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Climate and Agriculture of Jordan

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CLIMATE AND AGRICULTURE OF JORDAN

By

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CLIMATE AND AGRICULTURE OF JORDAN

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Ali Ahmad Mahmoud
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CHAPTER ONE

INTRODUCTION

The primary objective of this study is to identify, analyze, and explain existing and potential patterns of agricultural development in Jordan as they relate to the country's environmental resource base. Once established, an understanding of the intricate relationships that exist between environment and agriculture can enhance agricultural development planning and increase Jordan's agricultural potential.

Analysis of the variable patterns of the man (culture) and land (environment) relationship long has been a primary focus of geographic study. This study is limited to those relationships which exist between agriculture in Jordan and those environmental elements which directly influence this vital aspect of the country's economy, namely climate, soil, water, and vegetation. In attempting to develop a comprehensive overview of Jordan's agriculture-environment relationship patterns, this study will focus/address four major factors. They are: 1) a survey of existing agricultural patterns in relation to environmental conditions, 2) an examination of both the environmental and technical problems which hinder agricultural development, 3) identifying potential means of expanding agricultural lands, and 4) to suggest means by which agricultural production can be increased.

Agriculture has been the primary occupation of Jordanian people for centuries. Agricultural production is dependent upon numerous factors, including climate, soil type, plant and animal genetics, insects, disease, and such cultural considerations as technology, capital, perceptions of the environment, traditional crops and farming practices, available land, and economic needs.

Although Jordan can never be self-sufficient in all of its agricultural needs, production can be increased by adopting modern farming methods such as machinery and the use of fertilizers and chemicals. The non-irrigated agricultural areas are more affected by the variation of rain totals than are the irrigated areas. An increase in agricultural production can be achieved by expanding the arable area and with the use of new technology. The Jordan Valley (Ghor) is the main agricultural area in Jordan because of its climate, soil, topography and the availability of water. By using modern agricultural methods in irrigated as well as in non-irrigated areas, Jordan is pinning its hopes of increasing agricultural productivity 300 percent by the 1980s (Jordan 1980: 18).

Justification and Need for Study

Most developing world countries are unable to feed their population adequately without some assistance. Technological assistance is needed to increase food production, rather than direct food aid itself. The application of modern technology can assist a country in utilizing its resources to their maximum potential, and in increasing agricultural production in order to become self-sufficient. If food alone is provided, less developed countries become dependent upon such aid, and they may continue to lack the means by which domestic food production can be increased. The use of agricultural technology to increase food production is important in these countries. Agriculture provides the people with the basic needs of survival. The use of modern technology in agriculture allows developing countries to approach the same productivity level as the developed countries.

Two decades ago, Jordan received food supplies from both the United States and the United Nations. This aid was gradually decreased as agriculture improved and crop production increased. Jordan continues to be classified as a developing country and it remains dependent upon imported foodstuffs. Jordan began its modern development in 1958, by implementing several plans to develop the country's economic system. These development plans concentrated primarily on improving agricultural land, farming techniques, increasing the arable area, and improving crops by selecting suitable seeds. Many agricultural experiment stations were established throughout Jordan in order to improve the suitability of crops for Jordan's land and climate.

Many Jordanian farmers still cultivate their lands without adequate knowledge of weather conditions such as wind storms, temperature, frost during the growing seasons, and other atmospheric factors. Unfortunately during drought periods farmers continue to loose their seeds. The recent five-year drought (1975-1980), destroyed the country's rainfed wheat and barley crops which usually account for 65 percent of the country's total agricultural production (Jordan 1980: 18). Not only is inadequate rainfall responsible for a decline in production, but other factors such as winds, frost, disease and insects also contribute to crop losses.

Research on the relationships between crops and physical aspects of the environment is needed if successful agricultural development is to occur. Explaining and understanding the climate elements, soils, topography, water resources in the relation to crops produced in Jordan is essential if the country is to achieve agricultural self-sufficiency.

Introduction to Jordan

The Hashemite Kingdom of Jordan is located between latitudes of 29^{o} and 33^{o} north and between longitudes of 34^{o} and 39^{o} east (Map 1.1). It extends eastward from the Jordan River, Dead Sea and Gulf of Aqaba into the Arabian desert. The country is bounded by the Republic of Syria in the north, the Republic of Iraq in the east, and the Saudi Arabia Kingdom in the east and south, and Occupied Palestine in the west. Its length from Ramtha in the north to the Aqaba in the south is 265 miles (425 kilometers). Its west-east width along the Baghdad Road is about 218 miles (350 kilometers). The maximum length of Jordan is from the northeastern corner to the Aqaba city in the southwest, is about 370 miles (590 kilometers) (Map 1.2). Jordan's area is about the same size as the state of Indiana.[1]

Jordan is primarily an interior country with a small coastline. Its only outlet to the sea is 16 miles (26 km.) of coastline that stretches along the northern most point of the Gulf of Aqaba. The Mediterranean Sea

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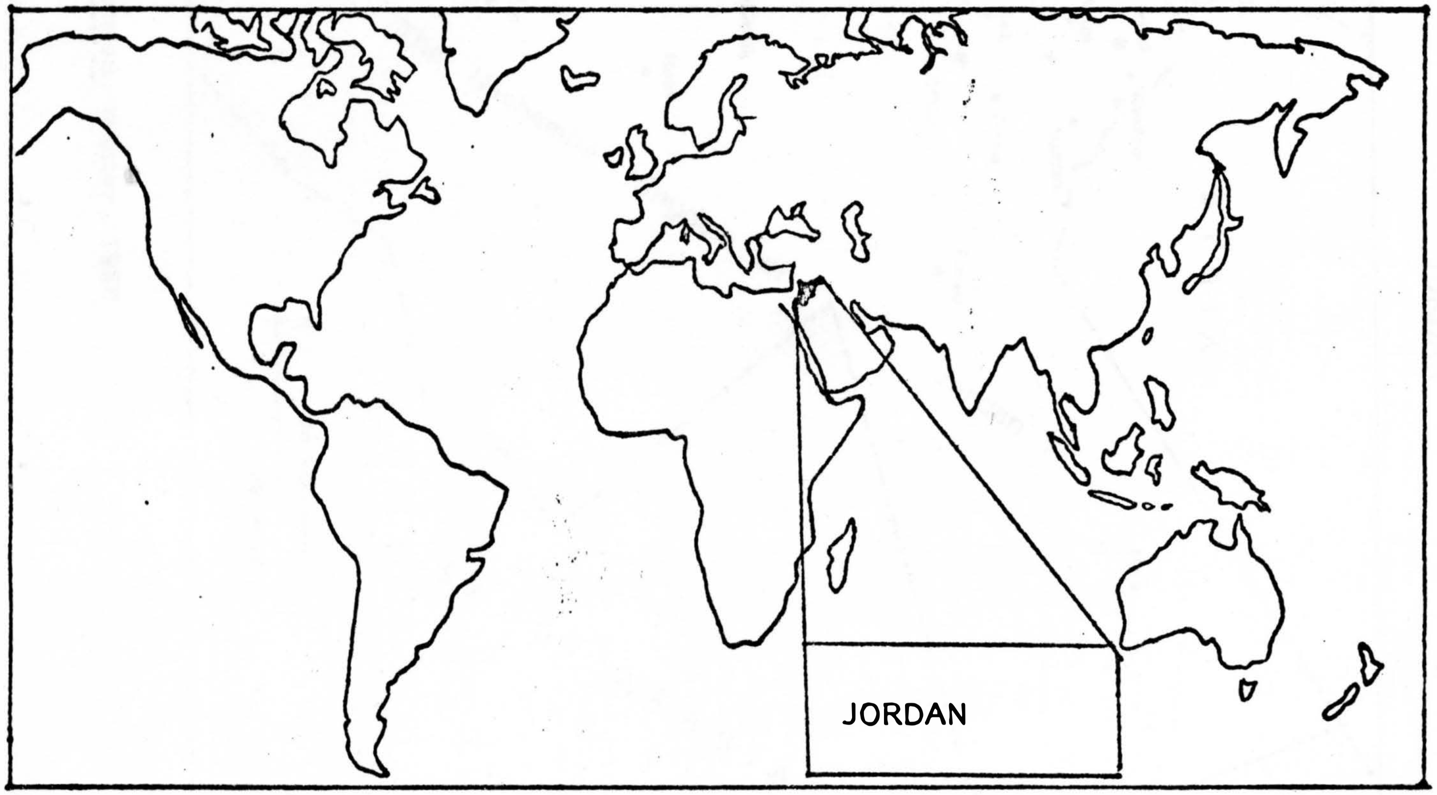
1. Jordan's size for both East and West Banks of the Jordan River is 36,832 square miles (96,188 square kilometers).

