CHAPTER 1

TRANSPORTATION AND ROAD DEVELOPMENT IN RURAL AREAS
1.1 INTRODUCTION

Transportation is a crucial factor in the development process, as the efficiency and effectiveness of its transportation network largely determine the endowment or prosperity of a region/country. There is an overwhelming need for an efficient transport network especially in a developing economy. The researchers of transportation and development state that the level of transport development and economic progress in a region are linked positively. In fact, transport structure has been termed as de facto barometer of a region's socio-economic progress. The growth and development of all major sectors of the economy including health, education, industry and agriculture largely depend on the availability of transport facilities. In the sphere of integrated rural development, transportation occupies a very important place. Rural transport facilitates production and distribution of agricultural products and promotes agribusiness. Industrialisation of rural areas is greatly dependent on the prevailing transport facilities. Thus it becomes essential to take an overall view of all the sectors of the economy. Scwatt (1987) has stated that rural transportation network will give shape to the living environment of villagers, rather roads of rural transportation are the connecting elements in our society. Since the beginning of human history, road network has been significant. Even in the present age of the most modern systems of communication, people will not renounce roads and lanes because of their community feeling. In fact, roads and lanes strengthen a sense of human fellowship and solidarity. Appropriate combination of various links both technically and economically can generate rural traffic infrastructure which should be prepared for the measure of land development (Boss, 1987). The primary objective of rural roads is to open up parcels of land, to collect the individual transport requirements and to connect them to the focal points. Gambard (1987) stated that rural roads are secondary network and play a
major role in the economic and social development of the country. Transportation linkage should be the response to the ever-growing contacts between individuals and societies and for the movement of commodities as part of national and global economies (Trolley et al, 1995). Ulman's (1957) view is that “Transportation” is a measure of relations between areas and is therefore an essential part of landuse expansion. Whites (1977) has stated a valid statement by referring to Ulman’s statement that the importance of transport lies in its being one of the principal factors affecting the distribution of social and economic activity. Owing to this there is a wide interest among planners either in transport per se as a significant human activity or in its influence upon the spatial distribution of other activities.

1.2 PROBLEMS IN RURAL DEVELOPMENT AND IMPORTANCE OF RURAL TRANSPORTATION:

Transportation planning in rural areas is highly complex on account of the multiple activities having non-specific interaction between any two places. The user travel often makes it difficult to assess the demand and to relate the connectivity pattern from the supply of a system. The inconsistent demand and supply interaction, suppression of latent demand by deficient supply are generating a wide gap in the development of interactive capabilities among potential demand-based villages. The interdependency in change of land use and transportation is not promoted in rural areas and this keeps the economic system inactive in these areas.

Konstantinous et al (1987) have stated that a very important factor that affects the integrated development of rural areas is the underlying transportation network. The traffic densities in many parts of rural Africa and Asia are often low to justify the extension of all
weather road networks. But the ultimate goal of securing a very prosperous rural society is possible by higher levels of accessibility.

In developing countries where agricultural output from rural areas is still a very significant component of the national economy, the small-scale transport systems are in turn an essential part of the national system of communications requiring much attention from transport planners. In Bavaria, 27,000 of 4000 settlement units, which are small villages and isolated farms, are still waiting for improved road accessibility. More than 80% of the Bavarian territory, about 60000 sq. kms are being cultivated and conserved by more than 200,000 farmers. There is considerable demand for rural roads that ensures the cultivation of farmlands (Schatt, 1987). The steady migration of farm labour, the continued development of farming techniques and the intensification of land use have led to a considerable mechanisation of agriculture which demands for surface roads. An improved accessibility of all quarters of a village is an indispensable prerequisite for the provision of adequate living conditions in rural areas. Places of residence, places of work and production must be accessible by vehicles at any time for economic, social and cultural reasons (Schatt, 1987). The role of rural roads is significant since well connected rural roads integrate different social, cultural and ethnic groups besides providing accessibility between villages, market places, processing centres, health care units and so on. These roads ensure better farm gate prices for the agricultural produce, help access to agricultural extension services and modern technology leading to adoption of scientific agricultural practices with timely availability of modern agricultural inputs. These roads facilitate all-round development of rural areas and reduce their migration to urban areas for jobs (Ramesh C.R. 1998).
The current level of road development in rural areas of India is very low. Only about 44 percent of the 6.00,000 villages are connected with all weather roads. The remaining villages require about 1.3 million Kilometres of new roads involving an expenditure of about RS 400 billion. The current availability of funds is only about 10 billion rupees per annum [Ashok Kumar, 1997]. There are serious constraints of funds for rural road development, which calls for an optimal utilisation of the funds. This scenario warrants a serious thought on planning rural road network in a scientific way. A World Bank financed survey on the impacts of rural road improvements in Bihar state, India showed that a shift towards employment over a period of time in non farm occupations in areas with improved roads, compared to control areas, showed an increase in agricultural improvement (Lal, 1987).

The social and economic benefits derived from rural roads are many. Research works on the impact of improved accessibility have been carried out and there are many examples, where it has been shown that average domestic product, literacy and employment opportunities have increased significantly to provide higher standards of living (Mahendru et al., 1998). World Bank has also attempted an economic appraisal of rural road projects for investment priorities. In this context NTPC (1980) clearly indicated that roads provide six times more employment potential than railways.

