CHAPTER – I

INTRODUCTION

1.0. OVERVIEW OF THE CHAPTER

This chapter introduces the research by laying deep insight into urbanization, mobility and accessibility characteristics globally and nationally, justification of research, salient issues and problem statements to justify the research. It deals with significance of present research, general background of the study area, research hypothesis & questions, aims & objectives, scope & limitations, methodology and data analysis tools.

1.1. URBANIZATION, MOBILITY AND ACCESSIBILITY

Urbanization has been a global phenomenon in the 21st century. Trends on urbanization indicate that proportion of urban population is going to increase to a great extent. Hence, mobility requirements of passengers and freight in urban areas are expected to increase as well, which will have direct implications on rising urban transit supplies. Accessibility to activity nodes shall be core area of concern for urban and transportation planning.

1.1.a. Global Trends of Urbanization

Predominance of urbanization is reflected through its growing share in the global population. As per United Nations [2008], since 1950 the world’s urban population has increased by about 2.63 times during 1950-2007 i.e. from 2.54 billion in 1950 to 6.67 billion in 2007 (refer annexure I-1.1),1 about 49 percent of the global population. Global urban population is expected to increase by 3.11 billion in 2050. However, as per United Nations projections rate of urbanization is expected to slow down by 2050,
from 2.42 percent average annual in 1975-2007 to 1.84 in 2007-2025 and 1.33 in 2025-2050. Thus, urbanization is going to increase at a decreasing rate. But at the same time about 69.64 percent of World’s population shall be residing in towns and cities. The trends also show that the increased population will settle in bigger cities and number of bigger cities will also rise. As per the United Nation’s report, 3.7 percent of World’s population resided in ten million and above cities in 2000, which is expected to increase to 4.7 percent in 2015. The number of mega cities is expected to be 27 in 2030, which were only 2 in 1950.

Thus, population pressure on urban land is going to increase tremendously and densities are going to increase, which will change the structure of the urban areas to a large extent. Concentration of population in urban areas would increase the mobility requirements manifolds. That way urban transport system is intricately linked with urban form and spatial structure. Hence, conceptually, urban transit is an important dimension of urban transportation, notably in high density areas. At the urban level, demographic and mobility growth have been shaped by the capacity and requirements of urban transport infrastructures, be they roads, transit systems or simply walkways. Consequently, there is a wide variety of urban forms, spatial structures and associated urban transportation systems [Rodrigue, Momtois and Slack, 2006].

1.1.b. Dynamics of Indian Urbanization

India is World’s second largest urban system. It has registered high strides in urbanization since independence. Its urban population has grown by about six times during last six decades i.e.1951-2011 (refer annexure I – 1.2). During last 40 years India’s urban graph has been very steep by the fact that more than 100 million Indians have inhabited urban settlements each decade. As many as 285 million and 311 million urbanites inhabited in urban settlements in 2001 and 2011 respectively [Luthra, 2012].
There has been threefold increase in the percentage of urban population to total population (degree of urbanization) over the century old history of Indian urbanization. The vitality of urban settlements is evident from the fact that 31.15 percent Indians live in towns and cities in 2011 compared to 17.29 percent in 1951. Since 1981 rise in degree of Indian urbanization has been to the tune of 2-4 percent each decade.

India’s urban dynamics is clear from the fact that whereas it has shown steep rise in its growth rate during 1901-1951, it has been on a declining path since then baring the period 1971-81. Pace of urbanization touched 41.42 percent mark during 1941-51 and another milestone of 46.14 percent in 1971-81. Otherwise urbanization in India is growing at a rate ranging between 32-38 percent in different decades during 1961-2011.

But Indian urban system is skewed towards bigger cities. The number of mega cities (> 5m) and metropolitan cities (>1m) is rising very fast. The number of mega cities and metropolitan cities has grown by three times and more than four times during 1981-2011. On the contrary the towns have more than doubled during the same period. Concentration of urban population in bigger cities reveals imbalance in the Indian urban system.

Looking at the progressive prospects of urban settlements McKinsey Global Institute [2010] has projected that India’s total urban population will be approximately 590 million in the next 20 years, resulting in the newfound importance of a city’s role. In another estimate it is projected that most of the Indians (about 700 million by 2050) will soon live in cities, and the trend of urbanization is irreversible [Asia Economics Analyst, 2007]. Future trends of Indian urbanization have been towards mega and metropolitan cities (refer annexure I – 1.3). Megacities are expected to register more than threefold increment i.e. from 10 in 2021 to 36 in 2051 and metropolitan cities are expected to double during the same period. Thus, infrastructural requirements, especially transport mobility, are expected to grow exponentially.
1.1.c. Urban Scene in Punjab

Punjab is ninth most urbanized States of India as per 2011 census, whereas it ranked fifth amongst the States of India as per 2001 census. Presently, about 37.49 percent of its souls live in urban settlements compared to 33.92 per cent in 2001 and the rate of urbanization has been 25.72 percent during 2001-11. Urban population in the State has been increasing quite significantly since 1961. It rose from about 23 percent in 1961 to about 28 percent in 1981 and 37 percent in 2011 (refer annexure I -1.4). The corresponding figures for the country are 18 percent, 23 percent and 31 percent for the same years. The share of urban population to the total population has always remained between 5-6 percent higher than the country as a whole. Thus, Punjab has been gaining heights in its urbanization level since its separation from Haryana and Himachal Pradesh. During the four decades since independence it has recorded more than threefold increase in its urban population and about 11 percent increment in its share to its total population.