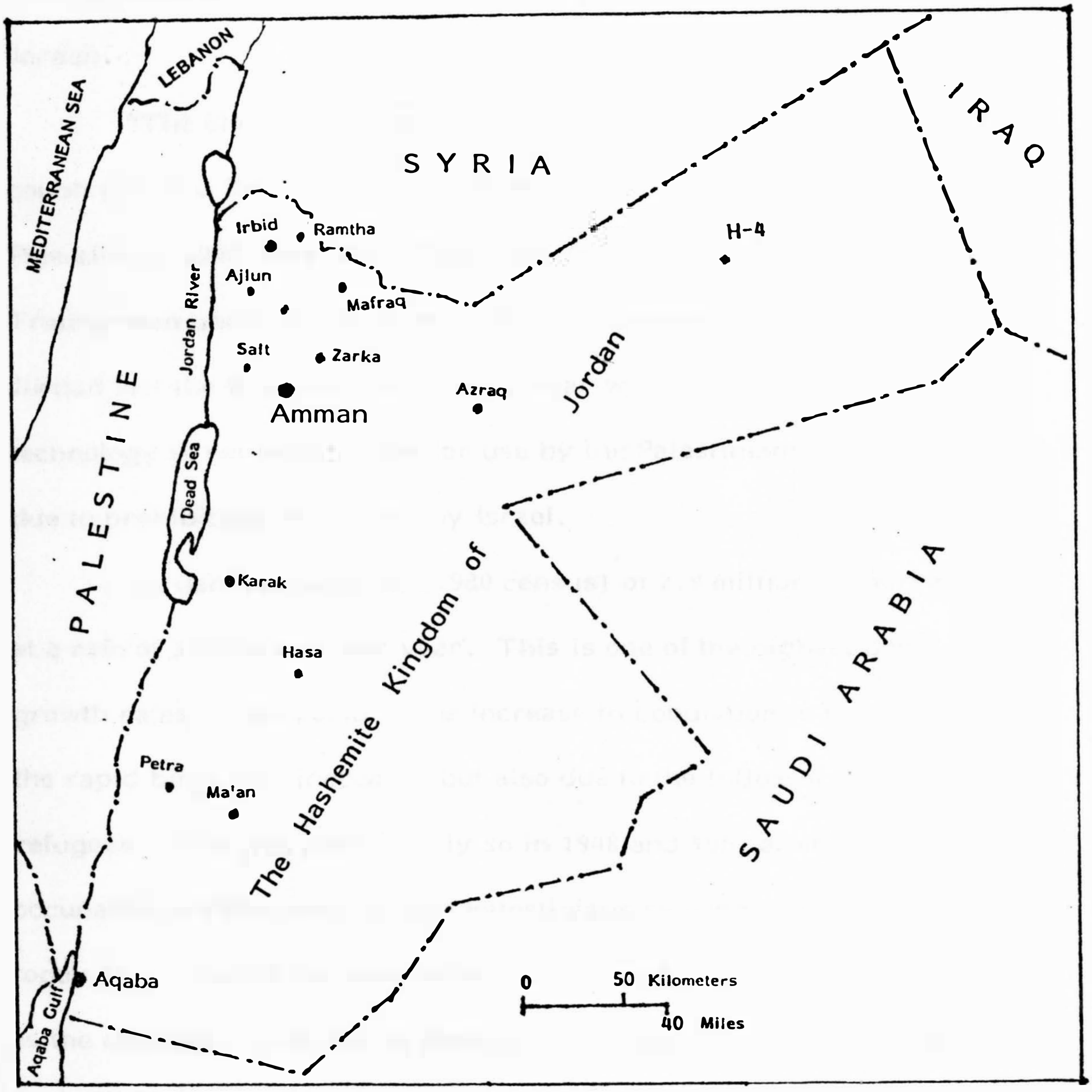
MAP 1.1

JORDAN LOCATION



MAP 1.2

JORDAN



SOURCE: Jordan, Winter, 1980.

is about 30 miles (50 km.) west of the border of Occupied Palestine and Jordan.

"The Emirate of Transjordan" was the name first given to the country by the British in 1921. After the creation of Israel from Palestine in 1948, West Bank Palestinians decided in 1951 to unite with Transjordan under a new name of "The Hashemite Kingdom of Jordan." Jordan lost the West Bank in the 1967 War with Israel. Agricultural technology is not permissible for use by the Palestinians in the West Bank due to prohibitions instituted by Israel.

Jordan's population (1980 census) of 2.9 million is increasing at a rate of 3.1 percent per year. This is one of the highest population growth rates in the world. The increase in population is not due only to the rapid birth rate increase, but also due to the influx of Palestinian refugees. This was particularly so in 1948 and 1967 after Israeli occupation of Palestine. Due to Palestinians seeking refuge in Jordan, today 70 percent of the population total in Jordan is Palestinian. Amman is the most populated city in Jordan, with a population of over 800,000 people. In terms of settlement composition the Jordanian population consists of three main groups: 62 percent urban, 35 percent rural, and 3 percent nomadic tribes. Arabic is the official language in Jordan with English as the second language. Islam is the religion of the majority of the people (90 percent), though there exists a small Christian minority (Jordan 1980: 42).

Jordan's economy depends upon mining, agriculture, industry, and tourism. The major mineral produced is phosphate, which is very important in the foreign exchange market. The primary agricultural products are: wheat, barley, vegetables, fruits, olives, and some tobacco. During the last decade industry has played an increasingly important role in Jordan's economy. The major industries in Jordan are: cement, oil refineries, and phosphate. Tourism also plays an important role in the country's economy. Approximately, 1.5 million tourists visit Jordan annually and spend more than $500 million while there (Showker 1982).