1.3 RURAL TRANSPORTATION IN DEVELOPING AND DEVELOPED COUNTRIES:

The fact that the existing state of transportation in rural areas of developing countries suffers from severe deficiencies is well established. It may be easy to assume that transportation might have been neglected in the past by developing countries, but it is far from the truth. The investment priorities for various public sectors may vary widely from country to country. However, the funds allocated to transportation constitute a
considerable portion of the total public sector investments for all the countries involved as per details shown in Figure 1.1

Variations in the character of transport infrastructure in different nations are often as high as the economies of those countries. There are substantial differences from country to country in the share of passengers carried by rail, road, water and internal air services. Contemporary systems are a reflection of the policies of Government and its control over the transport sector. In the developing Nations, investments in the transport infrastructure are often subjected to the policies of international agencies such as the World Bank. In some States National Economic Development plans incorporate specific proposals for the transport sector.

J. Risseeuw (1987) has stated that rural areas do attract much attention in the European country market. The "Year of the European Country side" was launched and stressed on development of infrastructure in rural areas. The research of Risseeuw in Netherlands concludes that the rural areas are to be opened up to "specific space requirement functions" which will spread all activities in a scattered manner.

Van Putten (1987) has identified development of infrastructure elements in relation to the reallocation of functions and stated that land use can generate a uniform development of a region. His work in Netherlands says that a lot of people live, work, and spend their free time in a relatively small area and therefore stressed the importance to create a social accepted plan to suit small areas.

H. Schatt (1987) has developed overall traffic planning of Bavaria and stated that rural road planning should be a measure of land consolidation which shall necessarily to continue and decisive with a view to preserve and stabilise farming, securing the future of rural areas and conserving natural resources.
TRANSPORT SECTOR INVESTMENT IN TOTAL PUBLIC SECTOR INVESTMENT IN DIFFERENT COUNTRIES
Boss et al. (1987) stated that in many places of Switzerland, the planning, design and construction of minor rural roads is based on rule of thumb and general statistics and the practice has unfortunately not been established as a procedure.

The road transport sector in advanced nations have received massive investments since 1950 in terms of infrastructure. The U.K., Germany, USA has clearly shown the dominance of road transport for freight and passengers and there have been substantial improvements in their countries in road networks. The rate at which these new roads have been constructed and highways improved have rarely kept pace with traffic growth.

Efforts to develop the economy through the medium and short-term plans are characteristic of many socialistic nations and the transport sector usually assumes an important place in their development programs. Both China and Poland have recently devoted attention to road improvement programs, particularly to encourage more use of motor transport for short distance carriage of freight and passenger traffic. The road densities in these countries are far lower than in western nations.

The Chinese transport authorities have announced plans to extend the National road network from 890,000 kms in 1980 to 2,090,000 kms by the year 2000, a massive 57% increase in two decades. There have been extensive road building and upgrading of existing roads with sealing of former gravel and earthen tracks. The various schemes are designed to help realise the aim of increasing freight carried by road three times between 1980 and the year 2000. About 90% of the existing road network in China has been either built or substantially improved since 1956. It is also planned to divert short distance travel to bus transport and by the middle of 1980's about 75% of all public journeys were by road modes.
Poland has a sealed road network which is much sparser than that of other European Nations. During post-war period, Polish road planning has had the objective of improving inter connections in the newly defined state. Until 1970, there was little increase in the vehicle fleet, but in the last two decades, it has increased in line with the expanded construction program. With the expansion of trade, a greater proportion of Polish exports are now made by road. The recent developments in both China and Poland indicate that road transport is becoming of much more importance within their economies.

The problems associated with transport operations in Developing Countries are examined and found that in Zimbabwe, Nigeria and Malaysia the larger part of railway systems were built during the periods of British colonial occupation. Bolivia, which became independent from Spain in 1825, established its first railways in twentieth century. Road transport now carries a substantial share of freight and passenger traffic in these countries.

Zimbabwe inherited a comprehensive and well-maintained road system on achieving independence in 1980 and since then the government's objective of developing rural areas has depended largely upon expansion of road network. The inter urban system of tarred roads carries well organised trunk freight services and a program of rural road improvement is extending sealed gravel routes into the more remote areas of communal farming land. The 1986 National development plan proposed the creation of a State owned transport corporation as a means of improving goods carriage and personal accessibility's in these rural areas. Since independence many African and South Asian states have paid increasing attention to upgrading and extending their road networks and investment in this sector has often exceeded than in all other areas of transport. Almost all roads were initially built by colonial authorities, primarily with economic motives, but now the
emphasis has shifted towards providing better roads in rural areas as a part of plans to improve access to rural areas to provide welfare facilities and to involve more farmers in commercial agriculture.

In Nigeria the main objective of road program has been to provide a higher percentage of all-weather sealed roads, to build additional links, to reduce journey lengths and to construct new high ways designed for high capacity freight vehicles. By the early 1980’s 100,000 kms of road were in use of which 30 percent were sealed. During each of the four national plans produced in the period 1962-85, the road systems share of total transport investment never fell below 54%. Roads now carry the major share of both exports and imports.

