decline in a social and an economic sense. With growth, the enlarged scale alters the density gradient. If transport efficiency is improved, favoring the substitution of outlying for central locations (as has been the case in Los Angeles), the slope of the density gradient is flattened, the region spreads out, and, depending upon the amount of population influx in relation to the area added, the density may go down.

How may such a view of urban structure and urban growth be used in anticipating urban form in the future? Guttenberg acknowledges that transport efficiency is not the sole variable. He notes that activities may choose a location in relation to a central place for reasons other than time-distance. For example, a change of economic composition in the region may produce new location patterns. However, assuming such other things are constant (similar economic conditions, terrain, tastes, and so on), he maintains that accessibility in term of time distance serves to sort activities spatially. If the additional assumption is introduced that the transportation system remains similar over time, he points out that there will be comparability in accessibility and therefore, we may anticipate similar patterns in the distribution of activities in the region. He does not discuss the complexities of prediction involved when constraints are relaxed and one by one the elements held constant are allowed to vary, but it is clear that by introducing differing combinations of assumptions the interplay of these elements quickly becomes exceedingly complex.

In the present age of development, this conceptual framework centres mainly on the physical aspects of a theoretical system of urban structure and growth. Its distinctive feature is emphasized. It gives interplay between the location of urban activities and transport efficiency. In the sense that activity concentrations and transportation are continuously interacting and that accessibility provides an organizing rationale for urban structure and a
regulating concept for urban growth, the framework is a dynamic one, supplying and evolutionary basis for explaining the urban form. While it has a well developed logical context and a direct relation to reality, Guttenberg’s statement gives no indication as to how this framework is to be translated into an analytical system and given empirical form.

2.5.b. Wingo’s Approach

Lowdon Wingo Jr. as cited by Chapin Jr., 1964\(^{82}\) provides a systematic and rigorous statement of urban spatial structure in the framework of equilibrium theory to propose in economics. Traditionally, economists have dealt with location as a constant, and there has been a disinterest or an unwillingness to examine location as a variable. In his work, Wingo lifts this constraint. He seeks to give explicit recognition to the way in which policy affects the market and how in turn these effects are reflected in urban spatial structure. In this sense, he is seeking to relate theory to real-world situations. However, in addition he seeks to bring developments in spatial models into closer harmony with general economic theory and to relate theoretical work on location to the broader concepts of the urban economy.

Directing his attention mainly to residential development, Wingo develops first a concept of transportation demand, considering the spatial relationship between home and work. With the journey to work viewed as "the technological link between the labor force and the production process", he defines demand for movement as the total employment of an urban area multiplied by the frequency of work – in other words, the number of trips required to support the production process. Wingo recognizes the propensity for urban society to substitute communications for transportation and stresses the necessity for taking into account technological developments in this respect. The supply aspect is expressed in terms of the capability of a movement system – a measure of its ability to

accommodate movements between home and work. Drawing on a somewhat similar concept of accessibility as that discussed above, he uses as a unit of measurement the cost of transportation based on the time spent in movement between points and the out-of-pocket costs for these movements, expressed in money equivalents for distance and number of trips.

The central problem of this kind of economic model is to achieve an equilibrium distribution of households of particular rent-paying abilities to sites with a particular structure of rents. Wingo achieves this location equilibrium by substituting transportation costs for space costs. Thus, on the supply side, he utilizes transport costs to establish the distribution of household sites at varying position rents. He defines position rent as "the annual savings in transportation costs compared to the highest cost location in use." On the demand side, if prices for other goods competing for the household dollar are held constant, the rents households are willing to pay are based on the marginal utility concept, which holds that the greater the unit rent, the fewer the units of space consumed. Clearly, this view of space use immediately involves density, and the smaller the quantity of space consumed in the more accessible locations, the higher the density. The spatial distribution of these densities in the urban area involves the density gradient concept with the slope falling off from the center of the city to the outskirts. To get at the characteristics of demand in the spatial context, Wingo constructs a demand schedule and utilizes appropriate position rents from this schedule to determine the point at which prices and densities are in equilibrium.

The economic model that Wingo advances functions under the usual behavioral axiom that those who control residential space and households who seek space will each behave to maximize their returns. He specifies as given: the locations of employment centres, a particular transportation technology, a set of urban households, the marginal value the worker
places on leisure and the marginal value households place on residential space. Wingo then uses his model to determine the spatial distribution of densities and rents, and the spatial distribution, value, and extent of land required for residential use.