Though Punjab has recorded high strides in its urban population, but the distribution of the same has not been uniform. The cities of Punjab are the nodal points of concentration where about 58 percent population resides (refer annexure I – 1.5). Cities are accommodating huge proportion of urban population of the state. In 1961 about 4 cities were accommodating about 38 percent of the urban population. But in 2001 only 14 cities are accommodating 58 percent of the total population of the state. Whereas percentage share of cities to total number of urban settlements has risen from 4 percent to 9 percent, their contribution to population accommodation has risen from 38 percent to 58 percent during 1961-2001. It is clear from the above said annexure that since 1961 the concentration of urban population in cities has been increasing at geometric rate. Whereas the share of cities increased by only 5 percent, the share of population has increased by about 21 percent during 1961-2001.
The large towns have shared some hand with the cities in accommodating the urbanites. In 1961 there were only 4 percent large towns and they accounted for about 8 percent urban population. The percentage share of large towns has increased quite steadily i.e. from about 4 percent in 1961 to 12 percent in 2001. The corresponding share of large towns in population accommodation has increased from about 8 percent in 1961 to 16 percent in 2001. During 1961-71 the large towns registered rapid increments in their shares in number and population accommodation. But since then there has been oscillating changes in their contributions.

Medium towns are primarily the dormitory or satellite settlements to cities or large towns. They are the suppliers of labour and raw materials for the production of final products to be manufactured in the bigger towns. They also provide the domestic markets for the final products of the larger urban settlements. Their significance in the urban space is reflected from the fact that their share to the total urban settlements of the State has remained to the tune of 20 percent-23 percent since 1961. But discouraging to note is the reduction in the percentage share of their population, which reduced by about 16 percent during 1961-1991, though there was some stability during 1971 and 1981. This reduction has got accommodated primarily in the cities. Thus, the towns that constitute about 1/5th of the total urban settlements are accommodating only about 1/10th of the State’s urban population as per 2001 census.

Still more interesting to note is the changes in the contributions of the smaller towns. Since 1961 there has been a gradual fall in their share as a result of migration to the bigger urban settlements in search of better economic opportunities. Whereas they constituted about 70 percent of the total urbanites in 1961, their share fell to about 57 percent in 2001. The trend of their share in population accommodation has been more or less similar to that of medium towns. But discouraging to note is 72 percent settlements accommodating only 25 percent of the urban population in
1961. The situation worsened in 2001 when about 57 percent smaller towns accommodated only 13 percent of the total urban population.

Thus, it is clear that fractional increments in cities have recorded high accounting in population accommodation. On the whole it can be inferred that where 92 percent towns (medium and small) were accommodating about 54 percent of the urban population in 1961, their contribution reduced to 25 percent. Urban population is being accommodated in 79 percent of such urban settlements in 2001. In other words, about 13 percent reduction in the number of small and medium towns has recorded about 29 percent reduction in the population accommodation. On the contrary only 3.67 percent urban settlements (cities) that were accommodating about 38 percent of the urban population in 1961 have increased to about 9 percent but accounts for about 58 percent of the total urban population in 2001. Thus, 5 percent shift in their number has recorded about 21 percent increment in their population accommodation during the last four decades. Hence, it can be inferred that the urban system in Punjab has been concentric one and is skewed towards the cities.

1.1.d. Transport Scenario and Mobility Characteristics

One of the immediate impacts of rising urban population has been the increasing transport and mobility requirements of passengers in the cities. Urban transport demand is expected to grow by 2.6 times by 2016 at the existing model split in the large and medium sized cities [Luthra, 2002]. Larger cities are expected to register yet higher demand. As per a study, it is estimated that total passenger trips per day will rise by about 111 percent during 2007-2031. Compared to 2286 lakh passenger trips per day in 2007, they are expected to increase to 2630.4 lakh passenger trips per day in 2011. By 2031, total 4819.2 lakh passenger trips per day are expected to be generated by Indian urban settlements registering about 1.83 times increment [Ministry of Urban Development, 2008].
The rising travel demand is not equally served by public transport systems in the cities. As per estimates of MGI the present share of public transport in total travel demand has been only 30 percent, whereas as per basic service standards in should be minimum 50 percent. It has projected that to cater the future travel needs share of public transport has to be raised to 82 percent [McKinsey Global Institute, 2010].

Deficiencies in public transport supply are generally countered by private vehicles. Unprecedented growth of motor vehicles plying on Indian roads has been the evidence for the same. Number of registered motor vehicles has increased from meager 0.31 million in 1950-51 to about 90 million in 2005-06. Amongst different types of motor vehicles, percentage of two-wheelers has shown rapidly (doubling in every 5 years) and it constitutes 70 percent of motor vehicles of India [Ramachandaran and Shwetmala, 2009]. Traffic composition of six mega cities of India (Delhi, Mumbai, Bangalore, Hyderabad, Chennai and Kolkata) shows that there is significant shift from the share of slow moving vehicles to fast moving vehicles and public transport to private transport [Luthra, 2002]. India is expected to have 246.1 and 372.7 million vehicles, indicating that the country is going to have 5 to 7.5 times growth compared to 2005 level in vehicle population in 2025 and 2035 respectively. Out of this 63-70 percent is expected to be two wheelers. Thus, the present trend of composition of vehicles is expected to remain the same in the next two to three decades (refer annexure I – 1.6) [Anon, 2011].

Direct effect of increased number of vehicles and disproportionate increase in the road network has increased traffic densities (number of vehicles per kilometer length of road) on urban streets. As per the study conducted for Mumbai it is clear that traffic density has increased from a meager 41.81 in 1951 to 791.05 in 2007 [Uddin, 2009]. Bangalore records about 331 vehicles in a stretch of 1 km [Anon, 2010]. The consequent result of rising traffic densities has been reduced journey speeds, rising congestion,
frequent jams, loss of energy and productive time on urban roads. As per the study conducted for 87 cities of India by Ministry of Urban Development [2008],\textsuperscript{14} it is evident that average journey speed ranges between 17-28 kilometer per hour. The study also reveals that the average journey speed reduces with increase in size of the city. In an estimate McKinsey Global Institute [2010]\textsuperscript{15} has projected that 2.5 billion square meters of roads will need to be paved, as well as construction of 7,400 kilometers of metros and subways to serve the urban needs.

