This is to certify that the

thesis entitled

A GRAPH-THEORETIC APPROACH TO THE
TRANSPORT DEVELOPMENT
IN IRAN

presented by

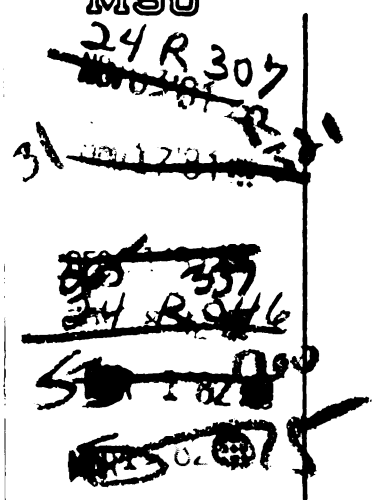
AZAM MORTEZAGHOLI

has been accepted towards fulfillment
of the requirements for

M.A. degree in Geography

Major professor

Date 2/22/79



A GRAPH-THEORETIC APPROACH TO THE TRANSPORT DEVELOPMENT IN IRAN

By

Azam Mortezagholi

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Geography

1979

ABSTRACT

A GRAPH-THEORETIC APPROACH TO THE
TRANSPORT DEVELOPMENT
IN IRAN

By

Azam Mortezagholi

Transporation development is one of the major stimuli towards economic development in developing countries. It is associated with socio-economic and government policy changes. The purpose of this study is to analyze the interrelationships between the expansion of Iran's highway network in 1914, 1943 and 1975 and economic growth.

The Taaffe, Morrill, Gould model on the graph theory measures to study the historical processes and current patterns of the highway network. The Taaffe model was found to be only partly useful as the historical, economic and political developments were different in Iran than colonial West Africa where Taaffe's model was applied. Graph theory measures identified regional variations in transport development that were explained by historical as well as contemporary urban and industrial growth. The regional imbalance in the highway network is a major reason for inequalities in regional development.

ACKNOWLEDGEMENTS

My warmest gratitude extends to Dr. Stanley Brunn, chairman of my thesis committee and major academic advisor for his help and advice. Thanks for many hours spent reading and criticizing this thesis.

The guidance and assistance of Assefa Mehretu is deeply appreciated.

I would also like to express my appreciation to Dr. Wittick for his advice and for his valuable technical assistance with the computer analyses.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

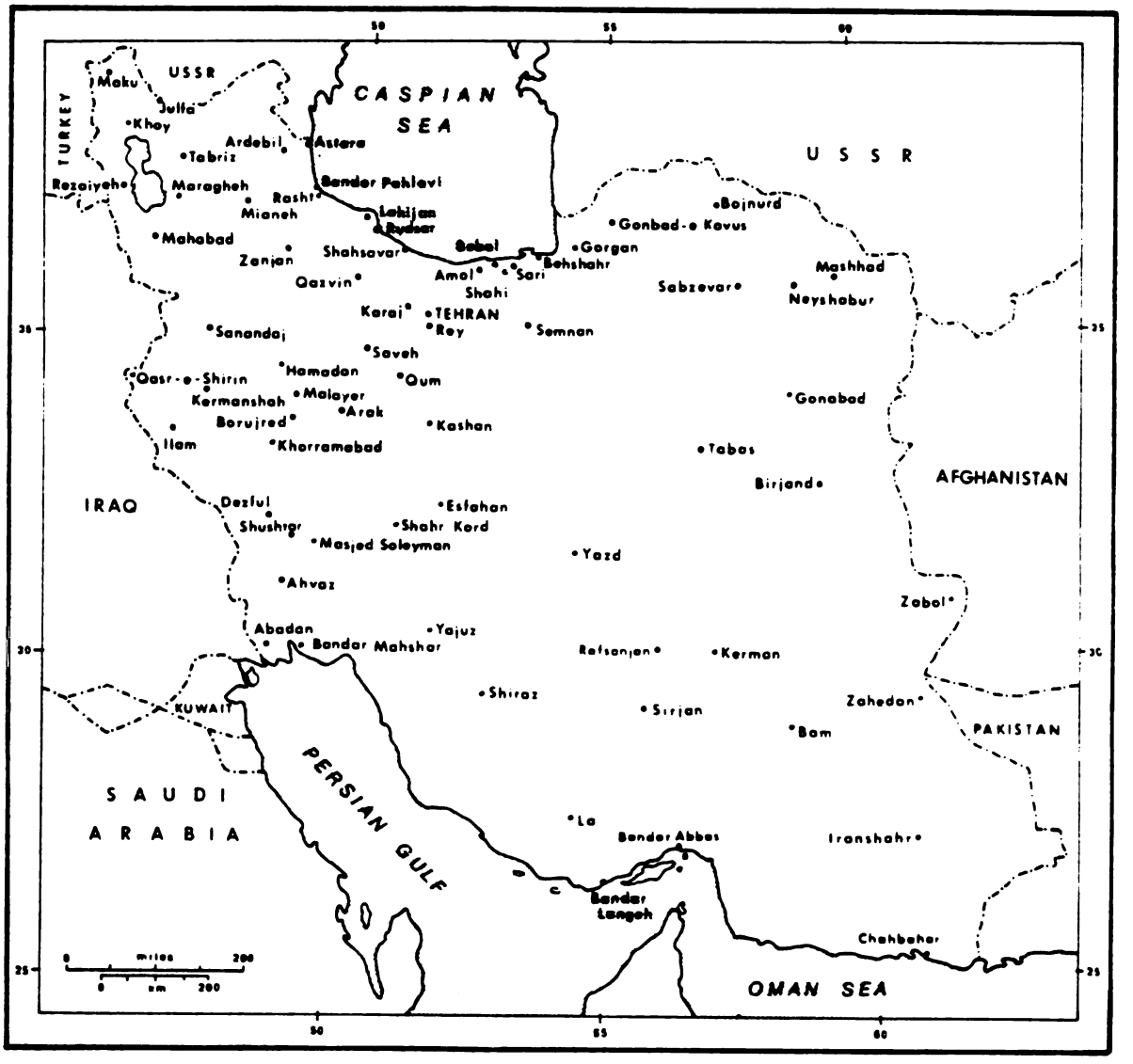


Figure 1. Boundaries and location of Iran.

Source: Julian, Bharier. Economic Development in Iran 1900-1970, London: Oxford University Press, 1971, p. 1.

CHAPTER I

INTRODUCTION

Transportation development is a vital issue, especially in developing countries. There are differences between transportation systems in countries with a low level of economic development and in those with high levels. Such differences are the result of dissimilar processes of transportation development. There are many factors operating to change the structure of transportation networks in developing countries. Expansion is affected by many economic and social factors that account for the interdependence between the transportation system and socioeconomic status. Also, the effect of a country's political ties with other countries and government's policies in regard to the transportation network and to transportation planning are important points that merit attention. While many economic and political factors are involved in changes in the transportation development of Iran, it is believed that economic factors play the dominant role in the process of that development.

STATEMENT OF PROBLEM

Considering the interrelationship between transportation development and economic growth in a country like Iran, many factors can be defined that influence the pattern of the highway transport network. For instance, in Iran great changes in the transportation network occurred through the participation of foreign countries which have attempted to exploit Iranian resources. Significant amounts of foreign investment have gone to transportation and to mining. Each foreign country attempted to root itself more firmly in the country and to build a transport network to satisfy its own benefit. The result has been an increase and a concentration of economic development in just a few regions.

This study is concerned with the general problem of explaining the evolution of the country's highway development and relating it to accompanying economic changes. The specific problem is whether there is any relationship between highway development and economic growth in Iran.

STATEMENT OF HYPOTHESES

A series of hypotheses can be formulated expressing the relationship between transportation or highway development and economic growth where the relationship focuses on the

spatial properties of the transport network and economic and social growth. Three hypotheses are advanced:

1. The processes of transportation development in Iran are not separate from economic changes that have occurred in the past decade.

2. There is a positive relationship between the expansion of the transport network and economic, social and political conditions in Iran.

3. The regions which have high levels of social and economic development are expected to have high degrees of connectivity and accessibility.

IMPORTANCE OF THE STUDY FROM A GEOGRAPHICAL VIEWPOINT

Transportation as a measure of the relationships or linkages between areas is an essential part of geography. While geography is concerned basically with the likenesses and differences among places on the earth or the kind and amount of variations that exist in space, the role of transportation geography is seen as one of being concerned with the kinds of organization and networks that tie together similar and dissimilar units in space. For this study, transportation geography seeks to comprehend how the likenesses and differences in Iran's transportation network are related to economic development.

The concept of transportation to the geographer is a

major part of geography of circulation. Ullman used this term and explained that:

> circulation is basic to the spatial interaction, and thus to the geographic term situation, which refers to the effect of phenomena in one area on another area. Specific processes relevant to the situation include diffusion, centralization, migration or transportation.[1]

The subject of transportation geography is mainly examined by geographers in its economic aspect. Improvement in transportation technology accounts for a great reduction of the cost per unit of moving goods between two places. This makes possible the economic specialization of the area. This regional specialization in turn produces regional differences or variations in economic production and land use patterns. However, understanding of the processes which are involved in changing the land use pattern of an area are major tasks within the field of geography. Regional geography finds it necessary to consider transportation because the organization of every region is to some extent a reflection of that region's transportation system.

Transportation geography is concerned with the following different objectives:

1. The study of the effect of environmental conditions on transportation and conversely the impact of the improvement

---

[1]E. L. Ullman, "The Role of Transportation and the Bases for Interaction", in Man's Role in Changing the Face of the Earth, ed. W. L. Thomas, Jr., Chicago: University of Chicago Press, 1956, p. 862.

of transportation technology on changing the face of the human and physical environment,

2. The study of the processes of economic growth for a region and the role of transportation development, and

3. The use of mapping techniques to show the evolution of a transportation network, the flow of traffic volume, and speed of movement from origins to destinations.

STUDY AREA

Iran is a developing country in the Middle East. It is located in a dry region where the hostile environment is perceived as a barrier to the expansion of the transportation network connecting all parts of the country. The population of Iran in 1976[1] was more than 34 million. Density of population varied from place to place. The Central Province has highest concentration of about 66 persons and the lowest concentration is retained in Sistanand Balochestan with 3.5 persons per square kilometer. The growth rate of population was 3.0 percent annually. Figure 2 shows the population density in 1977. The economic situation of Iran is comparable with other developing countries except that for the degree of economic dependency on foreign investment. The strategic importance and location of Iran in the Middle East and the existence of many valuable resources, as we will examine in

---

[1]Source: Population Data Sheet, 1976, Population Reference Bureau, Washington, D.C.

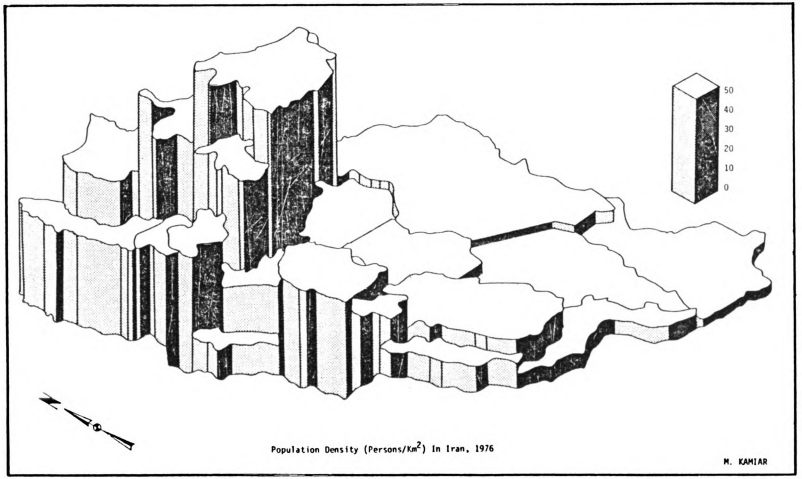


Figure 2. Population Density (Person/Km^2) in Iran--1976.

Source: Mohammad Sha Kammiar. "Spatial Pattern of Iran's Population Characteristic", Master's Thesis, 1977, P. 53.

Chapter 3, have been behind the initial development and expansion of the highway network. The present highway network in Iran has spatial characteristics that are the result of a number of different factors operating for the past century and more. It is important to be aware that there are immense obstacles to attaining a successful integrated transport network in developing countries.

The main reason I selected Iran to illustrate the ties between economic development and the evolving transport network is because (1) I have observed the importance of transport network to the country's total development, and (2) it was important to know what factors are behind this present situation not only for academic reasons, but also perhaps to propose solutions to existing problems that the country faces.

PURPOSE OF STUDY

The need to study in detail the transport structure of Iran and to recommend solutions to transport problems is evident. The country's economic development depends heavily upon how effectively the transport and in this case, the highway system functions. The existing situation and facts seem to indicate that an inadequate transportation network is the major factor impeding economic growth throughout the country. The lack of accessibility of all parts of the country to the nationwide network results in some areas remaining in a

primitive stage of regional development. Considering the fact that a high portion of government revenues are invested in transportation, this emphasis on transportation has not benefitted all parts of the country. In part, this is because of the absence of appropriate planning for transportation development. On the other hand, to understand the country's present and future, it is necessary to obtain knowledge about the historical processes of transportation evolution and the factors operating to extend and improve the transport network. Thus, one of the main purposes of this study is to shed light on the historical process of transportation development in Iran. Specifically, the main objectives of this study can be stated as follows:

1. to discuss in a historical context the interrelationships between economic growth and transportation development,

2. to examine the expansion of Iran's highway network by using the Taaffe, Morrill, Gould model of transportation development sequence in developing nations,

3. to test the applicability of the graphic theoretical model to the evolution of transport network and the evolution of the country's highway network, and produce an interpretation of network properties by applying the graph-theoretical method, and

4. to investigate the role of transportation on urban growth and population density and economic development.

METHOD OF STUDY

Considering that a major purpose of the study is to review the historical process of transportation development, Taaffe's model was considered an appropriate model of the spatial and temporal changes. This model for the first time was applied to analyze the process of transportation development in Ghana. Taaffe, Morrill and Gould[1] in 1963 defined the extension of transportation in Ghana mainly in terms of the growth of transport network from the coast. An earlier study done by Gould in 1960 set up a discrete stage model to describe the growth of Ghana's transportation network. Other studies in East Africa, Brazil, and Malaya provide the basis for a similar four-stage model of transportation development to what Taaffe et al. proposed. This model also provides a base for geographical studies. It is hypothesized that these stages are recognizable in the process of highway expansion and development in Iran. However, there are several differences between the economic and social conditions in Ghana and Iran that are discussed below.

In order to define the processes of network expansion and the present characteristics of the network structure, graph theory is applied. This method measures the properties of the network in a precise manner. Graph theory provides an

---

[1] Edward J. Taaffe, Richard L. Morrill, and Peter R. Gould, "Transportation Expansion in Underdeveloped Countries: A Comparative Analysis", Geographical Review, Vol. 53 1963, pp. 503-529.

appropriate language suitable for measuring and analyzing the structure of a transportation network. The pioneers who explored the utility of graph theory in geography were Garrison,[1] Kansky,[2] and Gauthier.[3] They used graph theory to analyze the transportation network structure in different settings and countries. In this study, graph theory is utilized in two classes of measuremets: (1) to measure the transport network in entirety, and (2) to measure individual elements of the transport network.

---

[1]W. L. Garrison, "Connectivity of the Interstate System," Papers and Proceedings of the Regional Science Association, Vol. 6, 1960, pp. 121-137.

[2]K. L. Kansky, Structure of Transporation Network, Chicago, Department of Geography, Research Paper, University of Chicago, 1963, p. 155.

[3]H. L. Gauthier, "Transporation and Growth of the Sao Paulo Economy," Journal of Regional Science, Vol. 8, 1968, pp. 76-94.

CHAPTER II

LITERATURE REVIEW

INTRODUCTION

The role of transportation in agriculture, mineral, and forest development, the location of industry, and in improving internal and external trade has a very strong impact on the total economic development of a region. Increasing the economic activity frequently results in more access to some places than others and improvements in transport facilities. The interrelations between economic development and transportation are important issues, especially in developing countries.

