Planners and decision-makers need efficient tools to quantitatively evaluate and compare the impact of alternative plans and designs, so that more worthy development choices can be made. Transport plays an important role in the development of a region. The founding, shaping and growth of human agglomeration throughout the history have been products of complex interactions of many forces. One major force has always been transport.

The relationship between efficiency of transport and its capacity to generate a high level of urbanisation, considered on the grounds of both logical and empirical observation, can be easily accepted as axiomatic (Mukerji, 1974).

Transport, the de facto barometer of economic, social and commercial progress has transformed the entire world into one organized unit. Transport helps in carrying ideas and inventions from one part of the earth to another. It has contributed to the evolution of civilization in a significant way. The demand for transport is as fundamental in human nature as demand for essential commodities. It is an indispensable part of culture, as the hallmark of civilization.

Transport constitutes one of the most vital organs of the modern economic system. In developing countries transport facilities are considered as an essential component of infrastructure. In the developed realm, it is seen as a basic and necessary social amenity. Whichever view is ascribed to, the conclusion remains the same. Thus, transport services are intrinsic to contemporary civilization. The importance of transport can be understood in terms of its three capacities in fostering development. Firstly, transport serves as a basic physical and economic infrastructure that enables raw materials, intermediate products and final products to be distributed to various locations at local, regional or international level. It also expands the geographical extent of the markets fostering large scale production. Secondly, transport serves as a basic social and political infrastructure, facilitating the flow of ideas, people, information and goods, at the same time enhancing the political and social integration of territories. Thirdly, transport serves as a boost to the process of industrialization in an area. It helps
in the movement of equipments, which are required at the site of industrial location (Saikia, 2003).

Road is the most important and popular mode of transport. Road is a symbol of motion. Truly, it is said that if the community is stagnant, road will indicate the fact. In the reconstruction of a region or a nation, roads invariably play a positive role. Outside home, most of our activities whether individual or collective greatly depend on the availability of cheap, smooth and quick means of transport. As Jeremy Bentham points out, roads are the veins and arteries of a country through which circulation of essential elements of development activities is possible. The vast importance of contemporary road transport is very much a reflection of unrivalled convenience to the user, especially in the conveyance of persons. No other form of transport is able to provide such a comprehensive door-to-door or origin-to-destination service nor does any other mode have such an extensive route network. Apart from this, road transport also provides a feeder or connection to other modes (Saxena, 2005).

The origin of a settlement and its growth is intimately linked with the development of transport facilities. The pattern and magnitude of a town’s growth has been largely influenced by transport systems and their capabilities. In case of large cities, suburbanisation and metropolitan growth are the consequences of advancement in road transport technologies. The future city growth and its image are dependent on the breakthrough in the metropolitan transport network system. The growth of cities starts breaking up in uncontrolled manner after a certain magnitude, because of inefficient transport and service systems. The growth process of settlements is affected by road transport network. The widening gap between the demand and supply of urban infrastructure and ever increasing city size has resulted in rapid growth of urban fringe and peripheral growth. This often resulted in high variation in density profiles along transport corridors and ultimately has led to an amorphous urban sprawl. The variations in density have direct implications for travel demand and for planning public transport system. It is well recognized that urban transport structure and transport systems are strongly interlinked and inseparable. Urban transport, both intra-urban and inter-urban plays a key role in influencing the pattern, growth and development of an urban centre. The sub-urbanisation becomes possible because of transport system. The transport
system serves the main urban centre, the satellite suburbs and new towns for the movement of people, distribution of goods and services (Gurumukhi, 1996).

After the independence, revolution in the channels of transport has gradually broken the insulation of rural communities and brought them, nearer to the cities and the industrial centres of production. Cities and towns tend to grow in an unplanned and haphazard manner with the passage of time. The problem has faster aggregated in the wake of rapid urbanisation and industrialisation. A concentration of activities has taken place around the large and medium settlements. The cities are growing beyond the municipal limits and taking the form of agglomerations. Thus, the actual limits of the cities have been doubled and this is a real picture of India and also in developing countries.

Historically, urban settlements in India have grown around major transport corridors. Initially, physical growth takes place linearly along the transport corridors and later on, growth extends by infilling the nearby pockets. This eventually leads to the formation of a heterogeneous road network. Normally, when the rural pockets are connected to a city by a road, at initial stages, development in the form of service centres such as shops, cafeteria, general stores etc., can be seen on the roadside. In due course of time, the area eventually becomes the hub of economic activities and forms a part of an urban centre. An enormous amount of upsurge could be observed along the roads. This type of upsurge caused by a road network between urban/semi-urban/rural centres is very much prevalent and persistent at most places in India.

