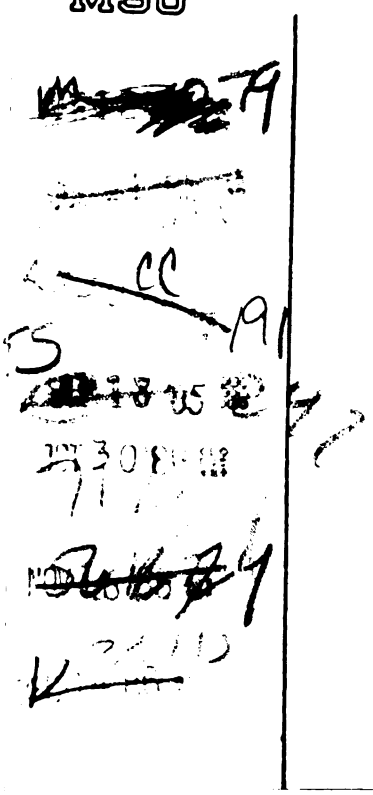

WATER DISTRIBUTION, AVAILABILITY AND PROBLEMS IN JEDDAH CITY, SAUDI ARABIA: A HOUSEHOLD SURVEY

By

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ABSTRACT

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IN JEDDAH CITY, SAUDI ARABIA:
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Jeddah is a rapidly growing major city in the Southwest and Western Region of Saudi Arabia. The rapid growth is not accompanied by comparable growth in essential public services such as an available water supply. The purpose of this study is to examine the perceptions of the residents regarding the water problems in the city. A survey was conducted of 500 residents throughout the city. The interviews were focused on five important factors: 1) water accessibility by districts, 2) water accessibility by type of house, 3) income and type of house by sources of water, 4) water uses by type of house, and 5) the reception of water from the network as influenced by construction work going on in the city.

The data were analyzed using chi-square, a series of analyses to identify if there were significant differences in the sources, types of uses, and types of housing. The results demonstrated that there are water problems in the city; that old districts have greater access

to water from the network than the new districts, that most high income people living in villas and apartments received water from the network while most people living in traditional houses and shacks do not receive from network, that people living in villas have gardens and use water from the network to irrigate the gardens whereas those in traditional houses and shacks use water only for domestic use, and that public constructions frequently impedes water reception from the network.

Water problems in the city can be attributed to three factors: (1) insufficient water from the existing natural resources to meet increasing demands, (2) lack of proper planning for the distribution of water, and (3) misuse of water for non-domestic purposes at home and in the city. On the basis of these results a series of recommendations are offered to resolve the problems identified.

DEDICATED

To my mother

Who is looking forward to seeing me in the near future to live with her in the holy places.

ACKNOWLEDGEMENTS

The author would like to express his deepest gratitude to the chairman of the Author's Committee and major advisor, Professor Stanley D. Brunn, for his guidance, comments, and encouragement. The author is indebted to Professor Ian M. Matley and Professor Jay R. Harman for their comments and suggestions. The author would like to thank King Abdulaziz University for their financial support. Also those in governmental office who were contacted by the author. Finally, to those friends who were behind the author in doing his research, his best wishes for them.

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CHAPTER I

INTRODUCTION

FOCUS OF THE STUDY

> The importance of water resources to society and to government is not diminished today. Our complex, metropolitan civilization and advanced technologies have generated new demands for water.[1]

Water is a fundamental need for human survival. The growth of urbanization world wide presupposes there is sufficient amount of water to meet the needs for development. Unfortunately there is often not enough water at the right places at the right time. The lack of an adequate water supply for any area can cause severe problems for the many and varied agricultural, industrial, and domestic uses, and for the public services sector as well. As the urban population of a country increases in numbers and area, and the industrial sectors as well, the need for a number of natural resources correspondingly increases with the greatest increase being water.[2] The existence of

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[1] Henry M. Jackson, "Foreward," in H. G. Deming, Water, the Foundation of Opportunity (New York: Oxford University Press, 1975), p. v.

[2] Lawrence M. Sommers, "Man-Water Relationship Research and the Application of the Geographic Approach, "Harold A. Winters and Marjorie Winters, eds., Applications of Geographic Research (East Lansing, MI: Michigan State University, 1977), p. 89.

water is one of the main factors in the city's existence. The quality and quantity of water available are both important in the social political and economic life of urban areas.[3]

In 1963 a survey on the water conditions in seventy-five developing countries, with a total population of about 1.3 billion, was conducted by the World Health Organization. It established that

> only one-third of the city dwellers and less than one-tenth of the rural population had water faucets and pipes. Two-fifths of the urbanites and almost three-fourths of the entire population were without regular water supply.[4]

Another survey also conducted by World Health Organization in 1975 looked at community drinking water supplies in developing countries. It included about 90 percent of the total population of developing world; China was not included. The survey indicated that about 144 million people or about 23 percent of the urban population in these developing countries and about 1.1 billion people or 78 percent of the rural population did not have the reasonable access to water supplies as of 1975.[5]

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[3]Melvin G. Marcus and Thomas R. Detwyler, eds., Urbanization and Environment: The Physical Geography of the City (Belmont, CA: Duxbury Press, 1972), p. 17.

[4]Georg Borgstrom, Too Many, An Ecological Overview of Earth's Limitations (New York: Collier Books, 1971), p. 181. For further discussion see World Health Organization, Urban Water Supply Conditions and Needs in Seventy-Five Developing Countries, Geneva, 1963.

[5]United Nations Water Conference, "Meeting Domestic Water Requirements of Developing Countries," Mar del Plata, Argentina, 1977, p. 3.

Saudi Arabia is one of the developing countries facing these water problems. It occupies an area covering about 2.2 million square kilometers.[6] While it is one of the largest arid nations in the Middle East.[7] It is also one of the largest countries in the world without a river. The mean precipitation for the entire country is only about 50 mm per year.[8] Because the rainfall is insufficient to meet the demand for water for residential, agricultural, commercial, and industrial uses,

> the ground water resources of Saudi Arabia are of great importance for agriculture. Two-thirds of the country is underlain by sedimentary formations mostly of sandstones, limestones, shales, marls, and alluvium; and these are the main resources of ground water.[9]

The geologic structure of the country is depicted on Figure 1. Rapid population growth due to both extensive rural-urban migration and a high rate of natural increase has made the water crisis a critical problem in urban areas of the country. At the same time, water demands in urban areas are increasing due to constant improvements in the living standards, economic status, level of education, and social life of

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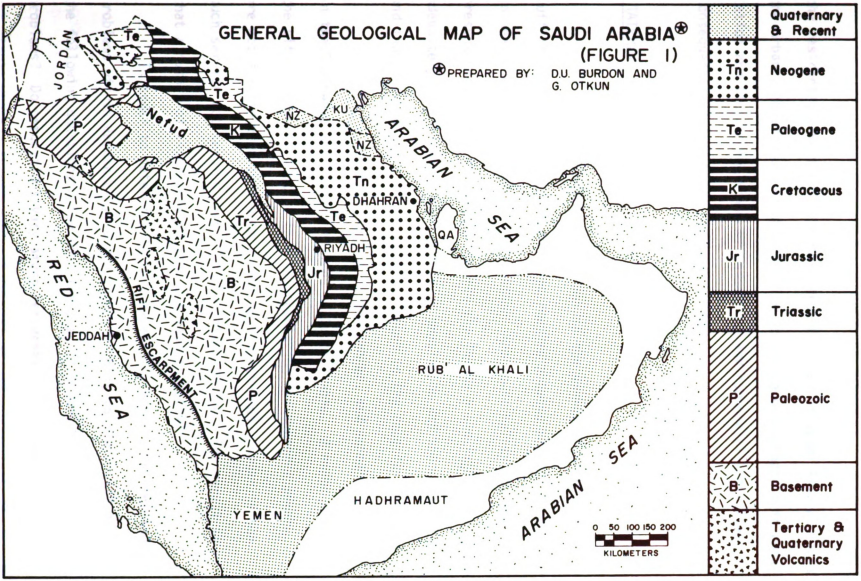
[6]Saudi Arabia, Ministry of Agriculture and Water, Seven Green Spikes, prepared by Abdul Basset El-Khateb, (Beirut: Dar al-Qalam Press Co., 1974), p. 3.

[7]Peter Beatumont, "Water and Development in Saudi Arabia," Geographical Journal, Vol. 143, March 1977, p. 1.

[8]Ibid., p. 2.

[9]Seven Green Spikes, op. cit., p. 6.


GENERAL GEOLOGICAL MAP OF SAUDI ARABIA®
(FIGURE 1)
®PREPARED BY: D.U. BURDON AND G. OTKUN
JORDAN
Te
Tr
K
P
Nefud
NZ
KU
ARABIAN SEA
Tn
DHAHRAN
QA
B
RIYADH
Jr
RED SEA
RIFT ESCARPMENT
JEDDAH
RUB' AL KHALI
YEMEN
HADHRAMAUT
0 50 100 150 200
KILOMETERS
Quaternary & Recent
Neogene
Paleogene
Cretaceous
Jurassic
Triassic
Paleozoic
Basement
Tertiary & Quaternary Volcanics

the residents. Jeddah, one of the largest cities in Saudi Arabia, faces the urban problems just described. The city is growing rapidly in population and the concentration of industries and commercial activities. Consequently, Jeddah has a water shortage.

STATEMENT OF PROBLEM

One of the important essentials in the growth of urban areas is sufficient water supply. Urban areas require growing amounts of water to meet domestic, industrial, irrigation, and municipality needs. At present many cities all over the world are facing a shortage of water to adequately supply their rapid growth in population and the commercial and industrial sectors of the economy. Such is the case for Jeddah.

Jeddah is the main airport, trade center, and commercial node in the Southwest and Western regions of Saudi Arabia. A major problem the city is experiencing is that its population and economic growth are not coinciding with growth in the public services. Water is one such service not keeping pace with population growth. The result is that a number of water-related problems seem to appear.

In order to determine to what extent there are water-related problems within Jeddah city, a geographer wishing to study them asks the following questions: How does the population perceive these problems? Do perceptions vary among residents in different parts of the city? Why are there problems? How is planning water use and

availability done within the city? In studying the perception of water related problems among residents, geographers also want to examine if there are variations in the amounts and uses of water among residents living in different types of housing.

OBJECTIVE OF STUDY

The basic objective of this study is to examine the variation of people's perception about the water problems in Jeddah city in Saudi Arabia.

ENVIRONMENTAL PERCEPTION

A number of studies that have been investigated by geographers on how humans perceive their environment. These studies are identified as dealing with environmental perception. Urban and environmental problems are among those that are receiving public and scholarly attention. Specific studies include dissatisfaction with the environment, which is characteristic of the modern human condition, and an awareness of physical and social problems the city faces.[10]

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[10]James Schmid, "The Environmental Impact on Urbanization," in Marvin M. Mikesell and Ian Manners, eds., Perspectives on Environment (Washington, D.C.: Commission on College Geography, Association of American Geographers, Publication No. 13, 1974), p. 213.

> The major problem in studying people's perception is that of measurement, since people often have difficulty articulating the conscious or unconscious feelings, attitudes, or ideas associated with perception.[11]

Geographic studies have dealt with how people perceive the environment. Baumann and Kates define environment perception, as it relates to hazards, as follows:[12]

> A person's perception of the hazard is an important factor related to the value of a warning system. People adjust to their environment, and the process of adjustment is influenced by individual personality, culture, and physical environment. Once ideas or perceptions are established, a person tends to maintain his personal set of ideas or cognitions about a particular phenomenon. Thus, a person's perception of environment accommodates both reality and his personal needs and dispositions.

Saarinen states that environmental decisions and behavior are based on individual or group perceptions of the real world. He concludes that people presumably base their decisions not so much on the world as it is, but rather on the world as they perceive it.[13] Many of the concepts and methodologies used to study how people perceive

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[11]Thomas F. Saarinen, Perception of Environment (Washington, D.C.: Commission on College Geography, Association of American Geographers, Resource Paper No. 5, 1959), p. 5.

[12]Duane D. Baumann and Robert W. Kates, "Risk from Nature in the City", in Melvin G. Marcus and Thomas R. Detweyler, eds., Urbanization and Environment: The Physical Geography of the City (Belmont, CA: Duxbury Press, 1972), p. 181.

[13]Saarinen, op. cit., p. 252.

their environments have come from other disciplines, especially psychology. Taaffe has stated that

> studies in environmental perception are concerned with efforts to understand how men structure in their own minds the world around them. Some studies give explicit attention to the ways in which men perceive elements of their natural environment and how they apprehend resources or national hazards such as floods and droughts. Other studies treat man's views of landscapes, especially in urban areas, and his perceptions of differing spatial organizations and attitudes toward places, as shown in "mental maps."[14]

A geographer with his interests and training in the social and physical sciences is in a good position to confront the environmental problems facing urban areas and understand how people perceive a problem such as a water shortage. Once it is known how and why people perceive environmental problems as they do, meaningful contributions can be made to solving specific problems, possibly by offering recommendations to ameliorate the situation and presenting the severity of the problem to the appropriate public officials. A study of people's perception about water problems in Jeddah city could help to explain and provide useful information about the water uses and problems facing different parts of the city.

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[14]Edward Taaffe, ed., Geography (Englewood Cliffs, NJ: Prentice Hall, Inc., 1970), pp. 31-32.

ORGANIZATION OF THE STUDY

Chapter I has provided a brief introduction to the study. Chapter II provides general information on the economic and social geography of Jeddah city. The water system in the city is described in Chapter III. The hypotheses, sampling strategy and methods of analysis are outlined in Chapter IV. The analysis of resident's perceptions of water supply problems is discussed in Chapter V. The last chapter gives the conclusions and recommendations and some suggestions for further study.

CHAPTER II

THE ECONOMIC AND SOCIAL GEOGRAPHY OF JEDDAH CITY

In this chapter the general background of Jeddah City is discussed, specifically site and situation of the city in the Southwest and Western regions of the country, its economic functions, land uses, and the recent population growth. The city has grown rapidly since 1970 and continues to expand at a rapid rate.

SITE AND SITUATION

Jeddah is situated on a coastal plain East of Red Sea at 21° 30' N and 39° 12' E (Figure 2).

> The general area where Jeddah is located is free from any significant topographic relief. Only gentle swells occur, and coral rock shows up where erosional or man-made cuts affect the topographic surface.[1]

The climate of Jeddah is affected by its location on the Red Sea. It is very hot and humid in the summer and warm in the winter. Based on the data for the period 1966-76, the highest mean maximum

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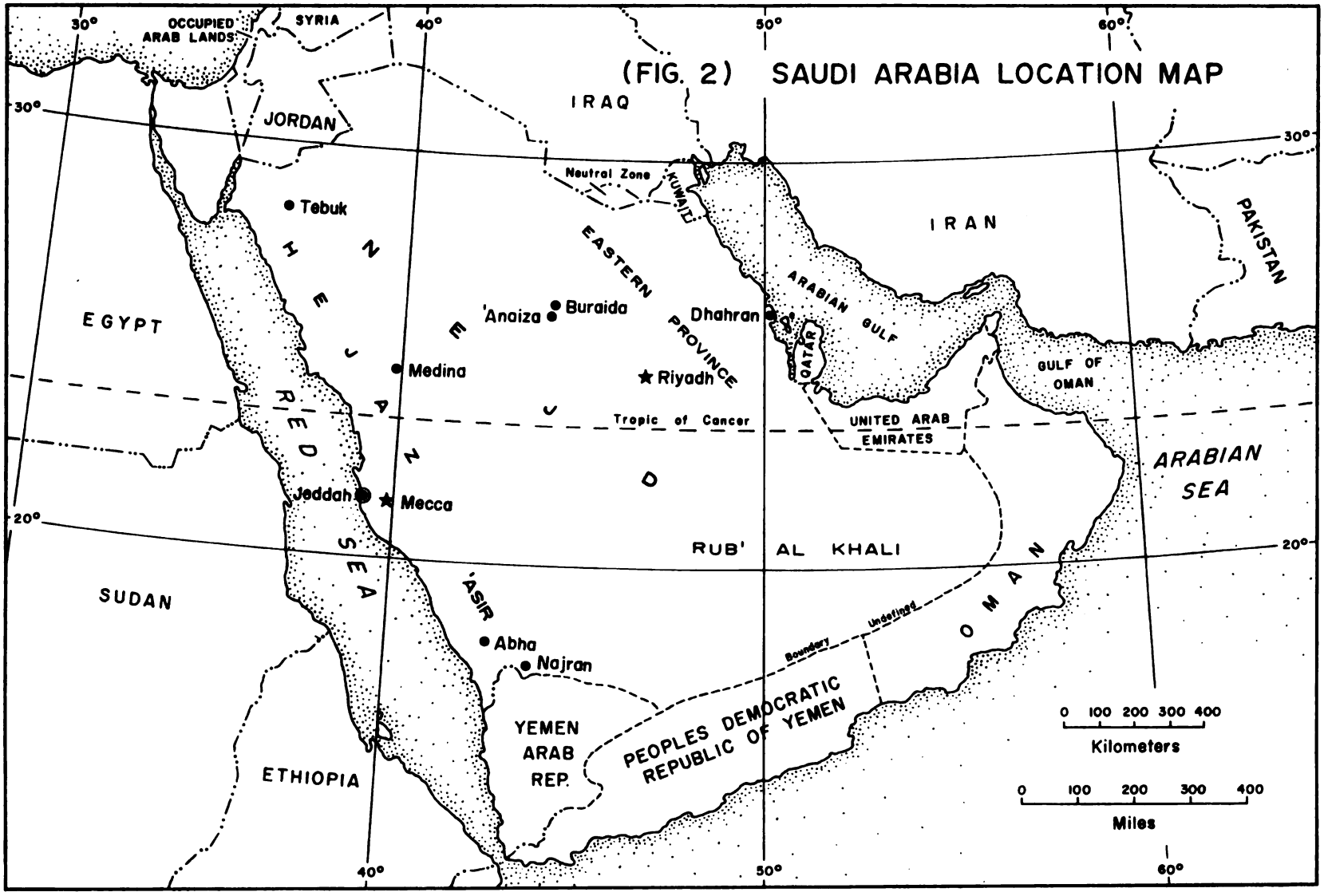
[1] Angelo Pesce, Jeddah, Portrait of an Arabian City (London: Falcon Press, 1974), p. 102.


(FIG. 2) SAUDI ARABIA LOCATION MAP
OCCUPIED ARAB LANDS
SYRIA
JORDAN
IRAQ
Neutral Zone
KUWAIT
IRAN
PAKISTAN
Tebuk
EGYPT
HEJAZ
EASTERN PROVINCE
'Anaiza
Buraida
Dhahran
ARABIAN GULF
QATAR
Medina
Riyadh
GULF OF OMAN
Tropic of Cancer
UNITED ARAB EMIRATES
ARABIAN SEA
RED SEA
Jeddah
Mecca
RUB' AL KHALI
SUDAN
'ASIR
Abha
Najran
Undefined Boundary
OMAN
YEMEN ARAB REP.
PEOPLES DEMOCRATIC REPUBLIC OF YEMEN
ETHIOPIA
0 100 200 300 400
Kilometers
0 100 200 300 400
Miles
30°
40°
50°
60°
20°

humidity was about 94 percent with the mean average relative humidity about 70 percent monthly.[2] The mean daily maximum temperature is about 36°C in the summer and mean daily minimum temperature about 19°C. The annual average temperature is about 27.5°C. The highest temperatures and the relative humidities bother the inhabitants in the summer; sometimes the summer winds carry dust which causes a great deal of inconvenience. The temperature goes down in the night and there is less relative humidity.

Rainfall is highly unpredictable. Most of the time there is no rain for months; sometimes there is none for years. When rain comes, it comes heavily and quickly bringing havoc and discomfort to the people and to businesses.[3] Most of the rain falls in November, December, and January. There is practically no rain most of the summer months. The average rainfall is about 50 mm. The graphs in Figure 3 for humidity, temperature, and rainfall provide a clear picture of the climate in Jeddah.

