CHAPTER –I
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INTRODUCTION

Transport is a function of various activities. It is considered as the major plank of infrastructure for growth and development. According to Srivastava (1971), “it is a defacto barometer of social, economic and commercial progress which has transformed the whole world into one organized unit”. Transportation, which undertakes nothing more than mere movement of persons and things from one place to another, has constituted one of the most important activities of man in every stage of advanced civilization. According to Ullman (1954), “the study of transportation provides a key for measuring the significance of likeness and differences among places on the earth surface. Transportation is a measure of the relations between areas and is therefore, an essential aspect of geography”.

Transport is regarded as a set of interconnected routes linking numerous destinations and providing pace for the movement of people and commodities. The system of transport is quite often compared to the nerve system of a human body and aptly so. Various means of transportation play a key role in world as the circulatory system of the body. According to Marthandan and Subhiah (2003), “transport network of a region plays a pivotal role in reducing the spatial disparities and brining about a balanced and integrated development. It helps in the proper utilization of available resources of a region and to move towards an economic equilibrium.

Transport is not merely an infrastructural facility but also a key factor in the regional development. It is difficult to imagine a situation where transport does not play a major role in regional development. In the modern times, transport has assumed much more importance and no country or region can think of its agricultural, industrial and socio-cultural development unless it has an efficient and quick transport system.

The regional development of a country and more so India is dependent on three important networks i.e. irrigation, power and transport, out of which transport plays an important role in the process of regional development. Transport network enables the integration among all economic activities. In the words of Munby (1968), “transport is ubiquitous and there is no escape from it”. It is an observed fact that, in any developing or
developed nation, transport network always boosts the process of regional development. **Vaidya (1998)** highlighted that growth with equality and distributive justice is possible only with a proper development of transportation network.

Transport is the focal point of all activities and fairly accessible transport nodes become sites for large cities and major service centers. In the words of **Jana (1998)**, “transportation system, in particular, has played a pivotal role as an artery for moving man and material between the regions and transport development helps in the better utilization of resources”. For the economy as a whole, transport ensures more efficient utilization of various resources as it is an important observer of scarce resources, enormous wrong directed or misplaced investments and has a major impact upon the economy. Poor transport is an obstacle in making effective use of regional resources. Most of the regional resources lie idle or are partially utilized due to lack of access as it is the function of transport to bridge the geographical gap between resources and consumers.

Easy accessibility to remote areas can open avenues for the extension of facilities relating to medical, health, education and new technologies etc. The existence of an effective transport system may be viewed as an indicator or initiator of development. Exchange cannot take place without an effective transport system and it is the exchange of commodities, people and ideas that allows an economy to grow. The greater the centralization and specialization of man’s activities, the higher is the need of efficient transport system. According to **Brake and O’ Hare (1984)**, “transport is a major agent which also brings a spatial change and its improvement may lead to new opportunities being created in new location, as they improve accessibility and change the relative location of places and phenomena”. Besides these, transport system also provides social advantages like high standard of living, attitudinal changes, dissemination of knowledge and new ideas, diffusion of innovations, development programs and social welfare etc.

Transport network plays a key role in the spatial diffusion too. An area which has witnessed a slow pace of transport development retards its progress and remains relatively isolated permitting stagnation for a longer time. So, transport intensification and development keeps relationship positively at global, national and regional level. Transport network is thus, a necessary element of spatial expansion. Transportation has been described as the lifeblood of civilization constituting an important item of infrastructure for
socio-economic and cultural development. In the present day, no economy can flourish in isolation. Transport network is a prime physical linkage creating a host of other linkages like social, economic, technological and administrative etc. Thus, the development of transport system is closely associated with the socio-economic development of the region. The transport system creates a tier with various points which have interest to interact with each other.

As postulated by Ullman (1956), three conditions affect the interaction, and thereby, the development of transport – Complementarity, Intervening opportunity and Transferability. The first condition for the establishment of the transport system is the existence of the demand for the things, ideas, and services etc. which are in surplus at other places. Those goods and services don’t avail intervening opportunities and at the same time, it should be feasible to transfer them from their places of surplus to the deficit and market areas.

Wagner (1960) has aptly pointed out the contribution which transport has been able to share in the integration of social phenomena and changes taking place everywhere in the world. He stated that the routes along which men, materials and messages move bind a society together. He defined the transport systems as the paths which form the links between each local group of human and their thoughts. In fact, transportation is a measure of relationship between areas and is therefore, an essential part of geography. It is also an explanatory factor in the spatial patterns assumed by the human activities, which are basic for geographical studies.

In the words of Hawkins (1962), “the pace of economic growth cannot be hastened in the absence of proper communication”. Transportation, by providing means to move people and goods to places where they can be proved more useful, permits the concentration of labor force and materials for carrying on manufacturing and trade and is therefore indispensable to the development of the cities (Mayer and Kohn, 1967). The improved facilities of transportation in a region considerably favour the growth of productive opportunities and potential markets and increase the possibility of economic expansion. Among the various infrastructural facilities, which are considered essential for the promotion of economic development, transport is considered to be the foremost. Thus, transport network leads to the economic development of a region.
Hoyle (1973) described that, “the relationship of transport and development is essentially a two-way interaction process and the results depend upon the level of development at which transport improvements are affected. In the less-developed countries, there is a widespread concern for transport to promote rapid regional development”. In the words of Hodder (1974) “the means of transport provide an effective system of vital arteries which can be considered as a functional organization. It spells the progress and growth of the economy”. Transport network serves both the short term purpose of satisfying the demand for movement between areas and the long term purpose of helping the development of places by inducing changes in inaccessible locations.

In this sense, ‘transport lines, networks and systems are brought into being only by the demand for transport generated by the economy and the society of the areas, they serve. But, in turn, the provision of transport net will alter the nature and distribution of the socio-economic system’ (White and Senior, 1983). One can witness the introduction of an element of dynamism in even the remotest regions if the modern means of transportation are introduced there. However, transportation system by itself may not lead to development. It is the utilization of transport facilities for various welfare purposes, which will determine the contribution of transport to the regional development of any area which has been connected by roads or other transport links. Thus development of both, transport system and regional development level are mutually interdependent.