There are several ways for the researcher to handle the various interrelated subjects treated in this study. One is to review appropriate literature in order to summarize and organize the information on three major areas: (1) transporation development in developing countries, (2) the economic history of Iran, and (3) the application of the graph theory model in different countries.

The first part of this chapter is allocated to a review of the transporation development in developing countries. Many geographers, economists, and regional scientists have

recognized the nature of the interrelationships between economic growth and transportation development in developing countries. Haynes[1] points out that Mark Jefferson[2] was the first researcher who paid attention to railway development and the level of economic growth on an international scale. Berry and Ginsberg[3] realized that this relationship is not limited to railway development, but includes other modes of transportation. Recently, many other researchers have drawn more attention to the interdependence of transport systems and economic growth in developing countries. Taaffe, Morrill, and Gould,[4] as mentioned above, have studied transportation development in Ghana and Nigeria. They stated that expansion of the transportation network is a continuous process which is influenced by many specific economic, political and social forces. The spatial patterns of economic development correspond with the expansion of transportation network in these countries. Because of the significance of this study for this investigation it will be examined in great detail.

1Kinglsey E. Haynes, I. P. Paulin, Population, Economic Development and the Structure of Transportation in the Province of Quebec, Canada. Tijdschrift Voor Economische en Sociale Geographie, Vol. 61, 1971, pp. 356-369.

2Mark Jefferson, "Geography of Railway Transportation in 1920-1927," Annals, Association of American Geographers Vol. 18, 1928, p. 64.

3Brian, J. L., Berry, Berry, Brian, J. L., and Norton, Ginsberg. Essays on Geography and Economic Development. Chicago, University of Chicago, Department of Geography, 1960.

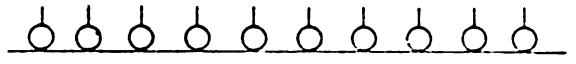
4Taaffe, et al., Op cit.

Taaffe identified four stages of transport network expansion. In the first stage a few trading centers as major points are scattered on the seacoast. They are not highly connected. In the second stage major penetration lines connect scattered points (coastal centers) to interior centers. In this stage many new points appear along the penetration railway lines. In the third stage, feeder lines begin to move out from the ports and the nodes along the penetration lines. In the fourth stage major trunk line routes emerge as all ports, nodes and interior centers are linked. (Figure 2).

Taaffe et al. believe the above process is the most realistic to expect in the expansion of transportation network. In Ghana the primary scattered points emerged on the coast from the fifteenth through the nineteenth centuries. It was the period when trade with European countries developed. These points were the major trade centers on the coast. As the authors pointed out, the most crucial stage of transportation development in developing countries is the emergence of penetration lines. The primary factors for the building of penetration lines were economical and political. In Ghana, because of a colonial relationship, the aim was to promote contact between the administrative center on the coast and interior centers linked by a series of the penetration lines. In addition, mineral exploitation and access to areas of agricultural potential were other factors contributing to the

Figure 2A. Taaffee Model-Ideal-Typical Sequence of Transport Development.

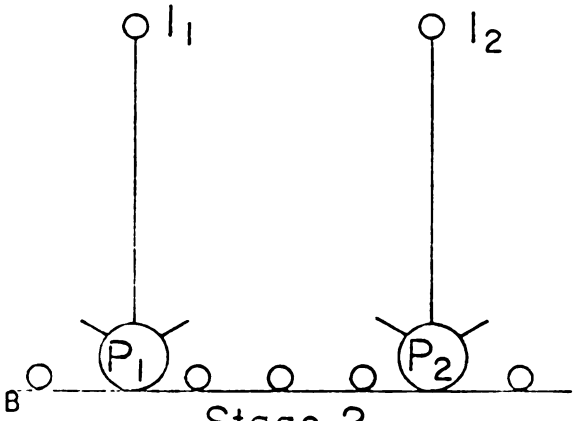
Taaffe, Edward J., Morrill, Richard L. and Gould, Peter R. "Transportation Expansion in Underdeveloped Countries: A Comparative Analysis." Geographical Review Vol. 53, 1963, pp. 503-529.



A

Stage 1

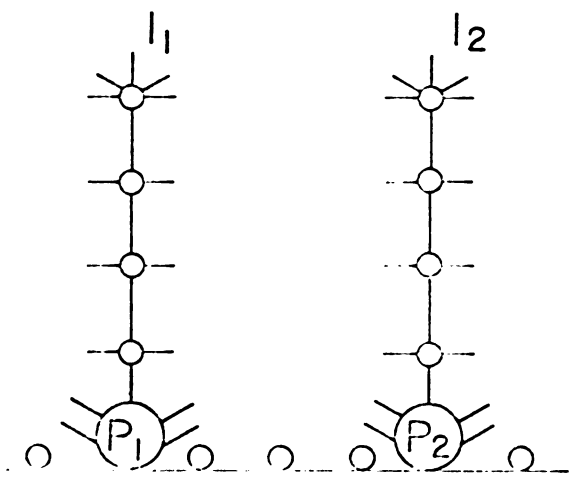
Scattered Ports



B

Stage 2

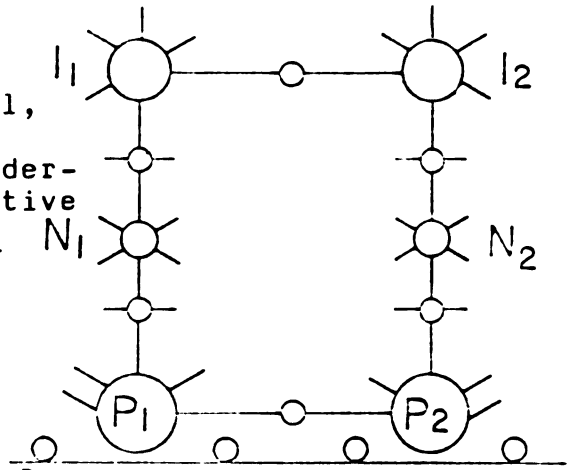
Penetration Lines and Port Concentration



C

Stage 3

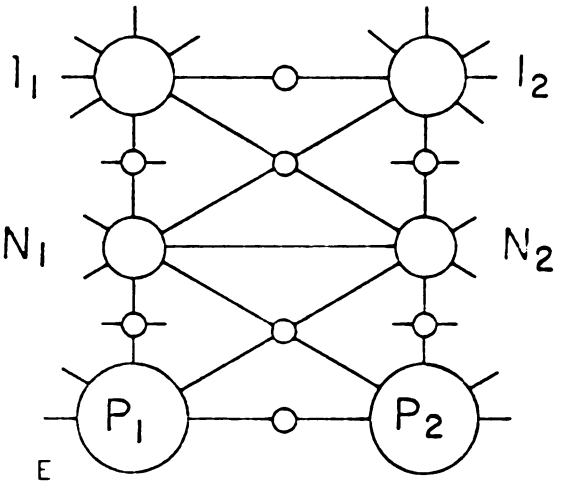
Development of Feeders



D

Stage 4

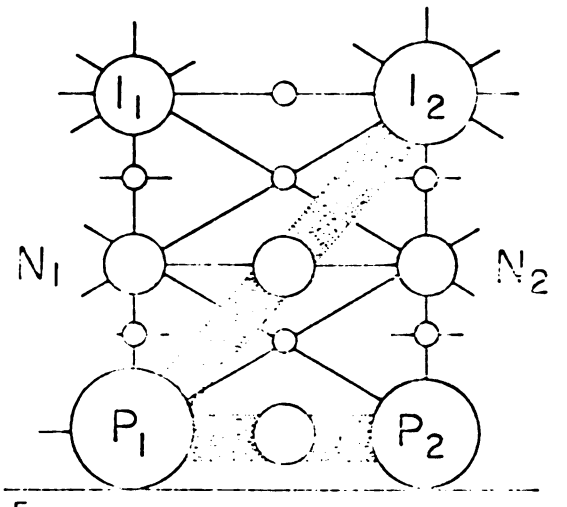
Beginning of Interconnection



E

Stage 5

Complete Interconnection



F

Stage 6

Emergence of High Priority "Main Street"

construction of penetration lines from coast to interior centers. Taaffe et al. also believed that mineral exploitation was probably the principal motive for railroad building in Africa. For example, the expansion of railroads in western Ghana was primarily due to mineral exploitation. This railroad network was very slow to develop in the eastern part of the country because of the lack of important mineral resources.

The third stage in transportation development is identified by the expansion of lateral connections as feeder lines. Ghana at this stage had feeder lines that were the most extensive in the northern part of the country. This was mainly due to the concentration of resources in that part of Ghana.

In Nigeria the process of building the penetration lines was similar to Ghana. However, political factors were the initial motives for the building of penetration lines. The major line connected coastal European settlement to important historic interior centers. Mineral exploitation was another initial motive for building the penetration line from the ports to interior centers. The connection of agricultural regions to the coast was not a major initial motive in Nigeria.

According to Taaffe's study the development of a transportation network is hard to identify only by the dominance of road over railroad. In a period when we find the emergence

of road traffic to initially complement the railroad, we eventually discover it competes with rail and eventually overtakes it. This evolution is frequently observed in the development of a transportation network. In regards to network expansion in Ghana and Nigeria, Taaffe et al. endeavored to find the factors which were responsible for the spatial diffusion of the transportation network. They discovered there was a strong relationship between population density and road distribution and the impact of other factors such as environment, income, and the competition between the railroad and the highway network development.

The methods which Taaffe et al. applied to show these relationships were the correlation-regression model and cartographic analyses. The correlation results indicated that population density accounted for about 50 percent of variation in road density while the size of area accounted for only 20 percent of variation in distribution of highways throughout Ghana and Nigeria. An examination of the residual maps suggests that other factors such as hostile environment, income, intermediate location, rail competition, and the degree of commercialization also affected the distribution of road development throughout both countries.

The second example of transportation development in developing countries is the study done by Gauthier on a portion of the Brazilian highway network. Gauthier (1968) in this study dealt with the interrelationships between

economic change and transportation development. He measured in detail the rate of urban growth in regards to expansion of the highway network in the state of São Paulo. Gauthier's emphasis in this study is on the expansion of secondary roads toward interior centers in the period when penetration lines were developed. This is the second stage of the Taaffe model. As Gauthier stated, changes in the pattern of internal accessibility have an effect on the rate of urban growth. Changing the network structure may influence economic development. It is evident from this research that the economic development of a region has a strong positive impact on the rate of urban growth of that region.

Gauthier believed that the interrelationships between the transportation system and urban growth should be measured precisely, that is, the property of network structure. In order to achieve this goal of precision, graph theory was applied. In this method the highway network was represented as a valid graph comprised of a set of vertices (nodes) and arcs (linkages). These models of connectivity were then appraised at different time intervals.

To determine the relationship between transportation development and urban growth, Gauthier divided the variables into two groups. The first group measured the structural dimension of the accessibility surface of the São Paulo highway network. The second group combined the variables which

measured the degree of urban growth. These included urban population, manufacturing and retail trade activity. Gauthier hypothesized a strong relationship between the construction of the highway network of São Paulo and the industrial development of the urban centers. Specifically, he expected to find a strong relationship between an increase in highway accessibility and urban population growth. The expectation is very similar to the relationships found between population growth and highway development in Ghana and Nigeria by Taaffe and et al. Gauthier discovered a significant fact in his study, that is, both balance and imbalance between the degree of development of the transportation network and urban growth. In the balanced relationship the investment in the transportation network occurs as an immediate response in the form of investment in the expansion of industries or increase in concentration of population in major urban centers. Conversely, in the unbalanced relationship, the lead or lag factors involve transportation development and urban growth. He believes that either lead (means that highway improvement preceeds the expansion of investment of manufacturing) or lag (means transport investment left behind the demand for industrial growth) factors cause pressure on the system by taking advantage of the decrease in transport cost either by increasing highway accessibility or reducing production costs by improving transport facilities.

The study by Laurence A. Lewis and David R. Reynolds[1] in Puerto Rico is another that investigates the relationships between the spatial structure of transportation and the level of socio-economic performance in Puerto Rico. In this study they attempted to examine the interrelation between transportation development and socio-economic factors. At the international level, it has been shown that countries having a dissimilar internal transport network structure will also have different levels of economic development.

The Lewis and Reynolds (1967) approach to the problem of transport development is similar to other researchers. They also applied the graph theory model to measure properties of the highway network structure. In order to examine the relationship between the transport system, and economic structure of the regions they divided the variables into three groups: (1) structural variables which define complexity, connectivity, and accessibility; (2) physical factors including local relief and size and shape of the region and (3) the socio-economic variables such as population growth, family income and employment which can measure the economic development of the regions. Their results revealed that highway mileage is more sensitive to the size

---

[1]Laurence A. Lewis, David R. Reynolds, "The Spatial Structure of Transportation Network, and Socio-economic Development: The Puerto Rican Example", Indiana Academy of Social Science Proceedings, Vol. 2, 1967, pp. 24-52.

of a municipio[1] while the number of edges is more sensitive to variations in socioeconomic performance and tertiary activities. There are additional factors such as: percent of urban population, unemployment rate, and educational facilities which were expected to be related to spatial variations of regions within the country. But in this study they were omitted because of the lack of easy access to them. One hypothesis testing the relationship between connectivity and the socioeconomic development was rejected. This result is contradictory to expected relationships between the connectivity of transport network and economic development that are observed to work at the international level. There is a positive relationship, however, between the size of the area, and structure of the network which suggested a positive correlation between socioeconomic properties such as population growth, population mobility, and expansion of transportation network. The high degree of mobility of the Puerto Ricans seems to have an increased relationship with the distance between urban centers. Likewise there is an indication that the areas close to the large urban centers are more accessible than those which are far away. This finding applies to most developing countries.

Political factors and colonial heritage in transportation

---

[1]Municipio is the unit used in this study.

development were important in Puerto Rico as they were in the study of Ghana and Nigeria. Lewis and Reynolds (1967) did not draw much attention to the colonial (Spanish) factor in explaining the spatial structure of the transportation network in Puerto Rico. However, the political factor is an important one in explaining the transportation development of many developing countries, even if it was shown not to be important in Puerto Rico.

A fourth study on the transportation network was done in Syria by Nuhad Kanaan.[1] He examined the spatial structure of the network in general and the road distribution in particular. Relationships between the density of the transportation network and level of economic activity were almost negligible in Syria. As Kanaan explains, agricultural development in Syria is highly correlated with the density of the transport network which is not surprising since agricultural activity is a major source of income. The major roads link the areas of production to local, national and international markets. In the case of the location of industrial activity and the road network, there is a weak relationship since industrial activity is still in the primary stage in Syria. Railroad competition affects the highway network development, and because of this a great

---

[1] Nuhad Kanaan, "Structure and Requirement of the Transport Network of Syria," Highway Research Record Number, No. 116, 1976, pp. 19-28.

amount of manufactured goods are transported by railroad in Syria.

Graph theory measures are used in Kanaan's study to measure the network structure and network connectivity of the highway in different years. Eight independent variables were selected to test the relationships between economic activities and the network demand. They were: population growth, transit movement, agricultural activity, industrial activity, railroad competition, and the size and shape of the region. Three variables were found to be positively related to the development of the network structure. These were: population growth, agricultural activities, and the topographic base of the region. The relationships between the economic activity and topographic factors is a strong one, but it is weak between population distribution and network structure. This situation is not uncommon in developing countries because many socio-economic factors besides the transportation system influence the population distribution.

ECONOMIC GROWTH AND TRANSPORTATION DEVELOPMENT IN IRAN

Most the the studies completed to date on transportation and economic development in Iran have dealt with the historical processes of transportation evolution and the economic changes that have taken place in the country.

The lack of data has been one of the major obstacles in such studies. A recent study of the interrelationship between economic growth and transportation development was done by Alexander Melamid.[1] This study mainly focuses on the role of petroleum production on the road distribution and the role of petroleum in identifying economic regions in Iran. He selected Iran as a case study to discuss economic growth and transportation development because of the crucial role that petroleum plays in the Iranian economy and the varied nature of Iran's physical and social geography. Melamid stated:

> A geographical study of the evolution of the distribution system for petroleum products offers significant clues for the identification of economic regional and transportation network and hierarchical structure that emerge in this region in the process of development.