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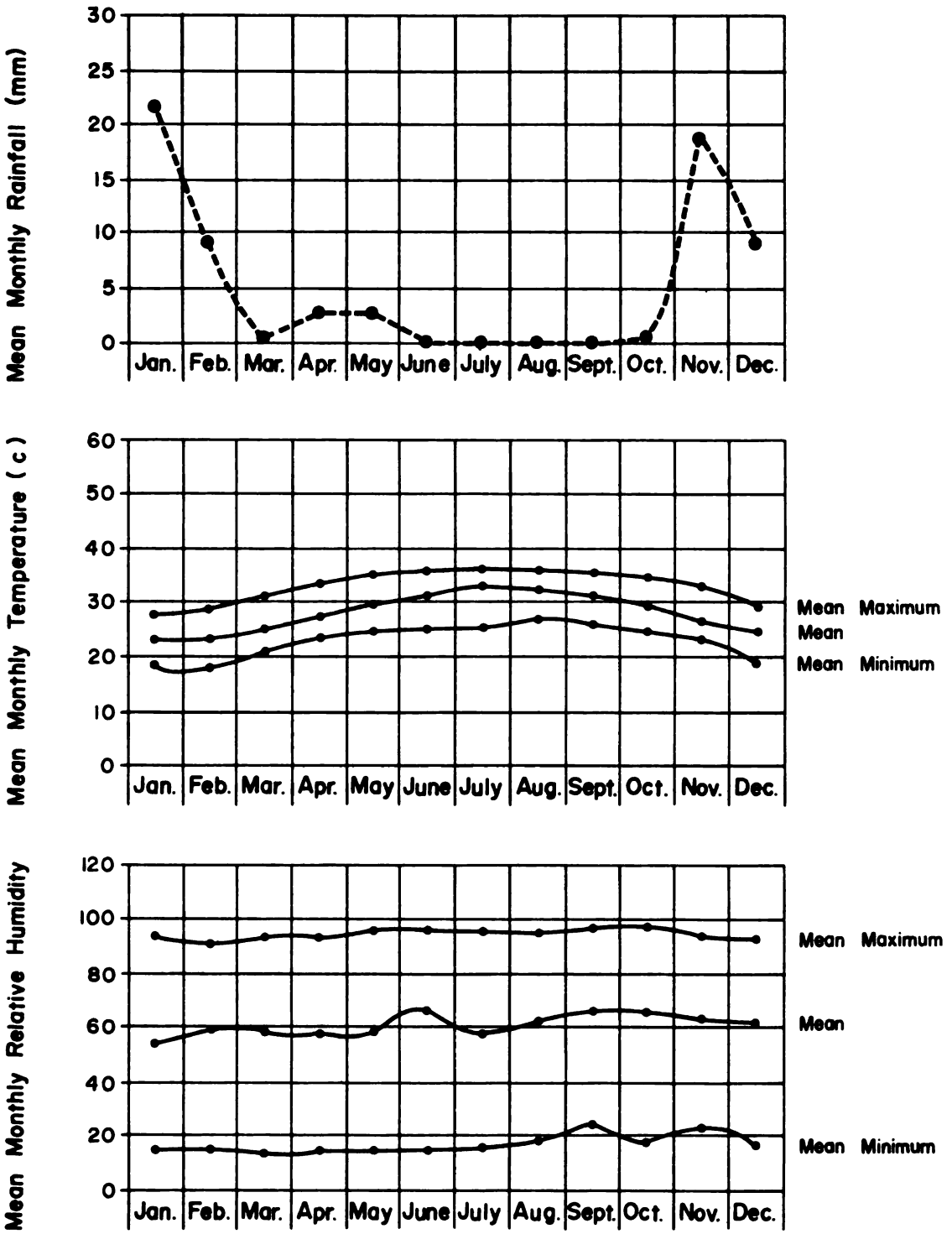
[2]Saudi Arabia, Ministry of Defense, Meteorology Department, Mean Monthly Climate Data for Jeddah City 1966-1976, Jeddah Station, p. 1.

[3]Saudi Arabia, Ministry of Interior, Municipal Affairs, Regional and Town Planning Department, Western Region Plan, Alternative Urban Strategies, Jeddah, 1972, p. 23.

JEDDAH CLIMATIC CONDITION 1966 - 1976 (FIGURE 3)



Source: Kingdom of Saudi Arabia
Mean Monthly Climatic Data For Jeddah City 1966 - 1976
Ministry of Defense, Met. Dept.

ECONOMIC FUNCTIONS

In 1945 a study by Harris and Ullman offered various explanations for the nature of cities.[4] The authors stated that cities perform various functions for society. Three of the important functions cities perform include providing comprehensive services, transportation, and specialized services. Harris and Ullman categorized the first group of cities as central places because they perform comprehensive services to the surrounding areas. The second group of cities are based on transportation. These transport cities perform break-of-bulk and allied services along transport routes. The third group of cities perform specialized functions such as mining and manufacturing, or services such as recreation for large areas including general tributary areas of nearby cities.

Most cities, according to Harris and Ullman, represent a combination of these three types of functions with the relative importance of each factor varying from city to city. Such is the case of Jeddah city as it provides comprehensive services as an important trade center for Saudi Arabia. It also has the main international airport in the Southwest and Western regions of the country and is the main industrial and manufacturing center for these same regions (Figure 4).

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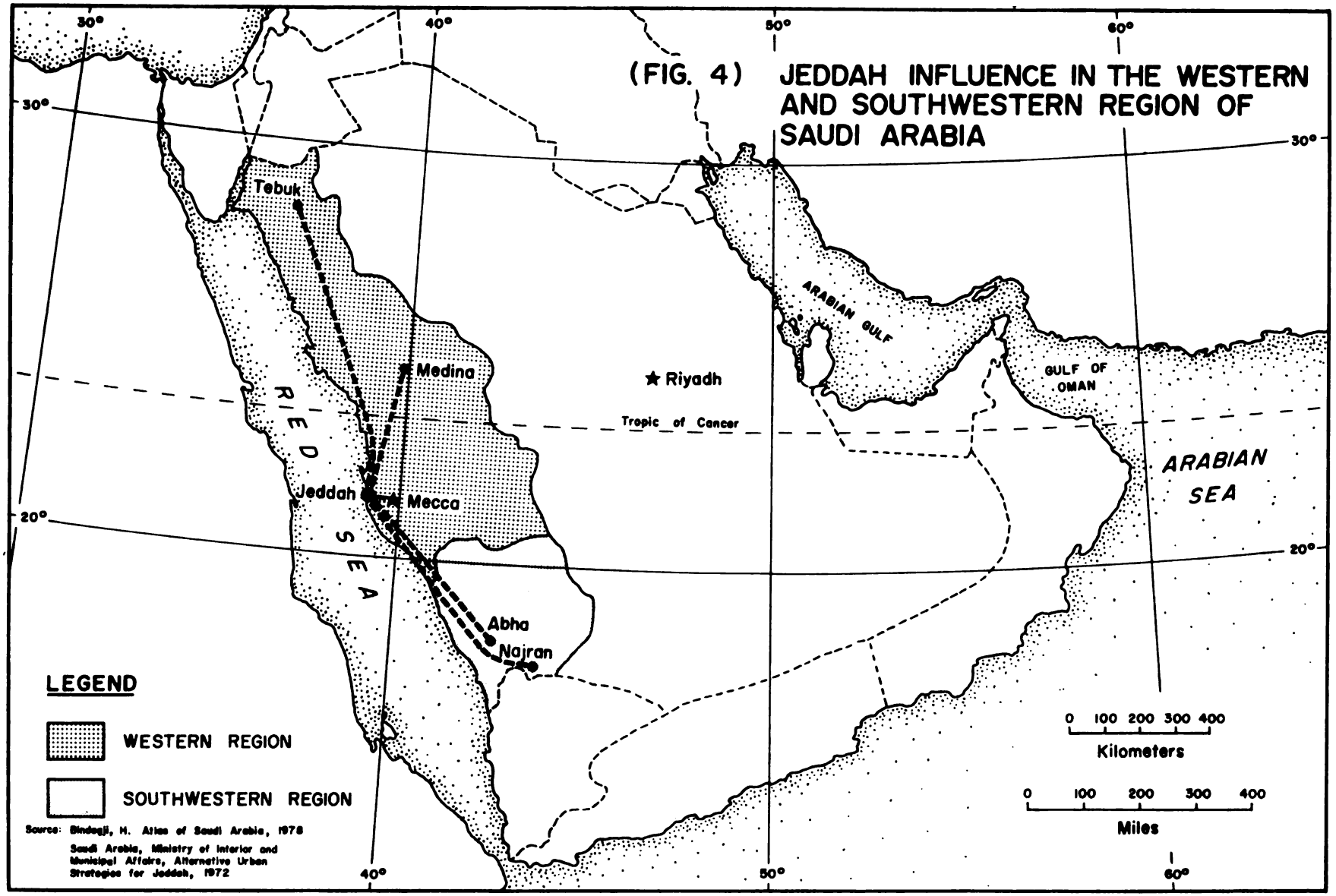
[4] Chauncy Harris and Edward Ullman, "The Nature of Cities," Annals of the American Academy of Political and Social Science, Vol. 242 (November 1945), pp. 7-17.


(FIG. 4) JEDDAH INFLUENCE IN THE WESTERN AND SOUTHWESTERN REGION OF SAUDI ARABIA
30°
40°
50°
60°
Tebuk
Medina
Riyadh
Tropic of Cancer
Jeddah
Mecca
Abha
Najran
RED SEA
ARABIAN GULF
GULF OF OMAN
ARABIAN SEA
LEGEND
WESTERN REGION
SOUTHWESTERN REGION
Source: Sindagji, H. Atlas of Saudi Arabia, 1978
Saudi Arabia, Ministry of Interior and Municipal Affairs, Alternative Urban Strategies for Jeddah, 1972
0 100 200 300 400
Kilometers
0 100 200 300 400
Miles

The strategic site of the city of Jeddah on the shore of the Red Sea gives it prominence as an important situation in the country's Southwest and Western regions, a situation that has been essential in accounting for its growth.[5] Jeddah city dominates the Southwest and Western regions in the following four ways.[6] First, it contains the most varied concentration of economic services. With the main port and airport it dominates the export and import trade; the city accounts for about half of the country's total trade. Second, the comprehensive services such as the commercial, financial, and wholesale are concentrated in Jeddah more than in any other city in these two regions. Third, Jeddah has the largest concentration of the manufacturing establishments and the largest Red Sea Port. Most of the capital investment and work force in manufacturing are located here. Fourth, Jeddah is the gateway to the holy place of Mecca. Every year thousands of devout muslim pilgrims from all over the world make their pilgrimage to Mecca by land, sea, and air. During this period the streets and shops in Jeddah are crowded because it is the main transit point for most of the pilgrims. Thus a combination of commercial, industrial, and other service functions make Jeddah the most important city in the

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[5]For further discussion of site and situation see Dean S. Rugg, Spatial Foundations of Urbanism (Dubuque, IA: Wm. C. Brown Company, 1972), pp. 79-98.

[6]Saudi Arabia, Ministry of Interior, Municipal Affairs, Regional and Town Planning Department, Western Region Plan, Master Plan Report for Jeddah, 1972, p. 13.

country's Southwest and Western Regions, and one of the most important cities contributing to the country's total economic development.

INTERNAL LAND USES

Three theories have been developed concerning the internal structure of cities.[7] The concentric zone theory states that the pattern of growth of the city takes place from its central area and spreads outwards in a concentric pattern. Five concentric zones have been identified in this theory developed by Burgess. The second theory, the sector theory, developed by Hoyt, states that the growth takes place out from the core of the city along major routes of transportation. The third theory used to explain urban growth is the multiple nuclei theory developed by Harris and Ullman. It postulates that the land use pattern in many cities is built not around a single center but around many discrete nuclei.

Of these three theories, the sector theory appears to be the most applicable in explaining the existing land uses and historic growth of Jeddah city. The city stretches outward in two main directions, the north and east, where they are along the main transport routes linking the city to Medina and Mecca (Figure 5). Before 1948 Jeddah was a small town surrounded by walls; it served as the port of

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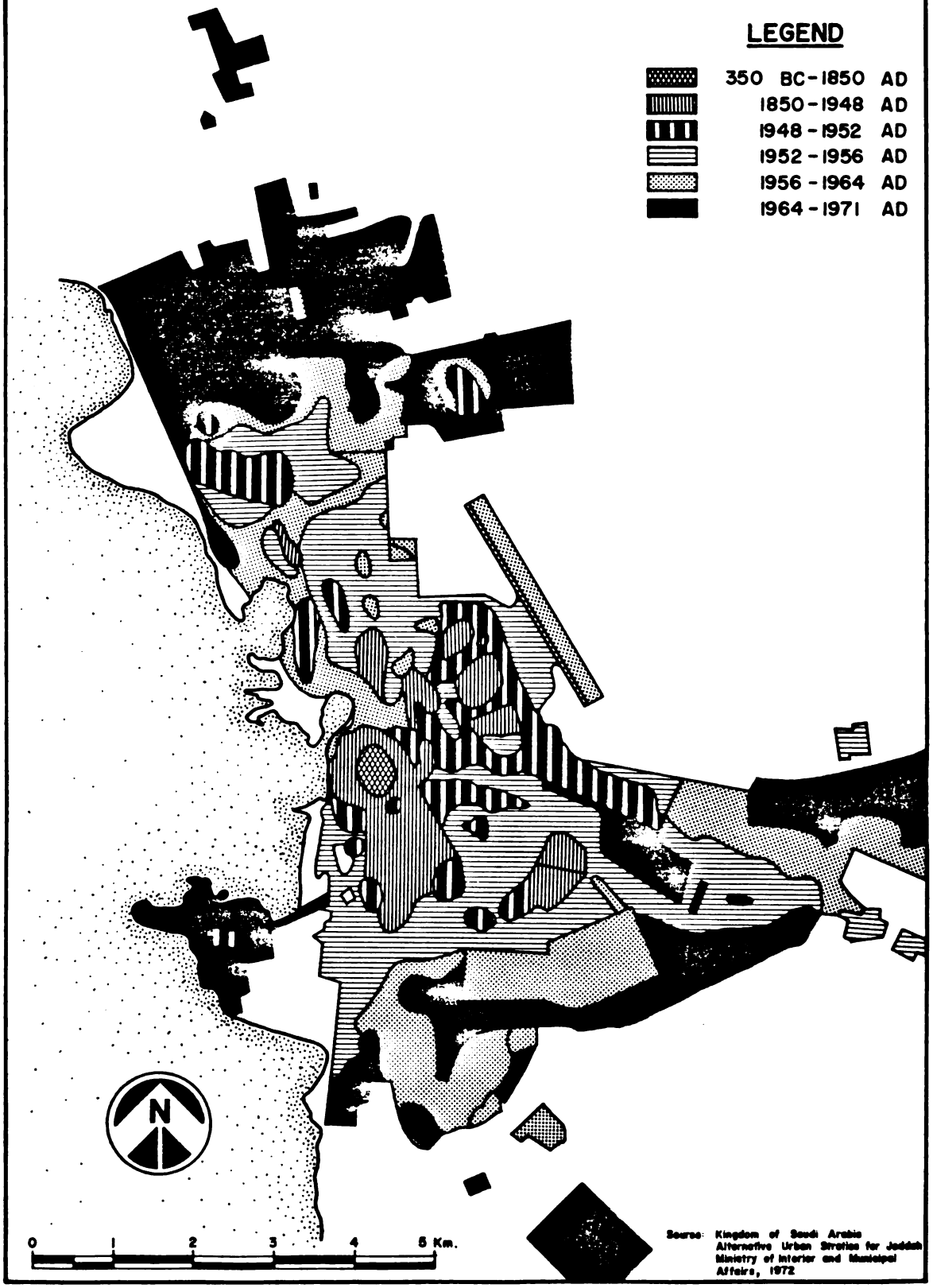
[7]Harris and Ullman, op. cit.

THE GROWTH OF JEDDAH
(FIGURE 5)



entry for the pilgrims who arrived by sea. Beginning in the 1960s, the town began to grow gradually with new dwellers residing in eastern and southern sections outside the walls. More recently the built-up area extended with the addition of the airport and larger harbor facilities and with more streets being laid out.[8] The city area has been expanding very rapidly since 1970.

In terms of land uses, most of the city's commercial activities are located in the central business district. The areas surrounding the CBD provide most of the retail services such as food, construction materials, domestic goods, banks, travel agencies and hotels. People in the medium income bracket live here.

The southern part of the city is where most of the low income residents live. This quarter is growing relatively slowly economically because it is mainly a slum area that experiences high levels of industrial pollution because of the petroleum refinery. It is also spatially disorganized in terms of the planning of streets, the designs of houses, the spacing between houses, and in providing public utilities. Land values in this quarter are low compared to other districts.

Land uses in the eastern part of the city are oriented along Mecca Road. The land values are high. Government and company offices, car dealers, car services, supermarkets, departmental stores, some

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[8] Master Plan Report for Jeddah, op. cit., p. 13.

industrial plants and mixed residential areas are found in this part of the city. Economic and population growth in this quarter is rapid.

Urban expansion to the North is more rapid than elsewhere. The existence of Medina Road is very critical to the rapid growth. This sector is a mixture of residential, commercial, and industrial activities. Most of the recent developments including high income residential villa, foreign embassies, company offices, and several industrial plants have taken place in this sector since 1970. About twenty-five miles along the Medina Road to the north of the central area, a new airport is under construction. The new airport will be one of the largest in the country and will relieve the heavy pressure on the old airport during the months when thousands of pilgrims arrive from all over the world. This northern sector has experienced better planning for human services than the other sectors described.

Housing construction is expanding rapidly north and east of the city, however, this has not been accompanied by good comprehensive planning that is designed to meet other needs facing the city. Successful integrated city planning should attempt to provide the inhabitants with essential utilities such as a water supply, electricity, a sewage system, transportation, good public health, and recreation facilities. Currently only some of these essential utilities are available within the city. Where many of these services are available, there is often a lack in proper organization and delivery to all districts and to the total

population. Ineffective administration could be tied to poor planning in the past and to the lack of experience necessary to provide good planning.