In Malaysia road building and road improvement projects are essential components of National plans for rural development, especially in the more remote eastern states of Terengganu and Kelantan. New trunk roads such as those between Kualalampur and Seremban and Karak link, the western and eastern coasts and a greatly extended network of rural roads have been completed to promote commercial farming in the formerly isolated eastern peninsular region. Over 80% of all peninsular roads are now sealed and Malaysia is now the leading nation in South-East Asia in terms of quality of its roads.

In Bolivia, the physical difficulties associated with high altitude and poor drainage severely constrained road improvement plans. There are only 4000 kms of roads suitable for motor transport and only one half of this network is all-weather roads. Most of the trunk roads were built since the 1950’s and many form part of overseas financed programs to establish international routes within South America.

Sierra Leone began access road construction project in 1975, focusing upon villages with agricultural potential for coffee and cocoa and where farmers have demonstrated a
positive attitude towards improvement plans. A study after providing access roads had revealed that improved routes serve an important social function by attracting teachers, doctors and other welfare activities into the areas.

In Sabah a scientific relation was developed between the areas under export crops, standard of available roads and distance between farms and service centres. A model was developed to estimate the area of cash crops likely to be produced per unit length of road. This pioneer study was successful in showing that the main parameters involved in rural development could be quantitatively assessed and the results are useful to forecast the likely effects of road building and the transport requirements of other areas for which development was proposed.

In Ghana, a causal modelling technique was developed by relating road density, population density and agricultural output in the area of central region of Ghana. The outcome of this analysis indicated that 84% of the variation in road density was explicable by that of population and by crop output variations. In this region a sealed road is planned within a reach of 6 kms from farmlands. In Ashanti region of Ghana, 98% of population is within 2 kms of all weather roads. A recent study concluded that further road improvements would have little effect upon village market price, since non-transport factors such as marketing practices are of more importance in the local agricultural economy.

In Kenya, a pilot study is conducted to identify the network orientation for transporting tealeaves within 24 hours to processing centres. Priorities of road improvements were identified after taking into account the costs of both road upgrading and subsequent maintenance.
It can be seen from this review that much of the research into rural road improvement has concentrated upon measuring its effects upon local agricultural economies.

Rural transport of developed countries in late nineteenth century is dependent on railways in rural areas of Europe and encouraged expansion of villages. But this transport medium was restricted in its extent and many areas are far and distant from stations continued to rely upon horse drawn carts for access to service towns. It was not until the introduction of motor buses in the 1920's that a more wide spread of public passenger service was first provided, but walking and cycling continued as important means of personal movement. With the growth of car ownership in the 1960's the rural population enjoyed a higher level of mobility. New opportunities were presented for employment, social and leisure activities, and there were substantial increase in both the number and length of trips made in rural areas. This has generated the creation of urban villages where the establishment of employed offices of towns and cities, establishment of many new industrial enterprises in rural locations and an increasing movement of retired urban dwellers into the countryside.

In the Western USA, interior Australia and the UK, where different population densities and settlement patterns produce different travel needs, which in turn create a variety of mobility and accessibility problems. In regions of the sparsest population such as the interior of Australia, the widely scattered agricultural stations are situated well beyond the range of any urban centre or any public transport service and almost all travel must be organised on a personal basis.

Much of the USA's legislation relating to rural transport has been focused upon the "Transportation disadvantaged" such as the handicapped, the elderly and infirm and the poor. At the federal level, legislation has not received the level of assistance necessary to
maintain adequate mobility standards. Social programs have included which are termed "human service" transport systems for the elderly, which has improved a better service.

In UK, the development of transportation network and land use planning was planned simultaneously which has established an ideal connectivity and mobility. Opening of locally based facilities such as retail stores, post offices, schools and health centres in rural areas has developed uniform road connectivity.

1.4 RURAL TRANSPORTATION IN INDIA:

In the developing countries, the provision of all-weather roads in rural areas is seen as an important political and developmental priority. In India there are about 630,000 villages of which only 37% are served by all weather roads. The proportions of villages in each of three population ranges, which remain to be connected, are shown below:

<table>
<thead>
<tr>
<th>RANGE</th>
<th>Number of Villages unconnected</th>
<th>Percentage of villages unconnected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 1500</td>
<td>17998</td>
<td>26%</td>
</tr>
<tr>
<td>1000-1500</td>
<td>26013</td>
<td>46%</td>
</tr>
<tr>
<td>Below 1000</td>
<td>333295</td>
<td>71%</td>
</tr>
</tbody>
</table>

The existing practice of planning road infrastructure on population basis may be empirical, but the overall development of land and accessibility to all villages warrant consideration of a strategic plan which avoids expensive planning in succession. The ultimate objective should be access for all villages at minimum overall cost. Swaminathan et al (1981) appealed for a systematic approach to the problem of connecting all the villages. The developing countries like India where 74.3% of population live in rural areas and 50% of labour force depends on Agriculture.