A history of the expansion of the highway network in Iran shows that the first roads were built to connect the areas of oil production to places of consumption. As Bharier in another study of the history of economic development in Iran stated, after 1914 a few routes were built and the first class roads were constructed in towns which were in the neighborhood of the Anglo-Persian Oil Company's operation.[2] At this time, Russian and British interests were influential in

---

[1] Alexander Melamid, "Petroleum Distribution and the Evolution of Economic Region in Iran", Geographical Review, Vol. 65, No. 4, 1975, pp. 510-525.

[2] B. W. Fisher, The Land of Iran, Cambridge University Press, 1968, p. 784.

rushing for the construction of routes in the northern and southern parts of the country. This was the first attempt to exploit Iranian resources. These roads serve as penetrating lines which connect major ports on the seacoast to the interior centers. According to Melamid, the network began to evolve with the use of many trails from the many points of entry. The Taaffe model shows that by improving the road quality of the penetrating lines, the number of entry points was reduced and only a few of them became major trade centers on the seacoast. According to Fisher, with the development of the oil industry and the continuation of the trans-Iranian railway during World War II, Khoramshar became the country's largest dry cargo port of the Persian Gulf in southern Iran.[1] Figure 3 shows the major ports in the north and south in 1914.

The expansion of the highway network took place gradually from the south to the northern part of Iran. This is mainly because of the reduction in exports from Russia after 1917. As Sventitski said: "Trade with Russia fell, and by 1917 it was practically non-existent."[2] He also pointed out that the road transportation in Persia changed during and after World War II. This change was necessary due to

---

[1]Khoramshar is a major port on the Persian Gulf in the southern part of Iran.

[2]A. S. Sventitski, "Transport Route in Persia", Journal of Royal Central Asian Society, Vol. 8, 1928, pp. 203-223.

difficult conditions in finding a market for production. Persian trade with Russia was much more expensive than with other countries. During that period all roads with a few exceptions were constructed by Russia to carry goods from the interior to major ports in the north. From Melamid's point of view, by increasing the trade dependency on oil production, the oil industry played a significant role in the evaluation of the economic regions in Iran. According to Melamid: "Overseas oil production export determined the location of the Abadan refinery, but beyond this it has no effect on the region."[5] In Iran the refineries formed a core for urban development, and economic regions coincided with the administration of regions where they were established by the National Oil Company. Melamid believes that the construction of additional refineries and the evolution of new regions in Iran have frequently reflected political decisions since 1950. An economic region is based on the network of transportation routes and hierarchies of various nodes. Usually many urban and industrial nodes emerged around the location of a refinery. Gradually new regions begin to evolve around these nodes. As Melamid states, the evolution of the transportation network took place by the construction of a few arteries and their feeders which formed the model for

---

[5] Ibid., p. 519.

subsequent transportation development. The emergence of these arteries can be compared to the "main street" in Taaffe's model. The arteries clearly define the boundaries of the region in Iran. It is evident from Melamid's study that the distribution of oil production has had a significant role in the expansion of the transportation network in Iran.

Considering the role of the oil industry in the Iranian economy and its impact on the development and expansion of the highway network, we need to examine the oil industry in greater detail.

CHAPTER III

TRANSPORTATION DEVELOPMENT IN IRAN

The process of economic development is a crucial factor which affects the expansion of the transportation network in a developing country like Iran. Taaffe's model of the ideal typical sequence of transportation development is regarded to some extent as a valid model in which to test its application and validity in a study relating transportation development to economic growth. In order to understand these relations in detail for Iran, the country's recent economic history can be divided into three distinct periods. The first period is from 1900 to World War I, the second period, 1914 to 1963, when land reform occurred, and the third period from 1963 to the present

FIRST PERIOD: PRIOR TO 1914

In this period, agricultural activity was the major economic activity in Iran. It accounted for about 80-90 percent of the GNP in 1900 and the largest portion of the country's labor force. Iran, at that time, was self-sufficient in wheat, barley, sugar, vegetables and fruit. A large amount of opium and high quality cotton were

exported to neighboring countries, especially Russia and India. All agricultural technology was extremely traditional as the Iranian peasant had little notion of agricultural implements used elsewhere in Europe. Pack animals were often used for power and for carrying the harvest to market.

Attempts were made before 1900 to introduce modern factories, however, these efforts failed. Manufacturing was virtually nonexistent, except in a few towns. Some manufactured their own special products, such as carpets and textiles. Carpets were a major product exported to other countries. Carpets were carried by pack horses or camels, imports were handled in the same manner. Compared to Middle Eastern standards in regards to factory development, Iran remained behind because of an absence of water, a widely dispersed population over a vast area, and the lack of good road transport. All these prevented the growth of markets. Only after World War I did foreign private capital begin to set up various enterprises in Iran. The British established the Anglo-Persian Oil Company; Russia built a few small refineries and developed the Caspian Fisheries.

Mining grew slowly in Iran as in other Middle Eastern countries. Although foreign demand stimulated the growth of the mining industry in several countries, long distances, and poor communication facilities prevented most development.

Minerals were exploited on a small scale. The mining industry in Iran was very small at the beginning of the twentieth century; a few open mines used very primitive technologies. The absence of transport facilities, and inadequate water supplies made the exploitation of resources generally very uneconomical. Russia received a concession for the first time in 1902 for exploiting all mines except coal and silver in the northwestern part of the country. Following this, a railroad was built between Julfa (boundary town on the border of Iran and Russia) and Tabriz (northern city of Iran) to carry coal and petroleum to Russia. However, no actual exploitation took place and the railway was abandoned.

In the southern part of the Persian Gulf, the iron oxide deposit on Hormoz island was exploited by the British firm of F. E. Strickand Company. Petroleum, however, eventually came to be the most important mineral. Its production deeply influenced the economic and even the political situation of Iran. There were a number of oil exploitation concessions before 1900, the first being by D'Aracy in 1903 which was changed to the Anglo-Persian Gulf Coast in 1905. This company took oil from major oil fields in the southern parts of Iran. In spite of large supplies of oil, comsumption oil was still imported from other countries, from Russia in the north and from British operated fields in the Persian Gulf.

Modern transport in Iran was first established on the seashores and via navigable rivers. The first steamship sailed on the Persian Gulf in 1838. A British Company started a mail service between India and the Persian Gulf in 1862. Steam vessels across the Caspian Sea in northern Iran were started in 1861; they established a regular service between Russia and Iran. Because of the growth of Iranian trade with Russia, and because of increasing Russian influence in Iran, the British turned their attention to the Karan River in the southwest and in 1887 established a steamship service from Khoramshahr (a port on the Persian Gulf) to Ahwaz (city on the north of the Karun River), a distance of about 100 miles inland. As a result of opening of this waterway, Khoramshahr became a major port on the Persian Gulf. The first step of Taaffe's model which is the period of emergence of scattered ports can be observed in Iran by the growing number of small ports on the Persian Gulf and the Caspian Sea. These ports functioned as trading centers with foreign countries, Russia in the north and British holdings in the south. Melamid defined these ports as points of entry.[1]

There are several major differences between the process of road development in Ghana and Iran. The major difference

---

[1]Alexander Melamid, "Petroleum Product Distribution and Evolution of Economic Region in Iran", Geographical Review, Vol. 65, No. 4, 1975, pp. 510-525.

is the existence of historical towns like Esfahan, Shiraz, Mushad, Tabriz and Tehran in the interior of Iran. Actually no city existed in Ghana before the growing of major ports along the seacoast. Another difference is the location of the point of entry. The cities on the Iran-Russia border functioned as points of entry. Such boundary towns did not exist in Ghana. As points of entry or major trade centers between Iran and Russia, penetration lines extended inland from these points. There were eleven such points of entry on the Caspian Sea and Russian border and six points on the Persian Gulf coast. The subsequent construction of roads and railroads connected these ports to the interior centers. Some increased their economic functions considerably during early decades of this century and became the major ports on the Caspian Sea and the Persian Gulf. With the growth of a few ports, the number of points of entry was reduced, and major activity became concentrated in only a few ports. For instance, the poor condition of Iranian ports on the Caspian Sea in the winter time was a great impediment to navigation between Iran and Russia. This was serious since 79 percent of Iran's foreign trade travelled by ship. To remedy this problem, Russia invested 1.3 million rubles in the improvement of Enzali (Bandar Pahlavi) on the Caspian Sea between 1902-1913. Nearly 60 percent of Iranian exports went to Russia and 38 percent of all imports came from this northern

neighbor.[1]

The ports on the Persian Gulf which handled most of the imports and exports were Bushire, Langen, Bandar Abbas, Khoramshahr (Figure 3). With the construction of new roads, some of the small ports became major points. For instance, completion of the road between Bushire and Shiraz gave a dominant role to Bushire, which gradually became a major trading center in the south. Also development of the Trans-Iranian Railway made Khoramshahr the largest dry cargo port. Bandar Abbas at the entrance of the Persian Gulf was being used less than Bushire for foreign trade, one reason being its inaccessibility to the interior and another its location in a sparsely populated area. Ports were the major points of entry for the first penetration lines developed into interior centers.

The development of a highway penetration line stimulated the growth of these ports. The first penetration lines extending into the interior were trail roads which connected these small ports to the interior centers before 1900. The dominant mode of transportation was pack animals such as the camel and the donkey. Later the modern asphalt roads replaced the trail roads. Because Iran's trade was much more extensive with Russia than with other countries during this period, road construction in the north was mostly

---

[1]Charles Issawi, The Economic History of Iran 1800-1914, 1971, p. 405, Chicago, University of Chicago Press.

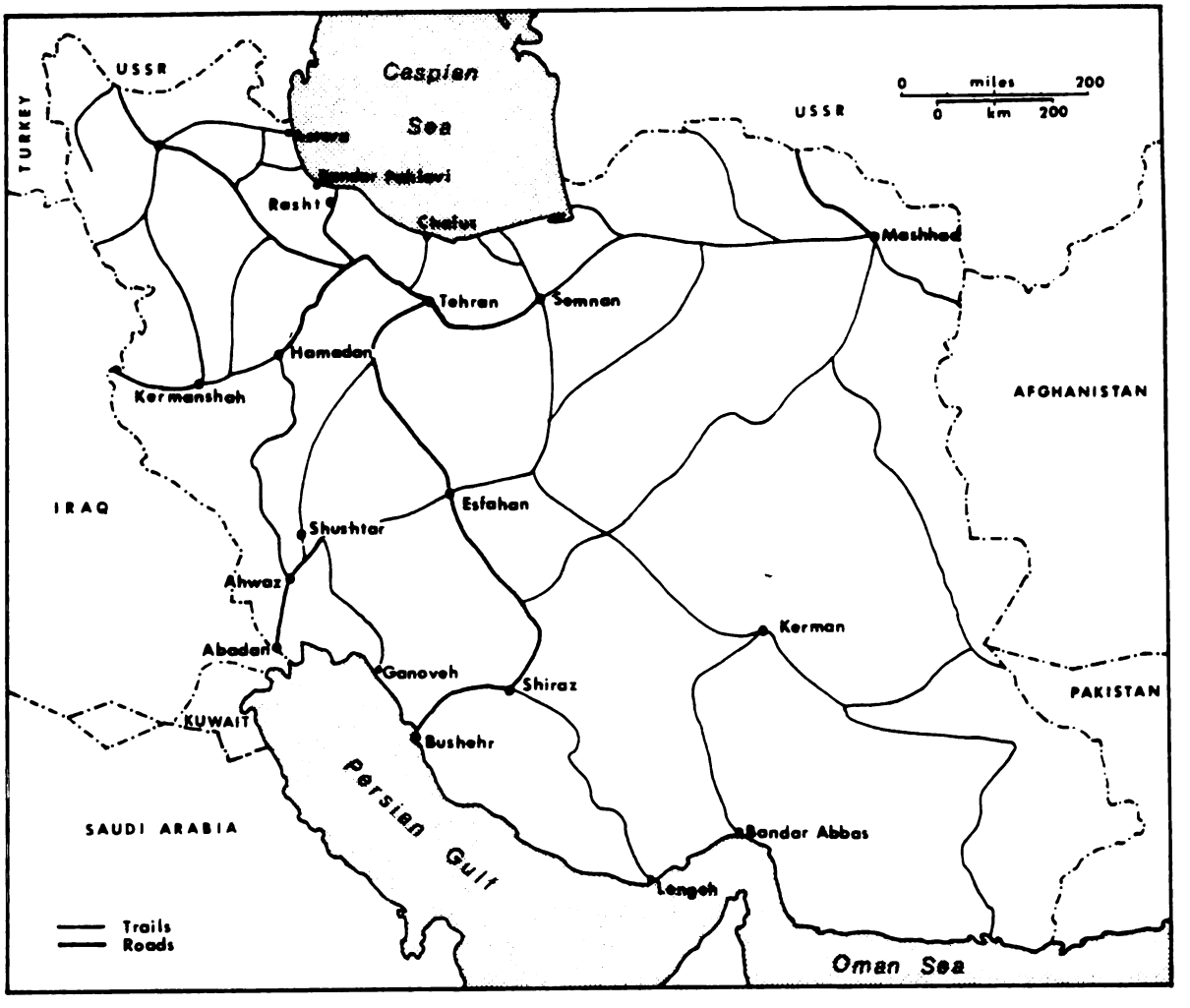


Figure 3. Major Ports in North and South of Iran.

Source: Alexander Melamid. "Petroleum Distribution and Evolution of Economic Region in Iran, p. 517.

carried out by various companies controlled by the Russian Government directly or through the Discount and Loan Bank. All roads built were based on a combination of improved caravan and wagon roads. Wheeled traffic (motorized) was rare and limited to local transport in Iran during the early decades of this century. The conditions of roads was poor. Except for Tabriz and Rasht in the north, Bushire and Bandar Abbas in the south, and Tehran, all which traded to some degree with foreign countries, all other towns and villages were economically self-sufficient and not connected to any national transport network.

At the end of this first period the major economic activity was still agriculture which made up 80 percent of the GNP. Three-quarters of the country's exports were of agricultral products. One of the most striking changes that occurred in agricultural production during this first period was the rapid growth of cash crops especially crops like silk, cotton, opium, rice and tobacco, all of which increased production several fold. Besides carpets, most of it was in agricultural products especially opium.

Petroleum products were gradually becoming an important trade item during this first period. At the beginning of the twentieth century in spite of the existence of large oil reserves, the country was unable on its own to provide the facilities and services needed to exploit her resources. As stated above, most oil consumed was imported from other

countries. Most of the oil imported in the early 1900's was kerosene from Russia. It was carried by pack animals along trails to key consumption points. The distribution of kerosene became a strong motive for the construction of the north-south penetration lines. The lines were extended originally from the Caspian seaports to the interior centers. Because of proximity to the market and the low transport costs for Russian oil products, imported oil from Russia was able to compete very successfully with American oil and even replace it. Russian oil products were imported into Iran in Astara and Enzali (major ports on the Caspian Sea). The first penetration line was constructed by Russia in 1902 from Rasht (a city close to Enzali) to Tehran, a distance of about 200 miles by road. The second line was built between Rust and Enzali before World War I. The third road, completed by Russia, connected Mashhad (a city in the northeast) to the Russian border in Turkestan. (Figure 4).

Inland transportation in southern Iran became easier as a result of the opening up of steam navigation on the Karun River to Ahwaz in 1887. Later Ahwaz was connected to Shushtar by 100 miles of caravan road. As a result of steamship service Ahwaz and Shustar became sizable towns in the southern region. Also another road was built connecting Ahwaz to Tehran in 1912. Upon completion of this road Esfahan, located on the highway, grew rapidly. Figure 4 also shows the roads built in Iran before 1914.