Related Literature

This study is divided into two parts, the physical environment and agriculture. The literature on the physical environment deals primarily with Jordan as a part of the Middle East, Arab world, or the Near East. W. B. Fisher and H. P. Kramer in their books, _The Middle East_, and _Climatology of the Middle East and Central Asia_ respectively, provide detailed information about the climate, soil, water, and natural vegetation.

The related literature discusses agricultural elements in detail in works such as The Economic Growth and Development, by M. P. Mazur, and The Economic Development of Jordan, by the International Bank for Reconstruction and Development. These works examine agriculture in Jordan and provide recommendations for potential development. The Agricultural Development of Jordan, by O. Aresvik, has specific details about agricultural development in the Jordan Valley district. A Study of Agroclimatology in Semi-arid and Arid Zones of the Near East, by C. C. Wallen, and G. Perrin de Brichamout, is a good solid work on climate and agricultural relationships. There are also other important reports about Jordan such as Report on Jordan, by the U.S. Department of State, and Jordan: A Geographical Introduction, by Y. T. Tony.

Organization of Study

The thesis is composed of seven chapters. The second chapter investigates the physical aspects (topography, soil and natural vegetation) that affect climate and agriculture. It includes discussion on the major topographic regions in Jordan: the rift valley, the mountains, and the desert plateau. Soil groups with their types and characters in their regions are examined followed by a discussion of the natural vegetation. The distribution of natural vegetation, along with densities, types, problems, and government policies for protecting the forests and establishing reforestation in the mountains are examined.

The third chapter is devoted to the climate regions and weather elements: precipitation, temperature, evaporation, humidity, pressure, and winds. The chapter contains a brief discussion on the impact of the Dead Sea and the climatic changes in the area.

The availability of water is investigated in the fourth chapter with emphasis on Jordan's water resources availability for agricultural use. Water resources in Jordan are divided into several types: rainfall, springs, wells, rivers, and wadis.

The fifth chapter deals with the agriculture in Jordan. Agricultural regions, land tenure, agricultural development, rainfed agriculture, and irrigation agriculture with emphasis on the East Ghor Canal project, are examined in detail in this chapter.

The sixth chapter is devoted to major agricultural products such as: cereals, vegetables, fruits, and livestock. The distribution of crops and their production are discussed. The seventh chapter examines the relationship between soil, climate, and topography, and their impact on crop distribution and agriculture. This chapter will suggest some possibilities for agricultural development, for the increase of agricultural production, and ways the government and farmers might minimize agricultural problems. The final chapter includes the conclusion and recommendations of the author.

CHAPTER TWO

PHYSICAL ASPECTS

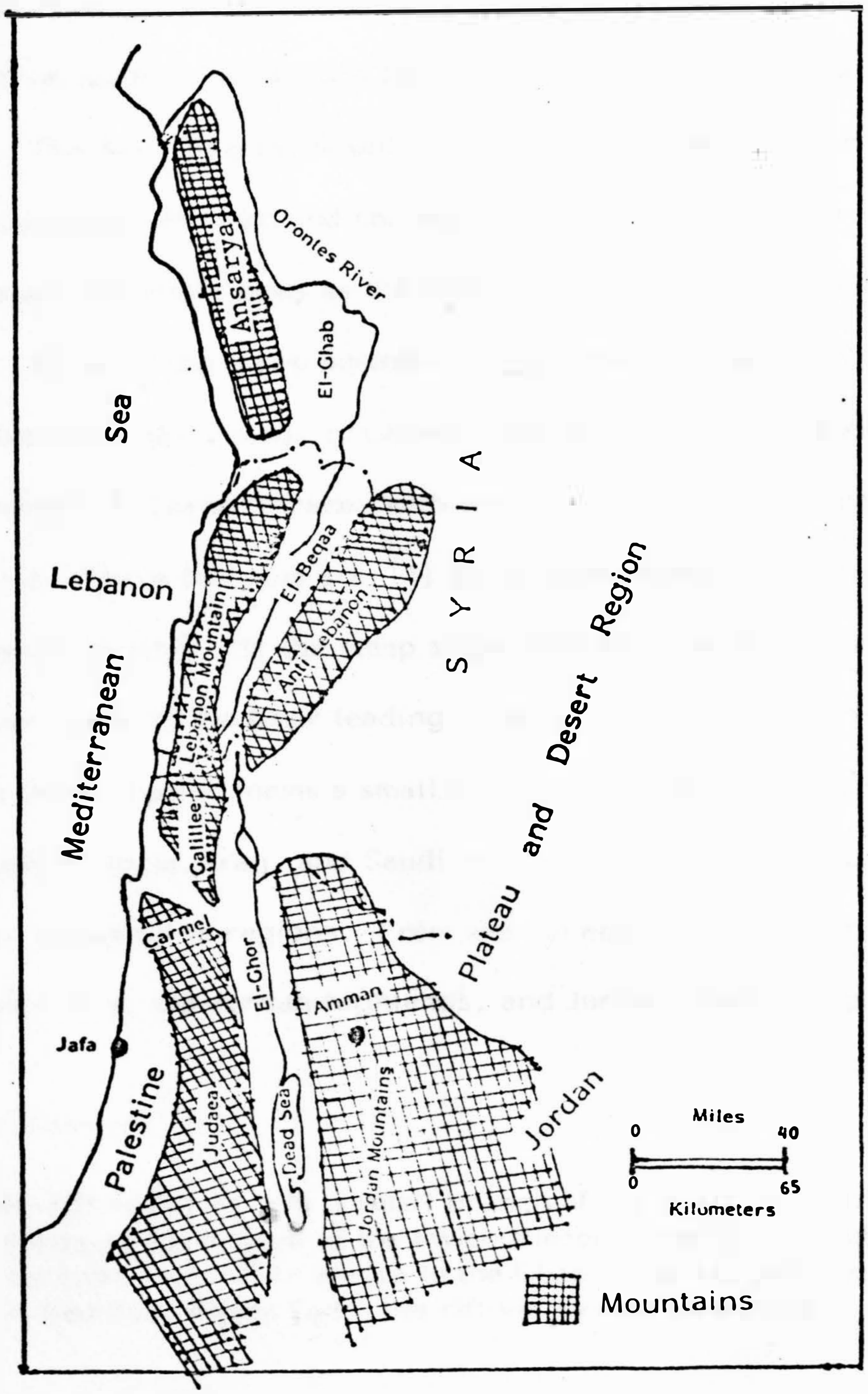
The physical aspects of environment, topography, soil, vegetation and climate, directly or indirectly affect agriculture. Soil quality and depth are influenced by topography and climate which play an important role in the formation of soils and in the type and density of vegetation. The degree of slope and vegetation cover determines the depth and type of soil which, in turn, are of greater importance to agricultural practices; modern agricultural machines are better adapted to flat or gentle slopes than on steep slopes. Generally, the bare slopes of vegetation are covered by shallow soil. Good soil is essential to agricultural production. In order to better understand these relationships, topography, soil and vegetation will be discussed in this chapter. Climate is so significant that a separate chapter will be devoted to its nature and importance to agricultural development in Jordan.