RECENT POPULATION GROWTH

Jeddah has experienced a high growth rate in population over the last two decades. This trend is likely to continue from a base population of 381,000 in 1971 to an estimated population of between 800,000 and 1.65 million by 1991 (Figure 6). These projections are included in a report on the master plan for the city prepared by the Regional and Town Planning Department.[9]

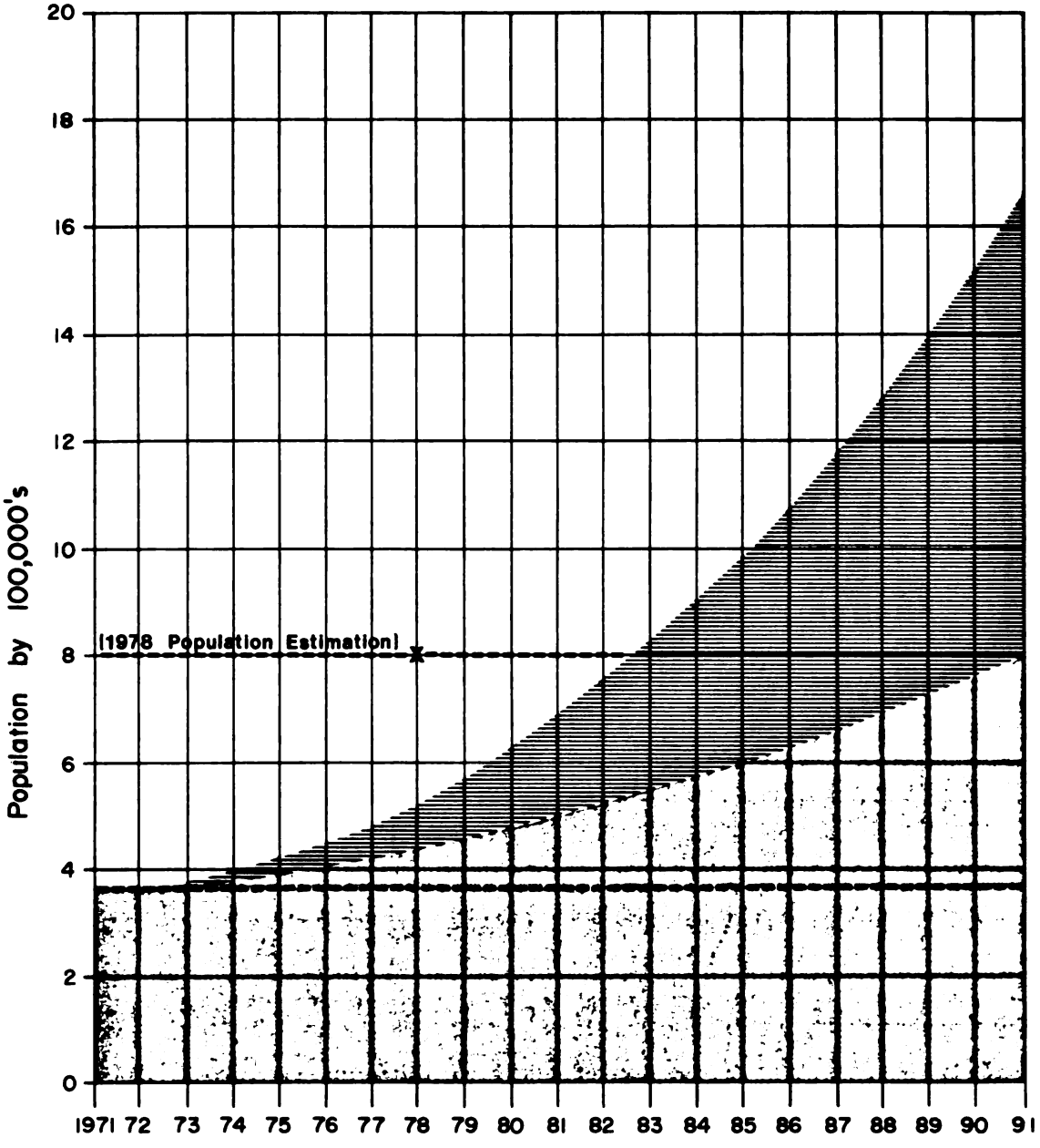
There are not accurate available data about the city's population. The lack of a census from a long time has meant that estimates have to be used. In a history of Jeddah city, one author included some data about the population in Jeddah that were collected from a variety of sources.[10] However, all data are just estimates (Figure 7). The last two population estimates cited in government reports are 381,000 in 1971,[11] and about 561,000 in 1974.[12] Most of the government planning

[9] Ibid., p. 41.

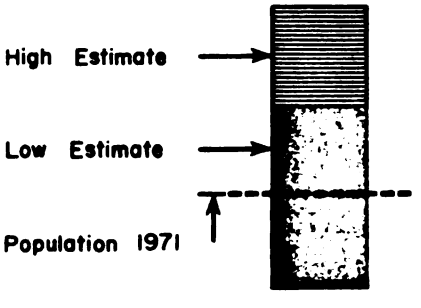
[10] Abdul Gaddous Al-Ansari, History of Jeddah (Jeddah: Dar Al-Asafehani, 1963), pp. 87-94.

[11] Master Plan Report for Jeddah, op. cit., p. 41.

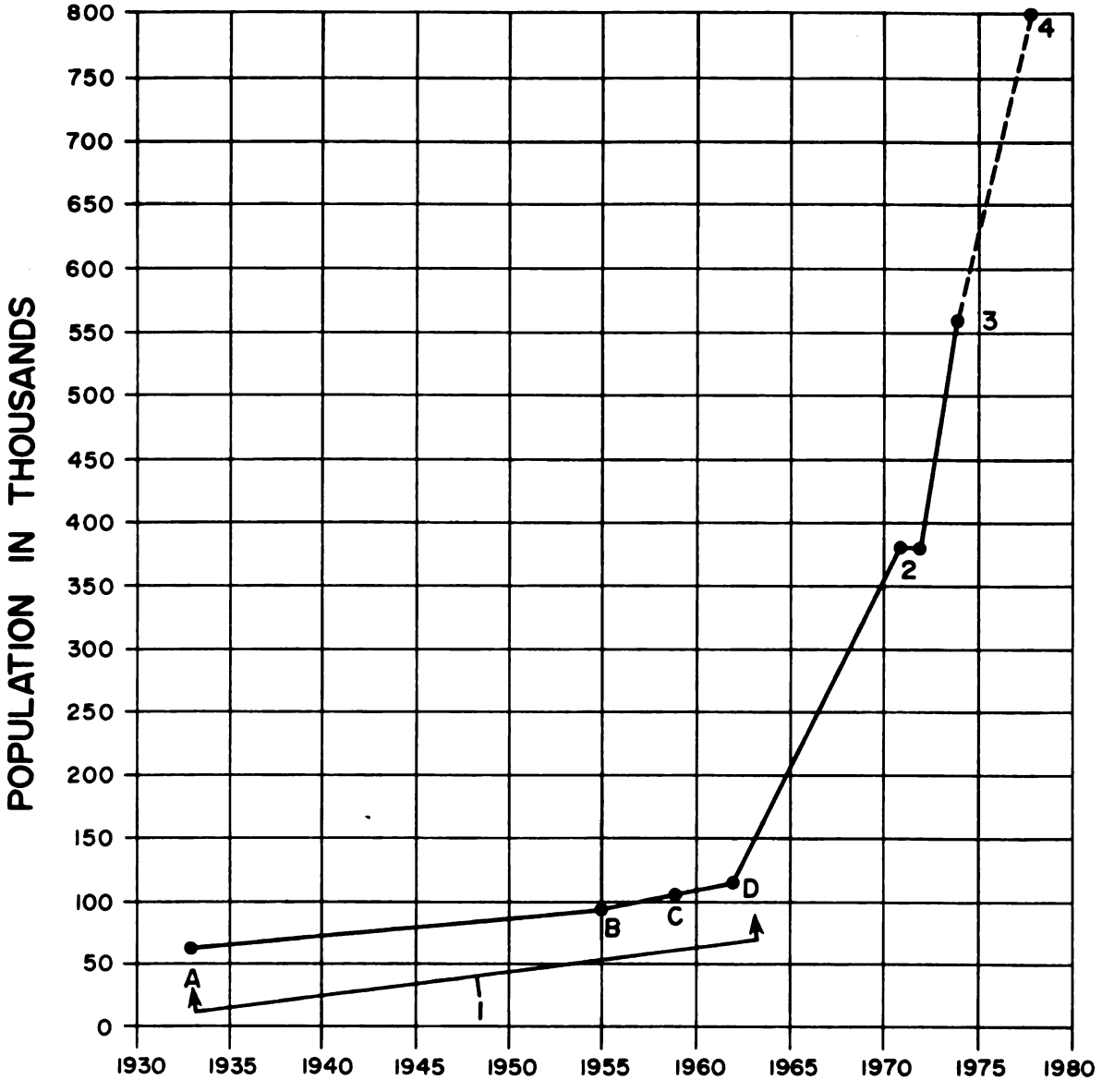
[12] Saudi Arabia, Ministry of Education, Data Center, Some Indications of Saudi Arabia First Population Census 1974, Riyadh, 1976, p. 9.



POPULATION GROWTH FORECASTS 1971 - 1991
(FIGURE 6)



Source: Kingdom of Saudi Arabia
Master Plan Report - Jeddah
Ministry of Interior, Municipal Affairs, 1972



POPULATION GROWTH OF JEDDAH: 1933 - 1978 (FIGURE 7)

Source: 1. Al-Ansari, A. History of Jeddah, 1963

2. Saudi Arabia, Ministry of Interior, Municipal Affairs, Master Plan Report for Jeddah, 1972

3. Saudi Arabia, Ministry of Education, Data Center. Some of Saudi Arabia's first population census prepared in 1974, Riyadh, 1976

4. From 1975 - 1978 is an estimation

agencies estimate the 1978 population for Jeddah to be 800,000. Recent population growth can be explained by five major reasons.

First, there is increased immigration from the rural areas to the city of Jeddah because of the greater opportunities for employment and better benefits than on the farm. In the city there are opportunities for work and study, more money is also available than in the rural areas. Most of the young people who migrated from the rural areas return to their villages for summer.

Second, most of the largest national and international companies and firms locate in Jeddah because it has the main airport, harbor, and is the focus of commercial activity in the Southwest and Western Regions. It is also the main city for commercial contacts with North and East Africa and other Middle East countries.

Third, Jeddah is occupied by an increasing number of non-Saudis. In 1961 about 35 percent of Jeddah population was non-Saudi.[13] According to a survey undertaken by the Regional and Town Planning Department in 1971-72, about 88 percent of families sampled were born outside Jeddah and of these 29 percent came to Jeddah within the last five years before the survey.[14] Of this 88 percent, about 60 percent were born outside Saudi Arabia. About 58 percent of the 29 percent who arrived in Jeddah within the last five years prior to the survey were living in

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[13]Abdul Gaddous Al-Ansari, op. cit., p. 93.

[14]Alternative Urban Strategies, op. cit., pp. 71 and 74.

foreign countries. About 42 percent of total sample did not report Saudi citizenship. Finally, about 53 percent of Jeddah's population consists of non-Saudians. The estimate of non-Saudians at present is between 55-60 percent. Most come from the Arab countries of North Yemen, South Yemen, Egypt, Sudan, Lebanon, Palestine and from non-Arab countries including Nigeria, India, Pakistan, South Korea, West Germany, Great Britian, and United States. The concentration of these people is found in Jeddah because of the availability of employment, proximity to foreign agencies, and easy accessibility of other cities and villages in the country to Jeddah. Most of the population from Western countries live in villas and apartments along Medina Road. The Yemenis, Egyptians, and Pakistanis live in traditional houses in the central area and Nuzla districts. Other nationalities live throughout the city. Most of the black population from Africa live in shacks in south Nuzla district.

The fourth reason for recent urban growth is attributed to the current five year plan (1975-1980) which is associated with a high rate of inflation. Land values have become more expensive. Obtaining a government loan for housing or an industrial project is possible for those who can raise about 30 percent of the capital. Hundreds of villas and apartments have been built; also many industrial plants have been established according to this plan. This has increased the demand on the labor force from outside Jeddah, within Saudi Arabia, and other

countries. Most people work in the construction industry, in various offices and companies, and for the government.

A fifth and final reason that accounts for rapid growth in the city is the flexible visa regulations which encourage non-Saudis to enter the country. Many from neighboring Islamic countries have come to Jeddah on the pretense of visiting the holy places only to remain indefinitely. Some decide not to return to their native countries. It is difficult to keep track of these people for lack of an effective immigration checking system that provides accurate addressess.

These are among the main reasons for the tremendous population increase in Jeddah; all contribute to a number of problems.

URBAN PROBLEMS

The current rapid population increase and anticipated growth are the basis for a number of problems facing Jeddah. Many problems are the result of insufficient planning and the absence of comprehensive coordinated planning schemes. Among the problems are increasing air pollution, a noisy airport, too many traffic accidents, poor health care services, lack of recreation facilities, insufficient parking lots and public facilities, and a sound water system.

One of the major environmental problems facing the city is lack of a sufficient water supply. This has increased particularly within

the last five years. It is examined in some detail in the following chapters.

CHAPTER III

WATER SYSTEM IN JEDDAH CITY

In this chapter six topics related to the city's water system are discussed: (1) an historic background to the city's water problems, (2) the three currently available water resources, (3) the existing and proposed water network, (4) the management of water supply, and (5) water uses and prices.

HISTORIC BACKGROUND

Most of the early travelers described Jeddah as the "thirsty city." They described the water crisis and how residents used cisterns and pits to collect rain water.[1] All of the regimes which have governed the city through its history have tried to solve the problem of insufficient water by transporting water from any district where there was a surplus.

In 1517 the Ottoman state governed the Hijaz, the district where Jeddah is located.[2] The Ottoman Sultan supplied the city with

[1]Saudi Arabia, Saline Water Conversion Corporation Projects, Water Unlimited (Napoli, Italy: Falcon Press, n. d.), p. 1.

[2]Abdul Gaddous Al-Ansari, History of Aziziah Water Supply in Jeddah (Jeddah, Saudi Arabia, n. p.), 1972, p. 43.

water from the springs of Waziriyah, a site about 6.8 miles east of Jeddah in the direction of Mecca.[3] These springs depended on rainfall which when it came provided sufficient water. However, when there was no rainfall, there was a water shortage. As described earlier, rains in and around Jeddah are irregular and these springs failed to meet the growing demands of water that the city needed. To meet the deficit in water resources, in 1907 the Ottoman government decided to import distillation machines from Europe.[4] Though the distillation machine was performing commensurate with the city's water demands, the machine itself performed irregularly.

During the 1924-25 Saudi Hashemite War, the coal supply, used to operate the distillation machines, was cut off.[5] This resulted in wood being used as a substitute to distill the water. But wood damaged the distillation machines. After this war the Saudi government tried in vain to repair the machines so that they could resume the increasing water supply demand by the city, especially for the large number of pilgrims arriving during the pilgrimage season. However, the damage proved irreparable. Finally in 1927 the government imported two new machines from Europe to distill water and meet the needs of the city.[6]

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[3] Ibid., p. 44.

[4] Ibid., p. 47.

[5] Ibid., p. 49.

[6] Ibid., p. 49.

In 1942 the Saudi government invited a technical mission from the United States to study the water situation with the aim of improving the water supply.[7] The mission reported there was a possibility to supply Jeddah with water from Wadi Fatima located about 34 miles east of the city. The government started the operation and by 1947 the project was successfully completed. Later, in 1967, another new resource called Wadi Khlais, about 70 miles to the north of Jeddah, was also tapped to supply water to the city.[8] In the early 1970s the desalinization plants, which are discussed more fully below, provided a good part of the city's water supply.

CURRENT WATER RESOURCES

Presently Jeddah receives its water supply from three different sources (Figure 8). They are from Wadi Fatima located about 30 miles east of Jeddah, (2) from Wadi Khlais located about 70 miles north, and (3) a desalinization plant site in the northwest part of the city of Jeddah at Kubbat Asherah. Each of these sources needs to be discussed further.

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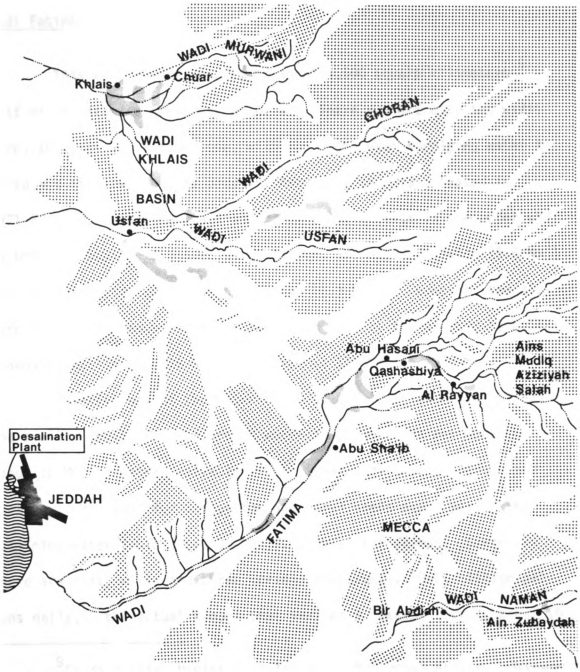
[7] Ibid., p. 53.

[8] Ibid., pp. 213-16.



JEDDAH WATER DISTRICT [FIGURE 8]

Source: Saudi Arabia
Ministry of Interior, Municipal Affairs, 1972

Wadi Fatima

This wadi covers an area of about 4,500 square kilometers.[9] Most of the storage areas are alluvial. There are actually two wadis here, an upper and a lower one, with the upper wadi supplying water to Mecca and the lower one to Jeddah. According to data released in 1971-72 (Figure 9), the exact amount of water storage in the upper wadi is unknown, but it is insufficient to meet the needs of Mecca (5.6 Mm^3) and for irrigation and rural population (2.3 Mm^3).* However, the picture is not that encouraging in the lower wadi as the storage level is gradually declining (315 Mm^3 in 1967-68 to 263 Mm^3 in 1972).

Observations of the water table in the lower wadi reveal that the average decline in the ground water is about 70 mm per month. About 10 Mm^3 of water available in the lower wadi goes to Jeddah and another 17 Mm^3 goes for irrigation and rural needs every year. The declining water table poses a special problem for Jeddah. Currently there are fifty wells and three springs that supply 16-20 million gallons daily,[10] the actual amount that arrives in Jeddah city is about 10

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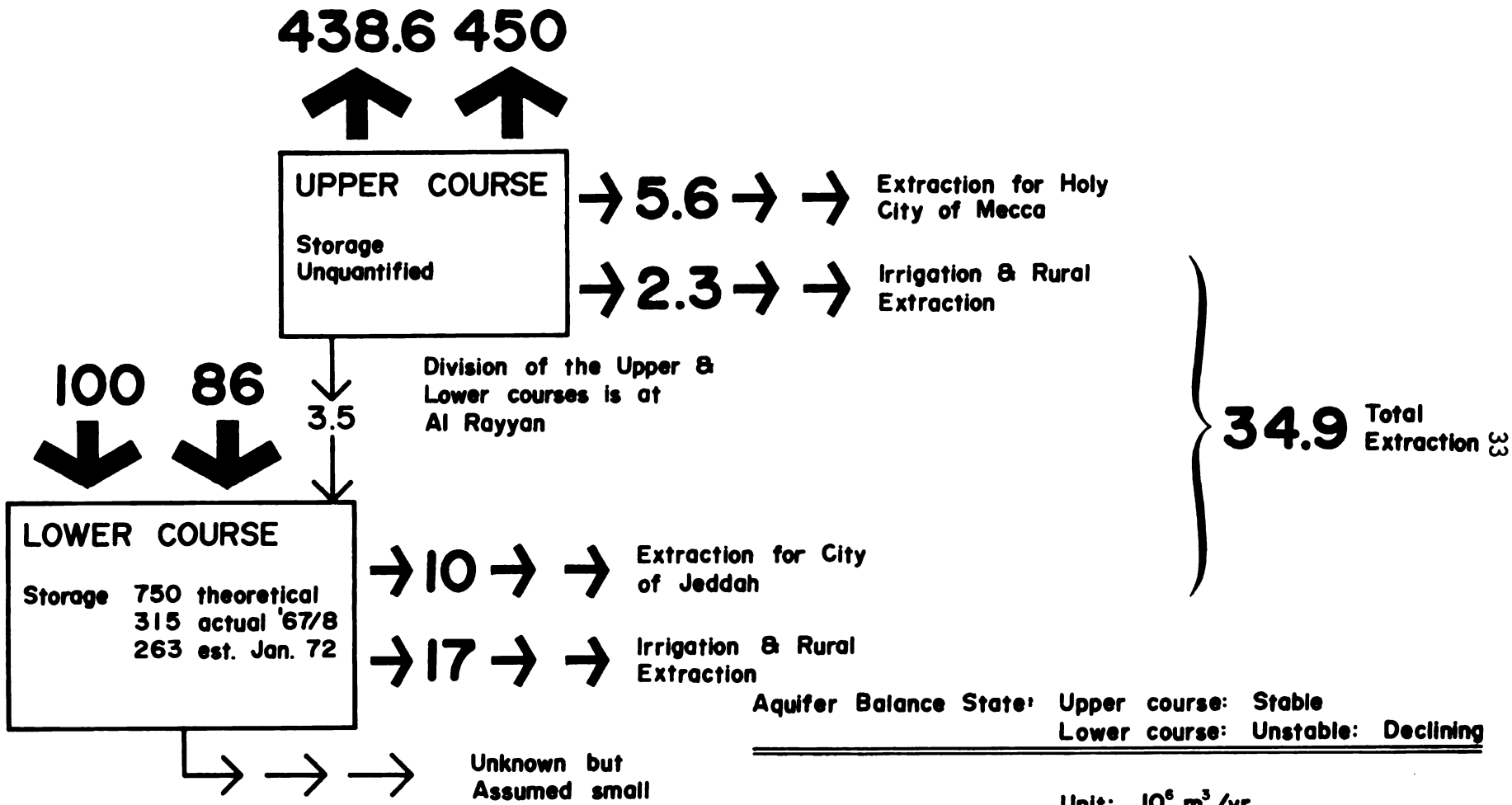
[9] Saudi Arabia, Ministry of Interior, Municipal Affairs, Western Region Plan, Immediate Action Studies Report, Vol. 3, Water, Jeddah, February 1972, pp. 23-24.