Thus, inadequate public transport supply, increasing number of private vehicles, inadequate road network, rising traffic densities, reducing journey speeds, frequent jams, etc. lead to reduced accessibility levels in the cities. Most of the Indian urban settlements have their origins in medieval era where narrow zigzag road network dominates the developments. Even presently, towns and cities are growing organically due to unauthorized, uncontrolled and haphazard developments. Interesting to notice is that urban settlements hardly see best practices of land use–transportation integration. Distribution of land uses does not match the transportation provisions. Concept of transit oriented development is completely missing. Hence, accessibility to different parts of cities is significantly inappropriate.

1.2. NATIONAL URBAN TRANSPORT POLICY (NUTP) AND ACCESSIBILITY

Taking account of the grim scenario of increasing mobility requirements and reducing accessibility levels in Indian cities the NUTP suggests for improving accessibility levels in the urban areas by stating that for urban areas to be able to support the required level of economic activity, they must provide for the easy and sustainable flow of goods and people. Unfortunately, however, such flow of goods and people has been facing several problems. One of the most prominent among them being access to jobs, education, recreation and similar activities becoming increasingly time consuming. Billions of man hours are lost with people
“stuck in traffic”. It recognized that the primary reason for this has been the explosive growth in the number of motor vehicles, coupled with limitations on the amount of road space that can be provided. For example, on an average, while the population of India’s six major metropolises increased by about 1.9 times during 1981 to 2001, the number of motor vehicles went up by over 7.75 times during the same period [Ministry of Urban Development, 2006].

Thus, the policy set the objective to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents to jobs, education, recreation and such other needs within our cities. This is sought to be achieved by:

- Incorporating urban transportation as an important parameter at the urban planning stage rather than being a consequential requirement;
- Encouraging integrated land use and transport planning in all cities so that travel distances are minimized and access to livelihoods, education, and other social needs, especially for the marginal segments of the urban population is improved;
- Improving access of business to markets and various factors of production;
- Bringing about a more equitable allocation of road space with people, rather than vehicles, as its main focus;
- Encourage greater use of public transport and non-motorized modes by offering Central financial assistance for this purpose; and
- Enabling the establishment of quality focused multi-modal public transport systems that are well integrated, providing seamless travel across modes.

To achieve the objectives of the policy it suggested for integrated Master Plan with a need to internalize the features of sustainable transport
systems. In developing such plans, attention should also be paid to channel the future growth of a city around a pre-planned transport network rather than develop a transport system after uncontrolled sprawl has taken place. Transport plans should, therefore, enable a city to take an urban form that best suits the geographical constraints of its location and also one that best supports the key social and economic activities of its residents. Unfortunately, transport planning has not received the extent of attention it should have in drawing up strategic development and land use plans.\textsuperscript{17}

Study on traffic and transportation policies and strategies in urban areas of India also stressed on investing on new roads & over bridges and mass public transport systems to improve accessibility and mobility in the cities [Ministry of Urban Development, 2008].\textsuperscript{18}

Till now isolated research is being carried out to appreciate the impacts of accessibility or changes in transportation scene on different components of urban design, be it design or architectural or physical, etc. The economic components that affect distribution and relationship of physical components as a result of changing transportation scene/ accessibility have least been studied. The present research shall try to model these relationships and distributions.

\textbf{1.3. JUSTIFICATION FOR THE STUDY}

Movement of men and materials has always been fundamental requirement of human societies in urban and regional environs. It has been an established fact that improved transportation facilities have direct impact on the growth and development of an economy or location. In other words, development of an economy is a reflection of cumulative relationships between transport infrastructure, economic activities and its built environment. In this sense transport infrastructure reflects the accessibility level of a place. Since transport infrastructure is not a constant phenomenon, therefore, different locations have varying
accessibility levels, which in turn impact the development of those locations. It is a proven fact that contemporary economic processes in urban and regional environs are accompanied by significant increases in mobility and higher levels of accessibility. So, dependence on transport systems has increased exponentially to support a wide variety of activities existing in the economies, especially urban areas.

Since time memorial origin and growth of human settlements is governed by accessibility factors. Navigational rivers were the usual locations to develop the human habitat. Movements within cities were restricted to walking, thus, making longer distances rather inefficient and time-consuming. As a result, congregated economic activity nodes emerged at one location. Hence, very compact kind of development used to emerge. The settlement’s structure was more of monocentric nature i.e. having strong core to serve all the needs of the resident population. Accessibility levels were very high as the facilities were at convenient distances. Dense urban cores of many European, Japanese and Chinese cities, for example, enable residents to make between one third and two thirds of all trips by walking and cycling [Rodrigue, Comtois and Slack, 2006].

Advent of automobile technology has transformed the human settlements all together. With faster means of travel longer distance can be covered with convenient travel time. Therefore, size, form and structure of a settlement have witnessed sea changes. The monocentric human settlements have turned into polycentric entities. In the words of Rodrigue, Comtois and Slack [2006], the evolution of transportation has generally led to changes in urban form. More radical the changes, more the urban forms have been altered. Among the most fundamental changes in urban form is the emergence of new clusters expressing new urban activities and new relationships between elements of the urban system. 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.