Population-wise accessibility of villages by all weather roads by the end of eighth five-year plan is given below for the recent time
There are about Six lakh villages spread over 3.28 million square kilometres area. The country has 11.13 lakh kilometres of panchayat roads, 8.15 lakh kilometres of JRY (Jawahar Rojghar Yojana) roads besides 2.25 lakh kilometres of project roads apart from National Highways, State Highways, P.W.D and Urban roads. Even after 50 years of independence, inspite of best efforts made by the Centre and State Governments still 50 percent of the villages remain unconnected with all weather roads. More than 67 percent of the rural masses depend on bullock carts, cycles and other non-mechanised means of transport. Only 41 percent of the rural roads constructed and maintained by panchayats are surfaced roads that are mainly rural roads. The planning, execution and maintenance of these rural roads are presently vested with Zilla parishads. They lack expertise and as such large investments are not ending with creation of useful tangible assets. Maj. Ramesh (1998) has stated that a coordinated approach of pooling out the resources and a scientific approach on the need based rural road development in line with the findings/recommendations of expert committee set-up by the Planning Commission in creating the tangible assets is the need of the hour.
1.4.2 An Overview of Rural Road Development Programs in India:

The road development plans in India were taken up in the following phases:

- Jayakar committee in the year 1927 assessed the inadequacy in the Indian road system and urged for its development, for the general welfare and better marketing of agricultural produce as well social and political progress of rural population.

- Nagpur plan emerged in the year 1943 was the first attempt on long range 20 year planning of roads on a uniform basis.

- Road development plan of 1961-81 advocated Star & Grid pattern and fixed accessibility criteria.

- Road development plan of 1981-2001 is a comprehensive plan covering design and construction standards, maintenance, environment, finance, resource management, man power management, organisational matters, construction agencies, R & D, social and economical development. This plan envisages all weather road connection to all villages by the year 2001.

Road development plans drawn periodically though clearly spelt programs, various schemes launched in rural areas focussed main attention on poverty elimination through employment generation. Rural road development was only incidental.

- Minimum needs programs were launched during the Fifth five-year plan.

- National rural employment program was introduced in 1980 replacing the earlier “Food for Work” scheme. This was centrally sponsored scheme with 50: 50 sharing between Centre & State Governments. Rural road construction was an important part of this program.
• Rural land less employment guarantee program entirely funded by the Central Government was introduced in 1983 to create employment opportunities for land less poor. Under this scheme, the share of road project was about 50 percent.

In addition, the following special programs are also being implemented

• Integrated rural development program.

• Development of infrastructure facilities in “No Industries Districts”

• Tribal area development

Some other schemes for inclusion of rural roads are

• Service Committee schemes (Punjab, U.P, Haryana)

• Famine relief schemes

• Command area development programs

• Employment guarantee schemes (Maharashtra)

• Special rural employment program (Tripura).

• Labour cum development Bank scheme (Kerala)

• Right to work Program (Gujarat)

• Halli Heddai, Harijan wada link road. Tethu Bandhana, Asphalting of village limits.

Construction of roads with peoples participation (Karnatak)

• A.P Economic restructuring programs of Panchayat Raj Department, Janma Bhoomi Programs (Andhra Pradesh)

The above employment oriented programs indicate that multiplicity of agencies are involved such as rural development department, Public works department, etc. The funding pattern varies from agency to agency and from state to state. This scenario brings to light the absence of uniformity in planning, designing, implementation and monitoring of rural road development program. It also results in inefficient utilisation of funds in th
absence of proper coordination among different agencies. In this context National Transport Policy Committee of 1980, therefore has made the following recommendations:

- Network approach should be applied to rural road planning. District-wise master plans for rural roads should be prepared in all the states.
- Rural road programs should be integrated with rural development program.
- Additional sources of finance should be supplemented in addition to state plan resources.
- A rural roads commission should be set up at the centre for coordinating various rural road programs at the national level; use of labour-intensive technologies, assessment of socio-economic impact of rural roads in quantitative terms, etc.

India is basically an agrarian country with vast rural settlements and its prosperity and progress eventually rest on development of the rural areas. Essentially this involves development of an efficient transportation system to make the countryside accessible. In view of the inadequate funds, planning of rural road network presents a challenge to highway planners and engineers. In spite of this, two long-term road plans were made to cover four decades from 1943 on broad-based national policy, subsequently followed by the Lucknow plan for 1981-2001. These plans have provided the road transportation fabric to the country in terms of well-defined categories such as National Highways, State Highways, Major District roads, Other District Roads (O.D.R) and Village Roads (V.R). Other District roads and Village roads form the rural road network.

All the three plans are based on the experience. They are empirical in nature and lack rational footing in the analysis. However these were accepted to achieve certain predetermined targets and there by increase the accessibility. Recently some advances have been made to provide scientific base to the planning process.
1.4.2.1 The National Road Plans:

The Nagpur plan (1943) is considered a major landmark planning of Highways in India. The need of an adequate system of road network in providing the essential accessibility to boost up economic growth of the country was realised therein. The O.D.R and V.R are defined in the plan pertain to the rural sector and their kilometreage is based on a number of villages and population stratified in four levels. Villages with populations 2000-5000 find more weightage. The Bombay road development plan (1961-1981) followed to suit to provide higher accessibility with a target of 32 km per 100 sq.km of area in the country. The plan intended to consolidate the Nagpur plan. The model for computation of ODR & VR was slightly modified. The Lucknow road development plan (1981-2001) has suggested 82 kms of all-weather roads per 100 Sq.Km.