Thus, transport development has great significance in the process of regional development of a country. Regional development inside an area occurs, most of the time, along a transport corridor. These corridors provide a higher accessibility level to its surrounding space and thus favour spatial accumulation. Current patterns of large scale developments in the world are therefore influenced by the alongside existing transport corridors. It is important to note that those developments are sustainable in nature.

It is to be noted that any investment in transportation has been found to be positive as well as negative in sectoral and spatial consequences. Thus it has to be meticulously investigated if it is advantageous to extend the net or whether limited capital resources available for investment might more efficiently or beneficially be used in other sectors of economy.

Suffice it to say; there is a symbiotic relationship between the level of transport
network development and the process of urbanization, socio-economic development, industrial growth, the continuous process of cultural change and interaction in a particular region or country. In real sense, transport network serves manifold purposes for regional development. Within this framework, transport has a multi-dimensional role to play. The more closely one examines the impact of transport improvement, the more closely one realizes how pervasive this impact is, in what a multiple of ways the transport system helps to determine the scope and direction of economic development and how important are transport improvements in creating new opportunities and incentives.

World perspective has tended to vary with intensification of relevant elements on the earth which has progressed through the events of inheritance, initiation, generation and regeneration. Elements, which compounded the sequence, have succeeded in a manner as: Nature to Man, Man to Society, Society to Settlement and Settlement to Transportation. Thus, transport represents the fifth element on the earth.

Transport network enables the homogeneity of people by breaking the barriers of language, customs and environment. In political and administrative field, transportation provides a dynamic support to the government and international bodies maintaining national and international unity and integration, defense, administration of justice, law and order. Thus, there is the traditional and generally accepted view that the provision of transport facilities is a pre-requisite for the regional development and results in a positive stimulus.

In general, there has been observed a reciprocal relationship between transportation and regional development. The former provides infrastructural base for the latter and the latter acts as stimulant to evolution and expansion of the former. It is pertinent to mention that the nature of relationship between transport and regional development is subject to change with reference to time and space.

Many factors contribute in the development of a transport system. The present day transport system of a country or a region cannot be explained by one factor alone. In fact, many interrelated factors are responsible for the development of a transport system as depicted in Fig. 1.1 which shows how a transport system is influenced by environmental characteristics and constraints (relief, climate, soils, hydrology and conservation); by historical inheritance (innovation, diffusion and colonialism); by economic (resources, land
use, production and employment sectors), political (planning, investment and regulation), demographic circumstances (Structure, density, distribution and mobility); technological changes (level, relevance and cost); and by trading conditions (Structure, flow and market control).

**FACTORS INFLUENCING THE DEVELOPMENT OF TRANSPORT SYSTEM**

![Diagram of factors influencing transport system]

**Fig. 1.1**  
*Source: Hoyle and Knowles (2000)*

All the above mentioned factors operate in positive, negative and neutral ways and affect transport systems in many ways, influencing each other as well as affecting transport systems directly and indirectly.

**TRANSPORT GEOGRAPHY AND ITS SIGNIFICANCE**

Transport geography is a sub-discipline of geography concerning to the movements of freight, people and information. It seeks to link spatial constraints and attributes with the origin, destination, extent, nature and purpose of movements. It is a field of appreciation borrowing concepts and methods from a wide variety of disciplines (*Rodrigue et. al.*, 2013).

Transport Geography, as a discipline, emerged from economic geography in the second half of the 20th century. Traditionally, transportation has been as important factor in
the economic representation of the geographical space, namely in terms of the location of economic activities and monetary cost of distance. Transportation stands as one of the four traditional components of economic geography: Primary production, manufacturing, marketing and transportation. Thus, it is a branch of economic geography dealing with patterns and modes of transportation, quantitative studies of the movement of goods and people, and the relationship between transport and other geographical factors.

Geographers have developed interest in the study of transport for two main reasons: (i) transport is a significant human activity with a strong spatial component, and (ii) it is an important factor influencing the spatial variation in many other social and economic activities. Transport geography is referred as ‘the Cinderella of Economic Geography’ and now has emerged as a subject in its own right. Transport is an indispensable feature of modern life and, because of its functions and importance; it has a profound impact upon human lives.

The growing mobility of passengers and freight justified the emergence of ‘Transport Geography’ as a specialized field of investigation. Ullman (1954) has rightly observed that geography is concerned with all spatial connections and interactions, including communications and transportation. The study of transportation or circulation thus touches all fields of human geography. In 1956, Ullman described that “transportation is closely related to the concept of geography as a whole and such studies contribute to the formation and evolution of geographical theories”. In 1960s, transport cost was recognized as a key factor in the locational theories. However, from 1970 onwards, globalization challenged the centrality of transportation in many geographical and regional development investigations. As a result, transportation became under-represented in economic geography in the 1970s and 1980s.

Since the 1990s, transport geography has received a renewed attention, especially because the issues of mobility, production and distribution are interrelated in a complex geological setting. It is now recognized that transportation is a system that considers the complete relationship between its core elements which are networks, nodes and demand. Transport geography is linked with numerous other elements too.

The development of transport geography has in many respects followed the path taken by geography in general terms of its contents, methods and the progress which has
been made to place current research within much broader societal perspectives. Transport is an indispensable feature of contemporary life, and because of its importance and the problems associated with it, there has been an ever-growing interest in the subject of transport geography.

White and Senior (1983) described that geographers are concerned with the study of transport for a main reason and that is; transport is a significant human activity with a strong spatial component and is therefore a legitimate object of study and an important factor influencing the spatial variation in many other social and economic activities. The approach of transportation geographer underlines the need for seeing areal differentiations on the earth not only as a geometric design of overlapping patterns but also as design of things in motion. So, transport geography is concerned with the explanation, from the spatial perspective, of the socio-economic, industrial and settlement framework within which transport develops and transport system operates.