There is, of course, a symbiotic relationship between level of road transport development on the one hand, and the process of urban growth and the concomitant process of cultural exchange on each other in any region. A high level of transport facilities in a region ensures a good and efficient interaction with other settlements.

The transformation of land mainly depends on the accessibility, land availability and value. These factors interact with each other and give rise to specific land uses in and around the urban centre. This interaction, which accompanies the development process, leads to the redistribution of land in space through the complementary tendencies of concentration and dispersion. As a consequence, some locations experience greater demand of specific land uses than others. Hence transport plays a crucial role in the subsequent transformation of land (Fazal, 2001).
In modern complex human society, urbanisation can be considered as a special spatial feature, note that there were no urban centres in the ancient civilizations, but the nature and magnitude of contemporary urbanisation is cordially different to its ancient counterpart. Often it is argued that the urbanisation process itself is the result of energy economy in the society, where large scale consumption and production centres are located in close proximity to reduce the cost of transport. However, with the increase in the magnitude and complexity of urban centres and urban systems, further efficiency for smooth and easy transport attracts the peoples. The cost of time becomes a significant variable like in India where investment in infrastructure is a major constraint, particularly in view of rapid urbanisation and growing size of urban centres. So the level of transport in a region as well as in a centre affects the physical, demographic and economic growth of the urban centres (Saikia, 2003).

The urban population is generally scattered in large geographical area. The services like education, employment, hospital, entertainment, marketing, recreation, administration and many more are the necessities of urban population. The interaction between land use and transport, nature of transport structure and their impact on the land use in the urban and sub urban areas are the important aspects which need investigation.

Road transport is the underlying force in the location, growth, rank-size and functional differentiation of cities. Cities develop at foci or break of transport points. They are the nodes of the route systems and their importance closely reflects the degree to which they possess the property, which is called nodality. Well-organized, transport facilities are of first importance for the overall development of our cities. Thus, transport, both inter and intra city, are of prime concern for both urban and transport geographers. With the growing urbanisation and growth of transport, it is necessary not only to examine the present pattern of transport but also their problems as well and suggestions should be given to the policy makers for the better planning. The present study is an attempt in this direction.

In the light of the above made observations, the present study endeavors to examine the evolution of regional road transport network in Rohtak division and its impact on the growth of urban centres. The findings of the study shall have immense value for the development and planning of the region.
1.1 REVIEW OF LITERATURE

A large body of literature has been evaluated for the role of transport in the growth of urban centres and their socio-economic development in various areas of the world. The main concerns of this type of studies are the observation of development of the road transport network which creates level of connectivity and accessibility between settlements. Its relationship with the rapid growth of urban centres both physical, demographic, land use pattern and socio-economic development, which have a direct affect on the total urban environment.

The literature in this field is available at international, national and regional level. The literature reviewed till date is as follows:

Smith, (1968) worked on “Modes of Transport Network Evaluation in India” combining various existing approaches in the field. He observed that some satisfactory results could be obtained only with the inclusion of some empirical variables like population, density, military activity and prediction for trade etc. The consideration of simple theoretical variables, e.g. distance, urban population, nearest neighborhood etc., failed to bring desired results.

Singh, (1967) worked on the nature of links and pointed out the degree of accessibility with a view of measuring the efficiency of present network in Bihar state. He also sought to correlate the status of transport and the existing structure of economy in the area. He concluded that lack of a strong tie or connectivity between the north and south of Bihar has been found to be largely responsible for the under developed structure of transport network (especially in terms of inferior types of links).

Singh, (1969) revealed in his study that transport links in any region exercise tremendous influence over structure of economy by virtue of providing major guideline to economic activities (trade and industries). The locations of roads and their relationship to the land surface are not haphazard but meaningful. Transport links are the product of numerous circumstances, for example, the radial pattern results from the facilities of construction on a plain in all directions together with planning which proposes to provide travel facilities to maximum places from urban centres. By explaining the factors behind the even distribution of road density, it was found that all the areas of high density are concentrated in that part of the plain which is
comparatively almost free from flood effects. The development of transport is regulated by interplay of two factors - feasibility and demand.

**Bannerjee et al, (1970)** conducted a study to determine the distribution pattern of the different transport elements in micro regional units in the state of West Bengal. They evolved a methodology to consider all the elements in their totality to determine a composite index for each micro unit. They concluded that only south-west-central belt contains a larger concentration of higher level central places. The occurrence of a large number of low level central places in the West Bengal is due to the reason that most of the roads are not meant for thorough traffic because roads are designed as feeders to the railways in an attempt to secure local traffic. Some of these roads are kucha and in the monsoon, they are impassable. Even during the dry season they do not serve as the best means of transport.