1.4.2.2 Study on Indian Roads Planning by Planning Commission:

Planning commission in the past has requested the states to prepare master plans on rural roads to facilitate the proportion of five-year and annual plans. This is basically to avoid ad-hoc approach. Many states have finalised their master plans but they need updating in the light of changes in economy. Owing to lack of scientific approach for rural road planning at micro level, planning optimum rural road network requires evaluation of large number of alternative networks having different levels of construction costs, travel costs and other socio-economic parameters, and this is just not possible.

The expert committee set up by the Planning Commission to study the integration of different programs for construction of rural roads submitted its report in December 1985 made the following observations & recommendations:

- There is absence of uniform criteria for selection of road works, planning of roads, fixation of alignments.
• Construction of rural roads by multiple agencies should be stopped and the work should be handled by a unified and technically competent engineering organisation.

• The monitoring of rural roads and villages connectivity should be strengthened.

• States should draw master plans for rural roads and these are updated periodically to cover the needs of new growth centres. The working group of Ninth five-year plan has taken note of the problems of multiple agencies and concluded that coordinated and scientific approach with support of good data bank is required for development of rural road network.

1.4.2.3 Efforts by Other Agencies:

Underlining the need for higher road growth in the rural sector, the Indian Roads Congress made its efforts to set up a committee in 1958 to recommend measures for rural road maintenance. The efforts were updated as Rural Roads Committee in 1969 to prepare a comprehensive reports on planning, specifications, financing, construction and maintenance of rural roads (Koshi, 1987). The Sinha Committee set-up by Ministry of Transport, envisaged the requirement of rural roads as 554,400 km in its report and recommended a high level Rural Board for each state (Rural roads, 1968). Another major attempt to coordinate the various transportation systems was made with the formation of the National Transport Policy Committee [NTPC Report, 1980]. It has recommended that on an average a village should not be farther than 1.6 km from a road by the end of the century.

Many states have made efforts in preparation of the master plans for rural roads to indicate the financial investment and kilometreage involved. Certain blocks were identified for integrated rural development during the 1978-83 plan period by considering the regional conditions, agricultural activities and aspirations of people.
1.4.2.4 Some Advances in Rural Road Planning:

The earlier long term road development plans formulated guidelines for the highway planners and implementation authority for the execution of road systems in various systems. Another attempt is made in the Lucknow road development plans for the period 1981-2001 and reclassified the road systems as Primary, Secondary and Tertiary systems. The tertiary system comprises of other district road and village roads as rural roads, which provides accessibility to large number villages in the country. The plan aimed that all villages or groups of villages of population above 500 are connected with all weather roads by the year 2001.

An effort to provide a rural road network on scientific footings has been made by Mahendru et al (1983,1988) over the conventional “target distribution” methodology. The concept of nodal points, settlement hierarchy and centrality score have been incorporated in these studies with due consideration to settlement interactions, the link, route and network efficiency, a computer model is developed to generate a rural road linkage pattern to provide alternative strategies.

Bhatia et al (1988) have developed a methodology in optimisation of initial cost of construction and long run operational cost and developed optimal network in two phases of maximum link efficiency and minimum spanning tree in an attempt on rural road network model for a district in Maharashtra State of India.

Srinivasan et al (1987) have considered multiple links for the settlements with rated approach and attempted for a district in Kerala State of India. Raji (1988) has attempted to develop cluster analysis algorithm to suit the rural road network development program in three districts of Kerala. Vijaya Raghavan et al (1985) have conducted studies on rural
trip generation models to provide trip models. Swaminathan et al (1982) have emphasised on systems approach to rural road development.

1.5 STRATEGIES IN RURAL TRANSPORTATION - NEED FOR SPATIAL PLANNING:

One of the important aims of plan preparation is to merge the different measures for the traffic and transport system into an integrated land reconstruction plan. The information with regard to the functions of agricultural activists, literacy rates and other land use activities is also involved in the development of rural transportation. The extension in agriculture has led to a growth in both supply and distribution of goods. Development of outdoor recreation centres in rural areas will change the functional use of road. The consequences due to this type of transportation system will change in demographic development of the population. Changes in the network will be possible when the factors like workers, literacy rate, population density is taken for analysis (Van Putten, 1987). Schatt (1987) has stated that there is an enhanced tendency for providing road networks as wide meshed for opening the land to develop in equal potentials of attraction. In his research he also stated there should be a routing of roads in villages with potential characteristics as design elements. Gevaert (1987) has commented that there are a lot of parameters influencing the location of a rural road, but there is no mathematical/scientific method to obtain a road network design. The existing practice in Belgium is almost exclusively a pragmatic approach centres on local circumstances. Gambard (1987) study on functional analysis is to determine the social and economic utility of the road to assess individual and community needs and hence to establish a ranking of road links, as well as levels of service and nature of improvements required. This analysis is based on an evaluation of transport demand and land consolidation objectives, taking into account the
demographic and socio-economic development hypothesis. Dave et al (1992) have stated that users of rural transportation often do not operate a fixed route service and orientation will change to the range of accessibility and connectivity provided.