Vaidya (1998) described the subject matter of transport geography in five major categories:

i. Geographical pattern of transport network

ii. Study of transport junctions and nodal points or terminals i.e. ports, airports etc.

iii. Study of commodity flow analysis

iv. Study of people movement at local, regional, national and international level

v. The entire system of hinterland and hierarchical relationship associated with transport

The linkages and flow between centers, their nature and size, function and accessibility are major consideration in structural aspects of transport geography.

Further, in 2000, Hoyle and Knowles described the importance of transport geography. Firstly, transportation network facilitates the infrastructure, occupies a substantial area of geographical space and also provides substantial numbers of widely spread jobs. Secondly, geography is concerned with interrelationship between phenomena in a spatial setting and with the explanation of spatial pattern; transport is frequently one of the most potent explanatory factors. Transport is a measure of the interactions between areas and enables the division of labor to occur in spatial differentiations.
Transportation fundamentally involves two aspects: (a) a vehicle or unit of conveyance, and (b) a medium upon which to move. Means of transportation are based on four elements: road, rail, water and air. The development of each type of transportation varies according to the stage of the development of the country concerned.

CHARACTERISTICS OF ROAD TRANSPORT

The first mean of surface transport is ‘road transport’. It was started as a mean of important lines of communication linking the old settlements with each other. ‘Roads may be defined as convenient way over which vehicles, cyclists, pedestrians etc. may lawfully pass for going from one place to another’. A road is a symbol of motion. Roads play a major role in the development of any region. It is considered as an integral part of the transport network of a nation. “Among the various means of transport, it has been well said that the roads are the main arteries for any nation and the traffic flows among them is the blood stream that gives it life” (Hawks, 1936).

Outside home, most of our activities, whether they are individual, regional or national, greatly depends upon cheap, smooth and quick means of road transport. The outstanding characteristic of road transport is its flexibility. 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 provides a feeder or connection to other modes of transport. Motor vehicles can supply services over public highways between any two points in a country, if necessary from door to door, on even or uneven terrain or on poor roads. On the basis of above discussion, the importance of the road transport can be traced in following points:

1. Roads play a very important role in the transportation of goods and passengers for short and medium distances. Goods can be loaded direct into road vehicle and transported straight to their place of destination.

2. It is comparatively easy and cheap to construct and maintain roads. Road transport requires much less capital investments in construction, operation and maintenance as compared to other modes of transport.

3. Roads are generally constructed by the government and local authorities and only small revenue is charged for the use of roads.
4. Road transport system establishes easy contact between farms, fields, factories and markets and provides door to door service.

5. Roads can negotiate high gradients and sharp turns as compared to other means of transport.

6. Roads act as great feeders to railways. Without good and sufficient roads, railways cannot collect sufficient produce to make their operation possible. The movement of goods and people begins and ultimately ends by making use of roads.

7. Road transport is more flexible than any other mean of transport. Means of road transport may be stopped anywhere and at anytime on the road for loading and unloading passengers and goods. This reduces cartage, loading and unloading expenses. Its routes and timings can be adjusted and changed as per individual requirements without much inconveniences.

8. Perishable commodities like vegetables, fruits and milk are transported more easily and quickly by roads.

9. Road transport is most suited for carrying goods and people to and from rural areas which are usually not served by rail, water or air transport. Exchange of goods, between large towns and small villages is made possible only through road transport.

10. Another advantage to road transport is that big businessmen can afford to have their own motor vehicles and initiate their own road services to market their products without causing any delay.

11. The weight of road transport sector within the economy is considerable, not only in quantitative terms but also in economic terms such as source of wealth, employment and in terms of support given to other economic activities.

12. Consequently, road network creates and stimulates positive synergy and enhances social cohesion and integration by giving citizens access to the same opportunities.

In the words of Hoyle (1973) “even in the most remote and least developed inhabited region, road transport in some form is a fundamental part of daily life”. In the several modes of communications, roads occupy an important place. The road systems, in fact, are economic arteries which form the lifeline of industry and commerce. Thus roads provide the economic infrastructure for the industrial and agricultural sectors.
The history of roads in India is as old as its civilization. Roads have been existing in India from the last 5000 years. India’s road transport network, which was considered suitable many years ago is still continuing in many areas by and large in the same form and with similar problems. The positive role of transportation in regional development has, however, been better acknowledged. In a more general and wider context, road transport contributes towards mitigating social, economic, cultural and political imbalances between urban and rural areas and among different regions. For integration among different weak and strong economic pockets, road transportation plays a vital role by linking up the various backward and developed economies. In real sense, it serves manifold functions in regional development.

PRESENT STUDY

In the present study, an attempt has been made to examine the road transport network structure and regional development in Haryana state. The study is spread over a time span of 40 years i.e. from 1971 to 2011. As road transport provides a strong stimulus to the development, it is realized that there is a need to evaluate and critically examine the road transport structure, physical accessibility of roads, rank surface analysis and road connectivity during 1971-2011. Finally, the relationship between levels of road transport development and regional development has been identified.

REVIEW OF LITERATURE

The study of road transport network and regional development is not a new field and different scholars have studied it in different ways. A large body of literature has been evaluated to study the different aspects like accessibility, connectivity and density of road transportation and its role in regional development in various areas of the world. The research work in this field has been done at regional, national and international levels from time to time.

In the present study, following major aspects of transportation have been reviewed from the existing literature on transport geography:
Accessibility of transport

One of the most important attributes in transport geography relates to accessibility, which is supposed to be a locational feature of the transport network in a region. It is a useful measure of socio-economic development of an area. Some major contributions in this direction are presented here.

Singh (1966) presented a thorough and well balanced analysis of transport geography of Uttar Pradesh. To measure the degree of physical accessibility, isodromes at 4, 8 and 16 kms distances were drawn along roads and each railway station. It was observed that the Ganga- Yamuna Doab experienced the highest accessibility by roads and railways and the Himalayan- West region was the highly inaccessible region of the state. He provided a measure of effectiveness of the existing transport networks, on the regional and inter-regional basis.