**Sinha, (1971)** studied accessibility by roads in Mysore state, pinpointed lacuna in the analysis. He claimed to provide a modified method with the help of widely used formula of Nagpur plan. He assumed that distance of a village from metalled road should not exceed more than 6.4 Kms in a developed region, 12.9 Kms in agricultural semi developed and 19.3 Kms in under-developed areas. On this account, firstly, developed, semi developed and underdeveloped regions have been demarcated with reference to which accessibility has been worked out. The connectivity of the state capital and district headquarter is measured and subsequently the relationship between metropolitan city and other cities have been examined with the help of topological diagrams of roads and detour index maps. He concluded that there is a perfect positive correlation between urbanisation and transport systems. Transport facilities are an important factor, which affected the socio-economic status of any region.

**Kayastha and Singh, (1972)** in their study on “Some Aspects of Transport in Dhanbad”, intended to bring out salient features regarding the aspects of transport in Dhanbad town by analyzing the characteristics and pattern of transport network including, the incidence, structure of traffic and few other relevant points. After detailed discussion it is found that Dhanbad is an important mining town of the country. Roads and Road vehicles constitute the main structure of transport of Dhanbad. Railways, which are double tracked, electrified and broad gauge, function as means of
extra town transport. The traffic flow which consists of trucks, buses, taxies have marked concentration along a few routes.

Singh, (1970) conducted a study on “Pattern of Transport Links in Bihar North of the Ganga”. This is one of the comprehensive studies of this category. Having introduced the characteristics of various components of network, its pattern and densities have been perused in regional context as well as in general with the help of over half a dozen useful maps. The regional contrasts and the causal factors responsible for transport links could be brought out in the study. He presented much generalized picture of transport systems of five states-Bihar West Bengal, Orissa, Andhra Pradesh and erstwhile Bombay.

Mukherji, (1974) widely studied the transport network in his paper, “Road Transport Network Structure and Level of Urbanisation in Rajasthan” tried to seek correlation between road network and level of urbanisation. The district level data has been used for this purpose. The newly introduced concept of Aggregate Transport Scores (ATS) has been computed and shown to be an important determinant of the level of urbanisation. It has been observed that all the structure indices are highly positively correlated among themselves, with ATS and the level of urbanisation, thus supporting a major premise that transport may be treated as an independent variable in the study, which itself is an element in matrix of socio-economic development.

Dutta, (1975) conducted a study on “The Network Pattern of Indian National Highways from Major Urban Centres to the National Capital Region”. He made an attempt to study the road network of Indian National Highways of 1961 and 1971, by taking the shortest routes to Delhi, the national focus of India. Strahler’s combinational ordering system for drainage network has been taken for the study. The importance of roads in reference to Delhi has been analysed from the standpoint of the hierarchy of path ordering. After analyzing the path network of 1961 and 1971, he concluded that only some minor changes are taking place in the first and second order paths, no remarkable change has been observed in the network inspite of growth of cities.

Gowda, (1979) in his study, “Urban Sprawl in Bangalore” described that existence of goods transport linkages act as a cause as well as a catalyst in the development of sprawl in Bangalore. Bangalore is a focal point of roads, railways and airways, having well connected links with other metropolitan cities of the country.
Sita, (1981) in her study, “The Role of Transport and Industries in the Urban Process in South Konkan” analysed the relationship of transport network and industrial locations with the intra-regional variation in the urban process. The bus traffic was analyzed to identify model centres and their hinterlands and also the flow of passenger traffic. The connectivity indices of the urban centres are derived by the application of graph theory. An analysis of the coastal transport brings out the fact that a number of the coastal towns are losing their port function, probably an important factor responsible for the decline of this group of towns. The analysis of industries brings out the market concentration in the northern part of Konkan. These findings help in understanding the regional variations in the urban processes on South Konkan.

Dasgupta, (1982) presented a research paper entitled “Formation of Transport Network in the Brahmaputra Valley (1839-1914)”. He overviewed that the three modes—roads, river ways and railways, set up a complex system of transport-network in the Brahmaputra Valley since beginning of the 20th century. Roads connected the region with other provinces, and linked tea estates and the administrative centres to the steamer ghats and railway stations. This network was developed in such a manner that each of the three modes, in their functioning, were utilized optimally mainly in the interest of the tea plantations. The expansion of the transport network thus followed the development of an enterprise, which was export-oriented as well as import-based.