IRAN HIGHWAY NETWORK (1914)

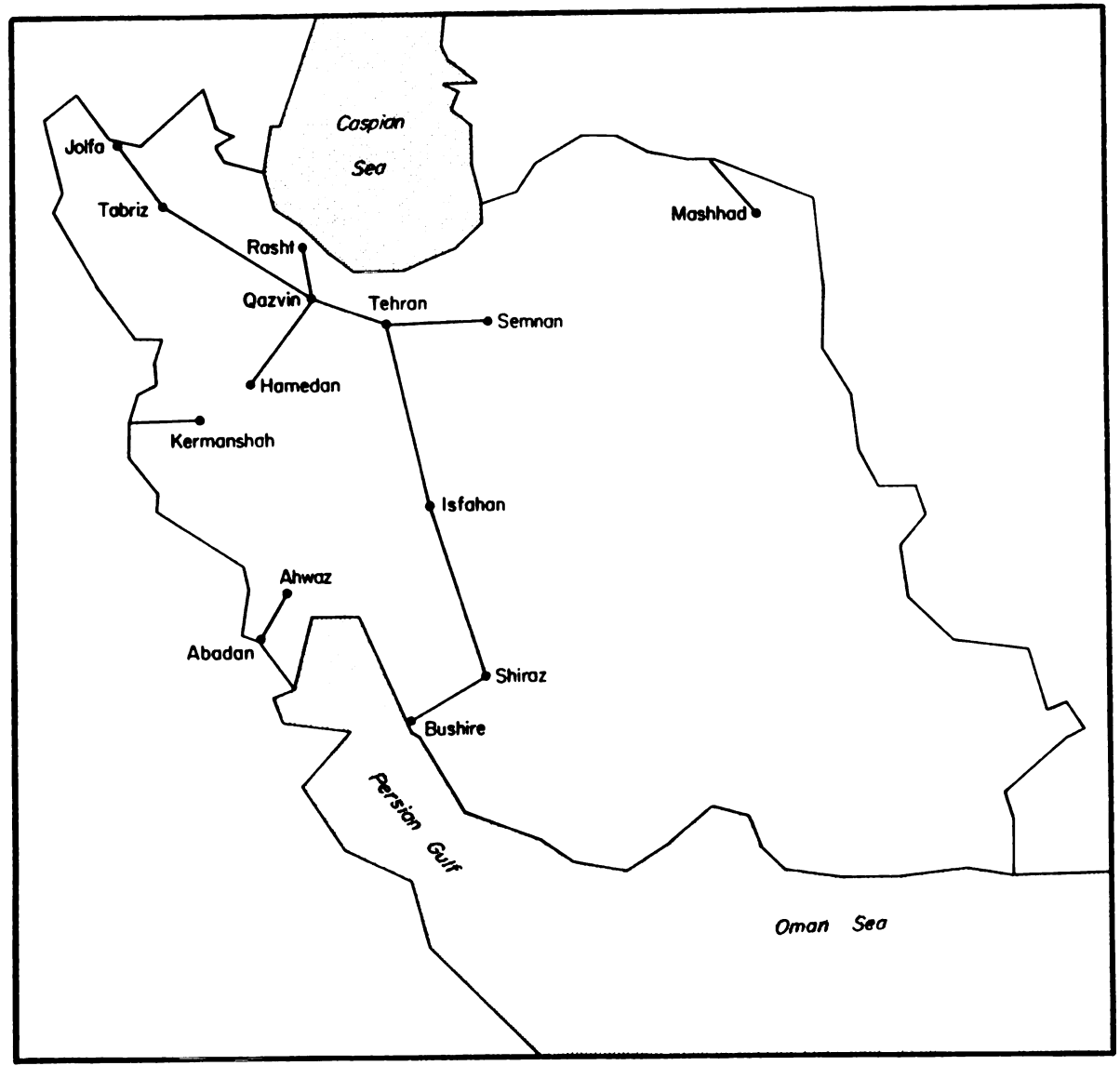


Figure 4.

Roads in the southern part were developed and built mainly by British interests. One of the important lines which British interests pushed was a road between Bushire to Shiraz (a city in the south). Their purpose was mainly for exploiting Iranian resources. This part of the country has the richest coal, copper and other minerals mostly which are found around Kerman; with construction of this road Bushire became a major port in southern Iran. In actuality, this road represented the first penetration line from the seacoast to interior areas. Bandar Abbas did not grow as fast as Bushire because the road which connected it to inland areas was not completed until after World War I. The road connecting Bandar Abbas to Kerman provided a good facility for foreign interests to have access to the central part of Iran and its rich mineral resources.

The completion of new roads changed the economic and social character of interior centers. They became major population centers and functioned as wholesale distribution points in the rapidly evolving transport system. A comparison between the second stage of transportation development identified in Ghana and compared with Iran shows some similarities. According to Taaffe et al. three factors were responsible for the growth of penetration lines. These were the desire (1) to reach potential agricultural areas. (2) to locate near areas of mineral exploitation and (3) to

connect major trade centers on the seacoast with administration centers in the interior. The major differences between the evolution of the transport networks in Ghana and Iran were the political factors influencing development. At the time of highway and railway expansion, Ghana was a colony and the armed forces and administrative staff of the mother country lived in Ghana. This situation does not apply to Iran, as her economy was deeply dependent on a number of foreign countries. Foreign economic interests were an important factor initially in building new roads in Iran, but not as strong as in Ghana. The strategic location of Iran in the Middle East encouraged competition between a number of foreign countries as they tried to extend their influence in Iran and control the economic and political livelihood of the country. However, the main political characteristic in this initial period was the competition between Great Britain and Russia in regards to Iranian resources. While Russia was searching for new and expanding markets in Iran and attempting to reach the rich agricultural area in the northern province, Britain was more interested in making a profit from oil in Iran.

SECOND PERIOD: 1914-1962

During World War I, revolution and civil war in Russia reduced Russian exports to Iran. There was at the same time

a gradual expansion of British interests in Southern Iran. After the war, the economic and political situation within Iran changed significantly. Centralization, modernization and a change in the group having power were the major contrasts between this and the previous period. The decreasing Russian influence was replaced by Great Britain, especially in its acquisition of the Anglo-Iranian Oil Company prior to its nationalization in 1953. The modernization in Iran brought new economic and social conditions to the country. Roads were improved greatly during the war and the post-war period. The improvement was partly attributed to the desire of Britain to obtain new markets in Iran. This stage in the country's transportation evolution is characterized by the improvement of the roads away from the nodes along the penetration lines. The construction of these roads was initially limited to a few roads connecting the major cities in the previous period. In the second period the rate of road expansion was faster than before. The stage which Taaffe et al. defined as encompassing the improvement of feeder lines occurred in Iran toward the end of this second period. The expansion of feeder lines in the north and southwest was much more intensive than in the southeast. A hostile environment is the major obstacle on the expansion of feeder lines in the eastern part.

During this second period the development of the oil industry came to play a significant role in the expansion

of the transportation network. The first refinery was established in Abadan (a port on the Persian Gulf) in 1925. The construction of this refinery changed the trade pattern for the movement of oil products in Iran. Increasing the refinery output gradually replaced the import of oil production from other countries. In 1929 Russia supplied 80 percent of petroleum products consumed in Iran but by 1933 it was reduced to 55 percent.

The distribution of oil products required new roads most of which were extended from the south to the north. Approximately 1400 miles of first class highways in the country in 1930 were new.[1] Table 1 shows that rapid road construction expanded during 1923-38, while Table 2 shows the rapid increase in the number of cars and other vehicles imported. The first motor car appeared in the streets of Ahwaz in 1912. However, serious use of the automobile for long distance travel did not begin until after World War I. The completion of the Trans-Iranian railroad in 1938 did not compete with road expansion. This is because the railroad was isolated from all international rail systems, and also because the two ports which were connected by this railroad were not the major trade centers on the north and south coasts. Under the government's Second Plan, 6.2 billion rails[2] or nearly

---

[1] Julian Bharier, Economic Development in Iran 1900-1970, Oxford Univeristy Press, 1971, p. 314.

[2] Rail is 0.07 dollar.

Table 1: Road Construction in Iran: 1923-38 (in miles)

Year of Starting Construction	First Class Road	Second Class	Third Class	Total
1923	380	--	--	380
1924	--	--	--	--
1925	1.130	--	--	1.130
1926	760	450	100	1.310
1927	--	--	--	--
1928	130	980	720	1.830
1929	--	550	750	1.300
1930	410	1.620	1.250	3.280
1931	100	560	--	660
1932	--	180	180	360
1933	--	370	120	490
1934	--	110	270	380
1935	170	--	270	440
1936	20	130	190	340
1937	110	40	80	230
Total	3.210	4.990	3.930	12.130
1938	--	--	--	1.240

Source: 'La Route en Iran' in Bank Meli, Iran Bulletin, No. 25, 1938, p. 223.

Table 2: Import of Cars, Trucks and Other Vehicles in 1924-50 (value in million rails)

	Cars		Trucks		Other Vehicles	
Year	No.	Value	No.	Value	No.	Value
1924	529	--	103	--	--	--
1925	1.111	--	492	--	--	--
1926	1.330	10.3	967	12.6	--	--
1927	1.112	8.0	977	11.9	--	--
1928	1.369	11.1	1.760	23.2	23	0.5
1929	1.529	14.4	1.515	19.1	10	0.2
1930	566	6.1	598	10.2	1	0.1
1931	315	5.1	570	16.9	4	0.1
1932	292	5.8	627	25.5	--	--
1933	617	8.6	1.435	33.1	9	0.2
1934	1.325	17.9	1.394	28.6	31	1.1
1935	1.317	20.9	1.800	37.7	20	0.9
1936	1.047	15.8	1.938	48.4	41	2.6
1937	400	6.0	1.496	41.3	15	0.6
1938	228	3.7	590	12.3	6	0.4
1939	444	7.6	99	2.0	5	0.3
1940	735	14.3	327	7.4	12	0.7
1941	551	11.6	845	14.6	1	0.0
1942	89	3.1	42	1.8	1	0.1
1943	117	6.0	92	3.7	4	0.3
1944	78	3.9	501	31.6	1	0.0
1945	242	7.6	2.716	86.1	46	1.6
1946	1.508	58.3	4.099	143.0	131	6.6
1947	2.969	141.5	2.179	121.1	155	6.6
1948	2.062	118.4	1.313	18.2	93	5.8
1949	3.329	189.2	2.844	261.6	179	11.9
1950	2.574	136.2	2.330	213.4	142	10.6

Source: Foreign Trade Statistics of Iran.

10 percent of the total budget was allocated for the construction of railroads.[3] The Trans-Iranian Railway, during its early stages of operation, faced many operating problems. One was the aridity of the country traversed and the use of steam power engines. For this reason the highway expansion became important even in an area directly served by railroad. Under the Second Plan, 19 million rails went to highway improvement and completing a number of unfinished roads. A total of 1,480 miles of feeder road were built. A major highway was constructed connecting the eastern and western parts of the country. This is part of a major highway linking Europe with Central Asia.

The completion of a small refinery in Kermansha (a city in the western part of Iran) was another reason for

---

[3]Regional planning in Iran came into being with the first Seven Year Plan in May 1949. During the First (1949-1955) and Second Plan (1956-1962) no specific goals were set. These plans consisted in spending the allocated money for planning and organization. They were limited to special programs of government investment and they were not the development plans which covered the whole economy. During the Third Plan (1963-1968) planning and organization were carried out. The Third Plan was supposed to provide coordination between the country's development and non-development expenditures. During the Fourth Plan (1968-1973) the main goals were the relocation of firms and the establishment of industrial plants near the large cities, the establishment of new factories within a 120 kilometers of Tehran, and the correction of the tax policy. The main goal of the Fifth Plan (1973-78) is to stimulate regional development. Five objectives of this plan are relevant to economic growth, income distribution, social and economic balance between regions, improving employment opportunities in all regions, reduce migration, and control internal population movement.

building a new road. Oil products were carried from the Kermanshah refinery by tanker to southern ports where they were distributed all over the world by different foreign countries. The improvement of transportation facilities brought increased concentrations of population in some areas. Figure 5 shows the expansion of the transportation network in this period. The areas of most extensive road building were in the north and southwest. Lateral interconnection was also well developed in this period. Only the eastern part of the country remained without a major transport link. Areas with extensive lateral interconnection in the interior experienced urban growth. These cities attracted many immigrants from small towns and rural areas. The growth of cities like Hamedan, Esfahan and Shiraz are examples. The declining Russian influence in the north led to cities like Tabriz, Rasht, and Mashad losing some of the previous economic significance.

During World War II Iran was occupied by both British and Russian forces. Occupying forces built and repaired many of the country's roads. The decreasing British political role in Iran after World War II meant her benefit from the Iranian transportation and other services declined. Gradually the United States replaced Great Britain and provided financial aid for road construction.

Following World War II, the economic history of Iran can be divided into two major periods. The first period

IRAN HIGHWAY NETWORK (1943)

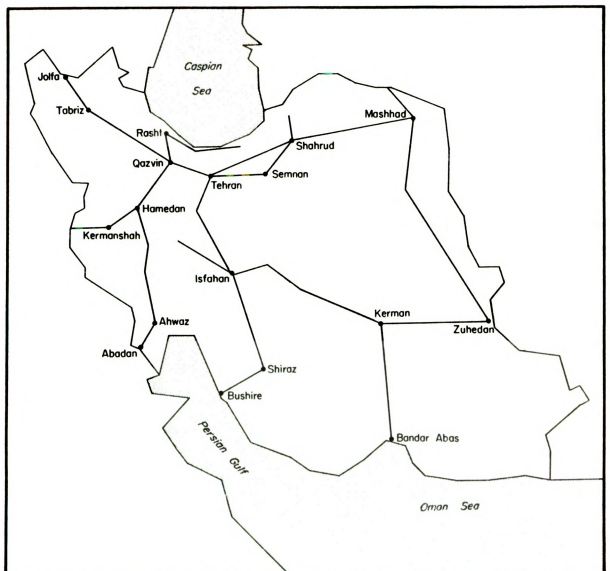


Figure 5.

is one of preindustrialization; it extended from the end of World War II to 1963. The second is following land reform which began in 1963. Before land reform Iran was predominantly an agricultural society as evidenced by the amount the agricultural sector contributed to the GNP and the labor force. Agriculture's contribution of the GNP remained about 50 percent from 1926-50; it fell to 33 percent in 1952. About 75 percent of the labor force was engaged in this sector in 1952; the industrial sector remained relatively small at this time. More attention was also being paid to building of an infrastructure, especially roads and railroads. Toward the end of this period (1926-50) Iran had 1,000 miles of all weather roads and 6,000 miles of other roads. Increased oil revenues provided the major source for transportation development while the actual development and improvement of agriculture and industry were ignored. The process of economic changes which started before the second period was taking place gradually. Cities that grew previously continued to grow as the traditional bazaar replaced westernized shops in major cities. During the period of oil nationalization from 1951-1955, the Abadan refinery was shut down while another refinery in Kermanshah continued to operate and maintain oil supplies for domestic consumption and export. Owing to the significant

role of Kermanshah refinery in the producing of oil, road construction increased at a high rate in western Iran. Most new roads served as feeder lines and had no real artery. The expansion of feeder lines along the southern coast proceeded very slowly because of waterway competition.

THIRD PERIOD: 1963 TO THE PRESENT

Land reform occurred in 1963 and because it deeply affected the Iranian economy, it identifies a separate period in the country's development. One of the major changes was the sharp decline in the share of workers in the agricultural sector and agriculture's contribution to the GNP. Table 3 shows the combination of different sectors to the GNP from 1962-1971. According to Clark and Carey the share of the agricultural sector in GNP decreased from 80 percent in 1926 to 33 percent in 1953, and to 25 percent in 1971.[1] During the 1926-1971 period the Iranian economy became increasingly more dependent on oil production. Figure 6 shows oil production from 1913-1974. After the nationalization of foreign oil companies in 1953, the United States, as mentioned above, increased its role in the Iranian economy at the expense of Great Britain. With land reform the economy has been

---

[1]Jane Perry, Clark Carey, and Andrew Galbraith Carey, "Iranian Agriculture and Its Development 1952-1973," Middle East Studies, Vol. 7, 1976, pp. 359-382.

Table 3: Gross National Product of Iran and It's Main Components 1962-71

Component	1962	1965	1970	1971
Agriculture	29.1	25.9	19.9	16.5
National Oil	13.0	14.8	18.7	20.0
Industry and Mining	14.9	17.1	22.3	32.8
Construction	4.4	5.1	4.2	4.2
Water and Power	0.7	1.5	2.5	2.6
Services	44.6	43.9	41.6	42.9
Transportation and Communication	7.8	6.9	7.0	6.8
Domestic Trade	11.3	10.7	8.0	7.3
Rent	6.5	6.1	5.8	5.0
Public Services	8.1	10.8	11.7	14.0
Private Services	5.0	4.7	4.9	4.9
Net Factor Income from Abroad (Excluding Oil)	-1.6	-1.7	-2.5	-2.2
Gross National Product	100.0	100.0	100.0	100.0

Source: Bank Markazi, Annual Report and Balance Sheet 1971. Tehran Bank Markazi, 1972, p. 15.