The total demands of the development are a starting point for the planning process of a road network. During the planning process one is looking for a road structure which comes up to as many different demands as possible or which is tuned in as well as possible on all demands. In the planning process spatial structure is alternatively tuned into the demands (Vanputten, Netherlands, 1987). Buck (1988) gives an example of planning process where a strong relation exists between the required functions of an area and the preparation of traffic and transportation systems.

Rural road network cannot be planned on the basis of travel to be performed on these roads. Thus it is not the trip frequency, which is to justify the network, but the connectivity among rural settlements within the spatial hierarchy to provide basic minimum level of accessibility. In this context the spatial planning of settlement hierarchy should guide the integrated area planning in turn shapes the dependence relationships of the settlements to formulate the linkage requirements (Mahendru et al. 1988).

1.5.1 Current Status of Planning:

Gevaert (1987) has stated that there is no accepted method on a technical/scientific basis for the planning of rural roads in Belgian rural development Even the rural development in Belgium, is nothing but a shy attempt to exceed the narrow vision of pure agriculture interest. But necessary steps have been taken to adapt the “HELP” method, built in Nether lands to their circumstances.

Putten (1987) has developed a rural road network orientation in Netherlands which basically attempts the concept of reallocation of land use activities and develop a link
choice on the basis of importance. He further attempted to provide accessibility to all potential areas and divided rural road planning into two phases—Functional analysis and Constructional analysis. In the functional analysis the network structure is identified with reference to demand of villages and no scientific modelling exists in practice. In the constructional analysis the ground profile and soil characteristics are taken for necessary deviations.

Kollmer (1987) has conducted rural road network planning in Germany. The methodology provides for connecting all necessary public and common installations and facilities with a framework and villages are connected in a shortest way. They classify road system of framework and connected roads as connection roads, main farm and minor farm roads and village streets.

Schatt (1987) has discussed on the road network development project under land consolidation scheme at Bavarian. They attempt to provide network covering the entire area with wide meshed type of structure. The objective is basically to provide accessibility and uniform connectivity facilities to all nodal points. Experience in the Bavarian land consolidation and rural development project has shown that it is essentially necessary to attain great importance to the weighing of different interests/factors in the planning stage.

Boss et al (1987) have conducted a study on the procedure followed in Switzerland rural road development is structure based road network, which will sustain environment and optimal land utilisation. They also argued that if the physical planning is initiated with land allocation of activities to road infrastructure, the spatial conflicts could be avoided. They attempted to identify optimal field lengths as an important design element for the horizontal network disposition and density. The field lengths are calculated as dependent
on cultivated area per farm, on the degree of mechanisation, on the soil utilisation system and on the crop rotation.

**Boss et al (1987)** have stated that the identification of spatially importance units followed by network planning will give an ideal road structure. The location, size of such spatial units, as well as their socio-economic characterisation is actually the subject of transportation/development planning. They suggested that the network orientation should be done with traffic potential comprises of agriculture, forestry and recreation.

**Jaarsma (1987)** has stated that shortest path do not suffice in a rural road network. He has attempted gravity model in identifying the trip distribution with travel demand as input in Dutch rural areas. The maximum coverage of demand is taken as basis in identifying the links.

**Buch (1987)** has stated that rural road networks should be oriented in two types—one is for recreational traffic and second is for agricultural activity. He has attempted with landscape elements and shortest distance as impedance factors.

**Gostovic et al (1987)** have attempted rural road network orientation with consideration of agricultural yield, direction of wind. In their research they concluded that orientation of access roads in rural areas is a function of agricultural yield which is again a function of direction of dominating wind.

**Horn (1987)** has concluded, on the basis of his research work, that importance of regional, local traffic should be given to develop minor rural road network which dominates the other types of urban roads in terms of length up to 2 to 3 times on average in developed nations and even more in developing countries where 95% of the network is consulted by such low traffic roads.
Konstantinos et al (1987) have developed a methodology by coordinating location of public services with development of road network in rural areas. They attempted accessibility levels in respect with location of services on rural areas of Greece. This study shows that improvements in the travel times of crucial road segments can reduce the number of public service facilities which are required to serve that area effectively.

Riverson et al (1983) have conducted research in Ghana and found that accessibility greatly affects both rural communities and the interaction between rural and urban areas. They have developed a methodology with the objective of agriculture development and social infrastructure changes by connecting the rural areas with servicing centres in an optimal way.


Makarachi et al (1991) suggested a methodology on identification of link choice with considering minimisation of travel and construction cost. The methodology developed is initiated with development of shortest spanning trees which suggest a minimum construction cost based network. On this network, each node is again scanned with user cost as a function of population and distance parameters. A link choice was identified which minimises travel cost. The outcome of this methodology suggests a network, which serves maximum population with consideration of construction cost.
Katti et al (1990) have stated that the three national plans in Indian road development provided the milestones in planning a road system with a strategy to enhance accessibility and monitor the road development programs at national level on concept of upgrading, providing missing links and extension of the existing network. The need for an integrated approach regional transport modelling and sophisticated computerised analysis through time-trend analysis, regression models, Input-Output models, Systems approach, Cluster analysis etc. have been realised by research workers to provide a scientific base for the plan. Yet the models have not taken a definite shape and need validation.