[10] Interview with Mr. Mohammed M. Al-Harbi, the Supervisor of the Geologists in Jeddah, The Branch Office of Ministry of Agriculture and Water in Jeddah, March 1978.

* Mm^3 = Million cubic meters per year.



INDICATIVE WATER BALANCE for WADI FATIMA
(FIGURE 9)

Source: Saudi Arabia
Ministry of Interior, Municipal Affairs, 1972

million gallons daily. The rest of the water is distributed to the villages via Ain (an aqueduct) between the wadi and Jeddah city.

Wadi Khlais

This wadi is located about 70 miles north of Jeddah. It is extensive and covers about 5,200 square kilometers.[11] It includes four catchment areas: 1) Wadi Murwani, 2) Wadi Ghoran, 3) some small drainage basins, and 4) the Wadi Khlais alluvial basin itself. If there is no rain, all four catchment areas run dry and understandably there is no water supply. When there is heavy rain, the lack of dams account for excess water runoff; high temperatures evaporate a great deal of surface water. The Ghoran basin receives about 1.5 Mm^3 annually from the floods of the wadi and about 1.25 Mm^3 from rainfall. An estimated 5.5 Mm^3 are extracted annually from the wells; about 60 percent is used for irrigation with about 2.2 Mm^3 returned back to the soil. These figures reflect the imbalance between the input and output. Wadi Ghoran is taking an overdraft of 0.55 Mm^3 per year. The Murwani basin receives about 24 Mm^3 from flood water and about 8.25 Mm^3 from the subsurface flow and the infiltration resulting from rainfall. The output annually is about 16 Mm^3 from the wells. There are 6 Mm^3 returned back to the soil, 4 Mm^3 outflow from the surface and 2 Mm^3

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[11] Water, op. cit., pp. 17-22.

from the subsurface outflow. The estimated extraction from the Murwani basin for irrigation consumption is about 60 percent with about 40 percent being lost through natural evapo-transpiration; this leaves nothing for wadi outflow and basin exports. In 1966 a field analysis done by Ital Consultant Company indicated that about 15-16 Mm^3 of water per year is consumed by phreatophytes. There is an insufficient amount of water to face the future demand both for irrigation or urban uses (Figure 10).

There are about thirty-five wells and three springs in the Khlais basin.[12] While the average water supply to Jeddah is estimated between 8-10 million gallons daily, only about 7 million gallons actually arrives to the city's reservoirs. The rest of the water is lost due to faulty connections. There is a 70-mile long pipeline between Wadi Khlais and Jeddah city. These pipeline connections are not regularly inspected and maintained. When a leak or break occurs, it may go unchecked for a period of time resulting in water loss.

In summary, there is an insufficient amount of water in these two wadis to meet the city's demands. Wadi Fatima is in an unsatisfactory and uncertain state because of a serious overdraft.[13] Wadi Khlais has entered a phase of virtually irreversible decline.[14] It is estimated

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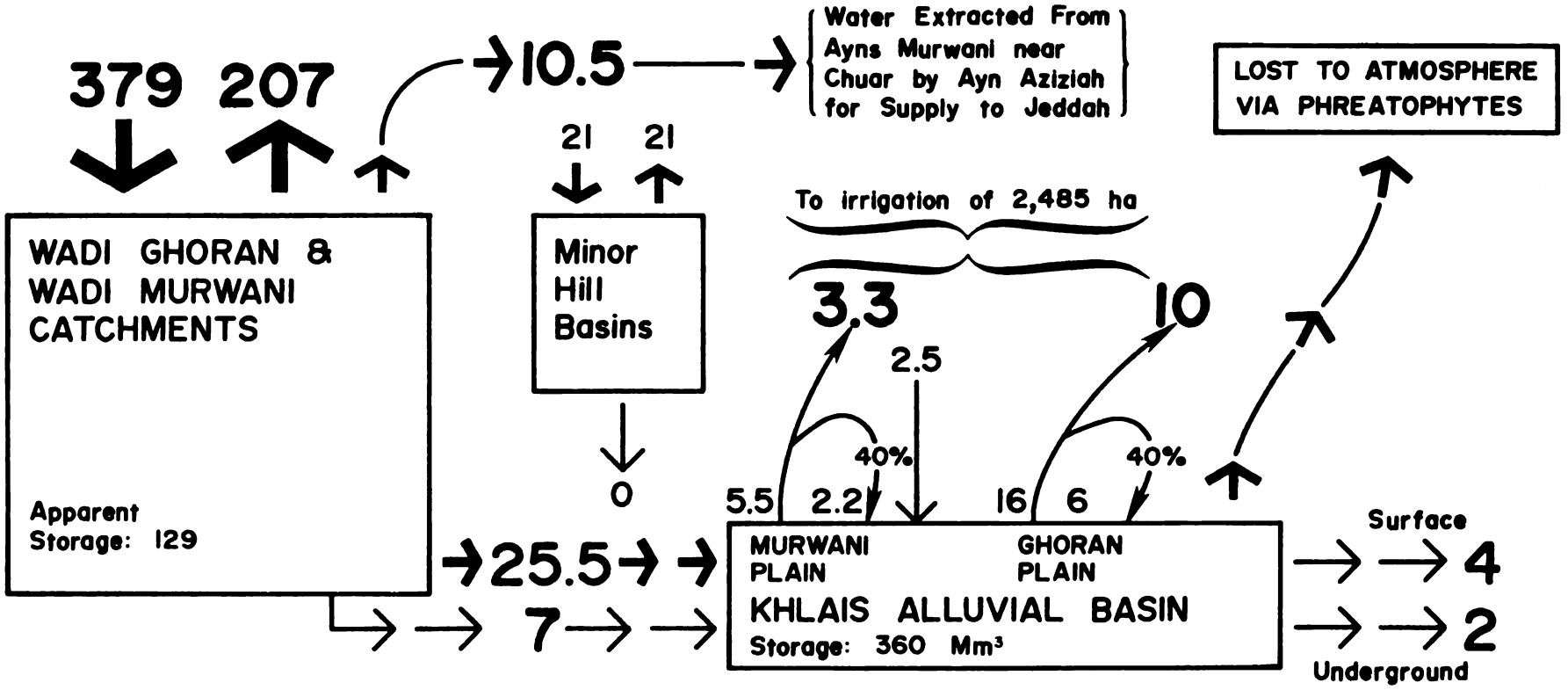
[12] Mr. Al-Harbi, op. cit.

[13] Saudi Arabia, Ministry of Interior, Municipal Affairs, Western Region Plan, Regional Framework, Stage Two, Phase Two, June 1972, p. 108.

[14] Ibid., p. 108.



Aquifer Balance State: Entering Decline

UNIT: 10^6 m^3/yr
60% Irrigation Efficiency

INDICATIVE WATER BALANCE for WADI KHLAIS
(FIGURE 10)

Source: Saudi Arabia
Ministry of Interior, Municipal Affairs, 1972

that the water table in this wadi is declining at 85 mm per month.[15] These water problems also have an impact on the agricultural sector. Many people have migrated from rural areas to the cities because of the lack of water (wasteful irrigation practices) and lowering water level of wells. There has been a gradual decrease in fruit and vegetable yields and little or no benefit gained by continuing to earn a living in the agricultural sector.

The Desalinization Plant

The best way to meet the growing demand for fresh water in Jeddah city is to look beyond the natural springs and other available water supplies in the immediate area to sea water, specifically the desalinization of water from the Red Sea. This source was first tapped in 1965 with an operation at Kubbat Ashrah, northwest of Jeddah city.[16] There are four different phases of the desalinization production process; the twenty year plan will terminate in 1983.[17] The estimates of water derived from these plants during these phases are graphed in Figure 11.

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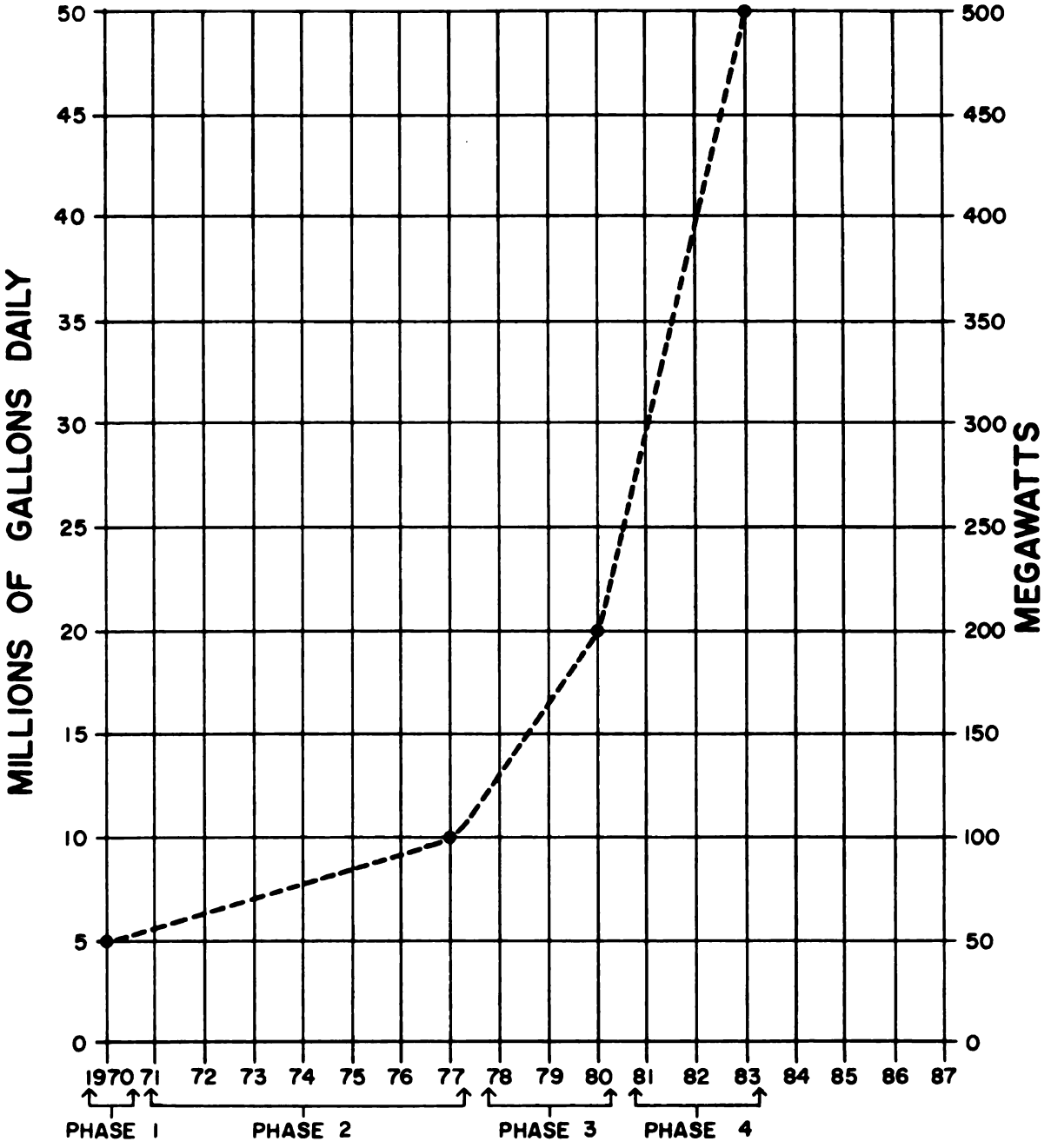
[15] Mr. M. Al-Harbi, op. cit.

[16] Water Unlimited, op. cit., p. 7.

[17] Ibid., pp. 9-10.



SUMMARY OF CURRENT OPERATIONS AND PROJECTS UP TO 1983 FOR JEDDAH CITY DESALINATION PLANT (FIGURE 11)

Source: Saudi Arabia
Saline Water Conversion Corp., Water Unlimited

Work on Phase 1 began in 1970 with production of 5 million gallons daily and production of 50,000 megawatts of electricity. Phase 2 started in 1970 with production anticipated in 1977. However, the expected actual production has been pushed back and was scheduled to begin in summer 1978. It is expected to yield about 10 million gallons daily and 84,000 megawatts of electricity. Phase 3 started in 1976 and once completed in 1980 will yield 20 million gallons daily and 200,000 megawatts of electricity. Phase 4 is scheduled to begin in 1980. It will provide about 50 million gallons daily and 500,000 megawatts of electricity by 1983.

Through the desalinization of sea water, Saudi Arabia hopes to meet satisfactorily the demands of Jeddah city for fresh water and electricity by eventually providing 85 million gallons of water daily and 850,000 megawatts of electricity. It should be mentioned that at present the desalinization plant does not provide the city with water it is capable of yielding.

THE EXISTING AND PROPOSED WATER NETWORK

The old network of the city's water supply covered most of the old districts like Central Area, Ruwais, and Nuzla. In 1967 and again in May 1969 VATTEN BYGGNADA BYRAN Company (VBB), a Swedish company, submitted reports and proposals to the Ministry of Agriculture and

Water regarding the water system and the distribution network in the city.[18] There are five stages in the operation of the existing Network that merit discussion.

The first and second stages include extended pumping stations and reservoirs at Medina Road Kilo 8. At the same time they distribute via the main network pipes water from the desalinization plants on the Red Sea shore; also water is pumped to the Medina Road Kilo 8 reservoir. At this main reservoir these two waters are mixed and treated and then pumped to the central areas of Jeddah city through the main network. To raise the water pressure in the southeastern side of the city there are booster stations at Mecca Road Kilo 5. These two stages were completed in 1973.[19]

The third stage comprises the house connections for the developed parts of the city like the Central area, the harbor, Ruwais and some parts of Nuzla district. A water tower with an effective volume of 13,500 cubic meters is to be erected at the Palace Gardens near Seaport Road. Work on the erection of this tower started in 1974 and is almost completed. (Figure 12).[20]

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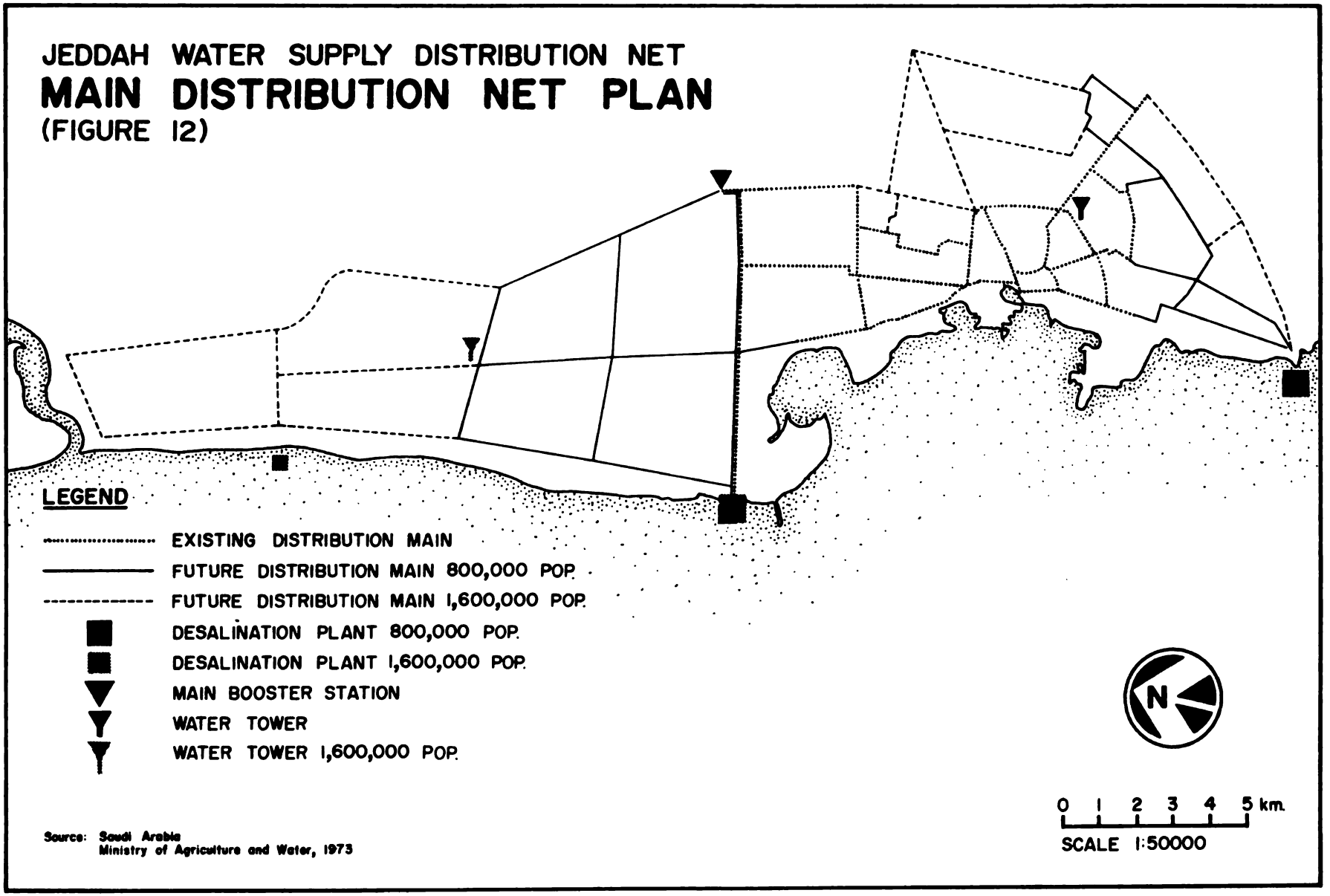
[18]Saudi Arabia, Ministry of Agriculture and Water, Jeddah Water Supply, Further Extension, VBB, Jeddah, January 1973, p. 2.

[19]Ibid., p. 2.

[20]Saudi Arabia, Ministry of Agriculture and Water, Jeddah Water Tower, Jeddah, n. d., p. 1.


JEDDAH WATER SUPPLY DISTRIBUTION NET
MAIN DISTRIBUTION NET PLAN
(FIGURE 12)
LEGEND
EXISTING DISTRIBUTION MAIN
FUTURE DISTRIBUTION MAIN 800,000 POP.
FUTURE DISTRIBUTION MAIN 1,600,000 POP.
DESALINATION PLANT 800,000 POP.
DESALINATION PLANT 1,600,000 POP.
MAIN BOOSTER STATION
WATER TOWER
WATER TOWER 1,600,000 POP.
N
0 1 2 3 4 5 km.
SCALE 1:50000
Source: Saudi Arabia
Ministry of Agriculture and Water, 1973

The fourth stage includes extensions of existing transmission lines, reservoirs, water towers, pumping station and distribution nets. Work on this fourth stage is expected to finish by 1980 (Figure 13). It is designed to provide another 85 million gallons daily in the early 1980's from the new desalinization plants at Kubbat Ashrah and 50 million gallons daily from the new desalinization plant in south Jeddah (to be completed by 1985).[21] The fifth stage does not exist yet, but plans call for a more extensive network in the northern and southern parts of the city.[22] Plans are also underway to build six new reservoirs for the city, hopefully by 1981, at Medina Road Kilo 8. The old reservoirs at Kilo 8 have a capacity of 10 million gallons. The total capacity of the old and new reservoirs is projected for 30 million gallons.[23]

THE MANAGEMENT OF WATER SYSTEM

When the Saudi government started to supply Jeddah city with water in 1947, it called the project "Aziziah Water Supply", which was an independent government agency with its own budget and facilities.[24]

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[21] Saudi Arabia, Ministry of Agriculture and Water, Jeddah Water Supply-Distribution Net--Fourth Stage, Jeddah, August 1975, p. 1.