Accessibility is considered as a direct expression of mobility either in terms of people, freight or information. Well-developed and efficient transportation systems offer high levels of accessibility (if the impacts of congestion are excluded) and vice versa. Thus, accessibility is linked with an array of economic and social opportunities. Accessibility is defined as the measure of the capacity of a location to be reached by, or to reach different locations. Therefore, the capacity and the structure of transport infrastructure are key elements in the determination of accessibility. Accessibility is a good indicator of the underlying spatial structures since it takes into consideration location as well as the inequality conferred by distance, cost, time or gravity factor. Due to differing spatial structures, two different locations of the same importance will have different accessibilities. Differentials in accessibility of different places tend to impact the developmental, social, economic and infrastructural characteristics of cities.

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.

Different researchers have measured accessibility based on different approaches such as spatial separation approach, cumulative-opportunity measure, activity-interaction approach, utility measure, travel-space measure, and transport mode measure. But there is no consensus on one approach being the best, as it is a case specific phenomenon. However, all these approaches have been tested to reflect significant relationships with different parameters of accessibility. Few researchers have also attempted to test whether different parameters of accessibility have strong correlation.
between each other under specific conditions.

With urbanization level rising around the world and in India as well mobility levels are anticipated to rise alarmingly. Inadequate road network, insufficient public transport facilities, rising number of private vehicles, and reducing speeds are leading to reduced accessibility levels in different cities and its parts. Hence, spatial, social and economic structure of the cities is going to face serious threats from all these forces, especially accessibilities. Reducing accessibility level to a place is expected to have adverse effects and vice versa. Research has revealed that in European countries as a result of decay of the core area due to rising traffic, more development is occurring in the suburbs of the cities. Hence, developed area, densities and land values are rising in the outskirts rather than in the centre of the city. Thus, the older theories i.e. different parameters of urban structure fade with rising distances from the central area of the city. With differing automobile technologies, different areas in the city have varied accessibility levels. Hence, their developed area, densities and land values are also higher. Present research shall be useful and significant from the standpoint of following issues viz,

- Different accessibility approaches calculate accessibility levels differently. There is no technique by which one approach can be declared as better than the other. However, closeness of different accessibility approaches can be examined to reveal which two accessibility measures are closer to each other so that they can be used interchangeably in case data for one is not available then simulation modeling is to be attempted. Internationally, some attempts have been made to evaluate such relationships. But no such research has been witnessed on similar lines in India.
- Since there is no uniformity in the road network and public transport system existing in the Indian cities, therefore, simulation and validation of any accessibility- urban structure model is not possible.
However, relationships between the variables shall act as guides for further research.

- Contrary to the present research, most of Indian research on accessibility is focused on its relative measure. Integral measurement has not been attempted. Present research shall measure the integral accessibility of different nodes to establish their comparative ranking to identify one node superior to other from ‘ease to reach’ point of view.

- There has been hardly any research in India where efforts have been made to calculate accessibility indices of different nodes with different parameters and then compared each one of them with developmental, social and economic parameters of urban structure. Present research is an effort to model these relationships with an objective to make accessibility a guiding factor for master planning different land uses, transportation facilities, and infrastructure provisions to present a balanced urban structure of a city.

Thus, present research shall be unique of its own kind as the researcher has not come across any such work in the Indian situation. Internationally also, isolated efforts are there to develop models for two or three variables. But present research shall attempt to develop different models for developed area, density and land value relationships exclusively as well as inclusively.

1.4. GENERAL BACKGROUND OF STUDY AREA

Amritsar, a border city of Punjab, is the administrative headquarter of the district and is spread over 142.37 square kilometers area. It commands central position in north-west India and is one of the biggest trade centres in the country besides being the religious seat of the Sikhs because of Golden Temple (Darbar Sahib). Locational and economic importance of Amritsar City is reflected in the growth of population within its boundaries.
1.4.a. Location and Regional Settings

Amritsar is an important border city in the north of India and one of the most sensitive international borders is only 27 kilometers away from it. It is located at 31.64°N 74.86°E with an average elevation of 234 meters. Amritsar is situated 217 kilometers northwest of state capital Chandigarh and is 32 kilometers east of Lahore, Pakistan (refer annexure I – 1.7) [Anon, 2012]. Population of its urban agglomeration has been 11.84 lakh persons. It has strong and high connectivity to other part of the state and country through National Highways, State Highways & Other District Roads and broad gauge railway line leading to national capital.

1.4.b. Population Characteristics

Amritsar is the second metropolis of the State accommodating about 10.16 lakh persons and 11.33 lakh persons as per 2001 and 2011 census respectively. As per estimates of Amritsar Municipal Corporation, it has about 11,19,063 persons residing in Amritsar Municipal Area in 2007. Growth trends of the city are evident from the fact that after the establishment of Municipal Corporation in 1976, as a result of merger of 3 municipalities, the population of the city grew to 5.94 lakh in 1981 from 3.25 in 1951. During 1981-91 the city population registered a growth of 19 percent. But with the expansion of Municipal Corporation in 1996 its population grew to 9.5 lakh, registering a growth of about 34 percent. Except the two externalities (i.e. 1976 and 1996), it can be inferred that the city is growing at a normal rate ranging between 15-20 percent. Thus, a small city at the time of independence has turned out to be a metropolis after 50 years.

1.4.c. Land Use Characteristics

Amritsar City, developed during medieval period, has grown haphazardly. It has seen dynasty of Mughal, British and modern India. The old part of the city i.e. the Walled City developed mostly during Mughal regime, suffers
from imbalanced development whereas other development characterizes the city with mixed land uses in most parts of the city and sporadic developments in the outskirts and periphery. Defective circulation system and traffic bottlenecks are the common features resulting in different accessibility levels in different parts of the city.