Topography

The Levant countries of Syria, Lebanon, Occupied Palestine, and Jordan, share the same fundamental topographic regions (Map 2.1).

MAP 2.1

THE GEOGRAPHICAL REGIONS IN THE LEVANT



SOURCE: Southwest Asia, Brice, 1966.

The Lebanon mountains, bordered on the west by the Mediterranean coast, complete the Ansarya mountains in Syria and extend into Palestine. In Palestine, from north to south, are the Galilee, Samaria and Judea mountains. The Anti Lebanon mountains to the east of the Lebanon Mountains includes Mount Herman and continues southwards where they are known by such regional names as the Gilead, Ammon, Moab and Edom mountains. Between these two mountain ranges there is the lowland that extends from Syria (El-Ghab), to Lebanon (El-Beqaa) and to the rift valley in Jordan.[1] Three terraces with two steep hillsides descend to the Jordan River. These terraces are: 1) the broken plateau or hill country of Palestine and Jordan, 2) the steep slope from these mountains to the Jordan River, and 3) the Ghor leading to the Zore (Figure 2.1). Finally, the Jordan Desert region forms a small portion of the Arabian Desert which includes part of Syria, Iraq, and Saudi Arabia. Jordan is divided into three major topographic regions. From west to east, they are: the Jordan Rift Valley, the Jordan highlands, and Jordan desert (Map 2.2).

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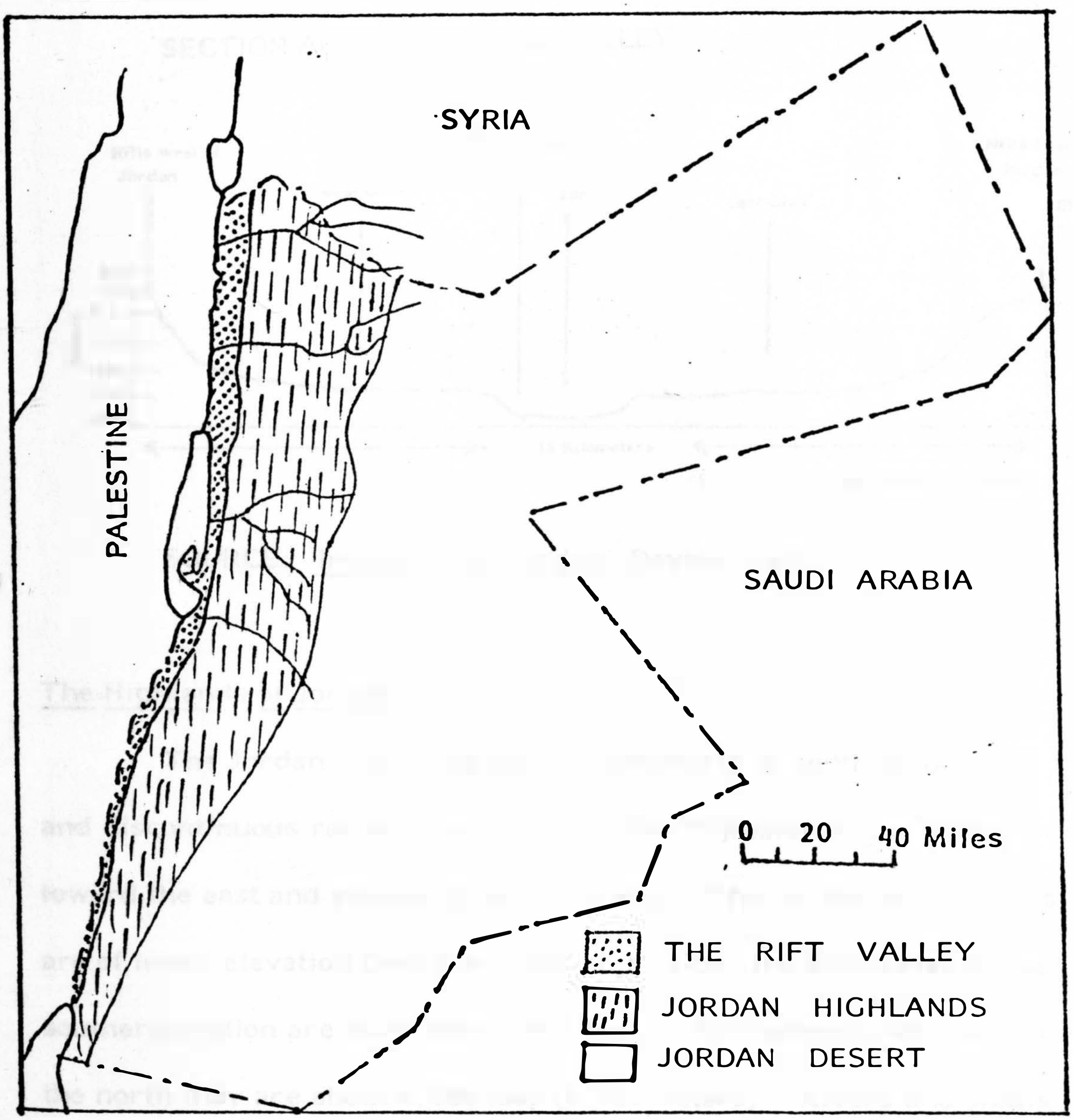
1. The rift valley is only a small branch of the Great African Rift System which formed in the lower Miocence period. It extends from Lake Victoria in Africa to the Ghab in Syria, passing the Red Sea, Aqaba Gulf, the rift valley and El-Beqa'a.

MAP 2.2

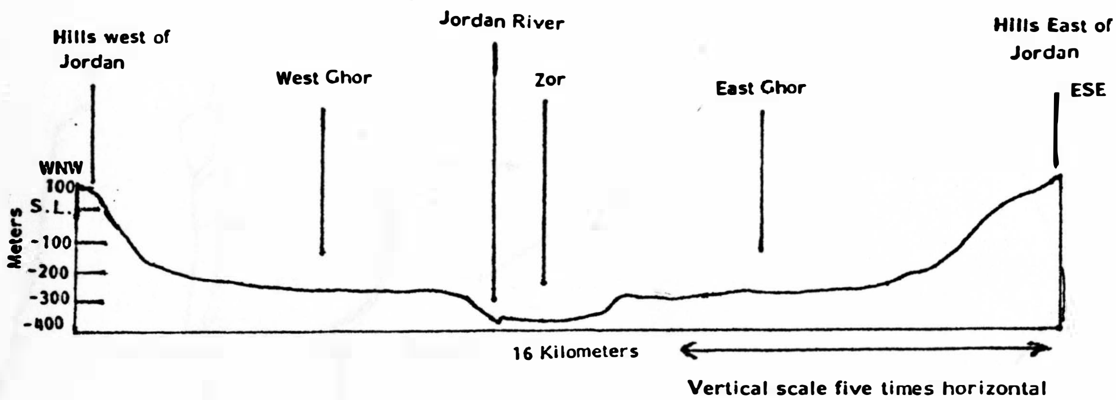
MAIN PHYSIOGRAPHIC REGIONS OF JORDAN



SOURCE: The Agricultural Development of Jordan, Aresvik, 1976.