[22] Saudi Arabia, OKAZ Daily Newspaper, Thursday, June 22, 1978, p. 5.

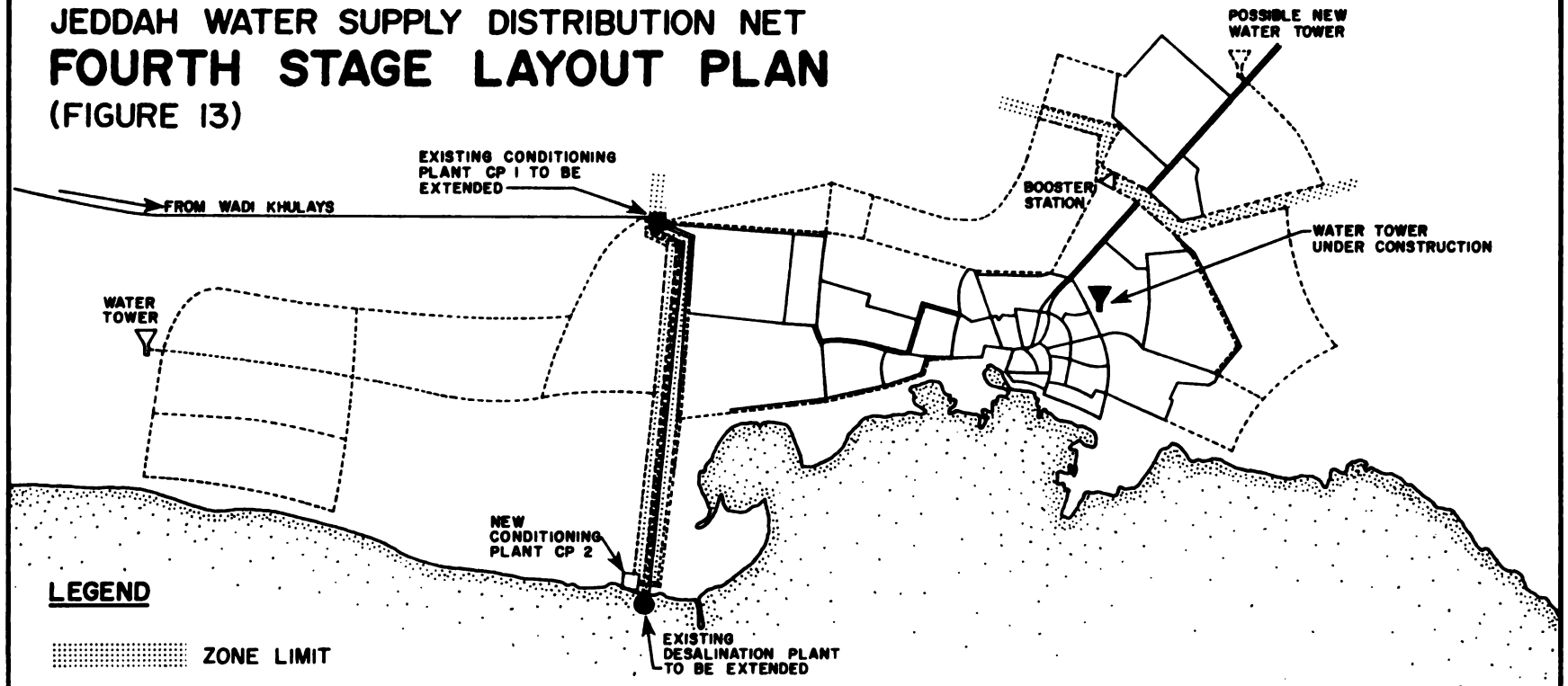
[23] Ibid., p. 5.

[24] Abdul Gaddous Al-Ansari, op. cit., pp. 12-14.

JEDDAH WATER SUPPLY DISTRIBUTION NET

FOURTH STAGE LAYOUT PLAN

(FIGURE 13)



Source: Saudi Arabia
Ministry of Agriculture and Water, 1975

It took care of the water supply to the city and its own management until about 1970. In 1965 the Ministry of Agriculture and Water started the desalinization project in the city of Jeddah.[25] This ministry signed a contract with the Swedish company referred to above, VATTEN BYGGNADA BYRAN (VBB), some time after 1965.[26] VBB is responsible for the water distribution network system, pumping stations, reservoirs and have connections.[27] Another company, Saudi Arabian BLOKAT, also takes care of the operation and maintenance of Jeddah water works.[28] Both VBB and BLOKAT are under the jurisdiction of the Ministry of Agriculture and Water, which has its branch office in Jeddah. The branch office has supervising authority over these two companies and represents the Ministry in the Western Region.

In 1971 the total amount of water delivered by the two wadis and the desalinization plant to the city of Jeddah was estimated to be 20 Mm^3 gallons a year (Table 1).[29] In the same year the consumption of the 20 Mm^3 gallons can be divided into four categories: 1) essential

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[25] Water Unlimited, op. cit., p. 7.

[26] Seven Green Spikes, op. cit., pp. 197-207.

[27] Ibid.

[28] Saudi Arabia, Ministry of Agriculture and Water, Saudi Arabian BLOKAT, Operation and Maintenance of Jeddah Water Works, Jeddah, January, 1978, p. 1.

[29] Master Plan Report for Jeddah, op. cit., p. 160.

or domestic urban, 2) municipal, industrial, harbor, etc., 3) gardening, and 4) network losses (Table 2).[30] The amount of water consumed in Jeddah city in 1971 for the population of 381,000 for various uses is shown in Figure 14. Based on current water usage the Ministry of Interior, Municipal Affairs Division, projected both the low and high population growths and low and high water supply needs to 1991 (Figure 15). Figure 16 shows the consumption per day in 1971 and estimates the demands to 1991.

Residents in the city of Jeddah obtain water from five different sources: (1) their home is connected directly via pipelines to the water work, (2) they purchase water from long water trucks (tanks), (3) small donkey pulled water carts, and (4) water peddlers who carry water in large buckets and tins, or (5) they carry their own water from the public standpipes. The scenes depicted in Figure 17 are common in Jeddah.

WATER USES AND PRICE

Water uses can be divided into three categories: domestic, commercial, and irrigation uses. Domestic uses cover cooking, washing clothes, and cleaning the houses. People who live in villas wash the floors of the houses and stairs about once a week. In the summer season

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[30] Ibid., p. 161.

TABLE 1

WATER RESOURCES IN 1971

Water Resource	Quantity (in gallons)
1. Wadi Fatima	7 Mm^3/yr
2. Wadi Khlais	7 Mm^3/yr
3. Desalinization Plant	6 Mm^3/yr
TOTAL	20 Mm^3/yr

TABLE 2

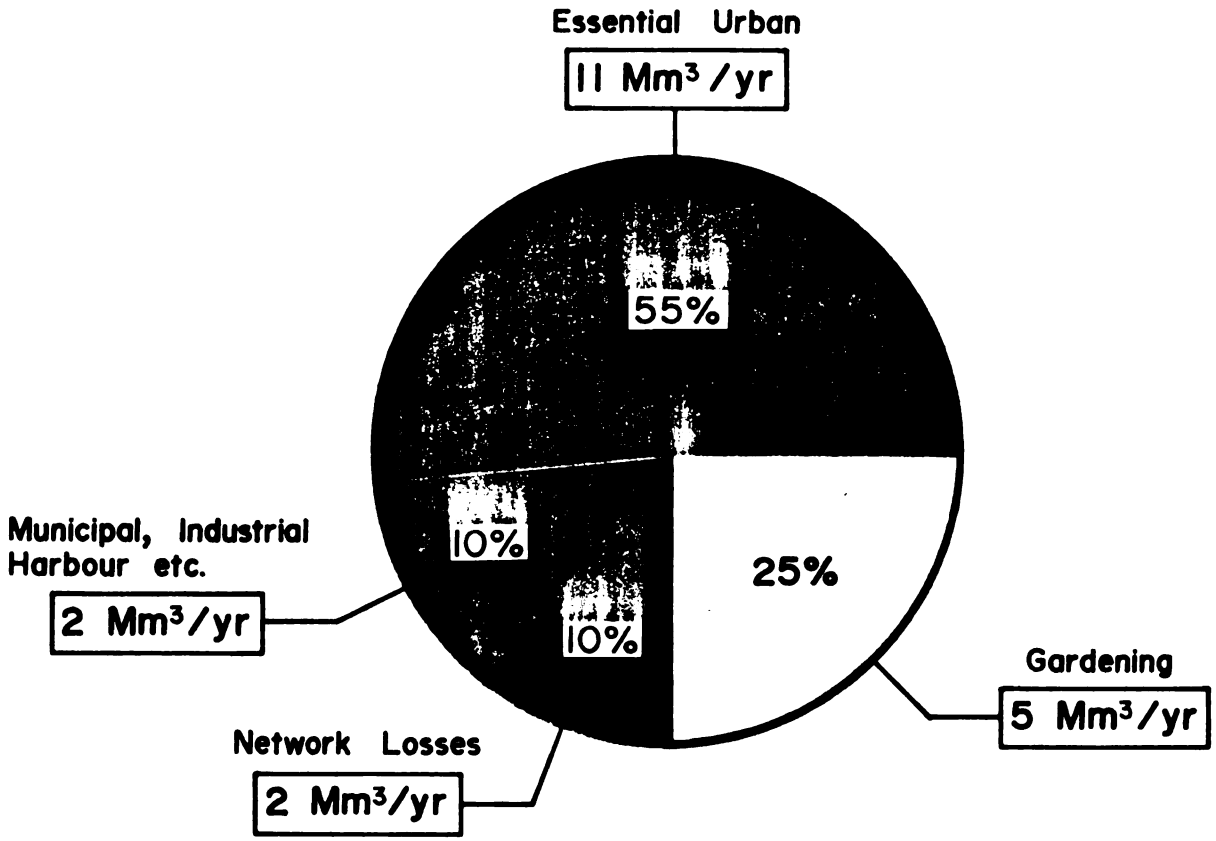
CATEGORIES OF WATER CONSUMPTION IN 1971

Category of Consumption	Mm^3/yr	% of Total	Daily per Capita Rate
1. Essential urban	11	55	80
2. Municipal, Industrial, etc.	2	10	14
3. Gardening	5	25	36
4. Network Losses	2	10	14
TOTAL	20	100	144

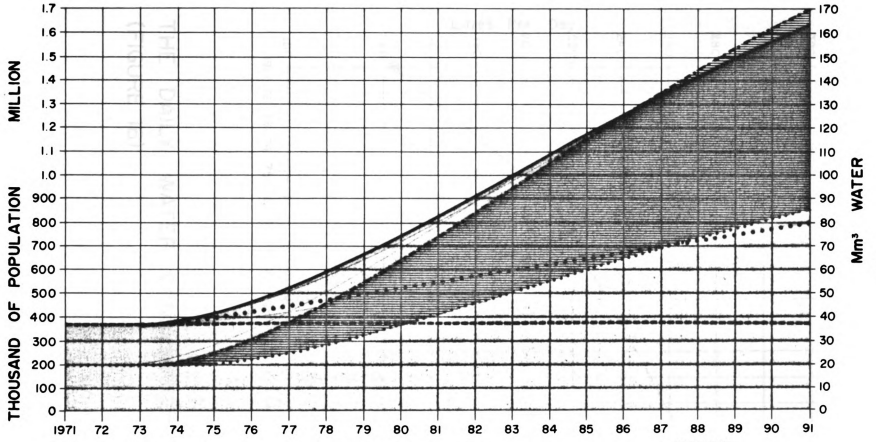
Note: Mid-1971 Population about 381,000.

Source: Ministry of Interior, Municipal Affairs, Master Plan Report For Jeddah, 1972, pp. 160-161.

PERCENTAGE OF WATER CONSUMPTION IN 1971
(FIGURE 14)

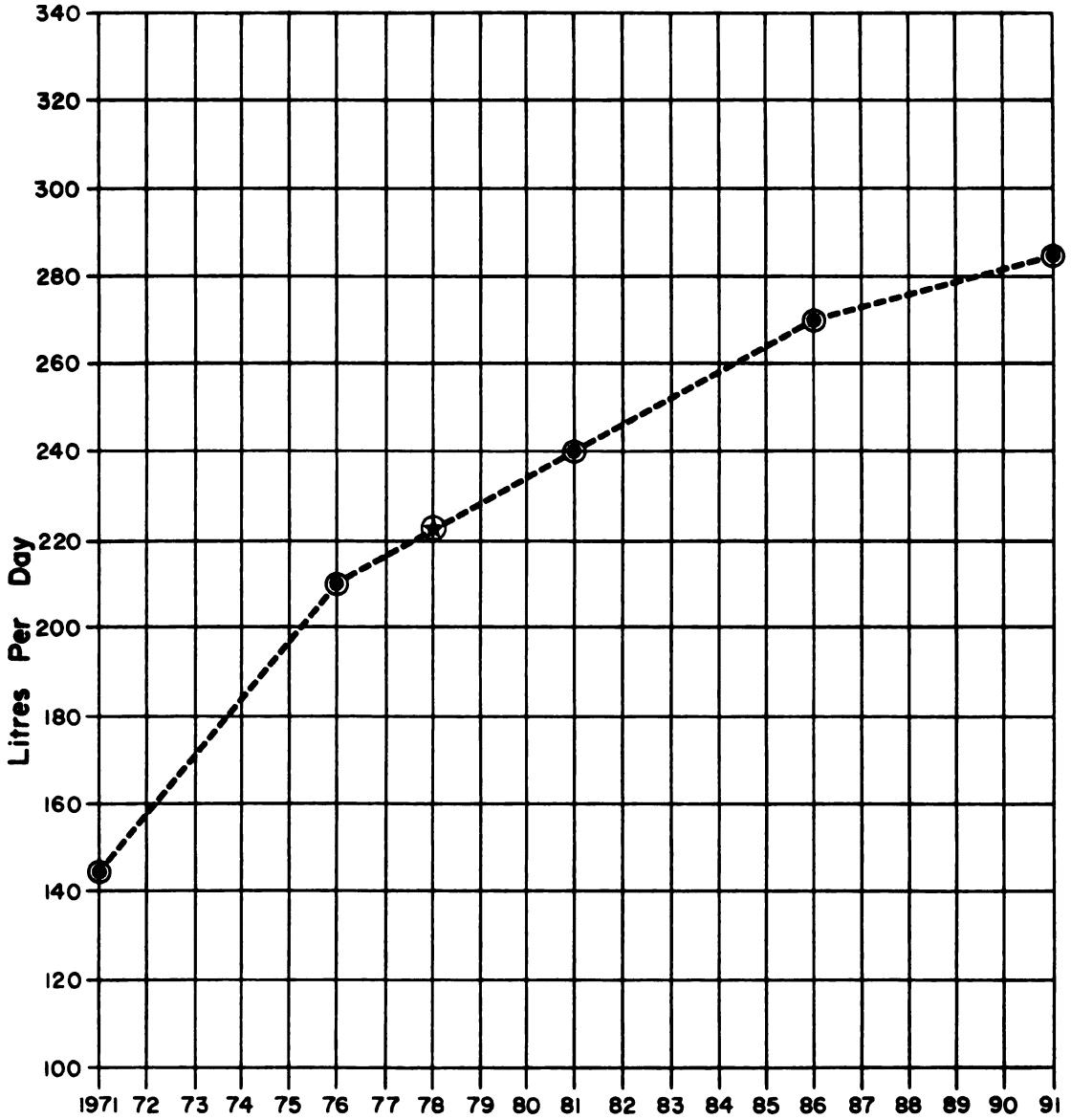


Source: Kingdom of Saudi Arabia
Master Plan Report - Jeddah
Ministry of Interior, Municipal Affairs, 1972



THE POPULATION GROWTH AND THE URBAN WATER DEMAND 1971 - 1991 (FIGURE 15)

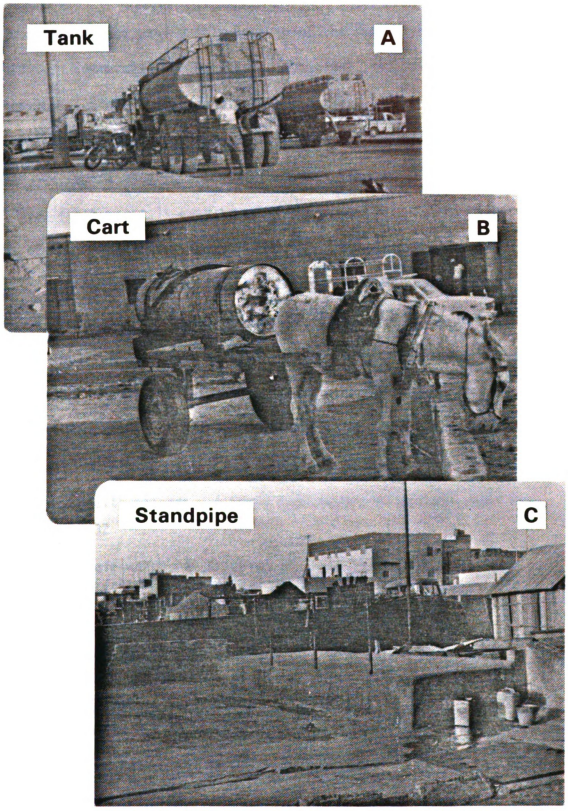
Source: Kingdom of Saudi Arabia
Master Plan Report - Jeddah
Ministry of Interior, Municipal Affairs, 1972



THE DAILY WATER CONSUMPTION 1971-1991
(FIGURE 16)

Source: Kingdom of Saudi Arabia
Master Plan Report - Jeddah
Ministry of Interior, Municipal Affairs, 1972

Figure 17: WATER SOURCES



most people in Jeddah city consume almost twice the amount of water they do the rest of the year mainly because of the very high temperature and humidity. Commercial use applies to municipal, industrial, harbors and businesses. Since there are pipelines in these places, people use fresh water for various purposes when they could actually use some other sources of water. Irrigating gardens is done in most of the villas. Fresh water is used to water these gardens. About 25 percent of the total water supply (1971) was used for such purposes.

The price of water from the network is very cheap compared to that of truck prices. The water supply administration in Jeddah has set the legal price of the water carried in a 4,000 gallon truck at about $45.[31] People can also purchase water from truckers for much less, but these truckers do not bring the water from the sources which are legal. Obtaining water from illegal sources and private truckers poses many health hazards. A World Bank Report on village water supplies states:[32]

> Lack of safe water for drinking and washing is also an important factor in the spread of other diarrheal diseases, which form possibly the most important single disease group throughout the developing world. . . . Numerous other diseases are also linked to poor water supply or sanitary conditions.

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[31] Saudi Arabia, OKAZ Daily Newspaper, Thursday, June 22, 1978, p. 5. One Dollar = 3.50 Saudi Riyal.

[32] World Bank, Village Water Supply, (Washington, D.C., 1976), p. 54.

Residents often do not know whether the water purchased is from legal or illegal sources; truckers as well do not realize the diseases carried in water taken from illegal wells. Sometimes the price of illegal water increases to $80 or more per tank in the summer.

How residents perceive the existence and seriousness of the water problems facing Jeddah city is the focus of the two chapters.