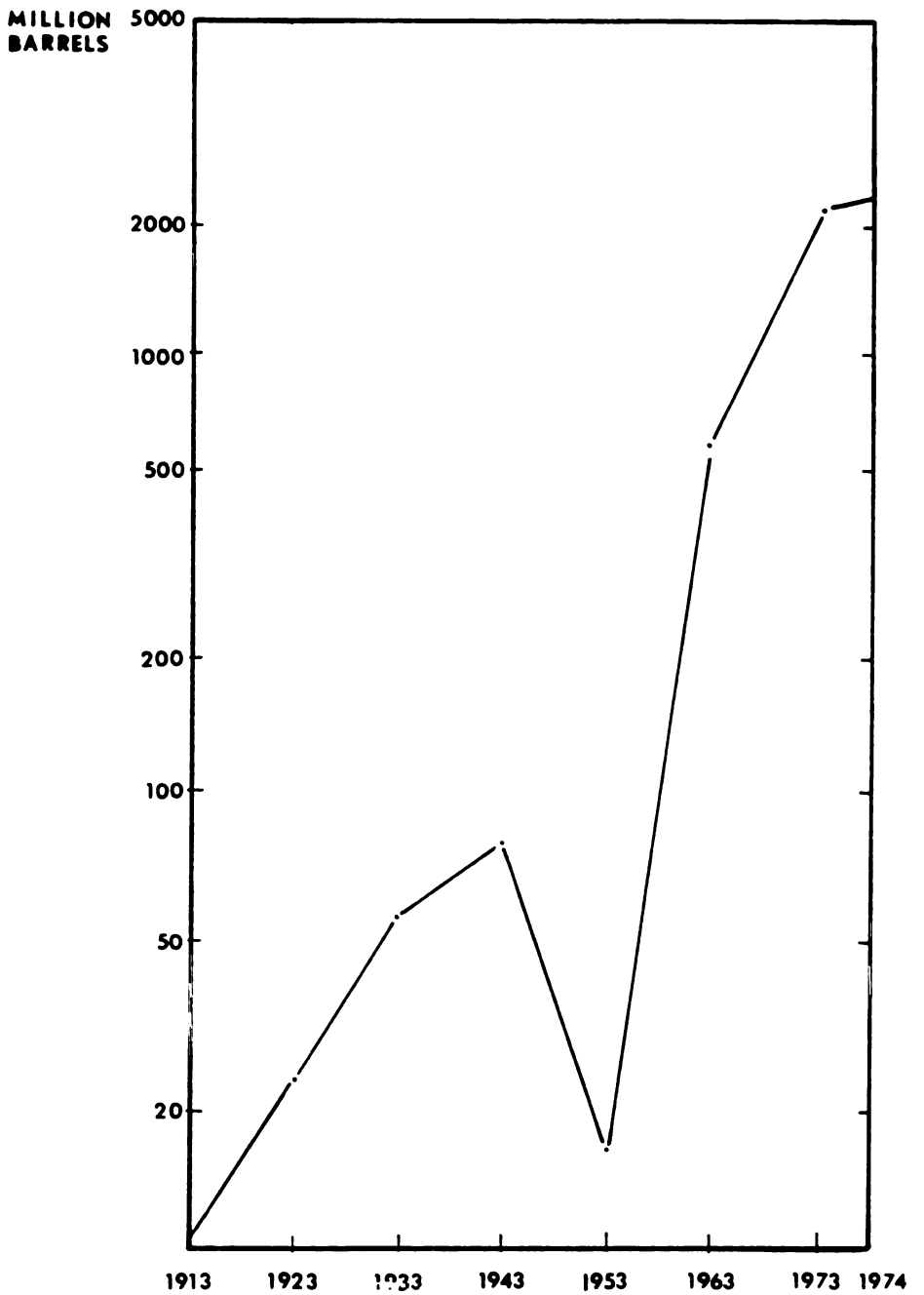


Figure 6. Oil Production From 1913 to 1974.

Source: Iranian Economic Census, 1975.

more dependent of foreign countries, especially the United States. Rapid growth in industrial activities brought in transportation and communication services. Mining activities also gained a growing share of the economy. Foreign interests contributed to the modernization of the mining activities. During this third period, some roads have been built in less populated southeastern parts of Iran. The discovery of large copper deposits near Kerman and lead and zinc deposits near Yazd have encouraged mining in this area and resulted in their economic growth. By the beginning of the Fourth Year Plan (1968-1973) heavy industrial plans were being designed. They included a steel mill complex in Esfahan, heavy metal plants and aluminum smelter in Arak, and a machine tools and tractor factory in Tabriz. Also during the 1968-1973 period two oil refineries were established in Tehran. The construction of these industrial plants brought about a greater concentration of industrial activity into only a few major cities.

CHAPTER IV

GRAPH THEORY ANALYSIS OF THE IRANIAN HIGHWAY NETWORK

The preceding chapter described the historical process of transportation development with respect to the economic changes in Iran. In this chapter the graph theory model and its application in analyzing the expansion of the transportation network of Iran are discussed.

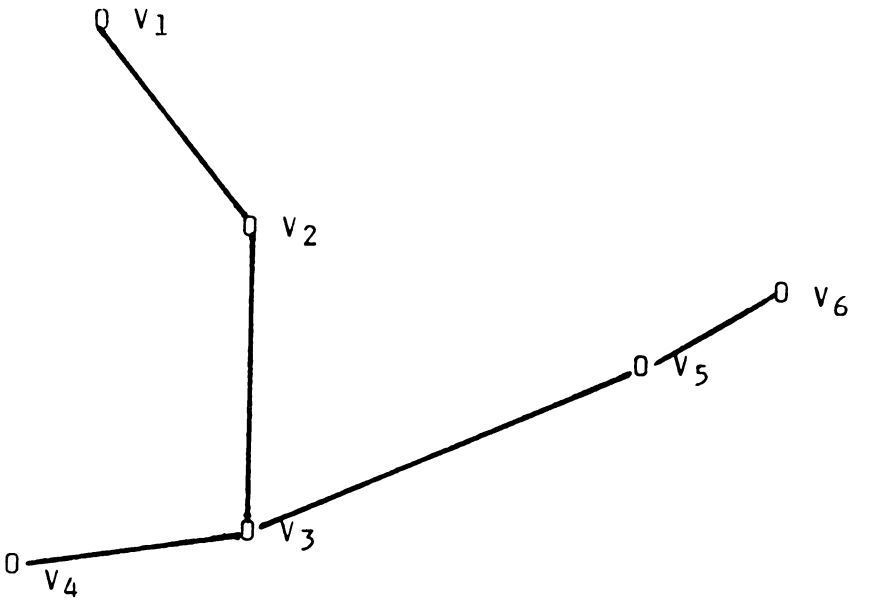
THE GRAPH THEORY MODEL

The Graph Theory Model is considered as a useful tool to analyze the transport network. It is especially useful in geographic investigations which consider the spatial structure of the transportation network. In order to apply the graph theoretic measurement to the structure of the network, the network is depicted as a graph. A simple definition of a graph is an abstraction of the transport system in which a set of nodes and linkages describe the topological structure of network. One of the major discussions about graph theory application in geography is by Karl Kansky (1963). He provides a complete picture of network structure and the graph theory model. According to Karl Kansky, a graph is a symbolic language. He believes that it is practically impossible to measure the structure of transport network without using the

symbols derived from graph theory. Garrison[1] and Marble have written another useful article on graph theory. According to Garrison's definition, graphs are an array of points which are connected or not connected to one another by lines. There is no concern about the length or orientation of the lines nor whether they are straight or curved. Analyses of graphs may reveal a common topological structure buried in apparently unlike networks. He defines this model as a tool which measures the network's properties. A network consists of three fundamental parts which are: (1) origins, (2) routes, and (3) destinations. Each occupies a geographical location. Kansky also includes examples of networks (Figure 7). A graph is a symbolic language which shows the transport network, and it is possible to measure the properties of that network structure by using graph-theoretic measurements. Kansky discusses a number of graph theory measurements in various parts of his book. One section is on non-ratio graph-theoretical measurement which measures the whole structure of network and its individual elements. The second is ratio-measurement which measures the relation between the whole structure of the network and the remaining elements.

---

[1]W. L. Garrison and D. F. Marble, "Factor Analytic Study of the Connectivity of Transportation Network," Papers of Regional Science Association, Vol. 12, 1968, pp. 231-290.



Nodes

Nodes	V1	V2	V3	V4	V5	V6
V1	0	1	0	0	0	0
V2	1	0	1	0	0	0
V3	0	1	0	1	1	0
V4	0	0	1	0	0	0
V5	0	0	1	0	0	1
V6	0	0	0	0	1	0

Connection Matrix of the Growth

Figure 7. Graph Representation of a Small Network.

USE OF GRAPH THEORY

The first study of a network in a topological sense began with Eule in 1736. The pioneers in geography who utilized graph theoretic measurements in their study to measure the structure of transport network were Garrison (1960) and Nystuen and Dacey (1961) who elaborated on the use of the connectivity matrix to make a nodal hierarchy for analyzing the interstate highway system and telephone message flows. Karl Kansky (1963) derived the basic graph theoretic measures and applied it to an analysis of highway structure and its relationship to economic development. Pitts in 1965 utilized this tool to compute the accessibility of Moscow during the twelfth and thirteenth centuries. A later study was done by Gauthier (1968) on a portion of the Brazilian highway in São Paulo State. He utilized graph theory to analyze the relations between transportation development and urban growth. In this area in Brazil, he used a powering of the matrix to show changes in the Brazilian highway network through time. Haynes and Pauline (1971) in another study extended the use of graph theory by attempting to explain the relationship between variations in the transport network structure and general economic and demographic development in Quebec. Kanaan (1976) as mentioned above utilized the connectivity matrix to examine the changes in the connectivity of the road system in Syria through time. Laurence Lewis and David Raynolds (1967), also cited above, used the graph theoretical measurement to measure the complexity, connectivity, and accessibility of the transport network in Puerto Rico.

GRAPH THEORETIC MEASURE

There are two types of graph theoretic measures which have been applied to define the characteristics of a network. As Kansky stated these two measures include a measure of the transport network in its entirety and measure of individual elements of the transport netowork. In most cases the geographical characteristics of a region shaped the structure of transport network. The first types of measurement are the diameter, cyclomatic number, redundancy ration, and the alpha, gamma and beta indexes.

1. Diameter:

The diameter is the minimum number of linkages which connect a pair of nodes which are the longest distance apart in the network. As the connectivity increases, the diameter decreases. The diameter is directly affected by the size of the graph and inversely affected by its connectivity.

2. Cyclomatic Number:

The number of independent circuits in a network defines the cyclomatic number. A disconnected graph and any tree have a cyclomatic number equal to zero. A highly connected network is one of the best tools to measure the evolution of a transportation networks in a country. The major characteristic of transport networks in developing countries is generally their lower cyclomatic number.

3. Gamma Index:

This index defines a simple ratio between the present number of edges and maximum possible edges (linkages) in a network. The gamma index increases by increasing the number of linkages. It is possible that the emergence of a new node decreases the ratio of the gamma index. The gamma index can be computed from this formula: $g = \frac{c}{3(v - 2)}$

where, g = Gamma index

c = Number of edges

v = Number of nodes

The value of Gamma index has a range between zero and one. As the number of edges added to the network increase the gamma index approaches one. Fewer edges gives a gamma index that approaches zero.

4. Alpha Index:

A ratio between the actual number of circuits to maximum number circuits in a network defines the alpha index. It is computed by this formula:

$$\alpha = \frac{\text{actual circuits}}{\text{maximum circuits}} \quad \text{or} \quad a = \frac{ev - 1}{2v - 5}$$

where: α = alpha index

v = number of nodes

e = number of edges

The alpha index ranges between zero and one or sometimes between

zero and a hundred. In a minimally connected network α is equal to zero while in a highly connected network α is equal to one. Multiplying the ratio by hundred provides the percent of redundancy.

5. Circuits:

A circuit is a closed path between two nodes in which the initial node of the linkage sequence will coincide with the terminal node.[1] Circuits may be obtained from this formula: $e - v + 1$

where: e = number of edges

v = number of nodes

6. Redundancy Ratio:

This ratio is a crude measure of the total circuit in a network. The higher the value, the greater connectivity in the network.

A second group of measurements are used in graph theory studies; they also measure individual elements of the transport network. These include the following:

(1) Dispersion Index: According to Haggett and Chorley, this index is the sum of all the elements in the shortest path matrix. By definition dispersion (N) of a network is:

$$D(N) = \sum_{i=1}^{n} \sum_{j=1}^{n} d(i,j)$$

where: $i = 1$

$j = 1$

---

[1] Edward J. Taaffe and Howard L. Gauthier, Geography of Transportation, Englewood Cliffs, N.J., Prentice Hall, 1973, p. 226.

dij = shortest path between two nodes in the network. A highly connected network has a high dispersion value.

(2) Mean Local Degree: This is the average number of nodes connected to all nodes in the network.

(3) Accessibility: One of the basic structural characteristics of any network is its accessibility. The simple measure of accessibility can be derived from the connectivity matrix. Any network can be represented as a matrix. A matrix consists of a set of rows which define origin nodes and columns which define destinations. A value of one will indicate this connection. (Figure 7).

A zero element indicates an absence of a linkage between two nodes. The zero element is also recorded in the cells which make up the diagonal of the matrix. In a matrix only the presence or absence of connectivity are recorded for this connection matrix. Figure 7 gives an example of a graph which is represented in matrix form. Nodal accessibility or relative position of an individual node in a network increases when additional linkages are added to the network. For purposes of making a hierarchy of the cities according to their level of accessibility and to show the changes in the nodal accessibility of a network through time, the shortest path matrix was applied in this study to measure the nodal accessibility. Kansky has stated that accessibility is computed in terms of the distance between nodes. In order to

determine the shortest path between two nodes for the first time, Shimbel[1] introduced what is called the shortest path matrix. According to this method the node which has the shortest path connection to the other node has the greater accessibility. In fact there is an inverse relationship between the path connecting the node to all other nodes and the accessibility of the node. In the shortest path matrix the diameter which has the maximum number of linkages between each pair of nodes is shown by the largest value.[2]

ANALYSIS OF IRAN'S HIGHWAY NETWORK

In this study emphasis is placed on the evolution of transport network in Iran. It is believed that measures of the connectivity of the network are the best methods to show the changes which occur in the network through time. As Kansky states connectivity is the most important structural property of a network. The alpha, gamma, and beta indexes are the three graph theoretic measures which measure the connectivity. They are used to examine the highway structure in Iran during three different years. The data for analyzing the strucuture of the highway

---

[1] Alfonso, Shimble. "Structural Parameters of Communication Networks," Bulletin of Mathematical Biophysics, Vol. 15, 1963, pp. 501-597.

[2] P. Haggett and R. Chorley, Network Analysis in Geography, New York, St. Martin's Press, 1969, p. 43.

network are derived from three maps. The first map is the 1914 highway network, the second one for 1943, and the third map for 1971.

This study emphasizes only the first class roads in Iran. The first map which focuses on the 1914 highway pattern is comprised of 10 nodes and 9 linkages. The second map contains 29 nodes and 29 linkages. The third map has 146 nodes and 187 linkages. In terms of graph identification, Iran's highway graph[1] is a plannar[2] or connected graph.

In order to compute the various measures and indexes three separate computer runs were made. Measuring values for a small graph does not involve any great difficulty and can be done easily. But with a large graph and a large number of nodes and linkages, the computation created many difficulties because of computer limitations. For this reason it was necessary to divide the 1971 network in four different regions. In order to make a comparison between 1914, 1943, and the 1971 networks, the network in the first and second periods were also divided in four regions as follows: (1) the Caspian Sea region, (2) the Persian Gulf region, (3) the Northeast region, and (4) the Southeast region. Figure 8 shows these four

---

[1]The network can be regarded as a graph. Actually the graph is an abstraction of the network.