FIGURE 2.1

SECTION ACROSS JORDAN VALLEY



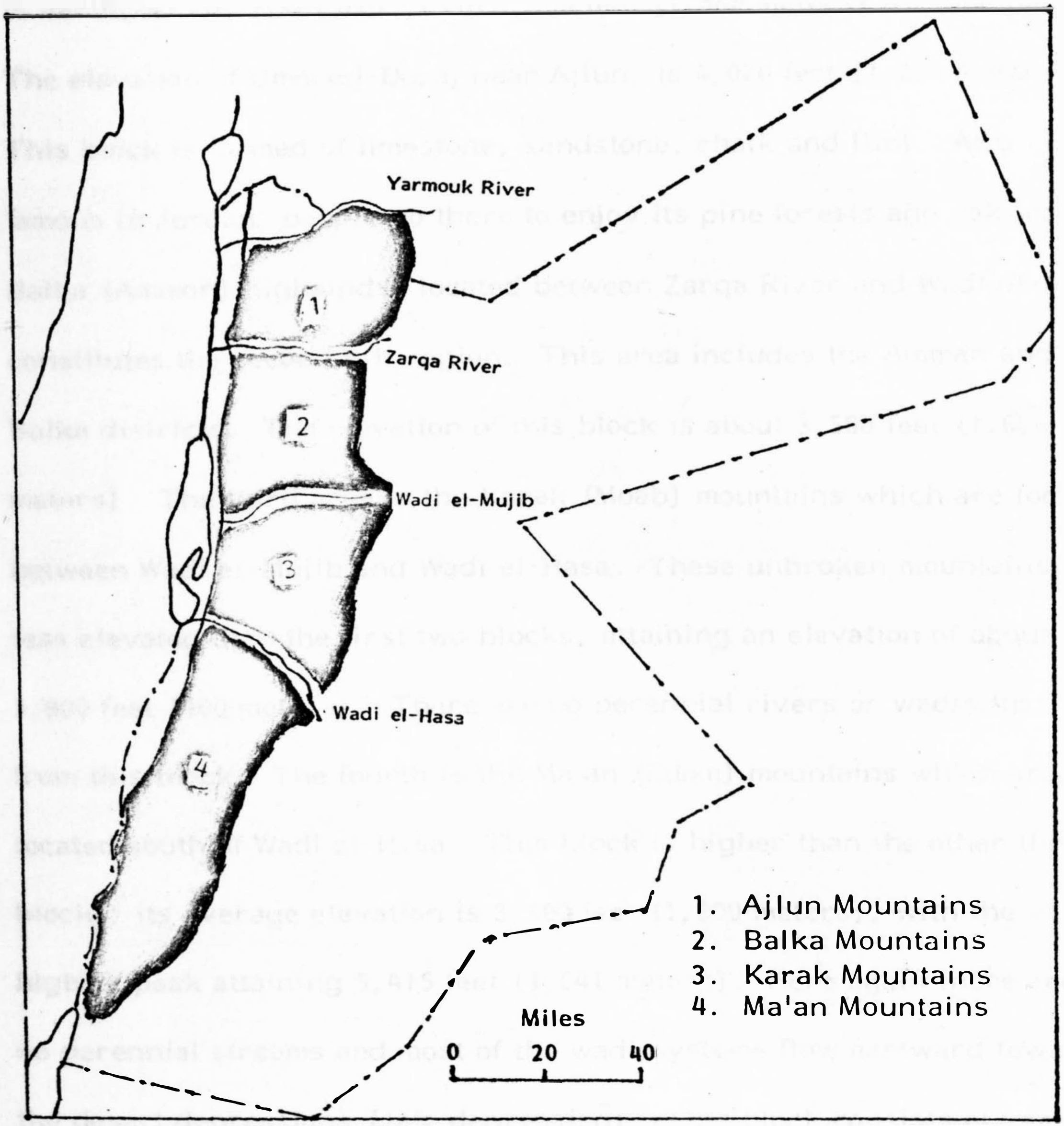
SOURCE: Irrigation in Jordan, Davies, 1958.

The Highlands of Jordan

The Jordan highlands extend from north to south as broken and discontinuous range of mountains. The highlands slope gently toward the east and steeply toward the west. The northern mountains are of lower elevation than the southern section; the elevations in the southern section are more than 5,400 feet (1,600 meters), whereas in the north they are about 4,000 feet (1,100 meters). Rivers and wadis divide the mountains into four well defined hill regions. Four main blocks divided by the Yarmouk, Zarqa, Mujib, and Hasa Rivers are readily distinguishable (Map 2.3).

MAP 2.3

JORDAN MOUNTAINS



SOURCE: Southwest Asia, Brice, 1966.

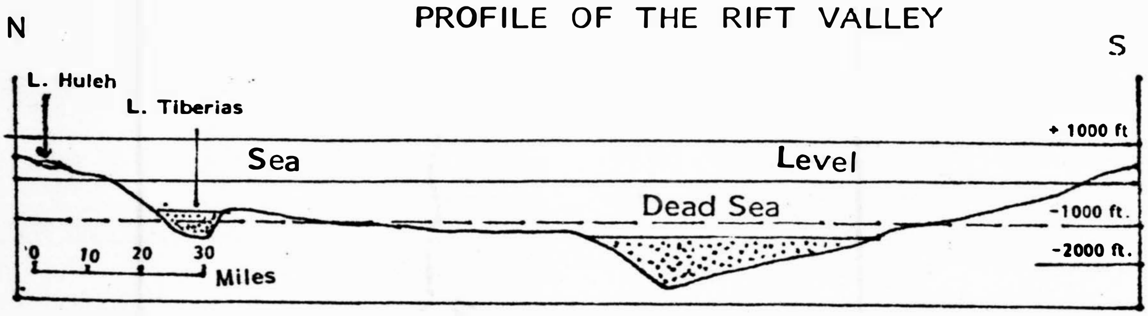
The first hill region, the Ajlun (Gilead) highlands, is situated between the Yarmouk River and Zarqa Rivers. It extends north to northeast and rises more than 3,300 feet (1,000 meters) in some parts. The elevation of Umm ed-Daraj near Ajlun, is 4,070 feet (1,230 meters). This block is formed of limestone, sandstone, chalk and flint. Ajlun is famous in Jordan; people go there to enjoy its pine forests and oak trees. Balka (Ammon) highalnds, located between Zarqa River and Wadi el-Mujib, constitutes the second hill region. This area includes the Amman and Balka districts. The elevation of this block is about 3,500 feet (1,600 meters). The third area is the Karak (Moab) mountains which are located between Wadi el-Mujib and Wadi el-Hasa. These unbroken mountains are less elevated than the first two blocks, attaining an elevation of about 3,000 feet (900 meters). There are no perennial rivers or wadis that flow from this block. The fourth is the Ma'an (Edom) mountains which are located south of Wadi el-Hasa. This block is higher than the other three blocks; its average elevation is 3,300 feet (1,000 meters), with the highest peak attaining 5,415 feet (1,641 meters). Here again there are no perennial streams and most of the wadi systems flow eastward toward the desert depressions (Jafr depression). This block consists of various types of rocks. From south to north, it consists of limestone, chalk with flints, sandstone and granite, and basalt rocks in the extreme south around Aqaba.