Hullar and Sinha (1971) studied the road accessibility in Mysore state. They modified the traditional analysis of accessibility by applying the formula proposed by ‘Nagpur Plan; i.e. distance of a village from metalled road should not exceed more than 6.4 kms in a developed agricultural region, 12.9 kms in semi developed and 19.3 kms in underdeveloped region. On this account, the developed, semi developed and underdeveloped regions were demarcated with the help of rank co-efficient method using six variables of economic development. It was also observed that inaccessibility was high in the developed region and low in the semi developed and under developed region of the state which indicated that road development was not in the accordance with economic development.

Wilbanks (1972) examined the association between accessibility to transport facilities and the rate of technological change in the northern India. For the analysis, a test of hypothesis was based on interviews and observations in three villages of Uttar Pradesh in 1967-68. For gathering the village level data, four districts were selected having maximum cultural differences and reasonably constant physical environment. By conducting sample survey, he concluded that the main impact of transport accessibility in these villages was on their responsiveness to the technological innovations.

Sharma et. al. (1991) examined the existing transportation system in the Amethi taluk; Uttar Pradesh. Physical accessibility, relative accessibility and nodal accessibility of
the district were calculated by drawing isodromes. It was observed that 88 per cent of the villages were within 2.5 km (high accessible) distance from the roads and remaining 12 percent from 2.5 to 5 kms (moderate accessible). There was no inaccessible (beyond 5 kms) village in the taluk.

**Gautam (1992)** computed the actual accessibility of roads and railways in Chambal division of Madhya Pradesh. For the computation of seasonal accessibility, roads unusable in rainy season were neglected. He used the isodromes of 5 and 10 kms as prescribed by Nagpur and Bombay plans and observed that actual road accessibility and seasonal accessibility (area lying within 5 km from a surface road) was 58.17 per cent and 40.19 percent respectively. It was also observed that districts prevalent rugged topography and forest area had low accessibility. Rail accessibility (area lying within 5 km from a railway station) was 11.44 per cent in the division.

**Karan vir and Asthana (1996)** studied the rank surface analysis of accessibility in Bhiwani district, Haryana. 1971 and 1981 census data were used for measuring the accessibility pattern in the district. The physical accessibility, accessibility matrices, rank surface analysis and block diagrams were used to bring out the salient features of accessibility in the district. They divided the district into several zones using comparative bars of different accessibility matrices. They concluded that the eastern sector of Bhiwani district was relatively more accessible than the western sector, which was perhaps due to physiographic differentiation and the administrative preferences.

**Durai et. al. (2000)** examined the planning system of rural roads in India. They constructed composite indices of rural road development to analyze inter-state disparities in 1993-94. The analysis highlighted the gap in the levels of road connectivity, accessibility and road development in 25 states. The data were collected for six variables related with rural road development. The principal component scores were calculated and were ranked into four levels as high, medium, low and very low. It was concluded that smaller states (in terms of total population and area) have achieved higher accessibility, whereas large states likes Bihar, Rajasthan, Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and West Bengal have comparatively very low level of accessibility.

**Chatterjee (2003)** studied the degree of road accessibility in Ganjam district of Orissa state. She used the distances of 1.5, 4, 6, 10 and beyond 10 kms to study the
physical accessibility. The composite micro regional decomposition index was prepared to understand the scenario of road transport at block level. It was observed that mostly in eastern and northeastern blocks, the decomposition index was less which means the effective distance from the district head quarters to those block head quarters was also less. It had provided inhabitants more or less short journey while the western and southern hilly tribal blocks were having great degree of decomposition in transport network.

Tiwari and Tripathi (2003) measured the road accessibility in terms of distances of 5, 10 and 15 kms from the roads in Gorakhpur district of Uttar Pradesh. They observed that 30 per cent villages of the district witnessed very high accessibility, 26 per cent high accessibility, and 18.89 per cent medium accessibility while the remaining 25.11 per cent villages were having poor accessibility in the district. It was also observed that accessibility was majorly affected by the physiographic conditions such as terrain, dense forest cover, fertility of soils and availability of water.

In the same year, Ramanaiah et. al. (2003) measured the degree of road accessibility in Anantpur district of Andhra Pradesh. Physical accessibility of road network was analyzed with the help of isodromes at 2, 5 and more than 5 kms distances from the edges. About 42 per cent of the total number of settlements in the district were located within 2 kms from the point of road facility, 24 per cent were located in between 2-5 kms whereas about 34 per cent of total settlements were located beyond 5 kms.

Tiwari and Yadav (2003) examined the accessibility of transport by roads and railways in Allahabad district of Uttar Pradesh. Areas of high, moderate and low accessibility were identified on the basis of the distances of 5, 10 and beyond 10 kms respectively from roads. It was recorded that central part of the district experienced high accessibility, northern part was having moderate accessibility whereas poorly accessible areas were scattered all over the region mostly along the periphery of the district.

Vinod et. al. (2003) examined the physical accessibility of roads in Kasaragod taluk of Kerala. They used the method of buffer zonation of 0.5, 1, 2 and 5 kms distance from roads and observed that the drainage in the taluk was the major controlling factor for the development of road network. Low accessibility was mainly due to the drainage pattern as the roads were running parallel to the drainage in east- west direction. The major problem
in the development of road network in north- south was the absence of bridges as people had to travel many kilometers in circuitous route to reach a place.

Mondal (2004) examined the levels of nodal accessibility and spatial pattern of non-primary activities in Mewat Region of Haryana in 1991. A composite index was prepared by combining the levels of nodal accessibility and weighted road capacity for the 21 large settlements of the region at tahsil level. By this exercise, Nuh tahsil witnessed the highest composite index. The distributional pattern of workers engaged in various non-primary activities and spatial pattern of non-primary activities (manufacturing, servicing, transportation, storage, trade and commerce etc.) was analyzed. The relationship between composite index of nodal accessibility and non-primary activities was calculated by using correlation co-efficient method and simple linear regression lines, which was strongly positive ($r^2= 0.89$) in nature.