Bhagabati and Sahariah, (1984) presented their views on the topic, “Urban Centres and Spatial Pattern of Road Accessibility in Assam”. In this study an attempt has been made to analyse the pattern of road accessibility of some selected urban centres of Assam and the relationship between the degree of accessibility and the population size of the towns. Connectivity Matrix has been adopted to assess the degree of connectivity of urban centres with each other. After deep analysis it is concluded that the spatial shape and natural environmental framework of this state have greatly influenced the degree of accessibility of different centres. The peripheral location of Dhubri on the west is mainly responsible for low connectivity. The findings of study proved that accessibility is greatly influenced by the locational pattern of the towns. The significant positive correlation between the accessibility and town size also indicated strong relationship with urban growth.
Chytanyapanditaradhya, (1985) examined “The Role of Transport in Urban Development: A Case Study of Mysore City”. The study is restricted to identify the urban growth of Mysore city during various historical stages and the impact of the urban road network on the morphology of the urban area. The main focus of the study was on these objectives: the urban setting of Mysore city and its growth, the road network pattern and its growth, the correlation between the road network and urban function, the problems of urban transport in Mysore, the future transport demands and the projected urban growth. He concluded that during the last one and half decade city has recorded a very high rate of growth, both in physical and demographical area and in population. The present area of the city is around 70 Sq. Kms and the population has crossed 4,80,000 mark. This is a main hub of industries due to the facilities of intra urban and inter urban road network. Many of the industries are established along the road radiating from the city. The important roads along which the industries have come up are the Krishnarajapura road, Hunsur road, Bannur road, Bangalore road, Mysore south and Heggadadevanakote road.

Famisa and Ogunjumo, (1986) tried to explain the pattern of road network in Ondo State, Nigeria. The main objective of the study is to analyze the existing road network in all the local government areas of the State, in relation to several other socio-economic variables so as to determine their relative adequacy. Findings of the study clearly show that there are variation in rural road network and socio-economic characteristics of the rural dwellers. The adequacy of the road networks need to be assessed for a purposeful rehabilitation programme in the State.

- Hullur, (1987) worked on, “Urban Centres and Connectivity Analysis of Roads: A Case Study of Belgaum Division in Karnataka State”. This study, regarding the connectivity evaluation, yielded good results. The study area of Belgaum division is a suitable region with good network of roads and 72 urban centres. The circuitous pattern of roads provides an alternative route for the computation of two step and multi step moves. The road network map with location of all the urban centres is the basic requirement of this study. One step, two step and multi step values of all the 72 urban centres in Belgaum division indicate that irrespective of their population size, the location with respect to the road network, is very important for high connectivity
values. Such studies provide a yardstick to measure the connectivity values of urban centres, which are comparable.

**Kanchan and Shukla, (1987)** conducted a study, “Dynamics of Transport and Industrial Trends in Madhya Pradesh”. Firstly, the growth of roads was calculated for the year 1982 in reference to 1958. After analyzing the growth of roads, accessibility was calculated on per lakh population and per 100 Sq. Kms. Then, the level of road transport was calculated by taking five variables into consideration; \(X_1\) percent of kilometer of metalled road, \(X_2\) metalled road per 100 Sq. Kms, \(X_3\) total roads on per 100 Sq. Kms, \(X_4\) total roads on per lakh population, \(X_5\) percent of kilometer of total roads. Finally, transport connectivity was drawn for railways and roadways separately. They concluded that though Madhya Pradesh occupies, the central position in the country, it has insufficient roads in comparison to other states. By looking to the level of road transport it can be said that the development of road length, improvement of surfaces, widening of roads and construction of bridges are badly needed. By constructing new roads in the inaccessible and backward areas, the supply of resources from these areas can be properly ensured and also people can migrate from surplus region to prosperous region, thereby reducing the economic and social imbalances.

**Mishra, Tripathi and Sharma, (1992)** conducted a study, “Transport Networks in Amethi Taluka of Uttar Pradesh”. They analysed the transport network which indicates spatial disparities and imbalances in their distribution pattern and connectivity. The density of roads and connectivity are higher in the Amethi and Sangrampur block in comparison of Bhadar and Bhatua block. The link or feeder roads are inadequate in the rural areas. The connectivity of all the central places except Amethi, Bhadar, Navgiowa and Vishesharganj is low.

**Mishra and Tripathi, (1991)** in their study on, “The Level of Transport in Basti District in Uttar Pradesh”, attempted to measure the level of transport development and its impact on the socio-economic status. For the study, four indicators were selected viz. (1) length of roads per 1,000 Sq. Kms, (2) length of roads per lakh population, (3) percentage of villages on roads, (4) percentage of villages beyond three kilometers from the road. The foregoing discussion leads to the conclusion that the district is not uniformly developed in terms of transport facilities. But undoubtedly, the
impact of transport on the growth and expansion of socio-economic facilities is positive and appreciable.