2.5.c. Bid Rent Approach

The bid rent theory is based on microeconomic theory and was mainly developed in the context of urban land uses and urban land values (Alonso, 1964 or Mills, 1972, Muth, 1969 and Hamilton, 1994) as cited by [Chapin Jr., 1975]. Alonso modelled bid rent theory for urban land uses in 1964 as an extension to Von Thunen’s model, which was applicable to rural uses. His model suggests land use, rent, intensity of land use, population and employment as a function of distance to the central business district of the city as a solution of equilibrium for the market for space. The bid rent function explains the relation between urban land uses and urban land values. In a very simplified view, households and companies make a trade-off between the land price, transportation costs and the amount of land they use. This results in a convex land price curve with the highest land prices near the city centre.

Alonso uses the market mechanism in a somewhat different manner to distribute space users to urban land. Instead of developing a demand function, he uses "bid price curves," which in interaction with the price structure of land are used as a basis for distributing agricultural, business, and residential users to sites. Beginning at the center of the city, land is "put up for bid" and on the basis of these curves the bid for the most central site is compared to the next preferred alternative, with this preferred alternative being the marginal combination of price and location for that particular use. On the basis of the steepest bid price curve, the highest

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bidder takes the most central site; the next highest bidder corresponding to the second steepest curve takes the next most central site still available; and so on (refer figure 2.4).

![Bid Rent Curve](image)

**Figure 2.4: Bid Rent Curve**

For the first space user the price paid at the bid location is determined by the price at the marginal location, but for the next user what was a marginal location for the first user becomes the equilibrium location for him, with his bid price determined by the price at the marginal location for this site, and so on down the chain.

**2.5.d. Monocentric Approach**

Alonso’s model as cited in [Anas, Arnott and Small, 1998]<sup>84</sup> depicts monocentric structure of a city, in which the city a envisaged as a circular residential area surrounding a central business district (CBD) in which all the jobs are located. Monocentric city structure is a closed city model with fixed population residing in it and is constrained by distance from CBD, measured as commuting cost to the CBD. Land use in the simple

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monocentric model is efficient i.e. the equilibrium density pattern is Pareto optimal. This is because there are no externalities and land use decisions are based entirely on tradeoffs between desire of space and commuting costs. The monocentric city model is criticized on the account that it implicitly assumes that businesses have steeper bid rent function than residents, so that all jobs are centrally located. This assumption does not hold true in practice as employment is distributed in a circular manner and commuters choose to move radially inward to work. A more fundamental limitation is that it is a static model.

2.5.e. Polycentric Approach

Theoretical models of urban structure are based on the assumption that all jobs are located in the central business district (CBD). Although this assumption was never literally true, it is a useful approximation for a traditional city in which the CBD holds the only large concentration of jobs. As metropolitan areas have become increasingly decentralized, traditional CBDs have come to account for a much smaller proportion of jobs than in the past. Large employment districts have arisen outside of central cities that rival the traditional city center as places of work. When these districts are large enough to have significant effects on urban spatial structure, they are referred to in the urban economics literature as “employment sub-centers.”

The distinction between a metropolitan area with multiple sub-centers (or a polycentric urban structure) and one with much more dispersed suburban employment has important policy implications. Public transportation can be designed to serve sub-centers. Buses can help alleviate severe congestion, and commuter rail lines may be able to serve large sub-

centers. Large sub-centers may have enough jobs to warrant designing public transportation that brings central city workers to suburban job locations, which can help alleviate problems of a “spatial mismatch” between jobs and central city workers. The term “urban sprawl” appears to be used to describe an urban area whose residents have moved farther and farther from the central city, while driving past pockets of farmland and open space to get to their suburban jobs. Sprawl is likely to be less of a problem in an urban area whose suburban jobs are concentrated in sub-centers. If jobs are confined to a relatively small number of suburban sites, workers will attempt to reduce their commuting costs by living nearby. This tendency toward suburban centralization is reinforced when transportation facilities are designed to serve the sub-centers.

Empirical researchers have long recognized that cities are not truly monocentric. Variables representing distance from various employment sites other than the CBD are frequently included as explanatory variables in empirical studies of housing prices, employment density, and population density. Although the monocentric employment density function implies that gradients do not vary across the urban area, multiple sub-centers or distinctive topographical features may lead to variations in gradients.

2.5.f. Other Urban Spatial Structure Models

In early 20th century different researchers gave spatial structure models for urban areas. The important amongst those are as under.

2.5.f.i. Concentric Zone Theory

Burgess [1924] as cited by Torrens [2000] developed the concentric zone theory of urban land use. The concentric zone theory of urban land use is

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based on the assumption that a city grows by expanding outwards from a central area, radially, in concentric rings of development.