Ashok Kumar et al (1991) have stated that intensive rural development programs are under way in most of the developing countries, warranting for comprehensive and coordinated planning of all the rural road development activities. The current planning practices are based mainly on ad hoc criteria that are not good enough for planning major schemes. The present practices of rural road planning leave plenty of scope for further improvements. Because of the absence of a scientific planning approaches, several ad hoc approaches such as attaining a particular road density/ bringing a village within a specified distance from a road or achieving road connection of a given proportion of villages within different population groups are resorted to in the road development plans [Road development plan 1981-2001- IRC (1984), Seventh Five Year plan, 1985].

The guidelines in present practice, in fact, fail to offer any direction to about the manner in which the target should be achieved. The costs involved can vary enormously between alternative approaches to the same numerical targets. There are no guidelines on the villages to be connected first and where they should be connected. Much is left to be interpreted by local authorities, which provides scope for wide regional variation. It is essential that the whole process of rural road development should be approached
systematically. The first step in this direction is the preparation of master plans on a regional basis by adopting a scientific based planning methodology. Some of the major guide lines like "Link all weather roads to All villages with population between 1500 and above and 50 percent villages with population between 1000 and 1500 by the year 1990" appear specific, they in fact fail to offer any direction about the manner in which the targets should be achieved. It is essential that the whole process of rural road development should be approached systematically. There has been a long felt need for suitable methodology on preparing a master plan of rural roads [Swaminathan et al (1981), A. kumar (1990)].

Rekha et al (1984) attempted to develop route network design for connecting various collection points to a centre point (Taluka/ District Head Quarter) so as to minimise the vehicle Kilometres. The input considered are spatial network, length of all edges, demand from every collection point, permitted deviation factors. The analysis is conducted with spanning tree as basis.

Swaminathan et al (1982) have developed a very simple and scientific approach to develop a rural road network. Principles from the graph theory and certain weightages are used in determining the optimum linkage. Analogous comparison drawn and certain features of electrical field are used and suggested a link identification methodology.

Mahendru et al (1982) have suggested that identification and classification for roads should be based on their functional utility. In a region there exists functional hierarchy and settlement hierarchy. Depending upon frequency of various functions and amenities, suitable weightage scale can be developed. Weightage scale thus developed can be used to assess centrality score or functional utility score of each individual settlement. Based on the functional utility score, using Gutman's scalogram technique settlement can be ranked
in different categories. Every settlement of lower order or rank has to depend upon the nearest high order settlement. After taking up the spatial planning of settlement and hierarchies needed, a linkage pattern has been developed by linking dependent settlement to their respective central places. Linkage thus developed can be used as the basic framework for generating rural road network.

Mahendru et al (1983) have suggested a linkage pattern in rural road network by taking concepts of total link length, total route length, settlement interaction, link, route and network efficiency, efficiency of interaction and these parameters were used to generate, analyse and evaluate alternate rural road link patterns. This methodology has been applied to Behat growth centre in Saharanpur, Uttar Pradesh, India.

Srinivasan N.S et al (1987) have suggested network-planning model in three stages- Node choice, Link choice and Network optimisation. For node choice, the concept of Transport priority index (TPI) has been developed and used. For link choice, various indices of network analysis have been considered. Network optimisation is carried out with Village affinity index (VAI) based on gravity concept having population, TPI, Distance as input. The links are identified on the basis of VAI values. This methodology is attempted on Malappuram District of Kerala State, India.

1.6 SEARCH FOR APPROPRIATE SOLUTION:

Situation analysis leads, on one hand, to problem oriented assessment of the solution and on the other hand, objective formation establishes the final state to be owned for (Christopher, 1987). In this context, the objective system represents the standard by which the ideal state is to be measured. The solution is intended to convert the actual state into the desired ideal state. The process of searching for a solution consists of the following steps: SYNTHESIS and ANALYSIS. Synthesis comprises of the conceptual combination
of elements of a particular solution to form a model. The analysis examines critically the resulting ideas and concepts to ensure the fulfilment of prescribed essential objectives, the capacity to function and of the completeness and comparability. Further one has to determine the intentional and unintentional consequences of a solution and the conditions under which it will function (Symans Engg 1978/1979). To simplify the search for the correct solution, it is advisable to start from the relevant instruments of implementation, such as land development/land reallocation by following wider aspect to detail (Boss, 1987).

A System approach recognises the influence of transport and accessibility on shaping the structure of rural areas. The familiar definition of a system as a set of objectives together with the relationships between objectives were accepted, then one can think of land use (such as service centres, high demand potential villages) and transport facilities like roads, as the objectives in our transport system. Any object has an impact on other objects and amount of traffic interaction or ability to interact is determined by the demand potential and the physical characteristics/structure of transport facilities. To understand a system it requires system analysis, a method which allows complex and dynamic interactions to be understood in broad outline and thus provides a useful frame work for planning, designing, and managing large scale systems.

An attempt is made in this study with the basic components of the analytic approach like- defining the problem, visualising the situation if the problem continues; Study on constraints; Study on alternative options and their pros and cons; model formulation; testing and evaluation.