Distribution of different land uses over last 30 years reveals that developed area of the city has increased by 2.72 times during 1971-2001. Residential area has grown by about 2.85 times and area under roads has risen by 2.67 times during the same period. Since roads are the arteries of a city and they link various activity areas. Whereas 16-20 percent area should be used for road network in a city, only 8 percent of city’s land is devoted to roads since last three decades. Hence, over a period of 30 years about 92 percent of developed area, put under different uses, is served by only 8 percent of its area that is devoted to roads.

1.4.d. Physical Growth Characteristics

Till 1900 A.D., development of the city remained concentrated within or immediately outside the Walled City. The growth was mainly due to the wholesale commercial establishments. The city was the centre of historical, religious and administrative activities. The development was compact but unorganized, the roads were narrow and zigzagging. British rule led to the development away from the Walled City. The development was a mix of planned and unplanned efforts and was of semi-compact type with narrow access roads/streets. Development of planned colonies by Improvement Trust away from Walled City has given a fillip to spatial growth of the city. These developments are characterized by wider roads.

After the establishment of Amritsar Municipal Corporation in 1976, it brought out many Town Planning Schemes for residential and commercial uses. Largely the development is concentrated in the northern and eastern parts of the city. Establishment of industries attracted new developments in
these directions. The circular road was widened in order to give access to various parts of the Walled City. Development on the outskirts still remained sporadic and unplanned. But still the roads and streets are sufficiently wider to provide better access to different areas.

In the last 30 years various planned developmental efforts of Improvement Trust and Corporation and private colonizers have given a complete fillip to the outskirts of the city. Many new townships have come up in the outskirts and peripheries of the city, are planned residential efforts in the city. But lack of Master Plan for the city has resulted in making these planned colonies as isolated entities. Master services like major roads are not developed resulting in reduces distance and time accessibility levels.

The city is largely governed by organic development having mixed land use development in most parts of the city. However, Walled City is the epicenter of economic activities apart from few more activity centres of the lower order. The city has grown in a concentric manner having multi nucleolus of activities. But unplanned road network has created differential in accessibility levels to different parts of the city.

In late 2010, Master Plan for the city has been approved by the State Government. It has proposed strategies for all round development of the city by suggesting required infrastructure for different parts of the city. Many new roads and grade separations have been proposed, which are expected to improve the accessibility levels in different parts of the city.

1.4.e. Road Network Characteristics

The growth and development of different land uses and activities over period of time also depict the picture of road network and transport system in the city. Overall, ring road surrounding the Walled City and eight regional roads form the primary road network of the city (refer Annexure II). Consequently, they are the high-density corridors accommodating mixture of land uses/ activities. Concentric ring development superimposed by ring
and radial road network pattern indicates better connectivity to all parts of the city. However, broad gauge railway line passing through the city divides the city in two parts, which is a limiting factor to connectivity in the city.

Since the city has undergone varying intensities of development, therefore, the existing road network and transport system provides differing accessibility levels in it. Consequent effect is quite visible in each of these, thus affecting the indices of urban structure differently at different places. The primary road network of the city has not been expanded. However, road widening and geometric improvements were done on these roads. The only new physical connection since the last decade can be viewed as the third rail over bridge and elevated road near bus stand. Thus, it can be inferred that physical accessibility has remained more or less same in Amritsar city.

1.4.f. Transport System Characteristics

Amritsar does not have city bus transport service. However, suburban bus service caters to the travel needs of the population residing along radial routes on which these buses ply. But suburban bus service caters to about 1 percent of the total travel demand of the city. Intermediate public transport modes, cycle rickshaw & auto rickshaw, cater to about 94 percent of the travel demand catered as public transport system [Luthra, 2006]. Auto-rickshaws operate on all the radial roads of the city. Cycle rickshaw is the predominant mode of transport to cater the travel needs within Walled City.

1.5. JUSTIFICATION OF AMRITSAR AS CASE STUDY AREA

Amritsar is a historic city having its roots in medieval era. It figures on tourist map of the world due to famous Golden Temple. Most of the city is organically developed and work places have come up haphazardly. In spite of disturbances at the time of independence or terrorism, Amritsar has grown steadily and is the second metropolis of the State. Administrative
and market driven forces have led the city grow in different magnitudes in different parts of it. Monocentric town of yesterday has turned to be multi-nucleus city of today. Lack of planning for the city has resulted in differential in developed areas, population densities and land values. Broad gauge railway line divides the city in two parts and only three rail over bridges connect the two parts with each other, thus limiting the accessibility to different parts.

To support, the city has not experienced any change in its road network. It is worth noticing that during past three decades the primary road network has witnessed only expansion in its width and improvement in road geometry. The only major change in the primary network can be accounted with the construction of third rail over bridge near bus stand. No new major roads have been constructed to ease the traffic on existing roads. That way the physical accessibility has remained almost unchanged over a period of time but traffic volume has increased geometrically on these roads in the last three decades. Widening of roads and improvement in road geometry have led to improvements in service or time accessibility. The changed service accessibility has affected the land use pattern, density distribution, intensity factors, land economics, etc. in the city.

City’s travel demand is largely met by private modes (74 percent), whereas about 25 percent trips are served by intermediate transport modes, especially auto-rickshaw and only 1 percent by bus transport [Luthra, 2006]. Transport scenario on city roads has been changing tremendously as 46006 new vehicles have been registered in 2007-08 in comparison to 33287 in 2004-05. Increased number of vehicle has led to substantial increase in the traffic volume on major city roads, which in turn has adversely affected the accessibility levels in different parts of the city.