Kumar (2005) studied the rank surface analysis of transport network in Haryana from 1991 to 2001. Keeping in view the average inter village distance of Haryana i.e. 2.74 kms, he used the isodromes of 3, 6 and more than 6 kms from national highways and state highways and termed the uniform bands as fairly accessible (45.5 per cent), moderately accessible (39.5 per cent) and inaccessible (15 per cent) respectively. Maximum fairly accessible and moderately accessible area was found in the central parts while inaccessible area was found in the form of patches in western and northern parts of the state.

Farrington (2007) has recently focused on the importance of linking a key concern i.e. accessibility to the transport geography with dominant narratives such as sustainability, globalization and mobility.

Accessibility of transport does not describe the spatial features of transport network and unsuitable for comparing the different transport networks. So, in order to explain the basic structural properties of networks, some prominent researches have been done taking the connectivity of the transport networks into consideration.

Connectivity of Networks

The degree of connectivity of a transport network is an indicative of the complexity of the spatial structure of the region it serves. The transport network is a very real feature of geography of an area and is an important indicator of the level of its development. So,
useful analysis in both developed and developing regions can be conducted with this technique.

Garrison, who is known for revitalizing the field of transport geography, formulated many techniques of graph theory to analyze the connectivity levels in different areas of the world. In 1960, he examined the structure of the inter-state highway systems of 45 places of the south eastern part of United States and discussed the descriptive use of graph theory techniques in the analysis of the transportation networks of regional and national economies. He also highlighted the importance of nodes and links on location and development of economic activities in an area. Garrison and Marble (1961) designed a set of measures based on concepts of graph theory techniques. These measures dealt with theoretical and empirical investigations of the structure of transport networks.

In the same way, Kansky (1963) undertook an extensive empirical analysis of transport network structures and developed several descriptive indices i.e. cyclomatic number, alpha, beta and gamma for measuring the connectivity of transport network. Further, Haggett and Chorley (1969) emphasized the role of linear features with their basic geometry in a region by highlighting the different road network patterns in England and Wales.

Mukerji (1974) studied the correlation between road transport network and levels of urbanization in Rajasthan. By using the structural indices like cyclomatic number, alpha, beta and gamma at district level in 1971, the values of ATS (Aggregate Transportation Scores) were calculated. Extreme northern, eastern and western parts of the state recorded high ATS Scores and districts flanking the Aravalli range scored low and moderate ATS scores. It was observed that all the structure indices i.e. alpha (0.67), cyclomatic number (0.664), beta (0.553) and gamma (0.548) had a positive correlation with the levels of urbanization in Rajasthan. He also highlighted that the factors like terrain variations and administration preferences in princely rule areas had affected the levels of connectivity and urbanization in the state.

Ramachandran (1975) critically explained a series of graph theory techniques like alpha, beta, gamma, cyclomatic number, diameter, theta, eta, pi and iota etc. which were used in the earlier transport studies, for measuring the relative cohesiveness of a network
or the relative position of places on the network. He described these techniques as the ‘determinants’ for comparative analysis of the efficiency of different transport networks.

**Saxena (1980)** examined the pattern of road transport connectivity and economic development in Rajasthan. He calculated the road connectivity by using three indices i.e. beta index, cyclomatic number and connectivity index at district level. The composite connectivity scores (CCS) were computed by adding the respective ranks of above three indices and the whole state was divided into three categories of high, medium and low connectivity. He observed that high road connectivity was in the central part of the region stretching from west to east whereas medium and low connectivity were observed in northern and southern parts respectively. Further, by comparing the road connectivity levels with the levels of economic development, it was recorded that seven districts (27 per cent) out of total twenty six districts of Rajasthan attained high road connectivity as well as high level of economic development, whereas four districts (15 per cent) had medium level of economic development profile and low road connectivity. There were four districts (15 per cent) where the levels of development as well as level of road connectivity were both low.

**Bhaduri (1992)** analyzed the road transportation efficiency in West Bengal. She measured the degree of road connectivity by using structural indices like alpha, beta and gamma and observed that high ways in the state had been designed in such a manner that they were not able to provide a number of alternate connections to the different cities. She also identified that the road network pattern was in a transitional position of network growth between Spinal pattern and Delta pattern. Spinal pattern shows minimal connectivity while Delta pattern shows maximal. Thus, there was a nearly maximal connected road network in West Bengal. Later in 2007, she worked on the road safety in India and observed that the high volumes, different speed of various motors and the pathetic conditions of roads have aggravated the problem of road safety in the country. In 2008, she examined the growth of vehicular population in six mega cities of India–Mumbai, Kolkata, Delhi, Chennai, Hyderabad and Bangalore and found that personalized vehicles were dominating the urban transport system in India.

**Badigar and Badigar (2003)** examined the historical development of road transportation system and its impact on the changing industrial structure in Goa state
especially after liberation (1961). The structural characteristics of transport network were studied by applying alpha, beta, gamma and cyclomatic number as well as nodal accessibility by shimbel index was calculated in urban towns of the study area. He observed a spatial imbalance in the transport development as the highly accessible areas were confined to the central parts of the state. It was concluded that road connectivity had been declined in that period from 1981-1991 due to disproportionate growth of towns (vertices) as compared to the development of roads (edges). However, the transport network still maintained complexity and offered a better connectivity in the state. A positive correlation was observed between road connectivity and industrial development.

Ramanaiah et. al. (2003) computed the degree of road connectivity in the drought prone area in Anantpur district of Andhra Pradesh. The analysis was done for the different points of time, i.e. 1961, 1971, 1981 and 1988. All urban settlements, administrative centers and settlements having more than 5000 population were taken as vertices. All national highways, state highways, major district roads and other district roads were considered as edges. The spatial structure of road network was analyzed in the terms of topological and geometric components (graph theory measures) by applying alpha, beta, gamma, pi, eta, theta indices as well as detour index, knoing number and shimbel index in the study area. The study revealed that settlements located in the central parts witnessed greater connectivity than the settlements located at peripheral areas. An increasing degree of road connectivity from poor to complex pattern was observed in the area.