Saxena, (1991) examined, “Pattern of Road Transport Connectivity and Economic Development in Rajasthan”. The main objective of the study was to compute the road transport connectivity and levels of economic development of each district of Rajasthan. In his study, connectivity has been calculated by three indices: (1) beta index, (2) cyclometric number, (3) connectivity index. The indicators selected for determining the levels of economic development are: (1) density of population, (2) percentage of total workers to the population, (3) percentage of electrified villages to total no. of villages, (4) per capita income of district. He concluded that seven out of twenty six district of Rajasthan record high connectivity and high level of development. In the same way, he found that four out of twenty six district have low level of development and low connectivity. The rank correlation co-efficient between level of development and degrees of connectivity is 0.26, which is statically insignificant. It means that the factors governing the development of road connectivity are not related to the factors governing the regional pattern of economic development in Rajasthan.

Rodrigue, (1994) in his study, “Transport and Territorial Development in the Singapore Extended Metropolitan Region”, concluded that the transport is a key factor in the emergence of extended metropolitan region. The main reason in Singapore is the investment in efficient intermode infrastructure for goods and information, thus offering a good transactional network. Container terminals are examples of Singapore’s efficiency for intermediate transport. Considering this, Singapore is likely to become the transport hub of south Asia, thus controlling most of the transactions and distribution of spatial accumulation.

Lancelet, (1997) tried to describe, “The Road Network Analysis of Tourist Centres in Tiruvanthapuram District in the State of Kerala in India”. A transport network map on 1: 2,50,000 scale connecting twenty two points (nodes) of all major tourist centres. Then a connectivity index, has been prepared and concluded that Palayam, Aruvikara, Kattakasa nodes are well connected on-route to all other places of tourist interest. Shortest path matrix indicates places like Varkala, Veli and Kovalam have less degree of direct accessibility from other centres. On the basis of the results it is assumed that with well developed road network and infrastructural facilities, there is
enough space for systematic development of organized and coordinated tourism promotional activities and also effectively utilizing the services and resources of all concerned governmental and non governmental agencies.

_Yeh and Li, (2001)_ used Shannon's entropy, which reflects the concentration of dispersion of spatial variable in a specified area, to measure and differentiate types of sprawl. This measure is based on the notion that landscape entropy or disorganization increases with sprawl. The urban land uses are viewed as interrupted and fragmented previously homogenous rural landscapes, thereby increasing landscape disorganization.

_Barman, (2003)_ in his study, “Transport and Agro marketing Services in Midnapur District of West Bengal”, defined the capital differences in the condition of transport and agro-marketing services that exists in the district of Midnapur of West Bengal and their influence on the agricultural activities. He had tried to bring out the importance of better marketing of agricultural products, which is only possible by improved transport network. He concluded that, the development of roads is also indicative of adoption of technology as diffusion of innovation necessarily makes possible for farmers to put their less accessible lands to more productive uses.

_Cheng, (2003)_ in his study, “Modelling Spatial and Temporal Urban Growth”, concluded that the developing world require a scientific understanding of complex urban growth patterns and processes. This knowledge is crucial for sustainable land management and urban development planning. Progress in modern remote sensing and GIS techniques has opened up great opportunities, and significant success has already been achieved in monitoring and managing fast urban growth. However, these techniques are still poor when it comes to support decision making on sustainable development, as reasonable theories and methods have not sufficiently and systematically developed to understand the complexity inherent to urban growth. Understanding the growth of urban system is a prerequisite for modeling and forecasting future trends of urban land use/cover change and its ecological impacts. As urban growth involves various factors with different patterns of behavior, scientific understanding must be based on elaborated complexity theory and a multidisciplinary framework. The theoretical analysis can provide a guideline for selecting modeling methods currently available in complexity modeling and in remote sensing and GIS environments.
Herold et al., (2005) in his study related to urban growth, "The Role of Spatial Metrics in the Analysis and Modeling of Urban Land Use Change", attempted simulation of future urban growth. There has been a lot of research carried out to understand, and represent the model of complex urban systems. Data availability, improved methods and theories in modeling urban dynamics are the few challenges to be addressed. This study is carried out to explore the combined application of remote sensing, spatial metrics and spatial modeling for the analysis and modeling of urban growth. The study reveals the importance of spatial metrics to quantify the temporal and spatial properties of urban development, and showed the impacts of growth constraints imposed on expansion by topography and by local planning efforts in the study area. It could be concluded that a combined and integrated application of remote sensing, spatial metrics, and urban growth models represent an innovative approach for the study of Spatio-temporal urban growth patterns. A combination of selected metrics was found to be an important tool for the analysis of remote sensing derived mapping products in an urban environment and effective in providing rich quantitative information about the structure and pattern of the dynamic urban landscape pattern. The results encourage the future exploration and integration of the metrics in model calibration processes.