The impact of differing accessibility levels and urban structure parameters can better be examined in a dynamic environment, therefore, a metropolis is a better entity to be taken as case study. Also, an urban entity that has
experienced an urban change over a longer period of time is considered as an appropriate unit for study. Mostly research on urban structure is confined to bigger urban areas viz., well established metropolises and mega cities. For the present research an emerging metropolis i.e. Amritsar, has been selected because it is the second most populated city of Punjab State and has a history of more than 400 years. The physical and socio-economic developments of the city have undergone tremendous changes in land use developments, population densities and land values in different parts of the city over a period of time. Apart from this, following are the reasons to conduct research on Amritsar city.

• Amritsar is a border city and is constrained by lopsided development. But still it has registered tremendous growth and is keeping second place in the State. It is an unusual feature of the city.

• Area under primary road network has remained constant over the past three decades. But improvements in service accessibility may be one of the governing factors in its changing urban structure.

• Division of city by railway line is a limiting factor to accessibility. But still city has grown across it in leaps and bounds.

• Land use transformations are occurring tremendously for the past three decades, which are changing the developmental, social and economic profiles of different areas of the city. Therefore, it is a unique feature to study the parameters of urban structure under nearly unchanged accessibility levels.

• Access to data and conversance with the city for about 35 years are the supporting reasons to do justice with present research.
1.6. RESEARCH HYPOTHESIS

Literature on accessibility-urban structure relationships reveal that the parameters of the two are positively and highly related to each other. Therefore, the study attempts to test the following hypothesis viz.,

Positive and higher correlation and goodness of fit exists between accessibility and urban structure indices.

1.7. RESEARCH QUESTIONS

To test the hypothesis following research questions are framed to develop a discourse.

- What is the nature and degree of correlation between different parameters of accessibility and urban structure?
- How accessibility impacts different parameters of urban structure?
- What are the issues concerning accessibility-urban structure relationships?
- What suggestions can be drawn from accessibility-urban structure relationships?

1.8. AIMS AND OBJECTIVES

Within the gamut of road network, transportation system and intervening economic activities different accessibility levels lash their impacts on indices of urban structure at different locations. Thus, a vicious web is formed between accessibility indices and physical (total developed and residential area), social (gross and net population density) and economic variables (residential and commercial land values) of urban structure, where it is hypothesized that higher accessibility levels directly and positively affect these variables. It is worth mentioning that accessibility indices shall be worked out for the general population and not for any special section of the society such as disabled persons, gender,
economically weaker section, elderly, children, etc. Also, distance, time and population based gravity have been considered to be the parameters for the present research.

1.8.a. Aim of Present Research

The aim of the present research is to model the impacts of distance, time and gravity accessibility indexes on physical, social and economic indicators urban structure i.e. developed & residential area, gross & net population densities, and residential & commercial land values and to make suggestions for general population of Amritsar city and suggest applications of concept of accessibility in urban planning and transportation in general.

1.8.b. Objectives of Present Research

To achieve the above said aim following objectives have been set viz.,

1. To measure integral accessibility indices by spatial separation (distance and time) and gravity (population based) approaches for general population to examine the distribution pattern of these indices at city and area levels;

2. To test correlation and goodness of fit between spatial separation and gravity approaches of accessibility measurement used in the present research at city and area levels;

3. To estimate physical (developed and residential area), social (gross and net population density) & economic (residential and commercial land values) parameters of urban structure by examining their distribution pattern at city and area levels;

4. To test correlation and goodness of fit between physical (developed and residential area), social (gross and net population density) & economic variables (residential and commercial land values) as
parameters of urban structure;

5. To model the relationships and impacts accessibility indices on parameters of urban structure and suggest areas of their applications in urban planning and transportation.

1.9. **SCOPE OF RESEARCH**

Amritsar is one of the fast growing cities of the State presenting different features of development representing the medieval era, Mughal dynasty, and British rule. Consequently, the physical and socio-economic developments in the city have their impacts on varying land use developments, population densities and land values in different periods. They seem to be so interwoven that each influences the other. As ward is the smallest administrative unit in a city, 65 wards as existing on 2007 has been taken as base to conduct the present research (refer annexure III). Later on these wards have been grouped into five categories viz., core, edge of core, intermediate area, outskirts and periphery, to represent different types of development and to examine the behaviour of accessibility and urban structure parameters in these areas and model the relationships and developments (refer annexure IV).\(^1\)

Accessibility indices to different wards have been calculated taking note of the general population, excluding the special sections of the society such as disabled, gender, elderly, children, etc. There are different parameters

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\(^1\) Locations of central area and distance from it have been the base of categorizing the city into different area. Since Walled City of Amritsar is the central area of the city, therefore, it has been considered as the core area. All wards within walled city have been grouped to constitute the core area. It covers a radius of 1 kilometer from the central point of the core area, which is considered as the most conveniently walkable area. Edge of the core is constituted of the wards whose boundaries are touching the core area. The spread of this area is upto 2 kilometers as the ward size is comparatively smaller and it is a walkable distance with little bit of inconvenience. Similarly, wards touching the edge of the core area constitute the Intermediate area, which is spread upto 3.5 kilometers distance from the centre of the core area. Need of automobile arises to reach the centre of the core area. Area between 3.5 – 5 kilometers is identified as outskirts of the city. Its ward boundaries touch the ward boundaries of the intermediate area. Wards touching the Municipal Corporation limit of the city are included in the category of periphery. This area has more of the wards beyond 5 kilometers distance from the centre of core of the city.
and approaches to measure accessibility indices. But spatial separation approach, which is based on network analysis, has always been considered as best to present a better picture of accessibility levels in different parts of the city. Planned public transport facilities are almost absent in Amritsar, which leads to no public transport service to many areas of the city. As, only road based transport system exists in the city, therefore, network based spatial separation approach has been followed to measure the accessibility levels or indices for different areas on the city. *Alan Hay’s cell value approach* has been followed to measure the accessibility in distance and time dimension. *Ingram’s approach* has been followed to discount the number of links or junctions travelled to reach a node. *Hansen’s approach* has been followed to test the impact of gravitational factor (population of ward) on accessibility indices. Later, correlations between these accessibility approaches have been worked out to test the nature and degree of relationship amongst them. The centre of the ward has been taken as the point to measure accessibility indices of a particular ward.