[2]Plannar graphs are charcterized as having no intersection or common point except at the vertix.

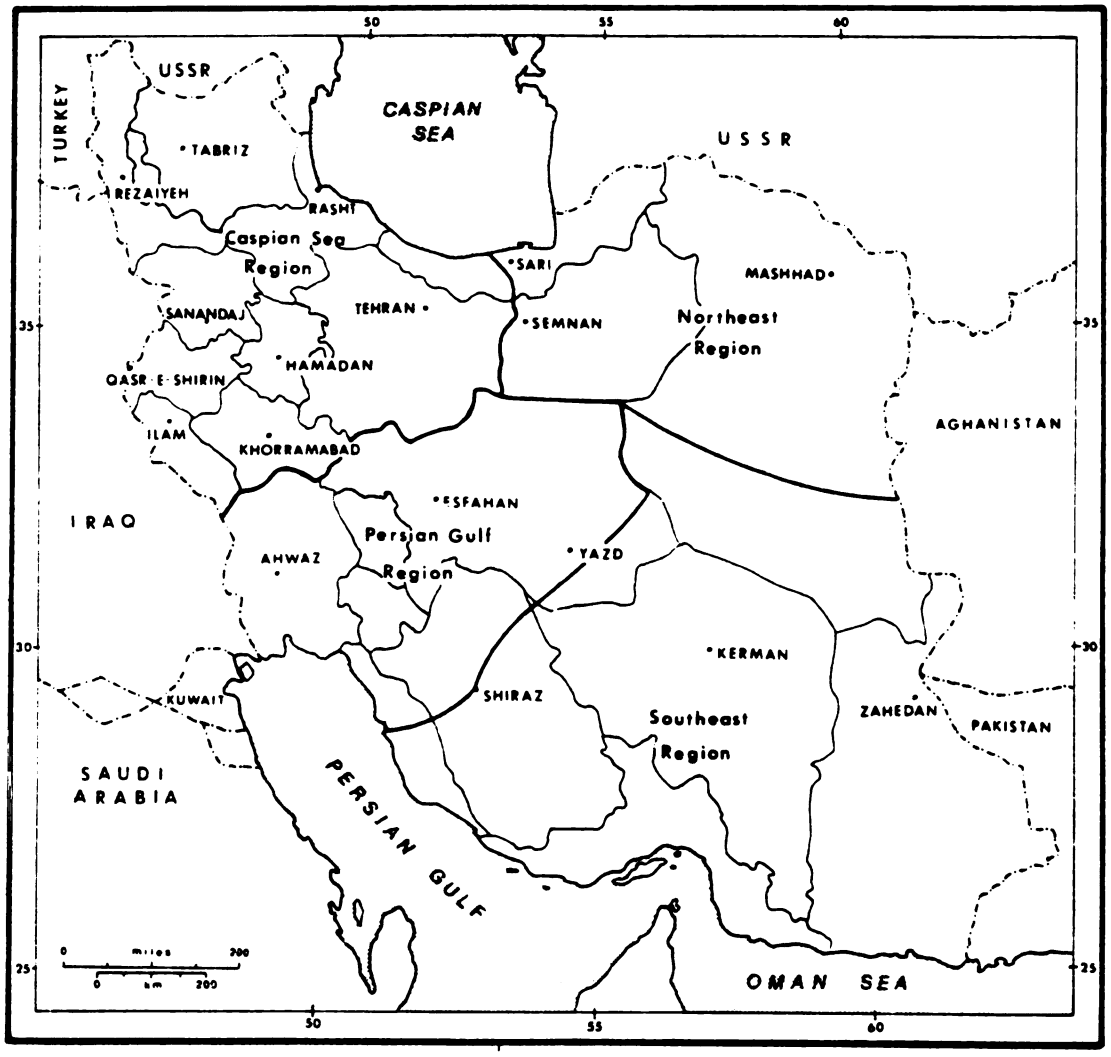


Figure 8. Division of the Regions.

divisions.

1. The Caspian Sea Region

This region extends from the northwest to the east and includes much of the central part of the country. It covers the area along the Caspian Sea shoreline. A comparison of the network for 1914, 1943, and 1971 suggests that the number of nodes and linkages increased. These are shown in Tables 4.1, 4.2, and 4.3. This increase shows the expansion of the network during these periods. The diameter increased from 4 in 1914, to 6 in 1943, and 14 in 1971 which indicates that as expansion occurred, the size of the network increased. The connectivity likewise decreased which supports Haggett's notion that the diameter is directly affected by the size of the graph and inversely by its connectivity. The dispersion of the network increased from 122 in 1914 to 544 in 1943 and 21,744 in 1971 network; this documents the overall expansion of the network through time. The redundancy ratio decreased from .5246 in 1914 to .3603 in 1943 and .1711 in 1971 network which also suggest a decrease in the connectivity. By definition a highly connected network has a high redundancy ratio. The cyclomatic number increased from 1 in the 1914 network to 18 in 1971. This increase suggests that a growth in the number of circuits. This increase is also reflected in a decrease in the Alpha index from 4.76 in 1914 to 2.56 in 1943 and 1.02 in

COMPUTATION OF THE SHORTEST PATH MATRIX FOR THE CASPIAN SEA REGION

Table 4.1: 1914 Network. The Caspian Sea Region

The number of nodes = 8
The number of edges = 8
Diameter = 4
The system dispersion index = 122
The redundancy ratio = .5246
The mean local degree = 2.00
The cyclomatic number = 1.00
The alpha index = 4.76
The gamma index = 14.29

Table 4.2: 1943 Network. The Caspian Sea Region

The number of nodes = 14
The number of edges = 15
Diameter = 6
The system of dispersion index = 544
The redundancy ratio = .3603
The mean local degree = 2.14
The cyclomatic number = 2.00
The alpha index = 2.56
The gamma index = 8.24

Table 4.3: 1971 Network. The Caspian Sea Region

The number of nodes = 61
The number of edges = 78
Diameter = 14
The system dispersion index = 21,744
The redundancy ratio = .1711
The mean local degree = 2.56
The cyclomatic number = 18.00
The alpha index = 1.02
The gamma index = 2.13

1971 network. Gamma indexes likewise declined which is indicative of expansion within the transport network.

The results obtained from the analysis of the connectivity matrix show an increase in the nodal accessibility for the networks in the three years. The hierarchial ranking of nodal accessibility for the 1914 network shows that Tehran, Qazvin, and Tabriz had the highest accessibility. In the 1943 network Qazvin still had the highest accessibility with Tehran, Hamedan in the next highest range. In the third network Rovan, Takestan, and Qazvin had the highest accessibility. Although some of these cities with high rankings are not the major cities, they have a high accessibility compared to other cities in the network.

2. The Persian Gulf Region

This region covers mostly central Iran and extends towards the south and southwest part of the country. This region covers the area along the Persian Gulf where major ports and large oil fields exist. The transport network in this area is more intensive than in the eastern part. This region was second to the Caspian Sea Region in the number of increases in nodes and linkages from 1914 to 1971. The diameter also increased which meant the size of the network increased. As the Tables 4.4, 4.5, and 4.6 show, like Region One, the dispersion of the network increased and the redundancy ratio decreased: the

COMPUTATION OF THE SHORTEST PATH MATRIX FOR THE PERSIAN GULF REGION

Table 4.4: 1914 Network

The number of nodes = 5
The number of edges = 4
Diameter = 4
The system dispersion index = 40
The redundancy ratio = .6250
The mean local degree = 1.60
The cyclomatic number = 0.00
The alpha index = 0.00
The gamma index = 20.00

Table 4.5: 1943 Network

The number of nodes = 10
The number of edges = 9
Diameter = 7
The system dispersion index = 282
The redundancy ratio = .3546
The mean local degree = 1.80
The cyclomatic number = 0.00
The alpha index = 0.00
The gamma index = 10.00

Table 4.6: 1971 Network

The number of nodes = 42
The number of edges = 57
Diameter = 10
The system dispersion index = 9114
The redundancy ratio = .1935
The mean local degree = 2.71
The cyclomatic number = 16.00
The alpha index = 1.95
The gamma index = 3.31

cyclomatic number increased from zero in 1914 and 1943 to 16 in 1971. Because of the nonexistence of circuits in the 1914 and 1943 networks, the Alpha indexes were zero, but in 1971 it increased to 1.95. Increasing the Alpha index suggests a more connected network in comparison to previous networks. But the Gamma index decreased here as in the Caspian Sea Region. On the whole, the nodal accessibility increased in the Persian Gulf Region. In 1914 cities like Fasa and Shiraz had the highest level of nodal accessibility while in 1943 other cities like Esfahan, Qum, and Naeen had the highest level. By 1971 cities like Tanyemalau, Khoramebad, Ahwaz were at the top of the accessibility ratings.

3. Northeast Region

This region consists mostly of the northeastern part of Iran and extends toward the south. Compared to the Caspian Sea Region this area has a less intensive network especially toward the south where the number of linkages and nodes decrease. This area is less populated which is mainly due to a hostile physical environment and absence of a prosprous economy. In the 1914 network this region contained only a few disconnected subgraphs. But a comparison of the 1943 and 1971 networks shows the changes which took place in the structure of the transport network. First the number of nodes and linkages grew considerably as Tables 4.7 and 4.8 show. The diameter

COMPUTATION OF THE SHORTEST PATH MATRIX FOR THE NORTHEAST REGION

Table 4.7: 1943 Network. Northeast Region

The number of nodes = 6
The number of edges = 6
Diameter = 3
The system dispersion index = 54
The redundancy ratio = .6667
The mean local degree = 2.00
The cyclomatic number = 1.00
The alpha index = 10.00
The gamma index = 20.00

Table 4.8: 1971 Network. Northeast Region

The number of nodes = 37
The number of edges = 47
Diameter = 10
The system dispersion index = 6252
The redundancy ratio = .2190
The mean local degree = 2.54
The cyclomatic number = 11.00
The alpha index = 1.75
The gamma index = 3.53

increased from 2 in 1943 to 10 in 1971 and the dispersion measure from 54 to 6252, both indicative of expansion in the network. The Redundancy ratio decreased from .667 to .219 while the cyclomatic number increased from 1.00 in 1943 to 11.00 in 1971. As in the previous regions, the Alpha and Gamma indexes decreased from 1943 to 1971, all which indicate that additional linkages entered the network and expansion took place.

4. Southeast Region

This region covers the southeast part of the country. In 1914 no linkages or nodes existed. Only after 1943 were a few roads built. A comparison between the 1943 and the 1971 netowrks shows only a small increase in the number of nodes and linkages (see Tables 4.9 and 4.10). As in previous regions the diameter increased, the dispersion of network increased, the redundancy ratio decreased, and the cyclomatic number increased. The Alpha and Gamma indexes also decreased which suggests that the additional linkages added to the network have not improved the minimally connected network. It should be noted that in this region the improvement of the transport network has occurred very slowly. The hostile environment is partly responsible for this situation. This southeast region has the lowest population densities in Iran and only a few scattered settlements. The hierarchy of nodal accessibility reveals that in 1943 Yazd, Kerman, and Gonabad had the highest level of

COMPUTATION OF THE SHORTEST PATH MATRIX FOR THE SOUTHEAST REGION

Table 4.9: 1943 Network. Southeast Region

The number of nodes = 7
The number of edges = 7
Diameter = 4
The system dispersion index = 88
The redundancy ratio = .5568
The mean local degree = 2.00
The cyclomatic number = 1.00
The alpha index = 6.67
The gamma index = 16.67

Table 4.10: 1971 Network. Southeast Region

The number of nodes = 23
The number of edges = 24
Diameter = 11
The system dispersion index = 2402
The redundancy ratio = .2202
The mean local degree = 2.09
The cyclomatic number = 2.00
The alpha index = .87
The gamma index = 4.74

nodal accessibility. In 1973 the percentage of nodal accessibility increased considerably as other cities like Dehshir and Surman, which are located on the boundary between the Persian Gulf and southeast regions, had the highest levels of nodal accessibility.

Now that we have demonstrated the evolution of the highway system in terms of network geometry, we can examine transportation development in light industrial and population changes occurring in this century.

URBAN AND INDUSTRIAL DEVELOPMENT

The growth of Iran's modern industry, which is both large scale and capital intensive, mostly produces consumer goods purchased by the high income group. As Oddvar Aresvik has stated, Iran's industrialization is not taking a right form.[1] Income distribution became increasingly more unequal during 1962-72 than previously. Recent income data estimate that the average per capita income in urban areas is four times more than in the rural areas. As a result of the deterioration of rural conditions and the concentrations of wealth in a few major cities, the migration rate between rural areas and the largest cities is growing rapidly. The existence of an income gap between rural and urban income level creates a regional imbalance in terms of the distribution

[1] Oddvar Aresvik, The Agricultural Development of Iran. Praeger Special Studies in International Economic and Development, 1976, p. 271.

of roads and other services. According to Aresvik, the per capita income in Tehran is 45 percent higher than the next largest cities and 70 percent higher than that of other small towns. The rural areas in the eastern and southern parts of the country have the lowest average family incomes.

Changes in the economy have affected the pattern of immigration. The migration rates before and after land reform show different forms. Between 1900-55 about 61 percent of the internal population movement was between urban places and the remaining 39 percent was between rural and urban areas. Of 1.76 million migrants moving to twenty-five towns in Iran, about 48 percent came to Tehran and 22 percent into oil towns like Abadan and Ahwaz. Between 1956-66 the pattern of migration changes and the proportion of total immigrants from rural to urban areas increased to 90 percent; this contrasts with the 44 percent estimate of Iranian planners. Table 5 shows the population growth in Iran between 1900-66 and Table 6 the population growth in urban places between 1900-66. Rapid population growth has occurred chiefly in the major cities which are the centers of industrial activity such as Tehran, Esfahan, Tabriz and Mashad. Oil towns like Kermanshah and Abadan and mining towns such as Kerman and Yazd have also grown. Figure 10 shows the comparative population size of Iranian cities in 1963. In Figure 11 the hierarchy of large, medium,

Table 5: Annual Rate of Population Growth

Period	Urban	Rural	Total
1900-26	0.08	0.08	0.08
1927-34	1.50	1.50	1.50
1935-40	2.30	1.30	1.50
1941-56	4.40	1.40	2.20
1957-66	5.30	1.70	2.90

Source: Julian Bharier, The Growth of Towns and Villages in Iran 1900-66, Middle East Studies, No. 8, 1972, p. 69.

Table 6: Urban Places of 1900. Population in 1900, 1956, 1966, (in thousands)

Town	1900	1956	1966
Aradabil	10	66	84
Dezful	16	52	84
Esfahan	100	255	424
Hamedan	50	100	124
Kermanshah	60	125	188
Mashad	75	242	410
Rasht	400	109	144
Shiraz	60	171	270
Tabriz	200	290	403
Tehran	200	1.512	2.720
Khoramshahr	5	44	88
Rezaieh	35	68	111

Source: Julian Bharier, Population Growth in Iran, 1972, p. 70.

and small cities is shown and their importance in total rural-urban migration. A comparison between Figures 9, 10 and Figure 11 indicates the close relationship between the most important economic activity in the country (oil production) and the pattern of the road network. Figure 11 shows the relationship between urban growth and industrial activity. This set of maps indicates a positive relationship between the areas of high density of road mileage and concentrations of population in the more productive areas.