The Jordan Rift Valley

The Jordan Rift Valley is comprised of three parts: the Jordan River, the Dead Sea, and Wadi Araba (Map 2.4). The Jordan River occupies the northern part which extends from the northern border of Jordan to the Dead Sea. The slope in this port is steep, between Lake Hule and Lake Tiberias its descent exceeds 100 feet per mile[2] (20.5 meters per 1 km), resulting in a series of cascades which cut through a basalt gorge (Tony 1969: 3). The valley, below Lake Tiberias, slopes gradually to the Dead Sea (Figure 2.2). The Dead Sea occupies the central part of the

FIGURE 2.2

PROFILE OF THE RIFT VALLEY



SOURCE: The Middle East, Fisher, 1963.

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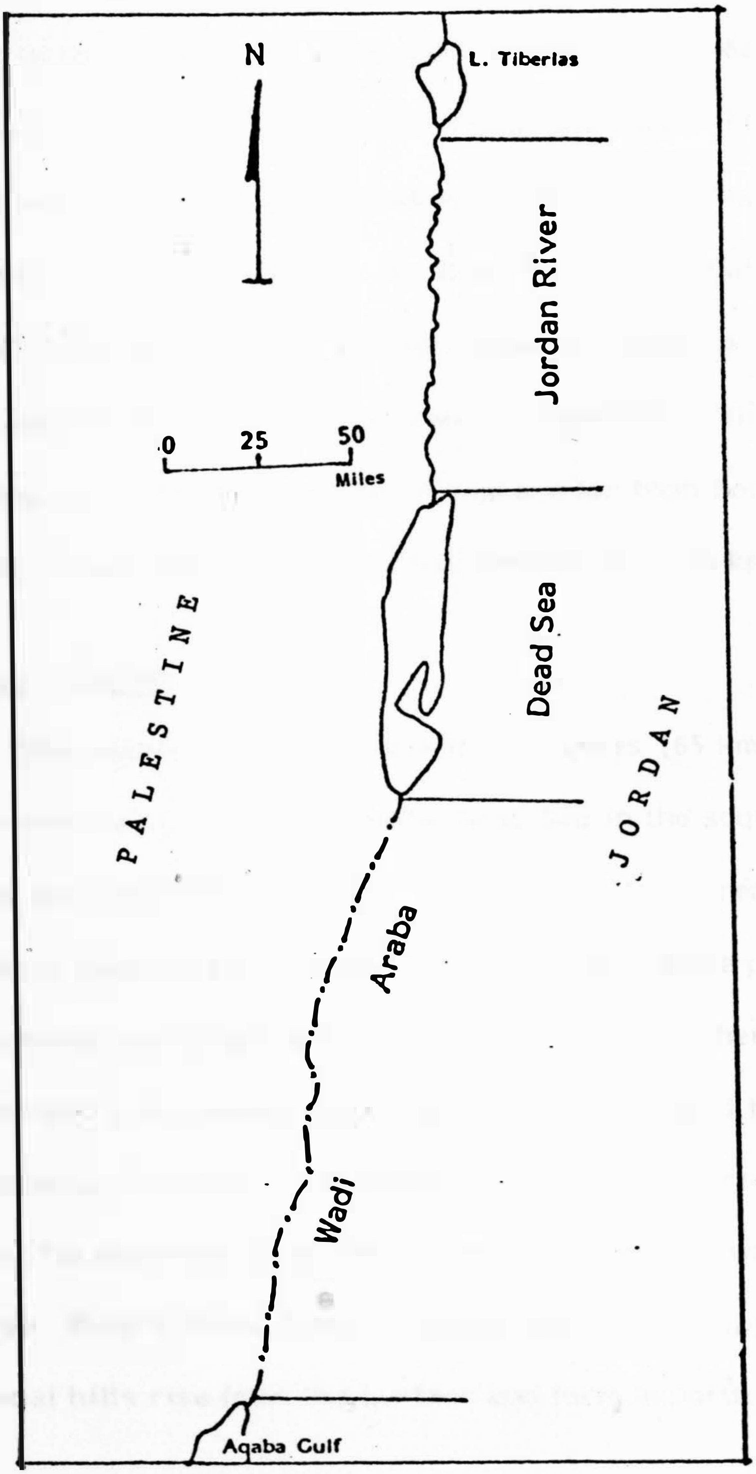
2. The distance between the two lakes is 9 miles (14.5 km). The Lake Hule elevation is 230 feet (80 meters) and Lake Tiberias is 696 feet (230 meters) below sea level.

MAP 2.4

RIFT VALLEY SECTIONS



SOURCE: The Jordan Valley, Khouri Rami, 1981 rift valley. The northern part of the Dead Sea is the lowest elevation of dry land in the world, 1,310 feet (396 meters) below sea level. Two wall-like cliffs lie on each side of the Dead Sea, the Jordan highlands in the east and west bank highlands (Judaea) in the west. The third part is Wadi Araba which extends from the Dead Sea to the Aqaba Gulf. This part does not lie entirely below sea level. Ghor El-Ajram is 790 feet (240 meters) above sea level and from there on the valley falls gradually to the Gulf of Aqaba. The sides of Wadi Araba are far from being clear cut since the width of the wadi varies from 4 to 8 miles (10 - 20 km.).

The Desert Region

The desert region comes within 40 miles (65 km) of the Jordan River in the north, and borders the Dead Sea in the south. This region occupies more than four-fifths of the country's total area. Its average elevation is about 1,650 feet (500 meters), but in some places the elevation reaches more than 3,000 feet (900 meters). The northern and northeastern sections have a southward continuation of the lava and basalt country of Jebel el-Druze in Syria. The southern desert is an area of sandstone and granite. On the whole it is a flat region with several wadis draining into the Zarqa, Wadi Sirhan, Qasr el-Burqa and el-Jafr depressions. Occasional hills rise from the surface and form important landmarks in the desert. Erosional agents have played the dominant part in carving wadis. Occasional rain and run-off is normally sufficient to carry away the weathered material to depressions or to the sea (Tony 1969: 7).

Natural Vegetation

Jordan's forests generally need more protection than almost any other area. Forests offer advantages to the country and people, serving as recreational areas that attract vacationers, enhancing the scenery with their colors, conserving soil from erosion by decreasing the impact of raindrops which fall indirectly and gently on the soil. Also root systems of the trees protect the soil from erosion by holding soil particles together. These factors are very important for agricultural production.