CHAPTER IV

HYPOTHESES AND METHODS OF ANALYSIS

Chapter III provided a brief description of the water system and the accompanying problems in Jeddah city. In this chapter five hypotheses regarding the residents' perceptions of water problems and their water uses are postulated. Also, the field methods used to collect the household survey data are discussed as are additional data sources that aid in examining the city's water use.

HYPOTHESES

The research hypotheses are based on an understanding of both socioeconomic differences within the city and knowledge of the city's water system. They are:

Hypothesis I: That residents in the old districts such as Nuzla, Harbour, Central Area and Ruwais receive water more from the city's network than new districts like those along Mecca Road and Medina Road.

Rationale: The growth in the new district is very rapid. Not adequate attention is given to this rapidly developing new district to construct water network system.

Hypothesis II: That villa residents have greater access to water from the network than people who live in traditional houses or shacks.[1]

Rationale: It is assumed that villa dwellers have high income, and they can afford to manipulate or influence the agency responsible for water supply to construct the pipeline to their residences, whereas those who dwell in traditional homes and shacks receive low income and do not have such influence to enjoy the privileges of a pipeline from the network.

Hypothesis III: That people who have higher monthly and annual incomes live in better houses and receive more water from the network than those living in shacks.

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[1] A villa is considered to be of excellent design constructed in concrete. A small garden usually surrounds the villa and a wall surrounds the whole villa. A traditional house is considered to be constructed with inadequate engineering design. The ceiling usually is made from wood and no yard surrounds this type of house. A shack is considered to be constructed from wood and old tin, usually consisting of two or three very small rooms without facilities, and very close to each other.

Rationale: A person's income is an important factor in determining one's social status. The rich people can afford the luxuries of a comfortable life, whereas the poor people have their limitations in this regard.

Hypothesis IV: That water from the network is used to irrigate gardens of villa residents.

Rationale: Gardens that are watered regularly are mainly found among those living in villas. Using fresh water from the network for the beautification of a garden is considered wasteful when those in other types of housing do not have a chance to obtain sufficient water from the network. Also there are other sources of water available to water the gardens.

Hypothesis V: That residents perceive ongoing public construction work as impeding water reception from the network.

Rationale: Lack of cooperative planning among various public construction agencies adversely affects the quality and quantity of water received.

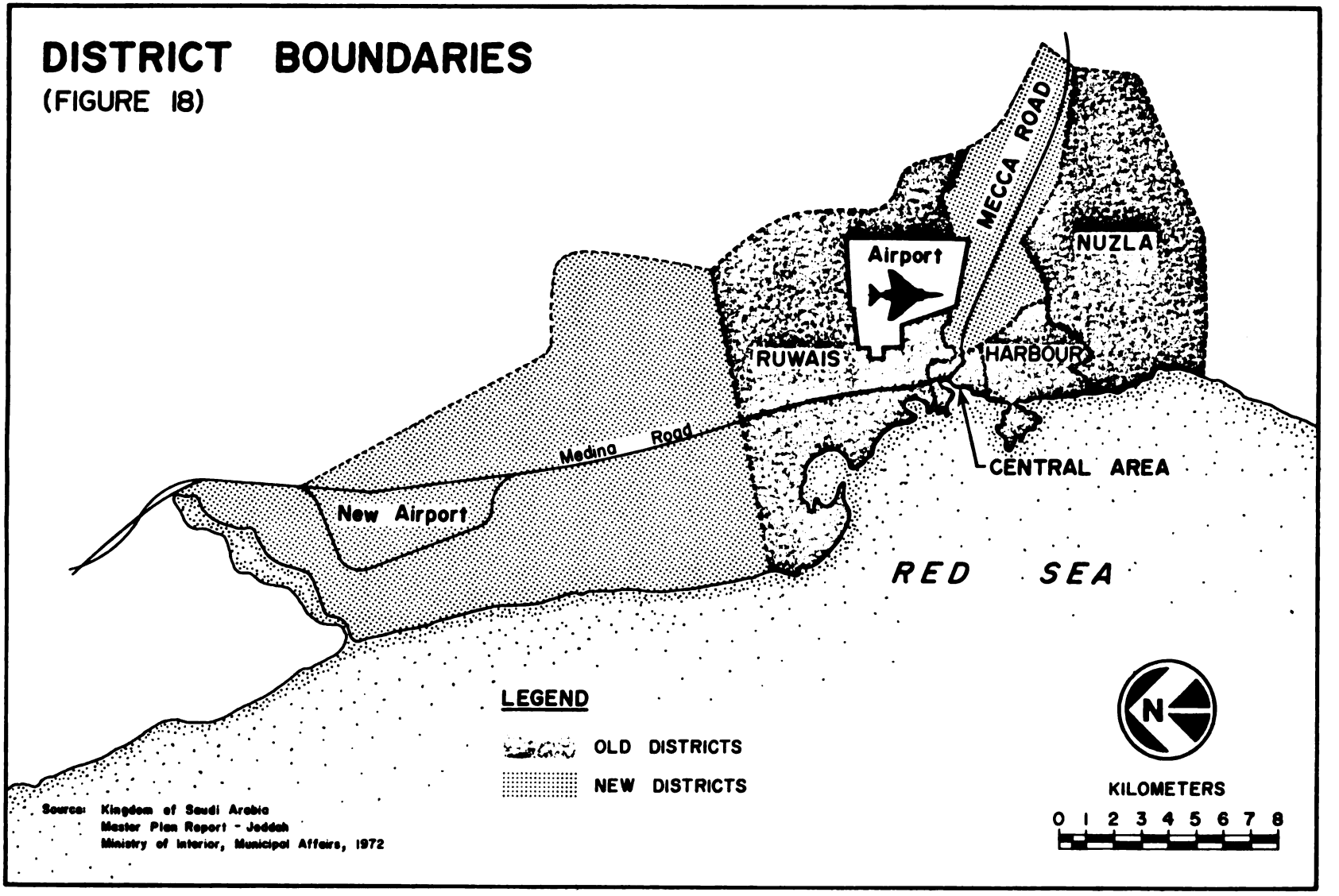
METHODS OF ANALYSIS

Researchers conducting household interviews or surveys in Saudi Arabia are confronted with a variety of problems. These problems are related to the selection of a representative sample, the actual collection of field data, the lack of readily available published census materials and maps, and the difficulty in obtaining unpublished reports and documents from government offices.

The collection of field data in a city like Jeddah is very difficult mainly because the city is organized in districts that often cannot be easily delimited and houses and streets that are difficult to locate for sampling purposes. Generally speaking, only the main streets have names. The small streets have neither names nor numbers. Moreover, there is no numbering on the houses at all, all which makes it difficult to identify residential locations for a sample.

A cross-section of residential areas and housing types was considered necessary in order to assess spatial variations in perceptions the residents had of the city's water problems and of the variations in water use. In order to obtain that cross-section of households in different parts of the city, a variation of the method adapted by the Ministry of Interior in 1971 for surveying and planning was used to divide the city into six districts: Nuzla, Harbour, Central Area, Ruwais, Mecca Road, and Medina Road (Figure 18).

DISTRICT BOUNDARIES
(FIGURE 18)



Administering the questionnaire was difficult because of the problem in discerning the type of housing and the social and economic status for those households. An attempt was made to sample within every district, and take a representative sample for all kinds of houses: villas, apartments, traditional houses and shacks (Figure 19). In the Central Area district, there were no villas or shacks, so no sampling was carried out. On a street map of the city provided by the Municipality Office of Jeddah individual residential buildings were shown. On this map each of the six districts was identified and the streets were given numbers. A random selection was made regarding which streets to sample. Likewise, on each street selected for sampling the beginning and ending of the street were identified and all the houses facing the streets were given numbers. Subsequently, a random sample of individual houses on each street was selected using the table of random numbers.[2] A total of 500 questionnaires were administered in the city. Ten students from King Abdulaziz University, Department of Geography, helped in conducting the household interviews. The field survey was carried out from January through March 1978.

Additional sources of data on general water problems, water networks and water use for the city were collected through meetings with some officials from the government agricultural and water ministry, the

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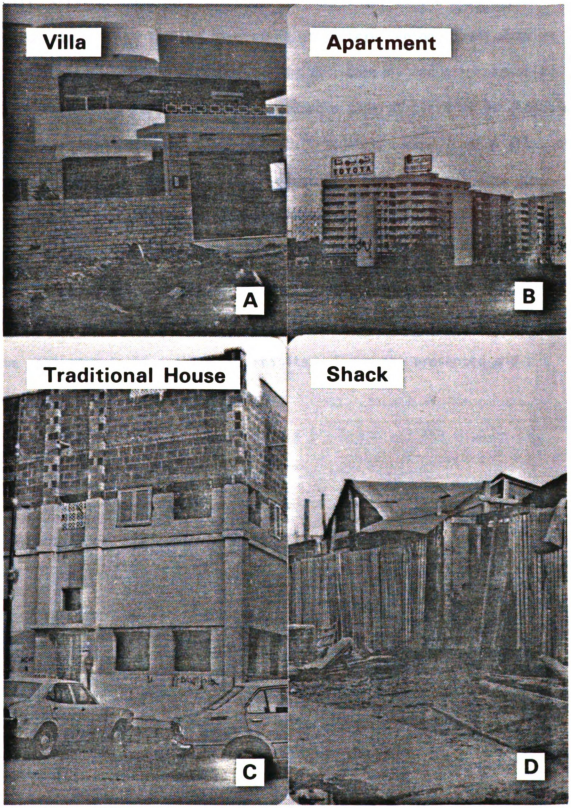
[2]Herbert Blalock, Social Statistics (New York: McGraw-Hill Book Company, 1972), p. 510.

Figure 19: TYPES OF DWELLINGS



public services department, the Jeddah municipality, the city's desalinization plant, the planning department of western region, Saudi Arabian BLOKAT Company, VATTEN BYGGNADA BYRAN (VBB) Company and other agencies. These interviews were useful in providing a general overview of Jeddah's water system. However, it was difficult to obtain maps, census data, or current reports. Officials in the government and other agencies contacted apparently had much of the information desired on the city's water situation, but they were reluctant to share it.

Now that the specific hypotheses have been formulated, and the methods of analysis used to collect the household data are outlined, the next step is to analyze the results. These are presented and analyzed in the following chapter.

CHAPTER V

ANALYSIS OF PERCEPTIONS REGARDING WATER SUPPLY PROBLEMS

The main objective of this study as stated in Chapter I is to examine the perceptions of residents in Jeddah city regarding the problems they face in getting sufficient amounts of water. The discussion below is focused upon five different sections, all of which are integrated into the hypotheses stated in the previous chapter. The five sections are (a) water accessibility by districts, (b) water accessibility and type of house, (c) income and type of house by water sources, (d) water uses and type of house, and (e) water reception from the network versus ongoing construction work.

In order to analyze these relationships and answer questions raised concerning water use and the perception of water problems, the five hundred households randomly selected were asked to respond to a questionnaire that included a variety of items dealing with water use and accessibility. The major items related to the type of houses, sources of water, problems involved in obtaining water, income of the household, and major uses of water. See Appendix for detailed copy of questionnaire.

Many of data obtained from this survey were analyzed using a series of Chi-Square tests with a 0.005 significance level used to accept or reject the hypothesized relationships.[1] Other hypotheses were accepted or rejected on the basis of the level of responses (that is, the percentages) to specific questions.

WATER ACCESSIBILITY AND AGE OF DISTRICT

In the first hypothesis it is postulated that residents living in old districts like Nuzla, Harbour, Central Area and Ruwais receive more water than the new districts on Mecca Road and Medina Road. That is, those residing in the old districts would be expected to experience fewer water shortages. The survey results of this question are given in Table 3. A Chi-Square test of the relationships between the type of district and degree water shortages exist is significant at the 0.005 level. That is, there is a significant relationship between the water shortage and age of the district. A further verification of this hypothesis is shown graphically in Figure 20; it shows that residents in new districts experience and perceive more water shortages than those in the old districts. The percentage of respondents who face extreme difficulty in the new districts is 37 percent while only 20

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[1] Herbert Blalock, Social Statistics (New York: McGraw Hill Book Company, 1972), p. 275.

TABLE 3

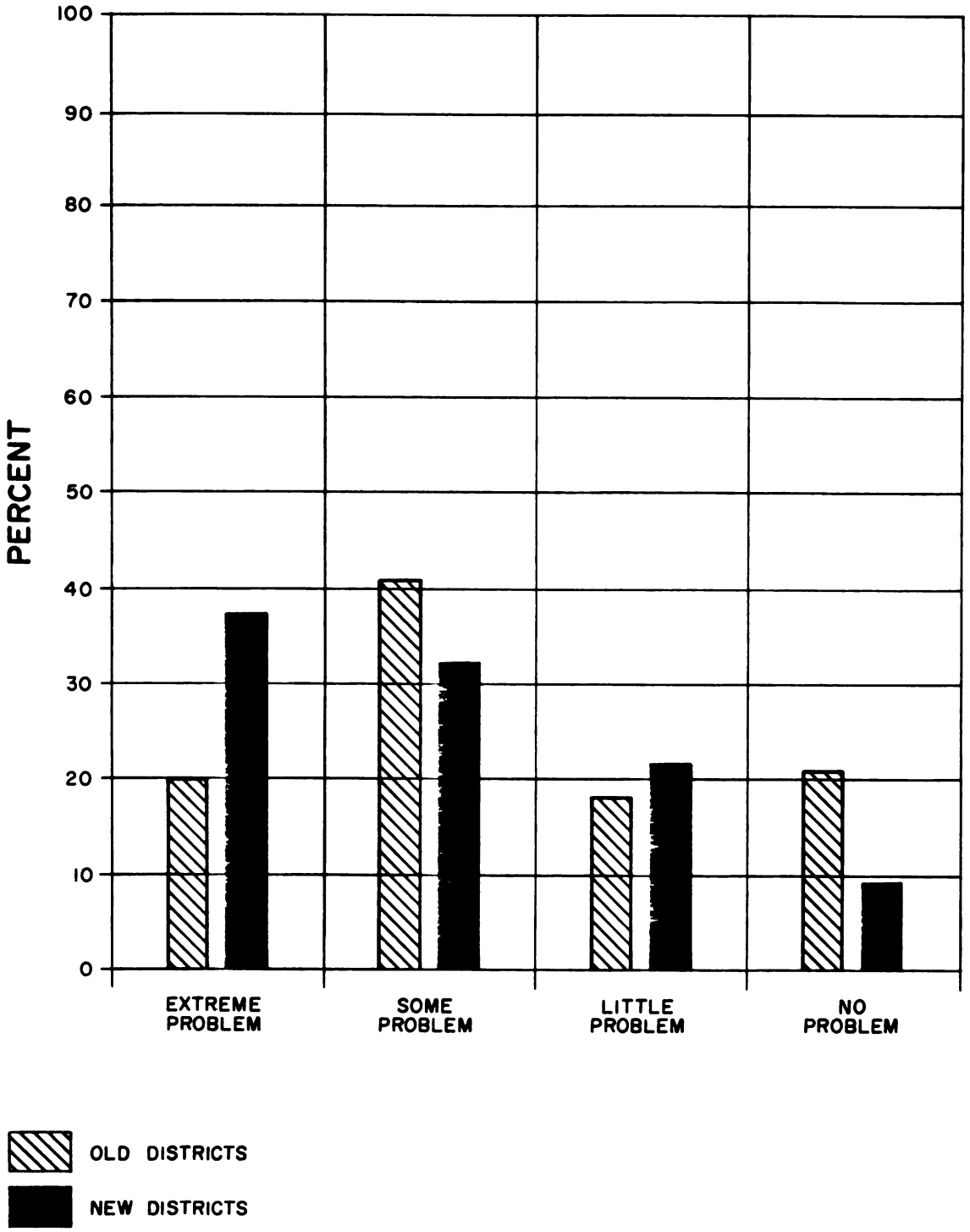
ASSOCIATION OF ATTITUDES TOWARD WATER SHORTAGE

AND TYPE OF DISTRICT

	WATER SHORTAGE				
	Extreme Problem	Some Problem	Little Problem	No Problem	Totals
Old Districts	(12.6)[a]	(25.7)	(11.6)	(13.2)	
	63	128	58	66	315
New Districts	(13.6)	(11.8)	(8.0)	(3.4)	
	68	59	40	17	184
Totals	131	187	98	83	499

$X^2 = 25.2$ p 0.005

[a]Numbers in parentheses are expected frequencies.



PERCEPTION OF WATER PROBLEMS IN NEW AND OLD DISTRICTS
(FIGURE 20)

percent in the old districts. On the other hand only 9 percent of the respondents in the new districts and 21 percent of those in the old districts have no problem getting water.

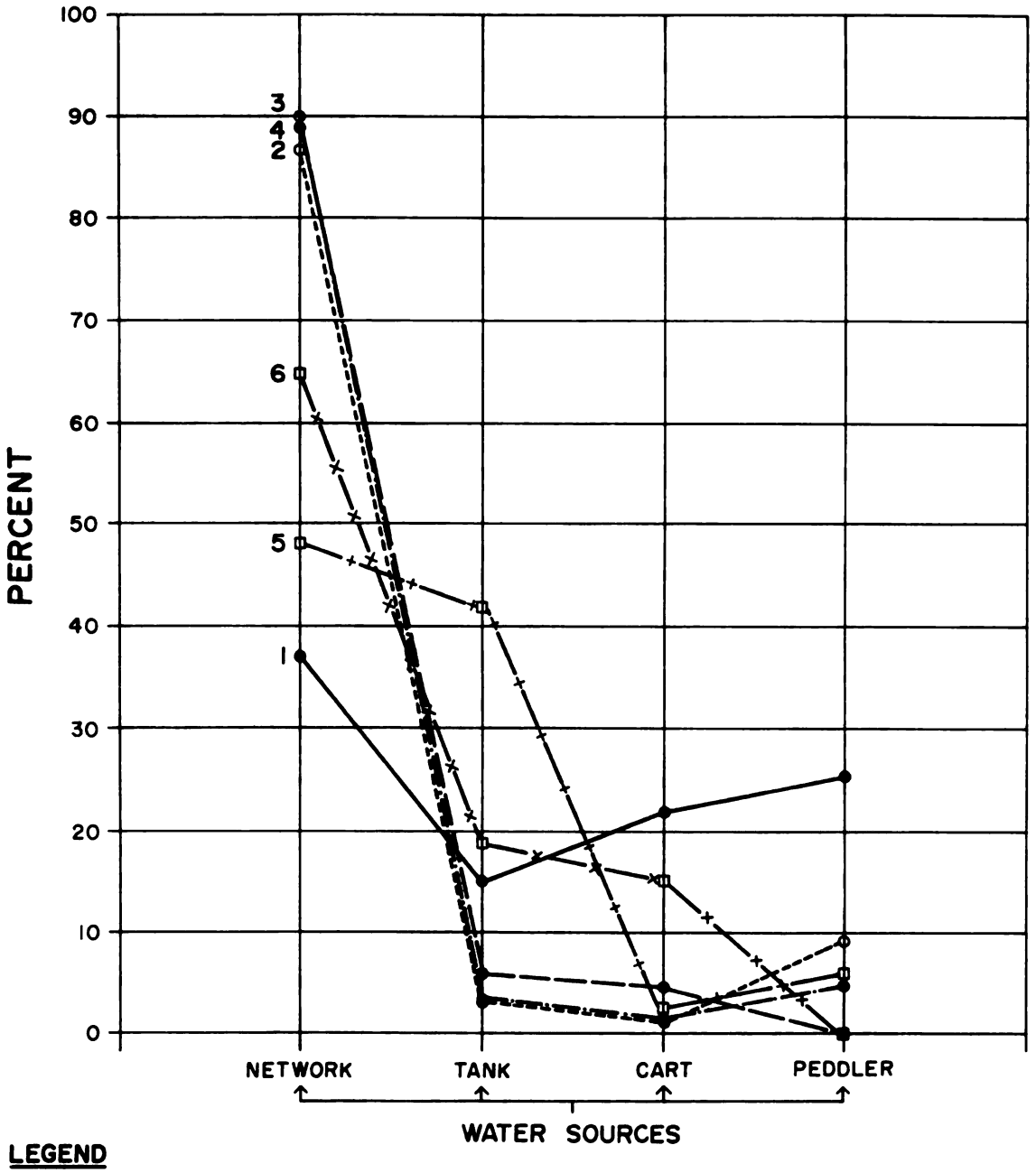
The results confirm the first hypothesis that residents in the old districts experience fewer problems than those in the new districts. This outcome could be explained by the lack of network system that provides sufficient amounts of water in some newer parts of the city especially. As we observed in Chapter III, the network existing covers almost all of the old districts and only a small portion of the newer ones. Although Medina Road is one of the two new districts with much recent development and good planning, it is not fully served by the water network. The water pressure in areas along Mecca Road, including King Abdulaziz University campus and the surrounding areas, is very weak. This can be attributed in part to the small degree of slope in the network.