Mondal, (2004) has made an attempt to find out the regional disparities in the level of nodal accessibility and spatial pattern of workers of urban centres in his study "Transport Accessibility and Non-Primary Activities – A Case Study of Mewat Region". The distribution pattern of workers engaged in various non-primary activities has been explained. Finally, the relationship between transport accessibility and non-primary activities has been highlighted. He found that there exists a positive relationship between transport and proportion of workers engaged in different non-primary activities in the selected urban centres of the region. There exist large regional disparities in the nodal accessibility which vary from 4.36 (max.) to 0.36 (min.). There also exists regional variation in the proportion of workers in the various non-primary occupations from one part of the region to the other part.

Fazal, (2004) explained the expansion and land transformation of the Aligarh city. The aim is to study the land use pattern of Aligarh city, its expansion and the pace of land transformation in various directions of the city. The remote sensing techniques
and satellite imageries have been used for generation of data. After this, he concluded that ribbon like urban development along main roads is a noticeable phenomenon in the city. The urban expansion is taking place in a peculiar way. In the first phase, agricultural land is converted into vacant land along the main roads. In the second phase, this land is used for constructing buildings. During the third phase, the intervening peripheral land between the roads is used for urban development. This process of urban development can be termed as frontal expansion, which is characterized by piecemeal accretion of built-up areas.

Seto and Fragkias, (2005) conducted a study on “Quantifying Spatio-Temporal Patterns of Urban Land-use Change in Four Cities of China with Time Series Landscape Metrics” concluded that a spatio-temporal landscape matrix analysis across buffer zones can lead to better understanding of the shapes and trajectories of urban expansion and then urban growth rates. The study was the first comparative analysis of a system of rapidly developing cities including inter and intra city analysis of spatial and temporal patterns of urban land use change with the help of landscape metrics. The choice of metrics was made in order to describe three aspects of the urban landscape which are: absolute size, relative size, and complexity of urban form. Six landscape metrics were calculated over the temporal period for three buffer zones drawn at 0-3 Kms, 3-10 Kms and 10-20 Kms from the city centres of four cities considered in the study. The reasons for considering three buffer zones with the specified widths were to capture the temporal variations in all the zones, closer to and distant from the center of the cities, effectively and also to extract information about the urban-rural fringe dynamics. The results concluded that the observed patterns were a function of social, economic and political processes.

Schneider et al., (2005) in their study “Urban growth in Chengdu, Western China: Application of Remote Sensing to Assess Planning and Policy Outcomes”, mapped changes in land cover using remotely sensed data and investigated the spatial distribution of development with the use of landscape metrics along seven urban-to-rural transects identified as key corridors of growth in the study area. To understand the fragmentation – infill process of the city, pattern metrics were combined with gradient analysis. Instead of applying metrics to the landscape as a whole, the city was partitioned into corridors extending outward from the city core. The basic assumption
of the gradient approach was that different levels of economic activity or demographic composition create different distributions of built-up land within each corridor. In this way, patterns of urban growth could be plotted across both space and time. Seven corridors were defined stretching outward from the study area’s CBD along major transport corridors, identified by the municipal planning bureau as key areas of growth. Spatial pattern metrics were calculated in a 4x4 Kms moving window along each corridor for the temporal period and could quantify patterns of urban growth successfully.

Yu and Ng, (2006) in their study, “Spatial and Temporal Dynamics of Urban Sprawl Along Two Urban–Rural Transects: A case study of Guangzhou, China,” employed a combination of remote sensing images, landscape metrics and gradient analysis to analyze and compare both the spatial and temporal dynamics of urban sprawl in the study area. This approach was helpful in understanding of landscape changes along the urban–rural gradient. The study provided a useful tool to compare the structural and functional differences of landscape patches at different orientations. The study also confirmed the hypothesis of the diffusion-coalescence urban dynamics model in the process of urbanisation. It demonstrated that in order to reveal the complexity of landscape pattern, temporal data is needed to capture the baseline as well as the spatio-temporal dynamics of landscape changes along the gradient. Combining temporal data with gradient analysis could characterize the complex spatial pattern of urbanisation.

It has been made clear by the above mentioned literature that so many works have been done on the road transport and growth of urban centres throughout the world. It is therefore evident that road transport structure and road network play a key role in the process of national development. There is a symbiotic relationship between the level of road transport development and the process of urbanisation. Rohtak division is main part of Haryana state. Its four districts out of five are located in National Capital Region. This region acts as transition zone between the New Delhi and Chandigarh. It shares approximate one quarter of total urban centres and 24.99 percent share to total urban population of Haryana state. This is very important zone where industrial hubs like Panipat, Sonipat, Karmal, Bahadurgarh and Rohtak are located which attract people from other states of country. So, there is a great need to study the development of roads,
growth of urban centres, their development and capacity to fulfill the demands of people.