Burgess classified the city into five broad zones (refer figure 2.5):

1. The central business district (CBD): the focus for urban activity and the confluence of the city’s transportation infrastructures;

2. The zone of transition: generally a manufacturing district with some residential dwellings;

3. The zone of factories and working men’s homes: this zone was characterized by a predominantly working class population living in older houses and areas that were generally lacking in amenities;

4. The residential zone: this band comprised newer and more spacious housing for the middle classes; and

5. The outer commuter zone: this land use ring was dominated by better quality housing for upper class residents and boasted an environment of higher amenity.

The Concentric Zone Model:

1. Central Business District

2. Transitional Zone
   - Recent Immigrant Groups
   - Derelict Housing
   - Factories
   - Abandoned Buildings

3. Working Class Zone
   - Single Family Tenements

4. Residential Zone
   - Single Family Homes
   - Yards/Garages

5. Commuter Zone
   - Suburbs

Figure 2.5: Concentric Zones

While useful in a descriptive sense for explaining the location of land uses
in a monocentric city not surprisingly come under heavy criticism. Amongst the complaints leveled have been accusations that the models are too rigid to ever accurately represent actual land patterns (the monocentric city assumption is perhaps the largest flaw). Burgess has also been accused of overlooking the important influence of topography and transport systems on urban spatial structure and have been criticized for failing to accommodate the notion of special accessibility and ignoring the dynamic nature of the urban land use pattern.

2.5.1.ii. Sector Theory

Development of the wedge or radial sector theory of urban land use is generally attributed to the work of Hoyt (1939). Hoyt’s model concerns itself primarily with the location of residential uses across urban areas; it refers to business location only in an indirect fashion. The model seeks to explain the tendency for various socio-economic groups to segregate in terms of their residential location decisions. In appearance, Hoyt’s model owes a great deal to Burgess’s concentric zone model. Hoyt presents wedge-like sectors of dominant urban land use, within which he identifies concentric zones of differential rent. The model suggests that, over time, high quality housing tends to expand outward from an urban centre along the fastest travel routes. In this way, Hoyt transforms Burgess’s concentric zones into radial or sectoral wedges of land use (refer figure 2.6).

![Figure 2.6: Hoyt’s Sector Model](image)

1. Central Business District
2. Wholesale and Light Manufacturing
3. Low Class Residential
4. Middle Class Residential
5. High Class Residential

Figure 2.6: Hoyt’s Sector Model
The innovative element in Hoyt's model was in considering direction, as well as distance, as a factor shaping the spatial distribution of urban activity. Hoyt's model also goes further than its predecessors in recognizing that the CBD is not the sole focus of urban activity. One major criticism, however, is that the model overlooks the location of employment, which itself is the major determinant of residential location.

2.5.f.iii. Multiple-Nuclei Theory

The work of Harris and Ullmann (1945) in developing a multiple-nuclei theory of urban land use is amongst the most innovative descriptive or analytical urban models. Their model is based on the premise that large cities have a spatial structure that is predominantly *cellular*. This, they explain, is a consequence of cities' tendencies to develop as a myriad of nuclei that serve as the focal point for agglomerative tendencies. Harris and Ullmann propose that around these cellular nuclei, dominant land uses and specialized centres may develop over time.

The novelty in multiple-nuclei theory lies in its acknowledgement of several factors that strongly influence the spatial distribution of urban activity: factors such as topography, historical influences, and special accessibility. The theory is also innovative in its recognition of the city as polycentric (refer figure 2.7). In this sense, it moves closer to explaining why urban spatial patterns emerge.

![Figure 2.7: Multiple Nuclei Model](image)

1. Central Business District
2. Wholesale and Light Manufacturing
3. Low Class Residential
4. Middle Class Residential
5. High Class Residential
6. Heavy Manufacturing
7. Outlying Business District
8. Residential Suburbs
9. Industrial Suburbs
2.6. ACCESSIBILITY - URBAN STRUCTURE RELATIONSHIPS

Urban transportation system is a basic component of an urban area’s social, economic and physical structure. Not only that, the design and performance of transportation system provide opportunities for mobility, but also over a long run it influences patterns of growth and levels of economic activity through the accessibility it provides to the land. Recognizing the importance of accessibility, World Bank’s Development Report [2009]87, ‘also states that accessibility is today recognized as an important factor in the development of territories, regions and cities. It is seen as a central agglomeration benefit and driver in the economic and social development of places’.