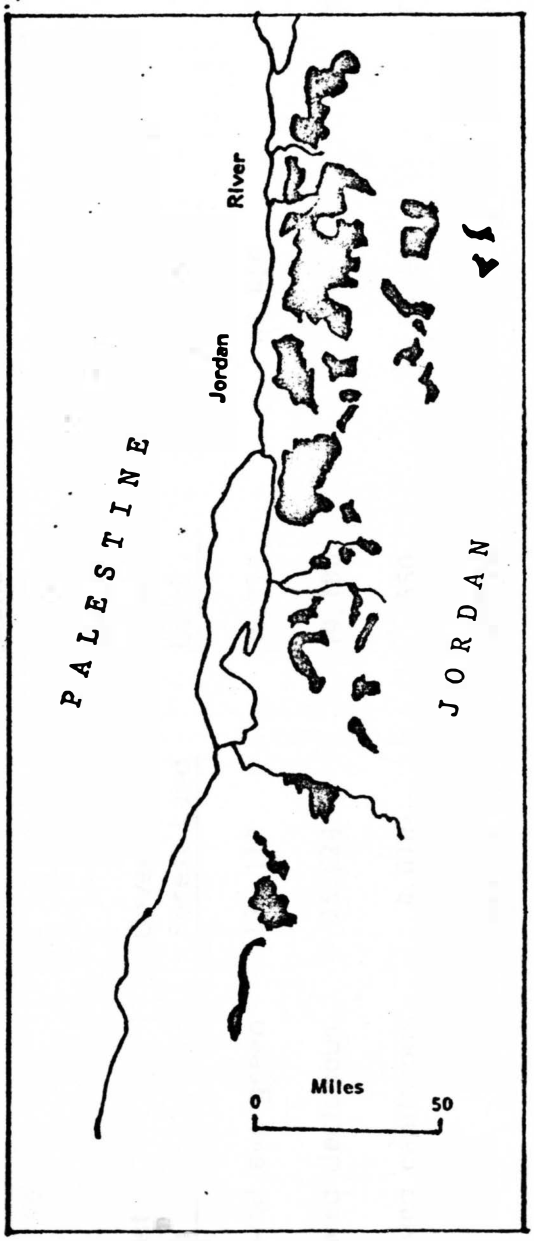
The amount of precipitation influences the distribution of vegetation. Areas with relatively heavy rainfall have forests, whereas areas with little rainfall have steppe, and there is desert where little rain falls. There are other factors that also determine the distribution of vegetation. These include differences in temperature, soil, underground water, and human activities. There are three vegetational zones in Jordan: forest, steppe, and desert. The boundaries of these regions cannot be sharply defined, because there is a broad transitional zone from one to the other (Aresvik 1976: 22).

Forest vegetation (Mediterranean type) is found in the mountains where rainfall is more than 12 inches (300 mm). Woodlands stretch from Ajlun in the north to the head of the Gulf of Aqaba (Map 2.5). These mountains are covered with forests of Juniperus phoenicia (pines), Cupressus sempervirens (Cypress), Quercus coccifera (oaks), and Olea europaea (wild olive). Forested area covers less than one percent of Jordan (under 40,000 hectares) (Table 2.1). Forested areas have decreased to a narrow and discontinuous strip along the escarpment of the rift valley and on top of the highlands. These areas are the remnants of a once more dense and larger forest that used to extend over the entire sub-humid and semi-arid areas. Forests have been destroyed over the centuries by cutting for fuel, agricultural clearing, grazing and by fire (U.S. State Department 1979: 47).

There are two main areas of forest in Jordan: the northern highlands and the southern highlands (Map 2.6). Rainfall in the north makes forest regeneration more possible in this area than in the southern highlands. The northern highland forests cover an area of some 800 square miles (2,000 square km) from wadi el-Arab to the Wadi el-Kuffrein. The maximum east-west width is about 16 miles (25 km) in Ajlun area. In the southern highlands the forests cover an area of some 100 square miles (240 square kilometers) in a narrow north-to-south

MAP 2.5

DISTRIBUTION OF FORESTS IN JORDAN



SOURCE: Agricultural Development of Jordan, Aresvik, 1976.

TABLE 2.1

FORESTS OF JORDAN

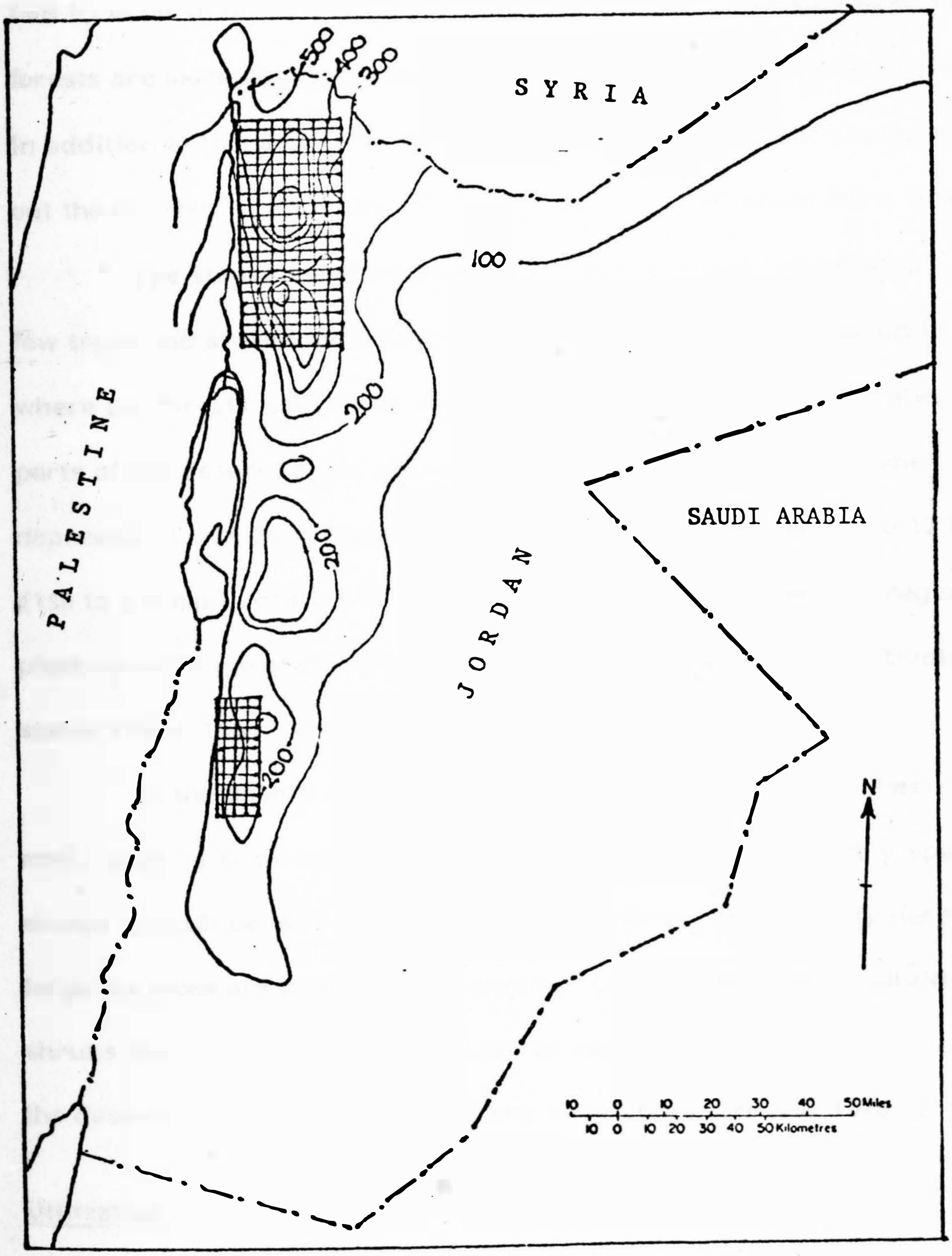
(Dunums)

Forest Type	Government Forest Land	Private Forest Land	Unsettled Forest Land	Total
Broad-leaved evergreen	126,110	36,270	47,460	209,840
Broad-leaved deciduous	25,620	14,180	----	39,800
Broad-leaved caniferous	4,010	550	74,600	79,160
Mixed	27,310	2,960	----	20,270
Wild Olive	970	90	----	1,060
TOTAL	184,020	54,050	122,060	360,130

SOURCE: Agricultural Development of Jordan, Aresvik, 1976.