Singh (2003) studied the spatial variations in the levels of road connectivity in Orissa state. He highlighted the analytical framework of road network in state by applying alpha, beta, Gama, pi and detour indices by identifying 328 centers at district level. A composite index was derived by applying the technique of principle component analysis. From the analysis, it was observed that the spatial variation in transportation development in the state was due to topography and obstacles created by rivers with large tributaries and distributaries.

Tiwari and Yadav (2003) examined the multi-functional role of transport in rural areas of Allahabad district. Rail and road connectivity was computed by applying beta index for the three physiographic regions of the district i.e. the Doab, the Ganga-par and the Yamuna-par. By this analysis, Yamuna-par region recorded the highest beta value
(1.40) followed by Doab (1.30), whereas lowest value of beta index was attained by Ganga-par region of the state as transport routes had very less branching in this area. The northern part of the study area (including Ganga-par) was comparatively less connected rather than the other two regions.

Recently, **Sarkar (2013)** conducted a research on transport connectivity in Cooch Behar district of West Bengal. He explored the existing pattern and spatial variations of road networks in the blocks of Cooch Behar district by applying structural indices i.e. cyclomatic number, alpha, beta and gamma. He also calculated the Aggregate Transport Scores (ATS) by simply adding the values of cyclomatic number, alpha, beta and gamma. The study revealed that most of the blocks of Cooch Behar district had experienced very low road connectivity due to lack of roads. He concluded that the shortage of roads (edges) in the region was due to physical constraints like flood and monsoonal rainfall which hindered the process of transport development.

In the same year, **Kaushik and Kumar (2013)** analyzed the road transport connectivity pattern in Haryana in 2009. They calculated the values of structural indices namely cyclomatic number, alpha, beta and gamma at district level and aggregate transport scores (ATS) were also derived. It was observed that the level of road connectivity was better in eastern part of the state as compared to western part and districts flanking in the Aravalli and Shivalik hills had the lowest values of ATS. Finally, the values of ATS were correlated with the levels of urbanization (0.221), agricultural output (0.154) and economic development (0.31) in the state and weak positive correlations were recorded among them.

Accessibility and connectivity of transport networks are important characteristics of a transport system. Transport is the underlying force in the development of an area and has a great impact on the regional development. Many geographers have confined their studies to the spatial implications of transport development and their impact upon the regional development in a particular region.

**Transport Network and Regional Development**

The geographical study of transportation and its relationship with regional development is an important and developing field of research. Hence, the relationship between transportation and different aspects of development has been traced out.
Taffe, Morrill and Gould (1963) produced an important research by developing a six stage model for the development of a transport network in developing countries. They applied this ‘ideal typical sequence model of transportation development’ on the modern transportation systems of Middle Eastern countries namely Ghana and Nigeria. This model was based on the conclusion that expansion of a transport network, from its beginning, is a continuous process of spatial diffusion influenced by many specific social, economic and political forces.

In the field of regional transport geography, which comprises both the morphological and functional aspects with a systematic integrated study of the transport, major contributions have been made by the department of Geography of Banaras Hindu University.

Singh (1965) presented a detailed account of the evolution of transport network in North Bihar, by corroborating the transport development during different periods with prevailing political and socio-economic circumstances.

Mehta (1984) assessed the impact of road transportation on the socio-economic conditions in rural areas of Almora district. He observed the frequency of road usage by households and found that road transport development has provided many opportunities to start new and non-agricultural activities and expanded the already existing activities in that area. It was also observed that the yield rate of major food grains and pulses had been increased and cultivators were shifting towards the production of commercial crops after the construction of new roads.

Famisa and Ogunjumo (1986) explained the pattern of road networks in Ondo state of Nigeria. They analyzed the existence of road networks in all the local government areas of Ondo state, in relation to several other socio-economic variables like population, rural farming household, schools, employees in manufacturing, cost of water supply etc. Findings of this study clearly showed that there were variations in the rural road networks and socio-economic characteristics of the rural dwellers in Ondo state.

Kanchan and Shukla (1987) studied the dynamics of transport and industrial trends at district level in Madhya Pradesh. The growth of roads was calculated for 1982 in reference to 1958. Accessibility was calculated on per lakh population and per 100 km² and then the levels of road transport development were computed by taking five variables into
consideration. Transport connectivity was also calculated for roads by gamma index and
advanced interconnected, simply connected and partially connected areas were
demarcated. It was concluded that insufficient roads were the cause of slow pace of
economic expansion, unexploitation of resources and wide gap between industrialized and
resource districts.

Dadibhavi (1990) assessed the development of roads in Karnataka state on the basis
of cross sectional data for the periods of 1961, 1971 and 1985. He also studied the
influence of economic factors on road building programme in the state. The measurement
of roads development was based upon the indicators: surfaced road length per 100 km²
area, unsurfaced road length per 100 km² area, surfaced road length per lakh population
and unsurfaced road length per lakh population. He identified ten districts in state having
deficit of roads by preparing a composite index. With the help of multiple regression
analysis, it was concluded that economically developed districts were endowed with high
level of road development in 1985. He emphasized on the quality of roads rather than the
road length as most of the unsurfaced roads remained unusable during rainy seasons.

Mishra and Tripathi (1991) measured the levels of road transport development and
its impact on the socio-economic transformation in Basti district of Uttar Pradesh. Four
indicators were selected to measure the road development: - length of roads/ 100 km²,
length of road / lakh population, percentage of the villages on road and percentage of the
villages from beyond 3 kms of the roads at block level. By calculating z-scores, it was
concluded that the impact of road transport on the growth and expansion of socio-
economic facilities was positive and appreciable, yet this impact was localized only in few
blocks, depriving the majority of the blocks for the same.