A closer examination of the relationship between the sources of water and specific districts shows that three of the four old districts, Harbour, Central Area, and Ruwais, obtain a high percentage of their water supply from the network (Table 4 and Figure 21). Only Nuzla district, which has most of the slum areas in Jeddah city, receives very little water from the network. Of the two new districts (along Mecca Road and Medina Road) only 48 percent and 65 percent of respondents respectively receive water from the network. These low

TABLE 4

DISTRICTS WITH WATER SOURCES

Water Sources	Old Districts								New Districts			
	Nuzla		Harbour		Central Area		Ruwais		Mecca Road		Medina Road	
	Respon-dents	% of Res.	Respon-dents	% of Res.	Respon-dents	% of Res.	Respon-dents	% of Res.	Respon-dents	% of Res.	Respon-dents	% of Res.
Network	22	37.3	82	86.3	54	90	89	89	54	48.2	47	65.3
Tank	9	15.3	3	3.2	2	3.3	6	6	48	42.9	14	19.4
Cart	13	22	1	1.1	1	1.7	5	5	3	2.7	11	15.3
Peddler	15	25.4	9	9.5	3	5	-	-	7	6.3	-	-



SOURCES OF WATER BY DISTRICT
(FIGURE 21)

figures reveal a need for planning water networks for these districts in the future. While it will take time to plan and to expand the network into these new districts, they are expected to continue growing which will likely pose more serious problems in the future.

WATER SHORTAGE AND TYPE OF HOUSING

It is hypothesized that people who live in villas experience fewer problems and have greater access to water from the network than people who live in traditional houses or shacks. The survey results, summarized in Table 5, show that those living in villas and apartments experience the fewest shortages. While only about 11 percent of villa dwellers and 10 percent of apartment dwellers face extreme problems with water shortage, about 35 percent of those in traditional houses and 63 percent of those in shacks face extreme problems in obtaining water. The Chi-Square results show the relationship between type of housing and perception of the water shortage to be significant at the 0.005 level. This result supports the second hypothesis. The acceptance of this hypothesis also verified the fact that the high income population living in villas has less difficulty in obtaining water than the low income people living in traditional houses and shacks (Figure 22) The degree of difficulty may be translated into the degree of accessibility to water.

TABLE 5

ASSOCIATION OF ATTITUDES TOWARD

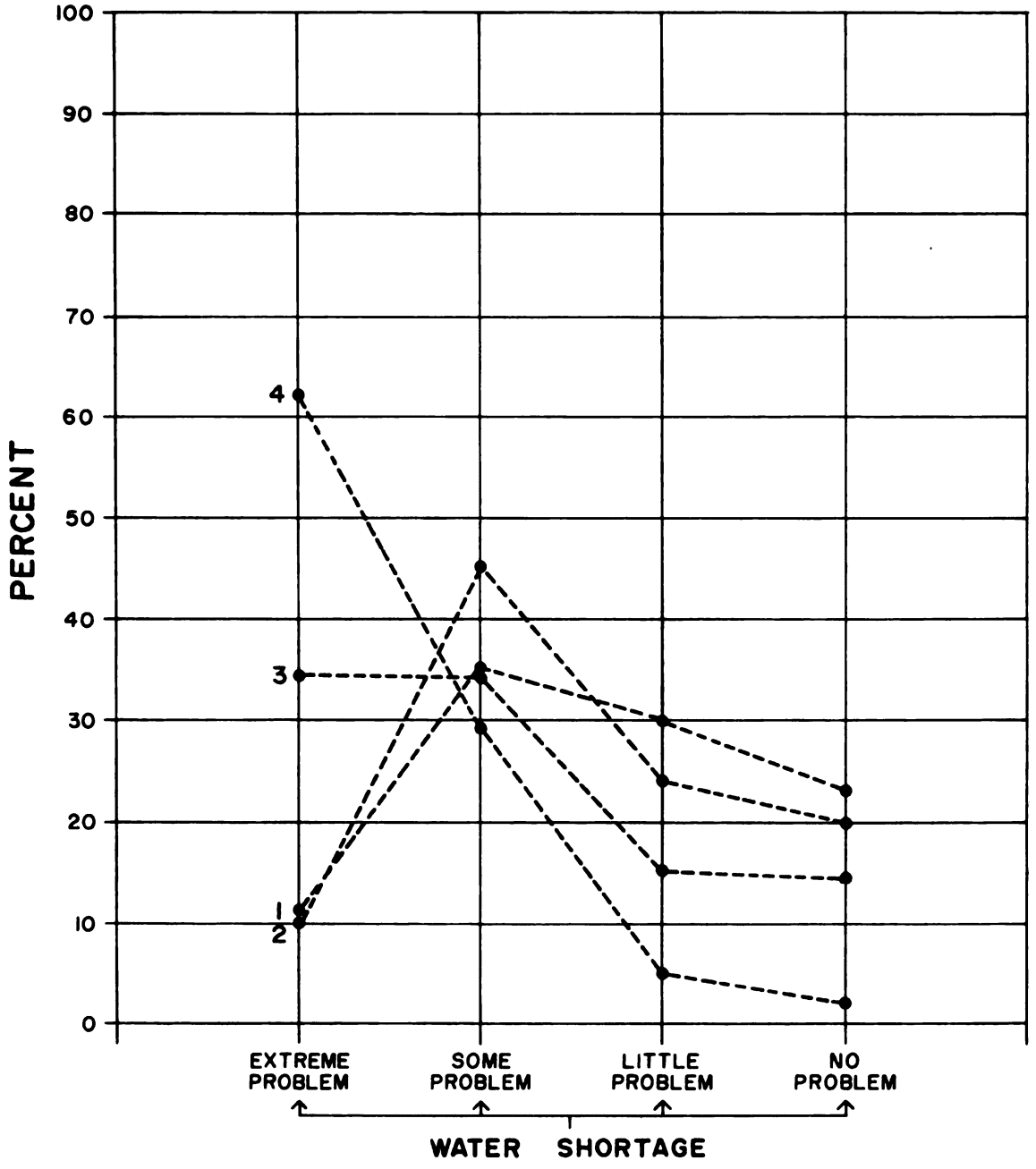
WATER SHORTAGE BY TYPE OF HOUSE

	Extreme Problem	Some Problem	Little Problem	No Problem	Totals
Villa	(1.6)[a]	(5.2)	(4.4)	(3.4)	
	8	26	22	17	73
Apartment	(3.2)	(14.4)	(7.8)	(6.4)	
	16	72	39	32	159
Traditional House	(15.0)	(14.8)	(6.8)	(6.6)	
	75	74	34	33	216
Shack	(6.4)	(3.0)	(0.6)	(0.2)	
	32	15	3	1	51
Totals	131	187	98	83	499

$X^2 = 80.8$ p 0.005

[a]Numbers in parentheses are expected frequencies.

There also is a significant relationship between the type of house and the water sources (Table 6). Both Table 6 and Figure 23



LEGEND

LINE 1 DENOTES VILLAS
LINE 2 DENOTES APARTMENTS
LINE 3 DENOTES TRADITIONAL HOUSES
LINE 4 DENOTES SHACKS

PERCEPTION OF WATER SHORTAGES BY TYPE OF HOUSING
(FIGURE 22)

show that more than 90 percent of those living in villas and apartments receive water from the network. This figure is contrasted while only 58 percent of those who live in traditional houses and only 16 percent of those living in shacks receive water from the network; most

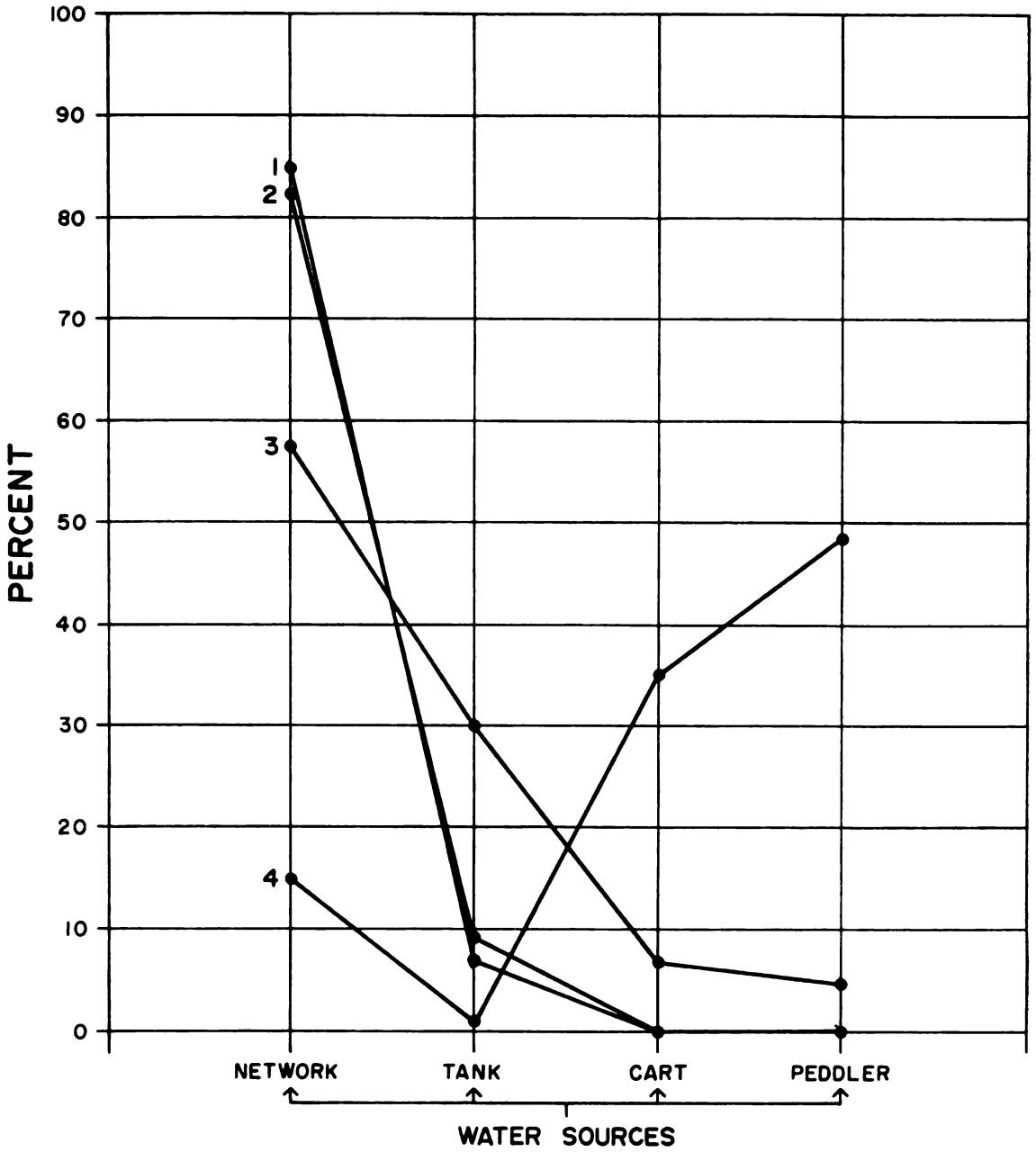
TABLE 6

ASSOCIATION BETWEEN SOURCES OF WATER AND TYPE OF HOUSE

	Network	Tank	Cart	Peddler	Totals
Villa	(13.9)[a]	(0.8)	(0.0)	(0.0)	
	69	4	0	0	73
Apartment	(29.8)	(2.2)	(0.2)	(0.0)	
	146	11	1	0	158
Traditional House	(25.1)	(13.5)	(3.0)	(1.8)	
	125	67	15	9	216
Shack	(1.6)	(0.0)	(3.6)	(4.8)	
	8	0	18	24	50
Totals	348	82	34	33	497

$X^2 = 316.8$ p 0.005

[a]Numbers in parentheses are expected frequencies.



LEGEND

LINE 1 DENOTES VILLAS
LINE 2 DENOTES APARTMENTS
LINE 3 DENOTES TRADITIONAL HOUSES
LINE 4 DENOTES SHACKS

SOURCES OF WATER BY TYPE OF HOUSING (FIGURE 23)

of the residents in shacks have very low incomes. The two most common ways for the low income residents to obtain water are to buy it from the carts or peddlers or peddle their own water. Almost half procure water through peddling. The survey results summarized in Table 6 reflect the unfair treatment the low income population suffer in regard to obtaining water through the local administration. Obtaining water from carts and peddlers, as stated above, is not sanitary as often the water is exposed to contamination by dust and germs.

INCOME, HOUSING, AND SOURCES OF WATER

Following the results obtained by verifying the second hypothesis, it is hypothesized that those residents with higher incomes live in better quality houses and receive water from the city's network. Table 7 shows a classification of monthly income according to types of housing.

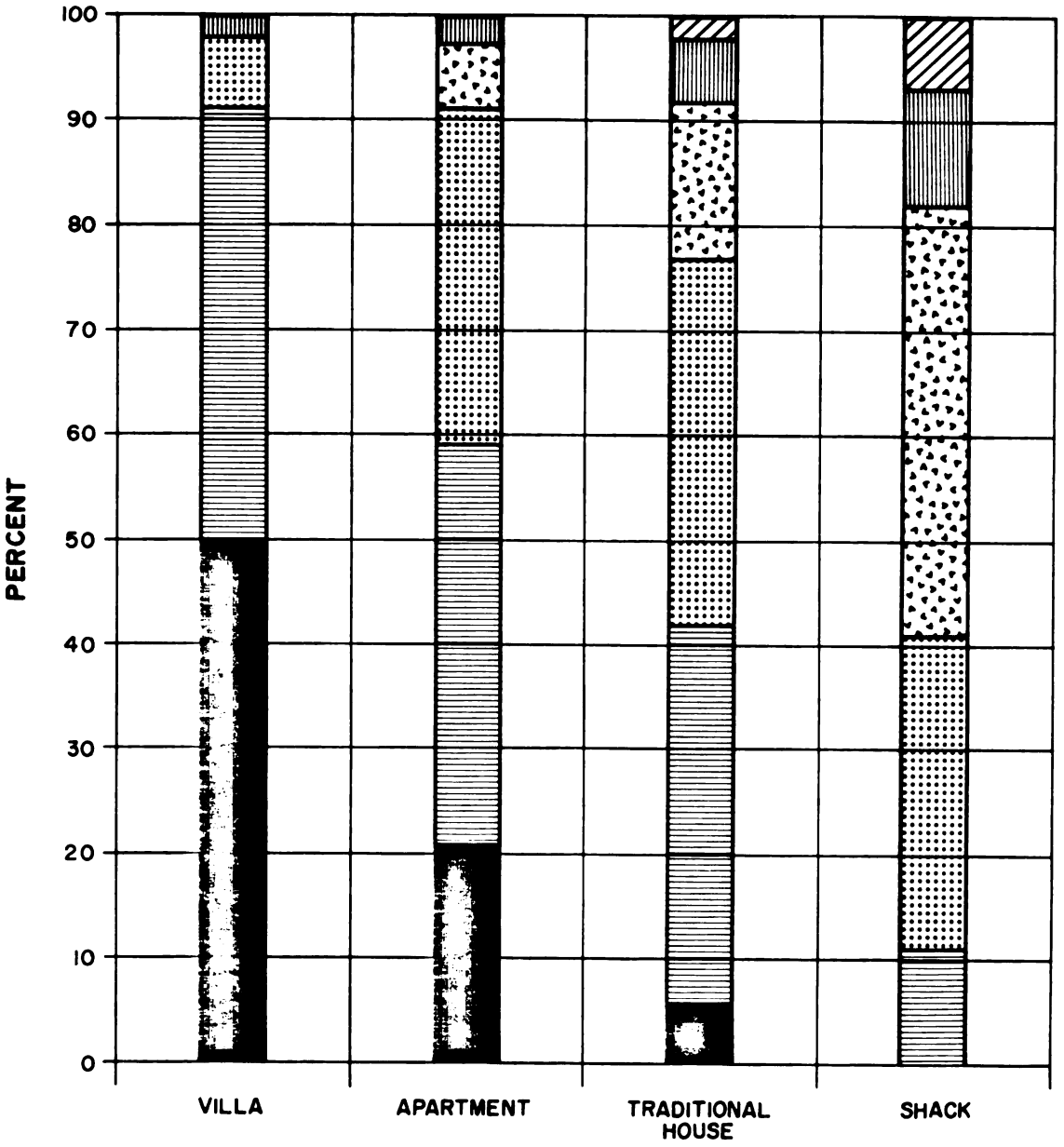
The survey results, summarized in Table 7, reveal that those people with the highest monthly income live in villas and apartments while those with the low incomes generally live in traditional houses and shacks. The relationship between the monthly income and the type of house is also shown in Figure 24. Half of those interviewed who live in villas have incomes of $1,000 or more per month per head of household. On the other hand only about 7 percent of those living in

TABLE 7

THE INCOME AND TYPE OF HOUSE

Income per Household	Type of House							
	Villa		Apartment		Traditional House		Shack	
	Respon-dents	% of Res.	Respon-dents	% of Res.	Respon-dents	% of Res.	Respon-dents	% of Res.
Less than $200	0	0	0	0	4	1.9	3	6.1
$200-399	1	1.6	4	26	9	4.3	6	12.2
$400-599	0	0	7	4.6	32	15.4	19	38.8
$600-799	4	6.3	51	33.6	74	35.6	15	30.6
$800-999	27	42.2	59	38.8	75	36.1	6	12.2
$1000 + more	32	50.0	31	20.4	14	6.7	0	0

traditional houses have incomes in this category; no heads of households living in shacks had incomes in this category. The survey further revealed that most households living in apartments and traditional houses earned between $600-999 per month while those in shacks earned less than $600 per month. There is also a strong positive relationship between monthly income and a household's connection to the city's water network (Figure 25). Eighty percent of those households in the highest income category receive water from the network; none obtain it from peddlers.