1.2 OBJECTIVES

• To examine the evolution of road transport in historical perspective.
• To study the level of road transport and changes in, during the three decades (1971-2001).
• To analyze the interrelationship between road transport network and urban processes with a special focus on urban land use in a selected urban centre in the region.
• To examine the nodal accessibility and connectivity of urban centres in the study area.
• To study the level of development of urban centres and to analyze its interrelationship with road transport.

1.3 STUDY AREA

The study area is located in the central-eastern part of Haryana state. At present, this area consists of five districts namely Rohtak, Karnal, Panipat, Sonipat, and Jhajjar. The division extends between 28°15' to 30° North latitude and 76°10' to 77°15' east longitude. The total geographical area is 9,467 Sq. Kms and comprising 25 urban centres of various sizes. The total population of the division is 5,341,007, out of which 71.38 percent (3,812,534 persons) is rural and 28.62 percent (1,528,473 persons) is urban.

There are 11 sub Divisions, 17 Tahsils, 8 Sub Tahsils, 27 Blocks and 1394 settlements in the study area. According to Census of India 2001, twenty five settlements enjoy the status of towns and 1369 are villages. Rohtak division is surrounded by Delhi and Uttar Pradesh on its eastern side; Kaithal, Jind, Hisar and Bhiwani on its western side, Kurukshetra and Yamunanagar on its northern side, Gurgaon and Rewari on its southern side. The Rohtak division has good road transport facilities which play an important role in the growth of its economy. It stimulates the development and growth of trade, industries, cultures and civilization.

Rohtak division has always enjoyed a well defined political and social status in the history of erstwhile Punjab. The history of Rohtak division is also related with the
struggle of freedom of India. The division is famous due to substantial contribution in education, industrial, commercial, urbanisation and transport development of Haryana state. This area is also famous for making a large contribution of its ‘Jawans’ to the force of India who established the traditions of Valour and Bravery.

This area has been selected to find out the relationship between development of transport network structure and growth of urban centres. The selected area is unique due to its central geographical location in Haryana. So many important roads, highways radiate and pass from here, which link this area to National Capital of India, Delhi. Because of the geographical location of its four districts namely Rohtak, Panipat, Sonipat, and Jhajjar in National Capital Region, preferably, it can be proposed as region of state headquarters/capital.

1.4 DATA BASE

The present study is based on both primary and secondary data. The databases are meant to serve an efficient system of information gathering, compiling, classification, transformation, storage, retrieval, synthesis/analysis and presentation. Database comprises of spatial information, which is derived from available maps and remote sensing satellite data as well as non-spatial information collected from different sources. The development of Information Systems for transport has gained a lot of momentum in the country. In most of the states, the importance and utility of such spatial databases built in a GIS has been fully realized.

The power of an integrated database for day-to-day planning, development and maintenance activities involving all levels of hierarchy in an organization is of tremendous advantage, easy to use, with desired capabilities for querying, generating reports, updating, analysis and modeling. The availability of satellite data in different resolutions has now made it possible to generate reliable spatial data on desired scales. The utility of the database on various thematic layers in various application areas have been demonstrated. Remote sensing data available in the Department of Geography, M.D.U. Rohtak and on NRSA website (Landsat TM & ETM) have been extensively used for spatial and temporal studies. Temporal collateral data such as Survey of India toposheets: (53C/6, 53C/7, 53C/8, 53C/9, 53C/10, 53C/11, 53C/12, 53C/13, 53C/14, 53C/15, 53C/16, 53D/1, 53D/5, 53D/6, 53D/7, 53D/9, 53D/10, 53D/11, 53D/13,
53D/14, 53D/15, 53G/1, 53G/2, 53G/3, 53G/4, 53H/1) (Map – 1.1) for 1971 on 1:50,000 scale and sheet NH 43-11, NH 43-12, NH -15, NH-16 Series U502, Edition I-AMS on 1:250,000 scale for 1955 has been considered necessarily.

Various road maps from Public Works Department, Chandigarh and land use/land cover maps of the urban centres from Town and Country Planning Office, Chandigarh have been collected. Socio-economic data, Primary Census Abstract (1971 and 2001), and Village and Town directories, (1971 and 2001) have been availed from Office of the Registrar General, India (New Delhi).