Transportation is a measure of relations between areas. The relations and connections between areas are frequently reflected in the character of the transportation facilities and in the flow of traffic, involving such basic concepts as spatial interaction and areal association. The overcoming of distance is so basic to geography that spatial differentiation cannot develop without movement. The character of transportation as a whole and in detail at any particular time and through its history is altogether determined by its inter-relations with physical & social forces and conditions [Hurst, 1974]88.

Ullman and Crowe saw movement as an indicator of the degree of connection between areas on the earth’s surface and as underlying all patterns of inter-change.

Thus, accessibility is an element inherent in the physical organization of space and movement systems. Much of the recent work on accessibility

87 World Bank (2009), Reshaping economic geography, World Bank Development Report, Washington DC, USA.
concepts have been primarily focused on transportation. Although this work has had a very considerable impact on research in urban spatial structure.

Hansen [1959] in his work on developing a model for residential land use for Washington D.C. based his research to the examination of relationships between residential development and accessibility to commercial, industrial and residential locations. He calculated the different between vacant developable area, which he termed as probable development, and developed area and assumed that the variance between the two is related to accessibility. Development ratio (actual development divided by probable development) was calculated and it was inferred that it has high correlation with accessibility to employment and population.

In the opinion of Ingram [1971] accessibility is a frequently used term in human geography in explanations of the spatial variation of phenomena. In urban geography, it is used in explanations of the growth of the towns; the location of facilities and functions; and the juxtaposition of land uses. Variations in the degree of accessibility are related to variations in population densities and land values.

Nelson [1973] in his study states that in choosing residential location consumers judge accessibility by considering monetary expenditure required for necessary household facilities and the amount of time required to get from that location to other locations in the city that they expect to visit. The locations for which the consumer would be willing to pay the highest rents would be those that are most accessible for the consumption of the largest number of goods which, up to every higher prices, will be consumed at a higher level. The extent to which the rents at those

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91 Nelson, R. H. (1973), *Accessibility and rent: applying becker’s ‘time price’ concept to the theory of residential location*, Urban Studies, 10. PP. 83-86.
advantageous locations exceed rents at less accessible locations depends on the extent to which the consumer can substitute other items of consumption as accessibility is reduced or rearranged consumption cannot be found, the consumer will obviously be willing to pay a high rent for accessibility in order to avoid great loss in utility as accessibility declines.

Kan [1976] attempted to isolate the impact on employment and household density of changing transportation cost as measured by accessibility. It attempted to develop a theoretical model of spatial development as a result of reduction in transportation costs. The structure changes in the said parameters were predicted for 159 counties of Georgia to account for improved and deteriorated transportation situations. Population density, household density, employment density, percentage of single family dwellings, and mean income are taken as dependent variables to determine the structural relationships. Most of the relationships obtained had direct and positive relationships with varying goodness of fit to reveal the impact.

Dalvi and Martin [1976] while comparing patterns of accessibility measured in terms of total employment, retail employment, households and population reveal that there are considerable variations with respect to total employment and retail employment reflecting high concentration of employment in the central area. Whereas lesser variations are recorded with respect to households and population. The degree of correlation between total employment and retail employment index is found to be quite high (+ 0.922), so is the case for household and population indexes (+ 0.968). The lowest correlation coefficient is found between total employment and population (+ 0.14). The study reveals that maximum


93 Dalvi, M. Q and K. M. Martin (1976), The measurement of accessibility: some preliminary results, Transportation, 5, PP. 17- 42.
Accessibility jobs is not at the centre of the city but in the ring approximately 5 minutes away from the centre in spite of the fact that large number of jobs are available in the centre. Similar pattern is seen for the retail employment with the difference that its peak value is lesser compared to total employment.

Black and Conray [1977] in their study for Sydney, Australia to identify areas having relatively poor accessibility to jobs with a view to suggest alternative models to improve the same identified that very few opportunities could be reached within 30 minutes for the study area. It takes about three-quarters of an hour to reach half the jobs of Sydney by car but it takes 80 minutes to 2 hours to reach the same proportion of jobs by public transport. Also, all outer suburbs have low accessibility irrespective of the socio-economic status of the area.

While evaluating the impact of alternative spatial structures it was revealed that the proposed relocation of jobs into public transport corridors had only small effect on accessibility for workers in the outer suburbs. While proposed dispersal of employment throughout the urban area (equal number of job allocated to each zone) far greater impact on altering resident’s accessibility. Improvements in public transport increased male accessibility slightly but female accessibility increased considerably.