Present research concentrates on measuring integral accessibility of a place (centre of the ward) to reach central points of all other wards. So place accessibility rather than individual’s accessibility is measured in the present research.

Socio-economic forces are important actors in shaping the physical structure of the cities. Thus, present research concentrates on examining the impacts of accessibility indices on developed area, residential area, gross population density, net population density, residential land values and commercial land values in the city. Information and data on the above parameters of urban structure have been collected at the ward level. Their distribution patterns and relationships with accessibility indices have been studied to model the impacts of accessibility on each one of them.
The results of analysis of accessibility indices, urban structure parameters and their relationships have been presented in GIS environment. Two dimensional and three dimensional imaging have been attempted in GIS environment to portray the skyline of different parameters of urban structure. Parameters of urban structure have been portrayed on distance scale from the centre to work out the generalized trend lines along the east-west and north-south corridors of the city. For the same, the city has been divided into distance contours of 1 kilometer each (refer annexure V), which clearly reflects the wards falling in a particular contour.

1.10. LIMITATIONS OF RESEARCH

Each research is carried out under limited conditions. Following are some of the limitations for the present research.

- Accessibility means ease of reaching a place by the inhabitants of a city. But the city has different sections of the society. Therefore, accessibility to a place cannot be same for all. Since special transportation infrastructure is required for some special sections of the society such as disabled, gender, elderly, children, etc. Since it is a research of its own kind, therefore, no special consideration has been given for these special groups in the present research.

- Non-availability of data on traffic volume, delay characteristics, number of trips, cost of travel, etc. has restricted the research to distance and time variables of accessibility. Therefore, multivariate analysis is not applied to calculate accessibility indices of the nodes.

- Also, various socio-economic considerations such as individual's income level, cost of travel, availability of a particular transport system, preference to a particular mode, time of travel, etc. may vary the accessibility level of an individual. As it is a subject of complete research in itself, therefore, accessibility to a place by different individuals has not been measured.

- Provision of special transportation infrastructure and transport
policies have differentials in the accessibility levels for different sections of the population such as special or disabled persons, gender, economically weaker section, elderly, children, etc. These attributes do impact their accessibility levels in comparison to the accessibility indices of general/common persons. But limited transportation infrastructure provisions are made for these special sections of the society. The National Urban Transport Policy 2006 also suggests low floor buses to take care of elderly and disabled. Even, special provisions have been incorporated in building byelaws and these have been mandatory in all public buildings including access to metro, rail and bus terminals. If special sections of the population like disabled are also considered it may affect the time and cost of travel. Therefore, present research is confined to measuring accessibility indices for general/common population and not for these special sections of population.

- Physical parameters of urban structure such as floor area ratio, building height, coverage, etc. are uniform in Amritsar city under the existing development control regulations. Therefore, the research has taken the available parameters like developed area, residential area, gross & net population density, residential & commercial land values for study.

- Urban structure is generally taken to represent the internal physical features/ morphology of an urban entity, where the principle and components of architecture and design are normally applied. The present research does not concentrate on examining or appreciating the urban structure from architectural or design aspects and only physical, social and economic aspects are studied to reveal the urban structure of Amritsar city.
1.11. METHODOLOGY

Present research has two components viz., accessibility and urban structure, and the effort is to examine the relation between the two. For the same, clarity about their concepts, parameters and approaches to measure their magnitude is very essential. Broad methodology for present research is presented in figure 1.1.

In the first stage literature on accessibility and urban structure is reviewed to clarify thoughts about concepts & definitions, parameters & indicators, theories & models and methods to measures the two variables under study. Critical analysis of these aspects would help in adopting the relevant parameters to establish the relationship between accessibility and urban parameters for the present research. Documentation and critical analysis of accessibility-urban structure relationships established by different researchers earlier shall help in highlighting the issues and avenues and shall help in building the problem for the case study city i.e. Amritsar. Books, journals and internet are referred for documentation of literature.

At the second stage regional settings, historical, physical growth, land use, population, and economic aspects of Amritsar city are discussed in detail to describe the profile of the city, which will help in understanding the spatial, demographic and economic structure of the city at a broader level. It will also help in correlating the reasons for accessibility-urban structure relationships and impacts at the later stage. Since Amritsar has only road based transport system only, therefore, existing road network, traffic characteristics and transport service shall be analyzed to appreciate the accessibility features in Amritsar. Information and data for the said aspects are taken from secondary sources.

Stage three deals with calculation of accessibility indices for the wards by applying spatial separation and gravity approaches. Distance, time, links crossed and population of the ward have been taken as parameters to
Figure 1.1: Flow Chart of Methodology
AutoCAD 10 software (refer annexure VII). Later, ground truthing of about 200 inter-nodal distances have been done before finalizing the inter-nodal distance. Simultaneously, time to travel the distance between sample nodes have been recorded and generalized and travel time is worked out for common road and traffic conditions. City level and area level variations in accessibility indices have been analyzed in GIS environment to depict the distribution pattern of accessibility levels. Measures of standard deviation, correlation and regression are applied to test accessibility variation levels, significance of relationship between different accessibility indices and goodness of fit of regression relationships.