Dayanand (1998) worked on road transport and regional development in Mandya
district of Karnataka. He selected 19 variables of regional development and cross related
them to identify the relationship as well as impact of road transport on the behavior of
these variables from 1971 to 1991. He concluded that the road transport pattern had
brought far reaching changes in the infrastructural development and economic diversities
of the area. Accessibility and rural- urban linkages had also been improved.

Mahajan (1998) explained the key role of road transport in the process of economic
development in Himachal Pradesh. He confined his study to evaluate the growth of roads,
motor vehicles registered during the period from 1985 to 1995 and growth of nationalized road transport. He analyzed that the double lane road length had registered a growth rate of 0.54 per cent per year, whereas single lane road length registered a growth rate of 2.91 per cent per year. The increasing economic activities of the region and the fewer means of any mechanized mode of transport led to the growth of road transport. He concluded that road transport was playing a key role in integrating the rural economy with urban growth centers in Himachal Pradesh.

**Nayak and Singh (1998)** evaluated the role of road intensity in the process of regional development (demographic, social, economic and ecological) in North-east India. Road intensity was very high in the Brahmaputra valley due to its significant accessibility and low in Arunachal Pradesh and Mizoram. They observed that there was a parallelism in the distribution of development indexes with road intensity and it was low due to physical hindrances of mountain terrain. It was recorded that road transport didn’t have any major impact on the distributional patterns of the development in North-east as transport network was just conceived as a tool of immigration of people and leakages of resources of the area rather than a positive and main element of infrastructure for mobilizing the economy of the region.

In the same year, **Sharma (1998)** studied the development of transport network in Madhya Pradesh. He computed the road density for all 495 development blocks and mapped out six zones of various levels of transport development. The Chhattisgarh region had recorded high road density due to rich in forest and mineral resources. It was observed that many industrial centres like Bhopal, Bilai and Durg etc. were developed due to the well connected road network.

**Laxmi and Krishnan (2003)** studied the levels of road transport and resource utilization in Madurai Metropolitan city. They selected 14 variables of resource development and 18 variables of road transport development. They evaluated the functional inter-dependence and complementary character of resources and transport by applying multiple correlation and regression analysis. A close relationship was observed between the development of resources and the road transport efficiency. The study also indentified the potential determinant factors of resources, which influence the road transport for better regional development.
Saikia (2003) evaluated the historical development of road transport in the North-eastern region of India. He computed the density of roads in relation to population from 1979 to 1999 in all seven states of North-east and observed that Tripura and Assam states had the highest road density per 100 km² area i.e. 74.63 kms and 72.19 kms respectively. It was suggested that more roads should be constructed in that region to exploit more resources like jute, tea and petroleum.

Vaidya (2003) examined the trends of road development in Maharashtra state. The distribution of roads was observed at the division level. It was recorded that Pune division had the highest share in road length (30 per cent) followed by Mumbai division (27 per cent) and Nagpur division (26 per cent) while Aurangabad division had the lowest share i.e. 17 per cent in the total road length of the state in 1991. The road density was computed for per 100 km² and per lakh population in the 29 districts of the state from 1961 to 1991. It was also observed that road transport (especially national highways and state highways) had provided a basic internal circulation for the raw material, capital and manufactured goods in the state.

Bhattacharya and Bhattacharya (2006) in their study of Barddhaman municipality revealed that transportation arteries in any region exercise tremendous influence over structure of economy by virtue of providing major guideline for location and market orientation. They suggested that the areas having high potential of resources like Barddhaman can be utilized fully with the help of well developed transportation system. Taking into account industrialization and rapid urbanization process in Barddhaman, a higher growth rate had been adopted for the preparation of future traffic plan for road network.

Shobha and Sathish (2008) studied the impact of economy on the traffic and transportation in Bangalore city. They observed that Bangalore being Silicon Valley of India was preferred by most of the people from all over India, which led to high range of demand to the vital transportation sector. All this boosted the growth of vehicular population. This boost in investment was also reflected in increase in NDP.

Mangat and Gill (2015) highlighted the spatial patterns of the levels of road transport development in Haryana and also analyzed the position of Haryana with respect to India in development of road transportation. They used the indicators like road length/ 100 km²
area, road length/ lakh population and number of motor vehicles to prepare a composite index of road transport development in the state. Districts namely Faridabad, Gurgaon, Ambala and Panchkula recorded very high and high level of road transport development while low and very low levels were witnessed by Fatehabad, Jind, Mewat and Palwal districts. The composite index of road transport development was correlated with the levels of urbanization, health, educational and agricultural facilities, work force etc. A very high positive correlation was observed with urbanization (0.88) which indicated that high degree of road connectivity had encouraged rural- urban migration in the state.

By reviewing the above literature, it can be stated that road transport network and regional development are closely related. Any improvement in the transport system contributes to the nation’s progress. The accessibility and connectivity of transport modes over the years has remained polarized in the economically developed areas. It is important to decentralize the activities of transport sector, especially the road sector to make it beneficial for the whole country.

In the present study, an attempt has been made to include all the important aspects related to road transportation like accessibility, connectivity, density and correlate them with the levels of regional development in Haryana. The analysis is done for the period from 1971 to 2011.

**OBJECTIVES OF THE STUDY**

Following objectives are underlined in the present study:

1. To examine the road transport structure and pattern.
2. To study the physical accessibility by roads and rank surface analysis of accessibility.
3. To identify the levels of road transport connectivity.
4. To analyze the levels of road transport development and regional development.
5. To examine the relationship between road transport development and regional development in study area.
STUDY AREA: HARYANA

Haryana is an important state of north-western India. It came into existence on
November 1, 1966 after the bifurcation of the composite Punjab State under the Punjab Re-
Organization Act, 1966. It stretches from 27° 39' 0" north to 30° 55' 5" north latitudes and
from 74° 27' 8" east to 77° 36' 5" east longitudes. The location of Haryana state in India
with 21 districts is shown in the map [Fig. 1.2]. The study area consists of four divisions,
74 tahsils, 154 towns and 6955 villages as per census 2011. The total area of the state is
44212 km². It constitutes 1.4 per cent of the total geographical area of the country. As per
census 2011, total population of Haryana state is 2.54 crore in which total male population
is 1.35 crore (53.26 per cent) and female population is 1.19 crore (46.74 per cent).