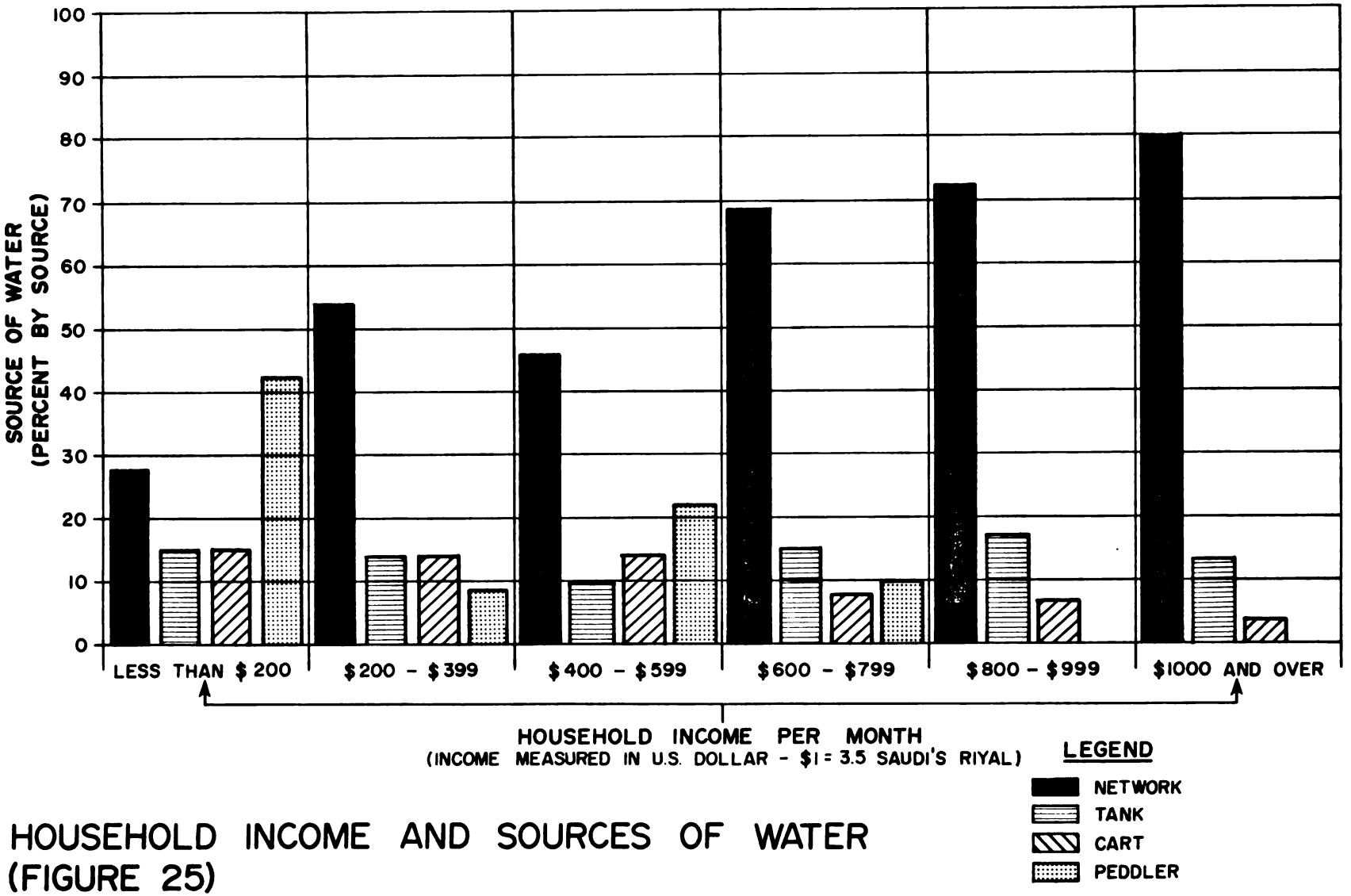
LEGEND

- LESS THAN $200
- $200 - $399
- $400 - $599
- $600 - $799
- $800 - $999
- $1000 AND OVER

THE HOUSEHOLD INCOME PER MONTH

INCOME MEASURED IN U.S. DOLLAR - $1 = 3.5 SAUDI'S RIYAL

INCOME BY TYPE OF HOUSING
(FIGURE 24)



HOUSEHOLD INCOME AND SOURCES OF WATER
(FIGURE 25)

Those with the lowest incomes obtain over 40 percent of their water through peddling; a small percentage receive water from the network. Tanks and carts are additional sources for those with low incomes. These results thus support the hypothesis that there is a relationship between income, type of house and sources of water. The high income people, it might be concluded, especially in regards to water, have access to the comfortable life and the poor to the uncomfortable life.

TYPE OF HOUSE AND WATER USE

Since it has been demonstrated that high income people live in villas and obtain water via the municipal network, it is hypothesized that they use water from that network to irrigate their gardens.

Before examining this hypothesis, a word about gardens and watering them is in order. Gardens are considered fashionable in Jeddah, especially for those living in villas; most residents have gardens within their compound. The Chi-Square results, significant at the 0.005 level, show a strong relationship between the presence of the gardens and type of house. The survey results revealed that 73 percent of those in villas while 3 and 4 percent of those living in apartments and traditional houses respectively have gardens (Table 8). Households with the lowest incomes do not have gardens (Figure 26).

The relationship between the type of house and uses of water was examined next. The results reveal there is a strong relationship

TABLE 8

ASSOCIATION BETWEEN TYPES OF HOUSES

AND PRESENCE OF GARDENS

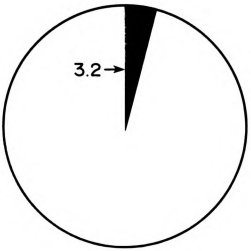
	Villa	Apartment	Traditional House	Shack	Totals
Garden	(10.7)[a]	(1.0)	(1.7)	(0.0)	
	53	5	8	0	66
No Garden	(4.1)	(31.0)	(40.7)	(10.3)	
	20	150	197	50	417
Totals	73	155	205	50	483

$X^2 = 251.7$ P 0.005

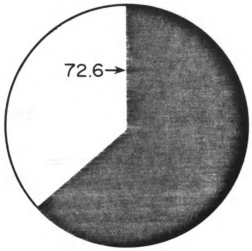
[a]Numbers in parentheses are expected frequencies.

between the type of house and water uses (Table 9). Almost 66 percent of those who live in villas use water for both household purposes and irrigating gardens; only 3.2 percent of apartment dwellers and traditional house dwellers use water for the same purposes. Those living in shacks use water only for domestic purposes. As indicated in Table 6, about 95 percent of those living in villas receive water from the network only; almost 66 percent of villa dwellers use water both for drinking and irrigating gardens (Table 9). These dwellers have much

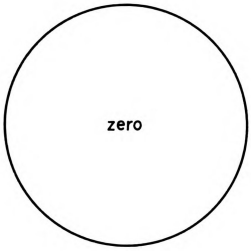
TYPES OF HOUSING WITH GARDENS (FIGURE 26)



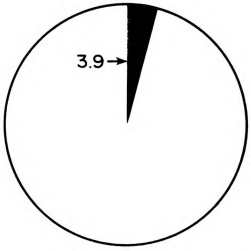
2. APARTMENT



1. VILLA



4. SHACK



3. TRADITIONAL HOUSE

LEGEND

PEOPLE WHO HAVE GARDENS

PEOPLE WHO DO NOT HAVE GARDENS

different uses of water than those in other types of housing (Figure 27).

TABLE 9

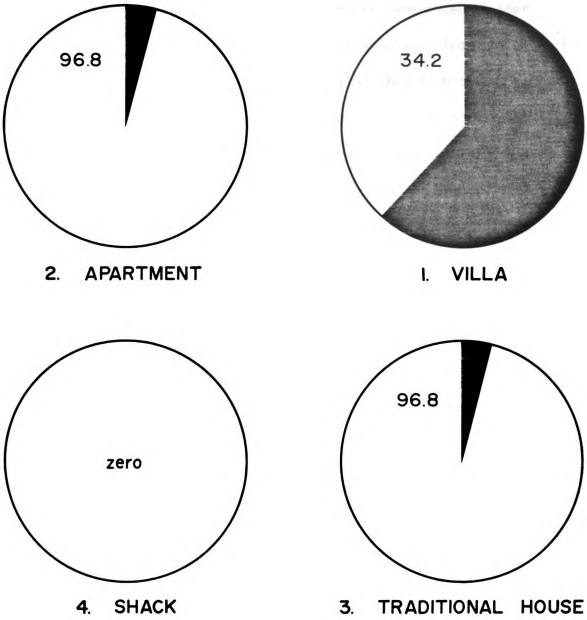
WATER USES AND TYPE OF HOUSE

Water Uses	Type of House							
	Villa		Apartment		Traditional House		Shack	
	Respondents	% of Res.	Respondents	% of Res.	Respondents	% of Res.	Respondents	% of Res.
Drinking	25	34.2	153	96.8	209	96.8	48	100
Drinking and Irrigating	48	65.8	5	3.2	7	3.2	0	0

WATER AVAILABILITY AND THE IMPACT OF CONSTRUCTION PROJECTS

Another problem that exists within Jeddah city involves the effect extensive and ongoing public construction in various parts of the city has on the availability of water. Ongoing construction work includes building structures, paving streets, laying telephone and electricity extensions, and drilling for and laying of sewer pipes. It is hypothesized that residents perceive construction and repair of

USES OF WATER FOR DRINKING AND IRRIGATION BY TYPE OF HOUSING
(FIGURE 27)



various projects as obstacles to their receiving water. The 348 respondents who received water from the network were asked whether they face any major problems receiving water regularly from the network. While 161 respondents (46 percent) stated that they do not face major problems receiving water regularly, 183 respondents (53 percent) stated otherwise. Four heads of households (1 percent) did not respond to this question (Table 10). The fact that over half of the households receiving water from the network experienced problems on obtaining water suggests the issue was worth examining in some detail.

TABLE 10

NETWORKS PROBLEMS AND PEOPLE WHO RECEIVE WATER FROM THE NETWORK

Network Problems	People who Receive Water from the Network	
	Respondents	% of Respondents
Satisfactory	161	46.26
Unsatisfactory	183	52.59
Missing Cases	4	1.15
TOTAL	348	100

Even though 151 respondents (43 percent) claimed that they have no problem getting water from the network regularly in spite of construction

work, 194 respondents (56 percent) claimed that their water supply is often temporarily cut off because of various construction projects (Table 11). An analysis of the survey results summarized in Tables

TABLE 11

PUBLIC CONSTRUCTION WORKS AND PEOPLE WHO RECEIVE WATER FROM THE NETWORK

Public Construction Works	People who Receive Water from the Network	
	Respondents	% of Respondents
Yes, they have problems	194	55.74
No, they do not have problems	151	43.40
Missing Cases	3	.86
TOTAL	348	100

10 and 11 reveals there is a slight discrepancy in the pattern of response to these two questions. About ten respondents to the first general question indicated they do not face any problems receiving water from the network, however, they did indicate in response to the next question at times their reception is impeded. This minor discrepancy could be attributed either to the lack of proper understanding of the first question or to the specificity of the second question.

Of those 194 respondents who face irregularity in the water they obtain from the network, about 60 percent of them attributed it to the drilling for and laying of sewage pipes, 30 percent to the laying of electricity extensions, and the remaining 10 percent to the building and paving of streets. An illustration of these problems was reported in the city's major newspaper, Al-Medina, on July 30, 1978. It related an account that people in some parts of the Central Area complained that their drinking water smelled and tasted of sewage. In the same report it also stated that people in some parts of Ruwais district complained of the same problem from a month ago, but the authorities had not done anything about it as of the time. This problem of bad taste and smell of drinking water could be attributed to the faulty connections between water pipes and sewage pipes, and directly hence to poor planning of the city's water and sewage systems.

These results lead to the acceptance of the fifty hypothesis which states that public construction work impedes water reception of those residents obtaining it from the network.

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

Jeddah city faces shortage of various public utilities, one of which is water. In spite of the four ways people obtain water, that is, via the network, tank, carting, and peddling, the water supply and water network do not keep pace with the growth of the city. In order to adequately ascertain residents perceptions regarding the shortage of water supply in the city of Jeddah, a survey was conducted with five hundred heads of households randomly selected from four different type of living units, villas, apartments, traditional houses, and shacks.

CONCLUSIONS

The raw data identified water problems and attributed them to three major factors: 1) a shortage of water supply from the main resources, 2) a lack of proper planning for the distribution of water, and 3) the use of water for non-domestic purposes such as irrigating gardens.

In regards to the first point, there are three main resources of water supply. These are Wadi Fatima, Wadi Khlais, and the

desalinization plant. The inadequate supply of water for the city from these three resources is caused by insufficient amount to balance the increasing extraction. At Wadi Fatima there is a gradual decline in the ground water table of 70 mm per month. Rainfall is irregular and only 50-100 mm per year. The water obtained from the desalinization plant does not meet present needs. Moreover, the plant functions on an irregular basis throughout the year.

There is an apparent lack of planning in the distribution of water to residents throughout the city. Two points can be made regarding this point. Firstly, the old districts are better served by the water network than the new districts. Yet it is the new districts that are growing and developing rapidly. There is currently a lack of planning to supply water to the new districts. Secondly, most of the rich people dwelling in villas and apartments in the old and new districts receive water through the network. Most of the people living in traditional houses and shacks throughout the city do not enjoy this privilege.

Access to water from the network and its use are directly related to the wealth of the household and the type of housing. High income people live in villas and apartments while low income people live in traditional homes and shacks. Those with very highest incomes, as the survey reveals, misuse water while those with the very lowest incomes do not have water available even for important domestic pur-

poses. Those living in villas frequently have a garden which is irrigated by water from the network. Low income residents do not enjoy such a luxury; they usually lack an extension of the network into their homes even to use water for cooking and drinking purposes. Water from the network is used in construction projects, to wash cars, and for various public uses, all of which take water which could be used for domestic uses.

RECOMMENDATIONS

On the basis of knowledge of the city's water system and residents perceptions of water problems and their uses of water, the following recommendations are offered as possible solutions to the water problems the city faces.

1. It is not possible to cut down the extraction of water from Wadi Fatima and Khlais, but the desalinization plant can be operated at a higher capacity and on a more regular basis and thereby increase the water output. Sea water is likely to be the only resource to supply the city with more water in the future.

2. The traditional houses and shacks have been in the city for decades. These dwellings as homes of permanent residents

should not be treated as temporary housing, but given fair treatment and provided with water from the municipal network. Municipal government agencies should endeavor to supply water to all residents in all districts whether the residents live in their own or rent their houses, whether they are rich or poor, or whether they live close or far from the city center.

3. Planning the future construction of any type of house in any district in the city should include water pipelines connected to the entire network. Water should be made available to the residents upon moving into their new home.

4. While many people living in the traditional houses and shacks lack sufficient water for domestic purposes, the villa dwellers are using the water from the network to irrigate gardens. This is a critical problem. The government should stop such misuse of water. This can be done through periodic and careful inspection of the house connections and water meters.

5. Regularly, various public construction works impede the water supply from the network to the residents. Such practices indicate a lack of communication and coordinated planning among the different government agencies. This situation results in problems the people face and areas undergoing con-

struction. Steps should be taken to encourage more communication and comprehensive planning between these agencies, so that such construction works do not impede continued water supply from the networks to the homes.

Additional recommendations that are not directly related to the study but will certainly help alleviate the water shortage problem in Jeddah city are presented next. These are:

1. The traditional practice of transporting water by tanks, carts, or peddlers should be discouraged because such practices expose water to dust and contaminate it. This in turn causes various diseases.

2. Many private water truck owners transport water from illegal sources to sell to the residents. The government should investigate these operations and put a stop to such practices.

3. The government should stop excess immigration from the rural areas to the city of Jeddah. Likewise it should also impose strong visa regulations for non-Saudians entering the country.

4. Much water from the network is used for irrigating gardens, for public work, washing cars and other non-domestic purposes. To avoid such wastage, the government should make immediate

plans to install plants to treat sewage water for such non-domestic uses. Water from these treatment plants could be transported by trucks to the various districts for the non-domestic uses.

5. The government should make good use of mass media such as radio, television, newspapers, magazines, schools, billboards, and public posters to educate the people about the regulations of using water and the need for water conservation.

6. The government should stop drilling more wells in Wadi Fatima and Wadi Khlais to save the agricultural sector and to stop the immigration from these rural areas to the cities. The agricultural sector is very important for Saudi life.

This study has considered the water uses, water quality, and the distribution of the network and perception of water problems within Jeddah city. However, for a more detailed study, a geographer needs to conduct further surveys regarding environmental perceptions of the city's residents. Through such studies it is hoped the city's water problems can be better understood and resolved.

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APPENDIX

APPENDIX

The Questionnaires

1. Age

2. Name of district

3. Marrital status

   1 - Yes
   2 - No

4. How many people live in this house regularly?

5. What is your occupation?

   1 - Work in government
   2 - Businessman
   3 - Laborer
   4 - Student
   5 - Nothing

6. Do you own your house or are you renting it?

   1 - Own
   2 - Rent

7. What is the type of house you live in?

   1 - Villa
   2 - Apartment
   3 - Traditional house
   4 - Shack

8. Do you have a garden in your house?

   1 - Yes
   2 - No

9. What is the source of water in your house?

   1 - Network
   2 - Tank
   3 - Cart
   4 - Peddler

10. Do you have general problems receiving water from the network?

   1 - Extreme problem
   2 - Some problem
   3 - Little problem
   4 - No problem

11. If you receive your water from the network, do you have problems in having the amount of water you need?

   1 - Yes
   2 - No

12. If you have problems when do you have them?

   1 - During the whole year
   2 - During the summer
   3 - During the winter
   4 - During the Hajj period

13. If you have it how many days during the week do you not receive water?

14. How much do you pay monthly for receiving water from the network?

   1 - $ 0-19
   2 - $20-29
   3 - $30-39
   4 - $40-49
   5 - $50 or more

15. If you consume water by tanks, how many tanks do you consume each month?

16. If you get water by the tank, how much do you pay monthly?

    1 - $ 0 - 99
    2 - $100 -149
    3 - $150-199
    4 - $200 or more

17. Of the total water you consume during the year, what is the percentage you receive through the tank system?

    1 - 25%
    2 - 50%
    3 - 75%
    4 - 100%

18. Suppose you do not receive your water from the network, how long does it take you to get water from another source?

    1 - 100-199 meter
    2 - 200-299 meter
    3 - 300-399 meter
    4 - 400-499 meter
    5 - 500 meter or more

19. If you rent the apartment, did you rent it including water?

    1 - Yes
    2 - No

20. If yes, how much do you pay monthly to the owner for water?

    1 - $ 0-19
    2 - $20-29
    3 - $30-39
    4 - $40-49
    5 - $ 50 or more

21. If no, how much do you pay monthly for that?

    1 - $ 0-19
    2 - $20-29
    3 - $30-39
    4 - $40-49
    5 - $50 or more

22. Do you have problems with the owner about water?

    1 - Yes
    2 - No

23. Do you use water for

    1 - Drinking only
    2 - Drinking and garden irrigation
    3 - Business
    4 - Other

24. What types of water do you receive through the network?

    1 - Fresh water
    2 - Salty
    3 - Fixed (fresh water and salty)

25. What types of water do you get through the tanks?

    1 - Fresh water
    2 - Salty
    3 - Fixed (fresh water and salty)

26. From your experience, which districts of the city do you think receive water more than others?

    1 -
    2 -
    3 -

27. Why do you think they receive much water?

    1 - Because the system and the distribution of the network are very well planned.
    2 - Because the water agencies paid more attention to it than others.
    3 - Because it is close to the reservoirs.
    4 - Other reasons.

28. If there is any construction in the streets, does that affect receiving water from the network?

    1 - Yes
    2 - No

29. If yes, which one have more problems than others?

    1 - The electric extensions
    2 - The phone extensions
    3 - The building and paving of streets
    4 - The drilling and laying of sewage pipes

30. Do you have problems from the rainfall?

    1 - Yes
    2 - No

31. During the last five years, do you feel the water supply was:

    1 - Better than today
    2 - Same as today
    3 - Worse than today

32. How do you evaluate the water supply in your district?

    1 - Very difficult
    2 - Average
    3 - Somewhat no difficulty
    4 - Not difficult at all

33. Suppose the water supply increased in your house, do you think your consumption will:

    1 - Increase
    2 - Stay the same
    3 - Decrease

34. What kind of suggestions do you give to improve the water supply in your area? (check one only)

    1 - Change the network
    2 - Build many reservoirs
    3 - Change the management

35. What is your estimated monthly income (head of household)?

    1 - Less than $200
    2 - $200-399
    3 - $400-599
    4 - $600-799
    5 - $800-999
    6 - $1000 or more