It is necessary at this point to mention that the process of industrial development in Iran is not comparable to the classical form of industrialization in advanced societies. No area with clustered urban settlement appeared as a result of industrial development. Only major cities grew as a result of the establishment of new industrial plants. The changes within the total economic situation of the country have infuenced the pattern of transportation network. Only after 1963 did the construction of major roads have a dominant role in this third period. The emergence of new nodes created a demand for more transport linkages. As the maps show the density of population decreases from northwest to southeast; the number of nodes and intensity of transportation network also decrease in the same direction. It appears that the physical barriers (mountains and deserts) and no valuable mineral resources are the major reasons responsible for the lack of population and transport routes in the southeast. The

IRAN HIGHWAY NETWORK (1971)

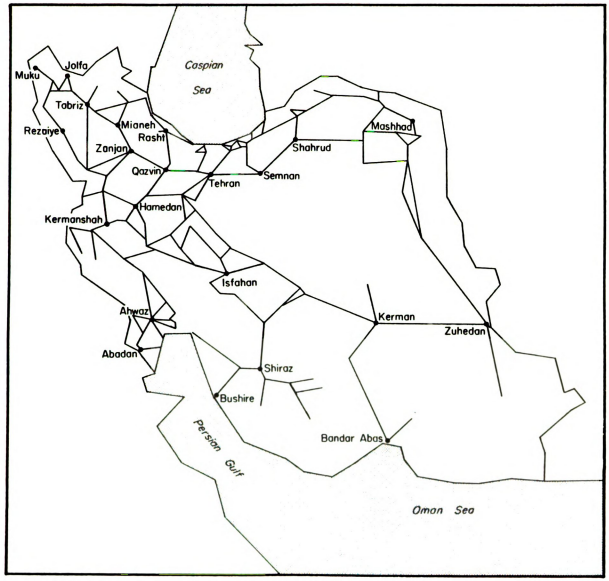


Figure 9.

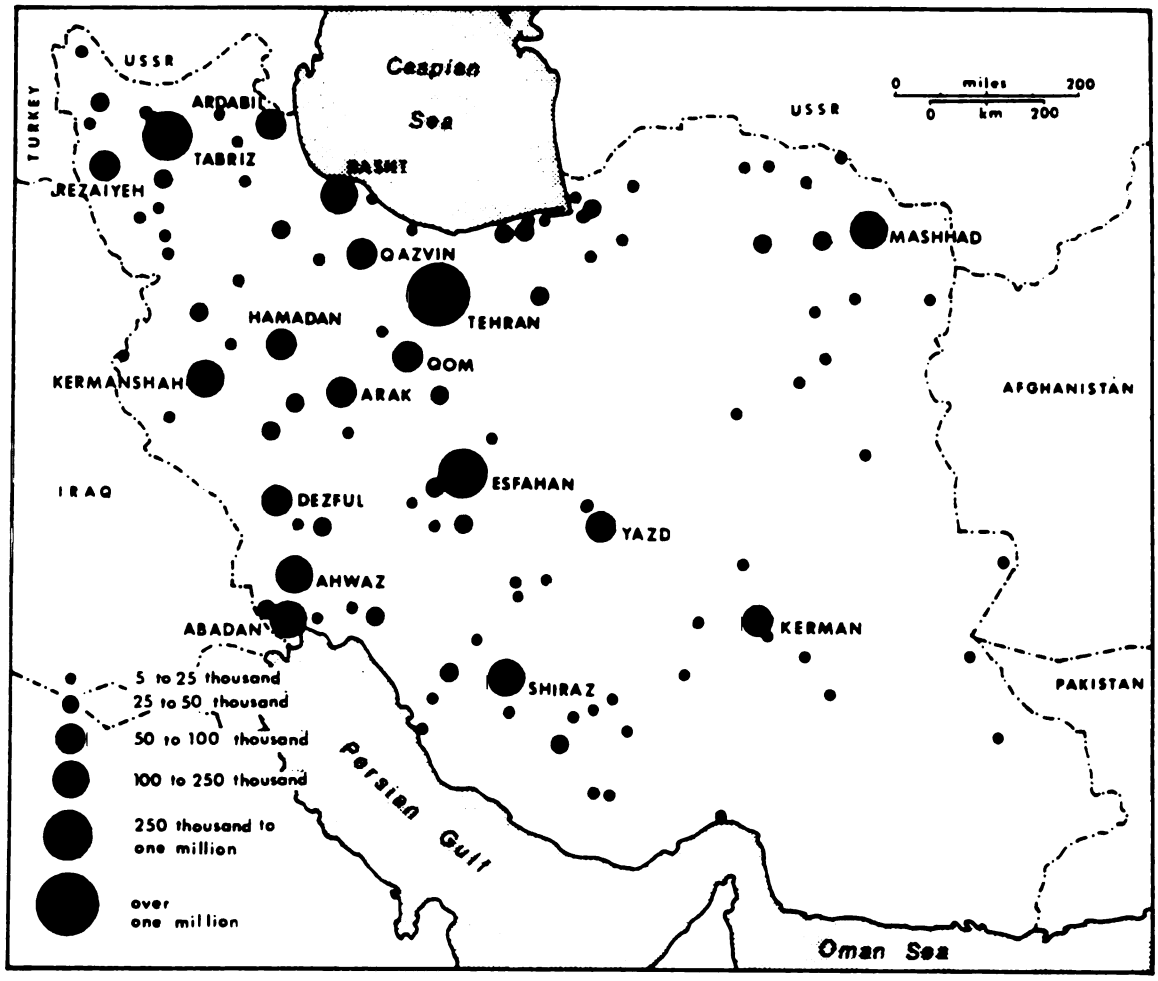


Figure 10. Comparative Population Size in Iran.

Source: Clarke, J. I. The Iranian City of Shiraz, 1963. p. 35.

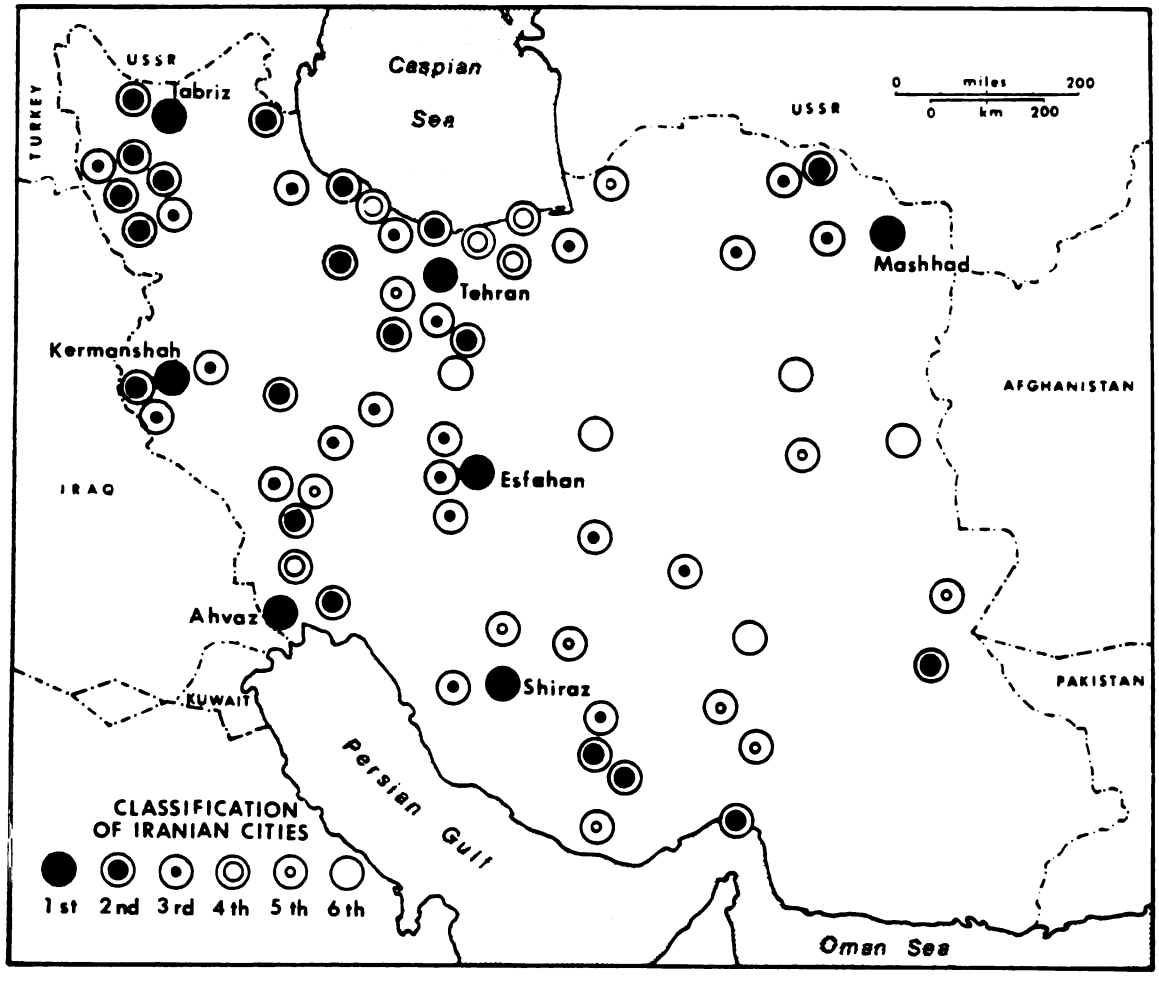


Figure 11. Classification of Iranian Cities.

Source: Clark, Brian D., and Costello, Vincent. "The Urban System and Social Pattern in Iranian Cities." P. 103.

intensity of the transport network is very far in this area and except for those few roads which connect the major centers, most roads are generally in very poor condition.

As mentioned before, the development of industrial activity changed the pattern of the network. The fourth stage of the Taaffe's model, which is the emergence of arteries, was evident during this third period in Iran. According to Melamid (1975) the construction of the Trans-Iranian railroad created the first artery in Iran. Before the feeders and arteries could not be readily distinguished in Iran. After that artery was constructed, it carried most of the traffic volume. The evolution of arteries in Iran is also comparable to the emergence of a high priority linkage or "main street" which Taaffe defined in his model. It is believed that in Iran those lines which run north-south, and the lines which connect the western part of the country to the eastern part, function as artery lines that identify the "main street." Many feeder lines have developed along these arteries and increased the interconnection of the overall transport network. Arteries in Iran are mainly for tanker transportation which carry the oil products and goods from the south which move to large and small population nodes throughout the country. These arteries also connect the major Iranian cities. Some cities like Esfahan became a major city because of its location on the major artery connecting Tehran to the Persian Gulf coast.

In summary, it is evident that Taaffe's four-stage model of transportation development as applied in Ghana has some application to Iran. There are some differences between the processes of transportation development in Ghana and Iran which are based on the differences between the economic and political situations of both countries and the historical processes of urban development in both countries. It was shown in Ghana that the ports were the first trade centers and also the major urban centers in the country. There were no urban centers in the hinterland before the development of ports. In contrast, in Iran there were several historical towns which were connected by trail roads. These towns did not grow significantly before the penetration lines which connected them to the ports. This connection resulted in the growth of these centers as large towns and also changed their economic and social functions. The growth of these penetration lines was the starting point of development of modern transportation in Iran. This is the major difference, but there are other differences including the existence of boundary towns on the Iranian border with Russia which function as a point of entry; few penetration lines moved out from them. There are no other significant differences in transportation development between Iran and Ghana.

The Taaffe model for some geographers has also been a base to study the "modernization process" in developing

countries. They identify the "modernization process" as a diffusion process from major urban centers to the periphery. Gould, Soja, and Riddel have developed the concept of the "modernization process" and have applied it to developing countries.[1] They mainly chose the variables of the infrasturcture to show the development of society and the "modernization process." However, it is believed that in developing countries a transformation from a traditional society to a modern society cannot be regarded necessarily as a modernization process. Some basic economic phenomena can measure the degree of development and others might measure the modernization of society. The concept of "modernization process" is discussed in Chapter V.

---

[1] All have been discussed in Edward W. Soja, The Geography of Modernization in Kenya, Syracuse University Press, 1968.

CHAPTER V

TRANSPORTATION AND CONTEMPORARY DEVELOPMENT

As was discussed in chapters III and IV economic development from the beginning of the twentieth century has affected the process of transportation development in Iran. Also previous chapters have examined the relationships between economic changes and the evolution of the highway transportation network. As the graph theory analysis of the structure for 1914, 1943 and 1971 shows, the expansion of the transport network took place rapidly between 1914-71. Before the twentieth century there was little expansion. An interpretation of the results of data derived from the three maps showing connectivity and accessibility indicate that although the transport network has expanded, the connectivity of the total network has not increased significantly. The shape of the network, the density of nodes and linkages in each of the four regions, and the lack of interconnections in other regions have shown that the location of nodes and linkages partly have been determined by a number of economic and political factors.

An indication of improvement in the internal system of transport within Iran was not the only objective of this

study. As was mentioned in the introduction, another goal was to investigate the relationship between economic changes and transportation development and to define the impact of other political and social factors on the improvement of the transport network in the country. In this regard first it is necessary to mention that Iran is considered an example of a developing country. The economic conditions and political situations of many developing countries are very similar. The processes of economic development and transportation evolution and social change in Iran as well as other developing countries cannot be isolated from the world economic conditions. It seems that many developing countries are likely to continue along the same path of economic development which means they are likely to arrive at the same point of advancement with only slight differences. The problems which Iran faces today are similar to those many others are facing now or will be in the future. A study of present situations in these countires and the historical processes of economic change shed some light on the future plans and help in finding a probable solution for many difficulties which they face. It is clear that when discussing similarities between developing countries this does not mean that the regional characteristics and the cultural background of each society have been forgotten.

The third chapter discussed the evolutionary sequence of transport network growth in Iran. The results indicate

that this process in Iran is somewhat comparable to networks examined in other developing countries. For more than half a century contact with Russia and England characterized the major coastal trading centers in the northern and southern parts of the country. The new changes in Iranian tradition began to take place when several transport lines were established between the coast and the interior centers. Most of these lines reached Tehran (the capital city) with the result that the economy of Tehran changed immediately. Many Russians, Germans, Austrians, French and British moved there to trade or supply the services. No one can deny the role of transportation and communication in economic growth. But transportation development in developing countries is not the only criterion which can measure the degree of economic growth. The main reason is that this process is influenced by many factors which led to profits earned by foreign investors and countries. It is clear from the direction of the transport lines that major roads connect the regions of rich mineral resources with major cities and ports. Indeed major local improvements took place where access to the internal market and resources were required. The improvement of the network brought economic progress to those districts which had the highest density of linkages.

There are a set of phenomena that can be used to determine the relationships between transport development and

economic growth more carefully. These are divided into four major factors: (1) degree of urbanization, (2) population growth, (3) level of education, and (4) the location of large industrial establishments.

URBANIZATION

In terms of urbanization it is correct to say that the proportion of urban growth in Iran is following the high rate of increase similar to that of other developing countries. Although the national rate of population growth for any town may differ from the overall rate of natural increase, any town which has shown an increase of inhabitants in excess of the overall rate can be assumed to have experienced net inmigration. According to the 1956 census out of the 1.759 million who migrated between 1900-56 to twenty-five towns in Iran about 1.060 million (60 percent) went to Tehran and 92,000 (5 percent) to Mashad. In this period, as the tables 8 and 9 indicate, the migrants who moved into Tehran and other major cities were mostly from towns and small cities nearby. This movement is in contrast to 1956-66 when the proportion of rural-urban migration increase accounted for about 90 percent of the total internal population movement. Tehran received 38 percent of the total migrants during this decade. The high percentage of migration to Tehran can be described by the "push-pull" concept. The concentration of wealth in the major cities

Table 7 indicates the annual rate of urban and total rural population growth between 1900 to 1966.

Table 7: Annual Rate of Population Growth

Period	Urban %	Rural %	Total %
1900-1926	0.08	0.08	0.08
1927-1934	1.50	1.50	1.50
1935-1940	2.30	1.30	1.50
1941-1956	4.40	1.40	2.20
1957-1966	5.30	1.70	2.90

Source: Julian Bharier, The Growth of Towns and Villages in Iran: 1900-66, p. 55.