The travel patterns in rural areas are not basically of specific orientation. The trip rate and travel attributes may not justify the Government for providing higher accessibility and
well-connected road network. But such road network is essential for development of any region. It is appropriate to identify a proxy to travel demand from the travel influencing factors. This is because collecting the data on diverse, inconsistent trips of all villages in a region is very difficult, expensive and generalisation of trip rate is also difficult. The other deficiency in the present planning is non-consideration of potential service centres from the point of view of impedance for interaction and the proportionate comparative value of influencing factors.

The need for development of rural road network has led to search an appropriate solution which can develop a well-connected road network and accessibility to service centres from all the villages. The obligatory points in network development are - The links should connect the villages having higher to lower order demand, having prime connection to service centre; linkages should have hierarchical difference in transporting the traffic with less impedance by keeping the functionality of road; link should be economical from travel and construction cost point of view; Links should promote higher accessibility to service centres and minimum user travel cost. Taking these requirements into consideration, different methodologies are suggested in identifying the network configurations for a study area.

1.7 OBJECTIVES OF STUDY:

Lack of accessibility and improper connectivity of villages in rural areas is hampering down the socio-economic status of the people and growth of the economy. Non consideration of future potential land use and activity centres is also disintegrating the connectivity patterns of rural areas. A broader phase of development in administrative, business and service centres with proper orientation of network can encourage rural area development and releases the mounting pressure on urban and suburban areas.
The existing practices in rural road developments have to be tackled with scientific inputs for effective reorientation of network elements and also to subdue the inconsistent growth of land use activity in regional areas. In order to achieve the desired network oriented to road user and system owner and to overcome the limitations in the current practices, the following aspects are considered forming the objectives of this work.

- To develop a simpler method of demand potential of nodes, which can serve as a proxy to the actual travel behaviour of users.
- To conduct a locational analysis which can identify the potential of service centres of a region.
- To develop a methodology which can identify uniform road connectivity for compatible development of area.
- To develop a user, system owner based and cross composition based network for wider coverage of a given area.
- Development of policy constrained road network with minimum cost as objective.
- Development of a methodology to identify a road network configuration, which can minimise the gap between direct and indirect costs.
- Evaluation and Validation of road network configurations developed from the above Concepts.

To illustrate the effectiveness of such a procedure a study is conducted in Medak district of Andhra Pradesh, India. For evaluation and cross validation, Ranga Reddy district of Andhra pradesh, India has been selected.

1.8 SUGGESTED APPROACH:

In the absence of a widely accepted scientific approach, practices like experience based, priority-based methods have given a scope to generate road network configurations
from different perspectives. The research works and the views on rural transportation have clearly stressed the need for a methodology to identify the linkage pattern for developing the social and business interaction and economic way of development having higher connectivity. The suggested approach with the objectives, formulation, recommended strategy is shown in Fig- 1.2. The approach suggested is initiated with development of proxy to travel demand. This proxy to travel demand and distance impedance is taken in objective function conceptualised for identifying potential service centres. An iterative-based operation is formulated with concept of p-Median to enable for identification of service centres. These potential service centres and villages are used as skeleton to identify different network configurations.

1.9 PRESENTATION OF THESIS WORK:

This research work is organised in 6 chapters including the introduction chapter.

CHAPTER 2 deals with the relational development between spatial structure and transport; and the problems, policies, and plans in rural transportation in developing countries and developed countries are presented. The elements for successful rural road network and road network developments in rural areas of various countries are reviewed. The modelling developments of recent times and features of rural road network models are presented. The modelling framework for the future and specific scope of the study are dealt with.

CHAPTER 3 deals with the relevance of spatial parameters on road networks, locational analysis on rural potential centres. formulation of demand potential as a proxy to travel demand is presented. Trends in rural transportation, different mechanisms, theories associated with rural transportation, recommendations, findings of expert committee/ researchers, different configurations adopted and characteristics of rural
FIG 1.2. SUGGESTED APPROACH IN IDENTIFICATION OF ROAD NETWORK CONFIGURATIONS
transportation are presented. The modelling procedures in network development and details of the suggested methodology into a working process are explained.

CHAPTER 4 presents the Description of study area and different characteristics relevant to the analysis obtained through field surveys and secondary sources are described in this chapter. Details of conduct of field studies, processed information reflecting the socio-economic characteristics, existing road network details of study area, demand potential calculation is dealt with. The identification of potential centres, development of general user based intra area road network, development of inter area road network, development of hierarchical based road network. Development of uniform coverage road network configuration, Minimisation approach on identification of network with details of conceptualisation, working methodology, example and algorithmic steps of the study are explained.

CHAPTER 5 contains the validation and evaluation of the concepts and methodologies developed under different perspectives. The fundamental identities of network are used to validate the outcome of the methodologies. The operational identities and structural indices of graph theory are adopted in evaluating the capabilities of the methodologies and concepts.

CHAPTER 6 Summarises the inferences drawn from the analysis carried out. The features of the methodologies suggested in different network configurations, features of recommended strategy are discussed and the strong points together with the limitations are presented. Conclusions in the form of applicability of the methodology to develop desirable network configurations are given as guide lines for implementation.