Dallal [1980] while mapping household accessibility to public transport, and proposing public transport plan for Borough, London revealed that high income people of the Borough have the tendency to live in high accessibility areas while converse is true for low income people. However, in the outer metropolitan areas high income population tend to live in low accessibility areas.


95 Dallal, E. A. (1980), Public transport accessibility measurement, Traffic Engineering and Control, October, 21, 10, PP.494-495.
In an effort to study accessibility to employment in Delhi Suryanarayana, Sarna and Malhotra [1986] used normalized version of Hansen’s accessibility measure and one way work trips from home to work for government service and other employment were considered for the purpose. The study revealed that accessibility to government employment is better than to total employment in case of all the zones for various modes. All the opportunities can be approached by car in 50 minutes by car in case of government jobs and 60 minutes in case of total employment.

Recognizing the role of transport in urban development Banister and Lichfielf [1995] mentioned that transport has a major impact on the spatial and economic development of cities and regions. The attractiveness of a particular location depends in part on relative accessibility, and this in turn depends on the quality and quantity of transport infrastructure. They also pointed that changes in accessibility give an area a new competitive advantage over the other areas, which in turn results in greater levels of efficiency and higher productivity.

Study conducted by Misra [1995] for assessing the impact of accessibility on the structure of metropolitan region (National Capital Region) reveals most of the accessibility measures adopted in the study showed consistency with the parameters of urban structure. Model share plays a very important role in determining accessibility for identical system characteristics.

96 Suryanarayana, Y., A. C. Sarna & S. K. Malhotra (1986), Accessibility to employment in Delhi - a case study, Road Research Papers, No. 215, Central Road Research Institute, New Delhi, India.


98 Misra, R., (1995), Critical evaluation of metropolitan region structure and accessibility; case study national capital region (Delhi), Unpublished Thesis, School of Planning and Architecture, New Delhi, India.
Manglik and Gupta [2000] while highlighting the importance and utility of accessibility in land use planning decisions concluded that travel distance based accessibility impacts land uses more significantly than time based accessibility. Thus, travel distance based accessibility is a better explanatory variable for assessing impacts on residential and commercial development.

Sarwal [2001] in her study on landuse and accessibility relationship for Chandigarh has assessed the public transport accessibility to major administrative, educational and workplaces of the city. Identified that there are large variations in accessibility levels between the areas close to the selected zones and the ones that are studied at comparatively more distances. The selected top ten most inaccessible areas have shown remarkable improvements in their accessibility levels after proposed increase the frequency of bus transport service. Thus, improvements in accessibility levels are expected to improve the land utilization rate significantly in these areas.

While addressing the role of transportation on urban spatial structure Bertaud [2002] concluded that transport has to be adapted to urban structures not the other way around and urban spatial structures are path dependent, some structures are irreversible. More rigorously, he points that urban structures are dependent on the interaction of the land market with regulations, but ignoring the land market to rely entirely on regulations to “optimize” land use has serious side effects. Dominantly monocentric cities


and high density cities are more favorable to transit than dominantly polycentric and low density cities. He suggested that whenever a city is dominantly monocentric and has a high or medium density is it legitimate to try to maintain this spatial structure through an enabling regulation and appropriate infrastructure investments. This will probably contribute to maintain a high level of public transport use. On the other hand, when a city’s current spatial structure is dominantly polycentric and low density, appropriate measure of transport has to be found to decrease pollution and congestion. A shift toward a higher use of transit is probably not among the feasible solutions.

In their study on evaluation of urban structure through accessibility criteria Reddy and Moorthy [2004] suggested that urban form with central CBD with square shape gives maximum spatial separation and maximum employment opportunities to the given residential zone. Whereas the urban form with eccentric CBD as well as the linear shape gives maximum spatial separation and minimum availability of jobs to the given residential location.

In a study conducted by Du and Mulley [2007] for examining the impact of transport accessibility on land values in Tyne and Wear region of UK it is reveals that the relationship between transport accessibility and land value varies over space giving clues to the interaction between transport infrastructure and land use, which have long been a key subject in the transport planning. The study suggests that a land value capture policy must take into account this lack of homogeneity and that the application of a uniform ‘tax’ would be inappropriate.


2.7. SUMMARY

Thus, there is no consensus on the concept and definition of accessibility and urban structure till date. The primary reason for the same is that changed conditions change the suitability of the parameter to measure accessibility. But even then distance, time and costs have remained in the base of every dimension of accessibility measurement. However, parameters of urban structure have been quite varying. But density and land values have been tested in most of the studies. Literature review also makes it clear that the concept of accessibility has wide application in urban & regional and transportation planning disciplines.