Physiographically, the central part of Haryana is largely plain and featureless whereas
the western part is traversed by numerous sand dunes. There are also some hills of Shivalik
system in the north and Aravallis in the south. The plain area of Haryana is a fragment of
the Indo-Gangetic plain, which was molded by displacement of the alluvial sediments,
brought by the Himalayan Rivers. Thus the soils of the state are alluvial in character.

The economy of the state is pre-dominantly agriculture based. Haryana is having a
well knit system of roadways. The total road length in the state was 11516 kms in 1971
which has increased to 27258 kms in 2011. The state has 14 national highways, 31 state
highways and 37 major district roads in 2011.

SOURCE OF DATA AND RESEARCH METHODOLOGY

The present study is based on secondary data. The census data of 1971 and 2011 has
been used for the study. Besides this, Ministry of Road Transport and Highways
(MORTH), National Highway Authority of India (NHAI), District Statistical Abstracts,
Dept. of P.W.D. & BR and various other government offices are consulted for the required
data. The systematic approach has been followed.

The suitable standard techniques, methods, ratio measures, comparative bar
diagrams, line graphs and pie diagrams etc. have been used to present the trends of road
length and distribution of roads in Haryana.
Fig. 1.2
The bands of uniform width on the both sides of the roads are employed as the conventional method of analyzing the physical accessibility patterns. Accordingly, areas lying within bands of a uniform width of 3.0 kms on either side of a national highway and state highway have been treated as fairly accessible and that within 3.0 -6.0 kms from a road as moderate accessible while areas beyond 6.0 kms from a transport artery have been defined as inaccessible. Accessibility is also measured by individual nodes by preparing the topological diagrams of road networks. The node selection is based on the development of road network in Haryana from 1971 to 2011. All urban nodes which are situated either on national highways or state highways and also have a minimum population of 20000 persons have been selected for the analysis.

The analysis of accessibility is done with respect to minimum mileage matrix, nodality matrix (transshipment or break of bulk), weighted mileage matrix, weighted nodality matrix, gross accessibility matrix and composite accessibility matrix. The rank surface analysis is done by using the technique of isochrones demarcation to bring out salient features of road accessibility in Haryana. Rank lines are drawn for the value of last limit of each class that is 5, 10, 15…. for the year of 1971 and 15, 30, 45… for the year of 2011 which have shown the gradient of changing accessibility.

To examine the levels of road connectivity in Haryana, the nodes have been identified on the basis of following criteria: (i) settlements having minimum population of 10000 persons (ii) all district headquarters and tahsil headquarters, and (iii) settlements having three or more crossings on national highways, state highways and major district roads. The connectivity of the network is measured by four empirical and measurable structure indices: cyclomatic number, alpha, beta and gamma. Aggregate Transport Scores (ATS) have also been computed by adding the values of three indices i.e. alpha, beta and gamma. On the basis of socio- economic characteristics, the study area has been divided into two sub- zones i. e. (1) Eastern Sector (2) Western Sector. Further, these two sub zones have been divided into six micro zones [North- Eastern Zone (1Ai), East- Central zone (1Aii), South- Eastern Zone (1Aiii), in the eastern sector and West- Central zone (2Bi), Western Zone (2Bii) and South-Western Zone (2Biii) in the western sector] with the help of super-imposition of the generalized regions of socio- economic characteristics.
i.e. percentage of urban population, density of population, literacy rate, sex ratio, work force, road density/100 km² and road density/lakh population. A vigorous exercise has been performed to analyze the regional picture of road connectivity in selected six micro zones.

The levels of road transport development are identified by four indicators: index of road network, total road length per 100 km² area, total road length per lakh population and number of motor vehicles per Km of total road length at district level. A composite index of road transport development has been prepared by adding the z-score values of above four indicators.

Eight indicators of regional development are considered in the present study and further grouped into three broad categories to depict the levels of regional development in the area: i) Demographic indicators (share of urban population and literacy rate) ii) Social indicators (number of recognized high/Sr. sec. schools per 100 km² area, number of medical institutions per 100 km² area, number of medical institutions per lakh population and number of rural development co-operative societies per lakh population) and iii) Economic indicators (number of registered working factories per 100 km² area and workers employed in registered working factories per lakh population).

Further, z scores of all the above eight indicators have been combined to find out the composite index of regional development in Haryana. To identify the relationship between road transport development and regional development, correlation and regression analysis have been applied. Maps are prepared with the help of Arc- GIS software (version 9.3).

ORGANIZATIONAL STRUCTURE OF THE STUDY

The present study comprises the seven chapters including summary and conclusion.

I. Introduction

This chapter includes introduction, transport geography and its significance, characteristics of road transport, review of literature, objectives of the study, study area, source of data and research methodology and organizational structure of the study.

II. Geographical Background: Haryana

This chapter deals with geographical background of the study area, which includes the information about nomenclature, location and extension, physical aspects, demographic
characteristics, agriculture, economy, industries and road transport structure of the study area.

III. Road Accessibility

This chapter describes the physical accessibility, topological networks and patterns of road accessibility by individual node in Haryana.

IV. Rank Surface Analysis of Road Accessibility

This chapter is a detailed study of the rank surface analysis of road accessibility by minimum mileage, nodality (break of bulk), weighted mileage, weighted nodality, gross accessibility, composite accessibility and comparative bars.

V. Levels of Road Connectivity

This chapter deals with levels of road connectivity by using structural indices like cyclomatic number, alpha, beta, gamma and aggregate transport scores.

VI. Levels of Road Transport and Regional Development

This chapter highlights the relationship between levels of road transport and regional development in Haryana.

VII. Summary and Conclusion

In seventh chapter, the research work has been summarized and some suggestions have been given for future prospects.
REFERENCES


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