Table 8 shows the urban population in nineteen (Ostan)[1]

Table 8: Distribution of Urban and Rural Population in 1966

	Name	Total Population	Urban Population %	Urban Population #	Rural Population
	Total Country	25788722	38	9794246	15994476
Caspian Sea Region	Central Ostan	4984828	70.3	3505970	1478858
	East Azarbyjan	2636089	28.7	755458	1880631
	West Azarbyjan	1087411	25.5	277646	809755
	Gilan	1293835	23.5	303694	990141
	Kermansha	818685	34	278539	540146
	Heamedan	88892	25.9	230833	659059
	Kordestan	619700	16.5	102398	517302
	Lorestan	767374	21.6	165634	601740
	Zanjan	461597	17.9	82598	378999
Persian Gulf Region	Esfahan	1424457	52.8	751811	672646
	Khozestan	1706757	51.7	883057	823701
	Charmahal	301359	29.1	87552	213807
Northeast Region	Khorasan	2520779	28.8	726690	1794089
	Semnan	207907	40.5	84182	123725
	Mazandaran	1845270	23.9	440997	1404273
Southeast Region	Kerman	841982	23.3	196476	645506
	Sistan Baluchestan	502626	14.4	72149	430477
	Yazd	281160	44.3	124542	156618
	Bushire	259101	21.1	54623	204478
	Boyer Ahmad	190542	8.1	15359	175183
	South Coast	349820	15.2	53000	296820

[1]Ostan is an administrative unit.

Source: Handbook of Social and Economical Statistics, p. 55.

Table 9 shows the urban population in major cities in each region. These data show the concentration of the urban population in the Caspian Sea Region.

Table 9: Population Growth of Major Cities Between 1900-1966 (in thousands)

Name	1900	1956	1966
Ardabil	10	66	84
Borujerd	17	49	71
Ghazvin	40	66	88
Ghom	20	96	134
Hamedan	50	100	124
Kermansha	60	125	188
Khoramadbad	10	39	60
Malayer	5	21	28
Khoy	60	34	48
Marand	15	14	25
Mashad	75	242	410
Miandoab	10	15	19
Mianeh	7	21	28
Rasht	40	109	144
Rezaiye	35	68	111
Sanandaye	32	41	55
Saveh	8	15	18
Tabriz	200	290	403
Tehran	200	1.512	2.720
Zanjan	20	47	59
Arak	7	59	72
Brojen	60	10	10
Dezful	16	52	84
Esfahan	100	255	424
Khoramsha	5	44	88
Ramhurmoz	8	7	9
Naeen	5	5	6
Kashan	30	46	58
Sheriza	8	29	34
Amol	18	22	40
Birjand	24	14	26
Chochan	10	21	29
Mushad	75	242	410
Sabzevar	15	31	42
Sari	8	26	45
Semnan	25	29	31
Shahrud	5	17	31
Shirvan	10	7	11
Babol	40	36	50
Bandar Abbas	5	18	35
Bushire	15	18	24
Darah	6	9	13
Kazeron	6	31	40
Kerman	60	62	85
Lar	8	14	22
Shiraz	66	171	270
Surmay	7	7	10
Yazd	75	64	93
Naeen	10	12	16

Source: Handbook of Economical and Social Statistics, p. 197.

paralleled the deterioration of rural life and resulted in high net inmigration to a number of major cities, but especially to Tehran. According to the 1966 census, the Caspian Sea region had the highest degree of urbanization of any of the four regions discussed.

POPULATION DENSITY

A comparison between the population density in four regions suggests that the Caspian Sea region is the most densely populated section in Iran. As was discussed in Chapter IV, the network density in the Caspian Sea region is also higher than the other three regions. There is a positive relationship between the network density and the density of population in this area. Table 10 shows the population size and average density for each region while Table 9 indicates the growth of the population of the major cities in each region between 1900-66. The growth of population in the Caspian Sea region is mainly due to rural-urban migration and migrants from towns in the other regions searching for a better life in these cities. In contrast to the Caspian Sea region, the Southeast region has the largest area, but the lowest population density and the lowest network density.

Table 10: Population Density in Four Regions

	Size in Square Kilometer	Population Number	Population Density
Caspian Sea Region	421538	12792037	30
Northeast Region	441800	4573956	10
Persian Gulf Region	174377	4332174	21
Southeast Region	673221	4009770	5

Source: Handbook of Social and Economical Statistics,

EDUCATION

The third criterion which measures the development of an area is education. The distribtuion of primary and secondary schools and colleges is shown in Table 11. Again the Caspian Sea region stands out today as the most literate and educated section of Iran. Most of the ostans show up favorably in primary education, because of recent improvements in facilities, and the tendency among people to educate their children. The primary schools are numerous, but the high schools and colleges are rare. Most schools are concentrated in major cities. Certain areas have attained a high level of education while others remain essentially backward. Within the Caspian Sea region, Tehran especially has the highest number of universities, colleges and secondary schools.

INDUSTRY

The distribution of the large industrial establishments is another criterion to measure the regional development and show the pattern of economic activity in an area. As Table 12 shows, most large industrial plants are concentrated in a few major cities in the Caspian Sea region, particularly in Tehran. These industrial plants are mostly market oriented with the raw materials needed for the plants coming from other parts of the country.

Table 11: Distribution of Elementary, Secondary Schools and Colleges (in 1973-74)

	Name	Elementary School	Secondary School	College And University
	Whole Country	18719	3728	148
Caspian Sea Region	Central Province	2952	1210	81
	East Azarbyjan	1211	189	7
	West Azarbyjan	923	108	4
	Gilan	873	292	6
	Kermansha	679	85	5
	Kordestan	597	35	1
	Lorestan	565	62	--
	Ilam	223	18	--
	Zanjan	249	22	--
	Hamedan	488	71	2
	Total	8760	2092	106

Source: Handbook of Social and Economical Statistics,

Persian Gulf Region	Esfahan	873	240	9
	Khozestan	1261	210	8
	Chaharmahal	209	22	--
	Total	2343	472	17
Northeast Region	Khorasan	1549	265	7
	Mazandaran	1489	288	8
	Semnan	202	32	--
	Total	3240	585	15
Southeast Region	Fars	1859	248	5
	Sistan-Baluchestan	380	44	--
	Yazd	286	60	1
	Bushire	241	29	--
	South Coast	401	24	--
	Boyer Ahmad	398	14	--
	Kerman	788	106	4
	Total	4353	561	10

Source: Handbook of Social and Economical Statistics.

Table 12: Distribution of Large Industrial Plan in 1948-61

	Name	1943	1961
	Whole Country	471	1868
Caspian Sea Region	Arak	3	7
	Tabriz	138	538
	Tehran	182	946
	Rezaiye	2	7
	Sanandaj	1	4
	Shahre Ray	10	22
	Qum	2	5
	Karaj	26	53
	Kermansha	19	27
	Hamedan	11	35
	Khoramabad	--	2
	Total	394	1636
Persian Gulf Region	Abadan	10	24
	Ahwaz	1	10
	Mahshar	--	--
	Khoramsha	1	4
	Dezful	--	2
	Kashan	2	5
	Total	14	45
Northeast Region	Babol	2	4
	Sari	1	6
	Semnan	1	2
	Shahi	3	6
	Mashad	31	101
	Total	38	119
Southeast Region	Bushire	1	1
	Bandar Abbas	1	1
	Zahedan	--	--
	Shiraz	17	52
	Kerman	26	53
	Total	45	117

Source: Handbook of Social and Economical Statistics.

All these data indicate that the Caspian Sea region is more developed than other regions. However, it should be noted that the function of these factors within a developing country is different from a developed country. It is not sufficient to rely on the criterion alone to show the development of an area in developing countries. In other words, even within a region, there is a big gap between different points because development is mostly of a nodal variety. For example, in the Caspian Sea region Tehran has been a highly developed area until now. It would appear that regional inequities of this nature are an expected feature of development in developing countries. Although Iran like other developing countries has devoted a large amount of public investment in transportation development, still there is an uneven growth of the transport network in different parts of the country. This has led to a wide gap among these parts especially between rural and urban areas.

For those geographers who would call the four stages of Taaffe's model a "modernization process" in developing countries, it is believed that first the true nature of such development or "modernization" should be determined. It is felt that the transformation of a traditional society and a modern society should not be limited to the transformation of culture, but is should cover the entire economy and other aspects of social life such as health and education.

It seems that in developing countries the development and "modernization" of transportation and of health and education is limited to the confines of a few major cities. The people in villages and smaller cities are still living a very primitive life. According to the census out of 25.08 million people about 15.2 million or 62 percent live in the 50,000 villages with less than 250 people in each.[1] The disproportionate share of the population is absent from the developments including the nationwide transport system; this has resulted in unfavorable conditions in rural areas and the rapid improvement of only about sixteen major urban settlements. The limitation in growth and development of modernization for most parts of Iran is not the result of friction of distance from the major cities, but on the other hand, it is the nature of this economic order to limit such modernization to profitable areas. The spatial distribution of resources in Iran is unbalanced. The region containing Tehran has less than one-fifth of the total population but produces about 40 percent and consumes more than two-fifths of the national output. About one-half of the national investment and manufacturing production are in the Caspian Sea region. There is a big gap in the regional income between this province and other provinces such as Bushire in the southern part and Sistan-Baluchestan in southeastern part of the southeast region.

---

[1] Julian Bharier, The Growth of Towns and Villages in Iran: 1900-66, Middle East Journal, Vol. 8, 1972, p. 51-61.

The per capita income in these provinces is between one-sixth and one-tenth that of Tehran.[1]

CONCLUSIONS AND RECOMMENDATIONS

It is clear that the main problem that Iran and other developing countries face is an economic and social imbalance between regions. Every plan in these countries should be pursued to achieve the goal of balanced regional growth. Considering the linkages existing between developing countries and the world economies, each recommendation for development in these countries should take this fact into consideration. These countries should generate their own development without economic dependency on developed countries. Each development plan should emphasize improving the rural condition in order to destroy or reduce the wide gap that exists between rural and urban areas. One possible way to achieve economic balance is to make a rational relationship between agricultural and industrial development. The equal distribution of welfare and social services in urban and rural areas is another recommendation for achieving more equality. It is clear that transportation development plays an important role in striving to meet these goals. As we have seen there is a close relationship between transportation

---

[1] Harry W. Richardson, "Regional Planning in Iran," Middle East Studies, Vol. 13, 1975, pp. 16-19.

and all aspects of development program. Although the main objective of the fifth development plan in Iran stresses regional development and economic and social balance between regions, what has been done to date is very little. There are huge problems that need to be solved and for many of them there are no easy answers forthcoming. The expected growth of urban population is projected to increase from 13 million to 32 million in the next twenty years. The social and political obstacles of the government's decentralization program parallel with a severely deficient interregional transport system are the problems which will cause many difficulties in the future. It is best that they are not neglected. Still there are some probable solutions to these problems. One of the most appropriate solutions is the improvement of the transportation system throughout the country to establish a viable marketing agricultural economy. This includes devoting more land to agriculture and using some techniques in arid regions to solve the problem of water shortage. These could help to improve the economy of rural areas. These are the major tasks facing the planner in an attempt to reduce the wide gap between rural and urban areas. The distribution of small industry plants throughout the country and among the regions is another plan which could help spread development more equally. As a result of economic development, more population could be attracted to areas

currently considered as the backward; it may reduce the migration to the large cities. In order to promote regional economic development it is necessary both to allocate specific funds to these programs and to increase the share of the regional development in the national development budget.

BIBLIOGRAPHY

BIBLIOGRAPHY

BOOKS

Baldwin, B. George. Planning and Development in Iran. Baltimore: Johns Hopkins Press, 1967.

Banani, A. The Modernization of Iran 1921-41. Palo Alto: Stanford University Press, 1961.

Bharier, Julian. Economic Development in Iran 1900-1970. London: Oxford University Press, 1971.

Berry, Brian J. L. and Norton, Ginsberg. Essays on Geography and Economic Development. Chicago, University of Chicago, Department of Geography, 1960.

Clarke, J. I. The Iranian City of Shiraz. Department of Geography, Research Paper, Series No. 7. Durham: University of Durham Press, 1963.

Fisher, B. W. The Land of Iran. London: Cambridge University Press, 1968.

Garrison, W. L. Studies of Highway Development and Geographic Change. Seattle: University Washington Press, 1950.

Haggett, P. and Chorley, R. J. Network Analysis in Geography. London: St. Martin's Press, 1969.

Issawi, Charles. The Economic History of Iran 1800-1914. Chicago: University of Chicago Press, 1963.

Kansky, K. J. Structure of Transport Network. Chicago: University of Chicago Press, 1963.

Oddvar, Areswik. The Agricultural Development of Iran. New York: Praeger Special Studies in International Economics and Development, 1976.

Soja, Edward W. The Geography of Modernization in Kenya. Syracuse, New York: Syracuse University Press, 1968, p. 325.

Taaffe, E. J. and Gauthier, H. L. Geography of Transportation. Englewood Cliffs, N. J.: Prentice Hall, Inc., 1973.

Ullman, E. L. "The Role of Transportation and Bases for Interaction." In Man's Role in Changing the Face of the Earth. Edited by Thomas, Jr., Chicago: University of Chicago Press, 1956.

PERIODICAL

Bharier, Julian. "The Growth of Towns and Villages in Iran 1900-66." Middle East Journal, Vol. 8, 1972, pp. 51-61.

Berry, Brian J. L. "Recent Studies Concerning the Role of Transporation in the Space Economy." Annals, Association of American Geographers, Vol. 49, 1959, pp. 328-342.

Bonn, A. G. "The Trans-Iranian Rail Way." Journal of the Central Asian Society, Vol. 25, 1938, pp. 219-227.

Campbell, Thomas. "Transporation in Developing Countries Special Reference of Kenya." Traffic Quarterly, Vo. 28, 1956, pp. 139-153.

Clark, Brian D. and Castello, V. F. "The Urban System and Social Patterns in Iranian Cities." Institute of British Geographers, Transaction No. 30, 1973, pp. 99-128.

Garrison, W. L. and Marble, D. F. "Factor Analytic Study of the Connectivity of the Transporation Network." Papers of the Regional Science Association, Vol. 12, 1946, pp. 231-290.

Gauthier, H. L. "Transporation and Growth of the Sao Paulo Economy." Journal of Regional Science, Vol. 6, 1968, pp. 1-18.

Gauthier, H. L. "Geography of Transporation and Regional Development." Economic Geography, Vol. 46, No. 4, 1970, pp. 612-619.

Haynes, Kingsley E. and Paulin, I. P. "Population Economic Development and the Structure of Transporation in the Province of Quebec, Canada." Tijdshrift Voor Economische en Social Geographie, Vol. 61, 1971, pp. 356-383.

Jefferson, Mark. "Geography of Railway Transportation in 1920-1927." Annals, Association of American Geographers, Vol. 18, 1928, pp. 64-78.

Kanaan, Nuhad. "Structure and Requirement of the Transport Network in Syria." Highway Research Record, No. 115, 1976, pp. 19-28.

Keddie, Nikki R. "The Iranian Power Structure and Social Change 1800-1969." Middle East Studies, Vol. 2, 1971, pp. 3-20.

Lewis, Laurence A. and Reynolds, David R. "The Spatial Structure of Transporation Networek and Socio-Economic Development. The Puerto Rican Example." Indian Academy of Social Science Proceeding, Vol. 2, 1967, pp. 24-52.

Melamid, Alexander. "Petroleum Distribution and the Evolution of Economic Region in Iran." Geographical Review, Vol. 65, No. 4, 1975, pp. 510-525.

Nystuen, J. D. and Dacey, M. S. "A Graph Theory Interpretation of Nodal Regions." Papers and Proceedings of the Regional Science Assocation, Vol. 7, 1961, pp. 29-42.

Owen, Wilfred. "Transportation and Economic Development." American Economic Review, Vol. 49, 1959, pp. 179-87.

Perry, Jan, Carey, Clark and Garey Andrew Galbraith. "Iranian Agriculture and Its Development 1952-1973." Middle East Studies, Vol. 7, 1976, pp. 359-383.

Pitts, F. R. "A Graph Theoretic Approach to Historical Geography." Professional Geograher, Vol. 7, 1965, pp. 17-20.

Richardson, Harry W. "Regional Planning in Iran." Middle East Studies, Vol. 13?, 1975, pp. 16-19.

Souza, Anthony and Porter, Philip W. The Underdevelopment and Modernization of the Third World. Commission on College Geography, Washington, D. C.: Association of American Geographers, Resource Paper, No. 28, 1974.

Sventiski, A. S. "Transport Routes in Persia." Journal of Royal Central Asian Society, Vol. 8, 1928, pp. 203-223.

Taaffe, Edward J., Morrill, Richard L. and Gould, Peter R. "Transporation Expansion in Underdeveloped Countries: A Comparative Analysis." Geographical Review, Vol. 53, 1963, pp. 503-529.