1.5 RESEARCH METHODOLOGY

For the study of whole division, a systematic approach has been followed after selection of topic. The data relevant to the topic were collected from various sources. An integrated approach using Remote Sensing and GIS techniques have been followed for the study. Remote Sensing aids in the collection of temporal data and GIS helps in spatial analysis of these data. Twenty six Survey of India toposheets of 1:50,000 scale have been used for making of road maps of year 1955 and 1971. First of all toposheets have been scanned and then their geo-referencing have been done in Erdas Imagine 9.3. All the toposheets have been stitched together with each other in mosaicing exercises. This mosaic of toposheets is used for geo-registration of LISS Image 2001. An area of interest (AOI) layer has been prepared for the Rohtak division from mosaic of toposheets and an AOI subset has been prepared from image also. Both digital and visual techniques of Remote Sensing have been used interactively. Primary thematic maps for road network, urban area, land use, built-up area and different cartographical map for prevalent data are generated. After the preparation of thematic maps, various statistics techniques have been used for data interpretation.

To find out the general level of road transport network structure in the study area at tahsil level following four indicators have been used:-

\[ X_1 = \text{Metalled Road Length} / 100 \text{ Sq. Kms.} \]
\[ X_2 = \text{Others District Road Length} / 100 \text{ Sq. Kms.} \]
\[ X_3 = \text{Metalled Road Length} / \text{Lakh persons.} \]
\[ X_4 = \text{Road Development Index}. \]
ROHTAK DIVISION
SATELLITE IMAGERY
(2001)

KURUKSHETRA
KAITHAL
JIND
HISAR
BHIWANI
YAMUNANAGAR
DELHI
REWARI
GURGAON

SATELLITE: IRS- P6
SENSOR: LISS III
RESOLUTION :23.5 METER

Map - 1.2
These indicators have been transformed into ranks with the help of Kendall’s ranking method to find out the general level of road transport network structure in Rohtak division (1971 and 2001). This chapter also finds out changes in road transport during these three decades.

Growth of urban centres also have been described as area in Sq. Kms (1961-2001) and demographic as growth of population (1901-2001).

To explain the level of urbanisation in Rohtak division at tahsil level, six urban oriented variables have been selected as:

\[ X_1 = \% \text{ of Urban Population to Total Population of Tahsil} \]
\[ X_2 = \% \text{ of Urban Population to Total Urban Population of Division} \]
\[ X_3 = \text{Number of Towns} \]
\[ X_4 = \text{Urban Area in Sq. Kms} \]
\[ X_5 = \text{Urban Population Density} \]
\[ X_6 = \text{Built-up Area along the Highways} \]


To delineate the sprawl of built-up area along the highways, various GIS layers such as built-up area along the highways, road networks, village boundries, built-up and non built-up area of selected settlements have been prepared. Supervised classification has been used to generate these layers using collateral data such as the toposheet mosaic and image of the area. Further, this analysis has been complemented with the computation of Shannon’s entropy (used by Ye and Li, 2001; Hurd et al., 2001; Epstein et al., 2002; Sudhira et al., 2003).

This helped in identifying the prevalent sprawl zone, rate of growth and potential growth location. The computation of Shannon’s entropy has helped in delineating region with dispersed and compact growth.

Buffering analysis has been adapted with the help Arc Info 9.2 to find out the land transformation of Rohtak city in various land use category along the main roads within 500 metres buffer area. Different geometric analysis method such as
connectivity index, nodal accessibility, shortest path matrix, shimbel index and centrality index are incorporated with this study to find out the degree and level of road connectivity of urban centres with other selected centres in Rohtak division. At last development of urban centres attributed the following census data:

\[ X_1 = \text{Weighted Aggregate Educational Facilities} / 1,000 \text{ Persons} \]
\[ X_2 = \text{Weighted Aggregate Medical Facilities} / 1,000 \text{ Persons} \]
\[ X_3 = \text{Weighted Aggregate Recreational Facilities} / 1,000 \text{ Persons} \]
\[ X_4 = \text{Weighted Aggregate Banking Facilities} / 1,000 \text{ Persons} \]
\[ X_5 = \text{Aggregate Electrification} / 1,000 \text{ Persons} \]
\[ X_6 = \text{Percentage of Workers} \]
\[ X_7 = \text{Literacy Rate} \]

(Used by Saxena, 1991; Sinha, 1988)

The seven attributes have been used to find out the level of development of urban centres in Rohtak division and for the further analysis of identifying alternatives of development has been carried out using state-of-art geographic information system. Suitable standard cartographic techniques have been used.

Simple Carl Pearson Co-efficient method has been used to analyse the degree and direction between the associations of road transport development and growth of urban process.

1.6 ORGANISATION OF THE STUDY

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