**Fourth stage** deals with analyzing the parameters of urban structure selected for present research. Variations in developed, residential, commercial, and industrial areas of the city have been analyzed. Ward level data for the same has been obtained from the land use data in GIS environment. To understand the social structure of Amritsar city, population distribution has been taken as a base. For the same ward wise data for population has been taken for 2007 from Municipal Corporation, Amritsar. Ward’s geographical area has been computed in GIS environment and gross and net population densities have been worked out and analyzed to examine their distribution patterns. With an objective to examine the economic structure of the city reserve residential and commercial land values have been obtained from the District Collectorate’s Office, in particular Tehsildar’s office. Since the data obtained is at the locality level, therefore, localities prescribed in the records of Tehsildar’s Office have been grouped ward wise after comparing them with the key plan of Amritsar City and the maximum value from it has been taken for the present purpose. Distribution patterns of developed area, population and land values in the city have been examined in GIS environment. Measures of dispersion, correlation and regression have been applied to estimate the variations correlations and trends for different parameters of urban structure selected for research. Correlation coefficients and regression
equations have been obtained for the parameters to test the significance of relationship and goodness of fit of regression equation.

**Stage five** deals with testing the impacts of indices of accessibility on developed & residential areas, gross & net density and residential & commercial land values. Coefficients of variations, correlation coefficients, regression equations and goodness of fit (R^2 values) have been calculated for the city as a whole and for different areas. Goodness of fit for relationships between the entire set of variables have been worked by applying regression approach to each of the relationships. Correlation coefficients have been worked out between the variables and t-test has been applied to test the significance of correlation coefficient between the variable.

**Last stage** deals with drawing the results and conclusions for the study. Broad suggestions have been made for application of accessibility as a parameter in urban and transportation planning disciplines. Models for accessibility-urban structure impacts have been worked out based on correlation and regression indices to reveal significance of coefficient of correlation through t-test and goodness of fit by R^2 value.

The data required for the indices of accessibility and urban structure for the present research is presented in annexure VIII.

### 1.12. DATA ANALYSIS TOOLS

Suitable analytical tools always prove to be helpful in bringing about the most appropriate results required for the study. As ‘integral accessibility’ has been taken as the base to assess the accessibility indices of the wards of Amritsar city, therefore, a special algorithm (named as SAI indicating Shortest Accessibility Index) has been developed to produce N X N matrix (65 X 65 in the present case) giving the shortest path between two nodes. Row total of the matrix produced, thus, gives the value of integral accessibility of a particular node.
As urban structure reveals the distributional phenomenon, therefore, all the parameters need to be spatially presented. For the same, ArcGIS 9.3 has been used to generate the maps for describing the accessibility indices and parameters of urban structure viz., developed area, residential area, commercial area, industrial area, gross density, net density, residential land values, and commercial land values. To describe the real-time feel of urban structure variables 2-dimensional and 3-dimensional views have also been generated.

Statistical tools such as mean, standard deviation, coefficient of variance, standard error, correlation coefficient, \( R^2 \), regression equation, regressed trend line, and t-test have been used with the help of window version of XLSTAT and excel.

1.13. CHAPTER OUTLINE

Present research is divided into seven chapters as follows.

**Chapter 1** introduces the research proposal by establishing theoretical base to it and identifying issues and problem concerning the research proposal, significance of the study, general background of study area, research hypothesis and questions, aims and objectives, data requirements, scope and limitations and research methodology.

**Chapter 2** deals with establishing the theoretical base of accessibility – urban structure interface by understanding the concepts and definitions of accessibility and urban structure, parameters and Indicators of accessibility and urban structure, methods of measuring accessibility, theories and models on accessibility, concepts and definitions of urban structure, parameters and indicators of urban structure, theories and models of urban structure, accessibility - urban structure relationships and models developed by different scholars.
Chapter 3 introduces the case study area by discussing its physical growth in the historical perspectives, population growth characteristics, land use characteristics, road network characteristics, transport system characteristics, and traffic characteristics.

Chapter 4 deals with measuring the accessibility indices of Amritsar city by applying spatial separation and activity-interaction approaches to reflect distance accessibility indices, time accessibility indices, Ingram’s accessibility indices, Hansen’s accessibility Indices, and identification of degree of correlation between accessibility indices.

Chapter 5 deals with examining the developed area, population density and land value structure of Amritsar city in terms of developed area distribution pattern, residential landuse distribution pattern, commercial landuse distribution pattern, industrial landuse distribution pattern, population distribution pattern, gross population density distribution pattern, net population density distribution pattern, residential land value distribution pattern, commercial land value distribution pattern, and relationship between developed area, density & land values.

Chapter 6 discusses the accessibility–urban structure modeling by analyzing the accessibility–developed area relation, accessibility-residential area relationship, accessibility-gross density relationship, net residential density–accessibility relationship, accessibility-residential land value relationship, and accessibility–commercial land value relationship.

Chapter 7 discusses the research results, suggestions and areas for future research.

1.14. FUTURE DIRECTIONS OF RESEARCH

Present research is restricted to network based accessibility analysis for Amritsar City. And urban structure parameters are confined to ward wise land use, population, and land value data. However, studies can be
extended to test the impact of accessibility measured in terms of public transport provisions, cost and other travel difficulties on other parameters of urban structure such as floor area ratio (FAR), market land value, housing density, facilities & services, employment, workforce participation rate, tenure status, income level, sex ratio, migration pattern, etc.

Research should be carried out to work out a mathematical model to make accessibility as a determinant to land use decision, density distributions, housing and infrastructure provisions, etc.

1.15. SUMMARY

As accessibility is a base phenomenon for bringing about different land uses and other socio-economic features in the urban settlements, therefore, effort has been made to establish a case for accessibility as important aspect of urban structure in general and Amritsar, as a case study city, in particular. Some hypotheses have been laid to achieve the aims and objectives set for the present study. Scope and limitations have been discussed in detailed to chalk out a clear cut methodology for present research.