MAP 2.6

POSITION OF MAJOR FOREST AREAS IN JORDAN



SOURCE: Forest of Jordan, Atkinson and Beaumont, 1971.

belt from north of the Wadi Dana to the Wadi Musa. The southern highland forests are more degraded than those of the north and cover a smaller area. In addition to the mountain districts, there are forests distributed throughout the country in wadi bottoms and in the Ghor (Atkinson 1971: 306).

The steppe region almost encircles the forest region with few trees and shrubs growing at the margins of the forest region in areas where the forests have been degraded. The steppe also penetrates into parts of the desert region along the wadis and in portions of some depressions. In this region, with rainfall varying between 6 to 12 inches (150 to 300 mm), climate is more continental than in the forest region. The plant cover is generally grass, especially where soils are relatively stable (Tony 1969: 15).

In the desert region, where rainfall is less than 4 inches (100 mm), there is scant vegetation. Desert vegetation is extremely sparse, except in wadi beds, runnels, and depressions. In the sandy desert, large surfaces are covered with shrubs, but between these individual shrubs there are areas that are bare of vegetation. Some large areas in the desert are completely bare of any vegetation (Aresvik 1976: 23).

Utilization

The production of wood in Jordan is very low and of little value due to the small number and poor quality of the trees (Table 2.2). Jordan depends almost totally on imports to cover its needs for wood products. The total value of imported wood in 1976 was $30,167,000 (U.S. State Department 1979: 50). Emphasis should be placed on the development of forest resources in Jordan in order to increase wood production and thereby lessen import costs and adequately provide the needs of the country's industry.

Deforestation

The results of deforestation are: soil erosion, loss of valuable timber resources, and damage to the watershed areas. Deforestation occurs in different ways. Primary causes are: overgrazing, clearing of land for agriculture, cutting trees for timber or fuel, fire, and long-term climatic changes.

Overgrazing: Goats have been a major cause of deforestation. Goats not only eat the leaves and small green shoots of the trees, but they also destroy seedlings and ground vegetation resulting in the loss of revegetation capability. Overgrazing has affected the southern forests more than those in the north because of herds of camels, sheep, and goats that are driven to the southern forests during the summer seasons for grazing by nomads from the East Jordanian Desert (Atkinson 1971: 311).

TABLE 2.2

WOOD PRODUCTION IN JORDAN

(Thousands of cubic meters)

	1963	1966	1971	1972	1973	1974	1975	1976
Industrial Round Wood	3	4	4	5	6	7	4	7
Fueld Wood	16	18	3	4	5	5	5	3
Total Wood Production	19	22	7	9	11	12	9	10

SOURCE: Report on Jordan, U.S. Department of State, August 1979.

Clearing of land for agriculture: The clearing of land for agricultural use was encouraged by the Agricultural Ministry of Jordan, in the northern highlands due to the suitability of climate for the production of wheat, vines, and olives. This practice removed much of the vegetation that protected the soil and resulted in massive soil erosion.

Felling of trees for timber: The cutting of timber has been practiced for centuries. The main cutting occurred in the early part of the twentieth century by the Turkish to cover their needs of wood (during World War I). Timber was used for housing, railroads, and other types of construction. Average yield of Jordan forests is one cubic meter per hectare per year, due to poor quality and the thinness of the forests. The average volume per hectare ranges from 10 cubic meters for low-density deciduous oak to 33 cubic meters for dense evergreen oak and 43 cubic meters for medium-density Aleppo pine. The total production of wood is about 311,000 cubic meters per year which represents about three percent of the value of imports of wood and timber in the early 1970s (Aresvik 1976: 184).

Collection of wood for fuel: Shortage of fuel led to massive destruction of trees especially in the southern forests. The destruction of forests reached its peak during the First World War. Timber was used during the war to cover the demands for firewood by the Turkish government. The amount of wood used for fuel has decreased within the last decade due to the increase use of oil, cooking gas, and electricity (U.S. Department of State 1979: 52).

Climatic changes: The impact of climatic changes is difficult to assess because of the lack of long-term rainfall records for Jordan. Indications show that the average rainfall for the first half of the twentieth century was lower than for the second half of the nineteenth century. Usually, the decrease in rainfall will decrease the rate of natural vegetation growth (U.S. Department of State 1979: 52).

Reforestation

The earliest governmental reforestation program in Jordan began in 1943, but it was not until 1948 that a systematic reforestation procedure was started. Table 2.3 shows the average reforestation figures each year from 1971 to 1976. The Forest Department (Agricultural Ministry) controls some 131,500 hectares (1,315,000 dunums) of land and implements reforestation projects. As a result of these projects, Jordan's forests have increased from 32,000 hectares (320,000 dunums) in 1958, to 94,000 hectares (940,000 dunums) in 1976 (U.S. Department of State 1979: 52). There are twelve forest nurseries currently operating in Jordan. They are located throughout the forest lands. Each nursery can produce about one-half million plants annually. The

TABLE 2.3

OFFICIAL REFORESTATION FIGURES 1971 - 1976

	1971	1972	1973	1974	1975	1976
Area newly planted with forest trees (in hectares)	830	1,920	1,220	2,500	3,600	1,800
Thousands of seedlings planted	1,338	1,734	1,201	2,500	3,600	2,000

SOURCE: Report on Jordan, U. S. Department of State, August 1979.

reforestation activities are implemented mainly on the bare lands close to the cities and towns (Aresvik 1976: 182).

Soils

Soil formation depends on many factors that determine the type and quality of soil groups. According to Donahue (1971: 86-99), those factors are:

Climate: The influence of climate, mainly precipitation and temperature, is an active factor on soil formation. Climate affects the soil formation directly (erosion, deposition, soil acidity and weathering), and indirectly through its relation with vegetation.

Biotic: Plant and animal life have a large influence on the process of soil formation. Organic matter, acidity, and bulk density are the soil characteristics most influenced by the kind of plants and animals present.

Parent Material: The type of soil depends on the variety of rock material from which it is derived. Granite rocks develop poor soils, sandstone develops soils of low productivity, and limestone develops very productive soils.

Relief: Relief influences soil formation by the degree of slope and its relation to water. On gently sloping hillsides and flat terrain, water passes through the soil to greater depths than on steep terrain.

Time: A long period of time is essential for soil to develop. Soil formation needs 200 years under ideal conditions; under poor conditions it could take thousands of years.

The characteristics of soil types are different in Jordan's highlands, steppe, valleys, and desert regions. Map 2.7 shows the distribution of soils throughout Jordan.

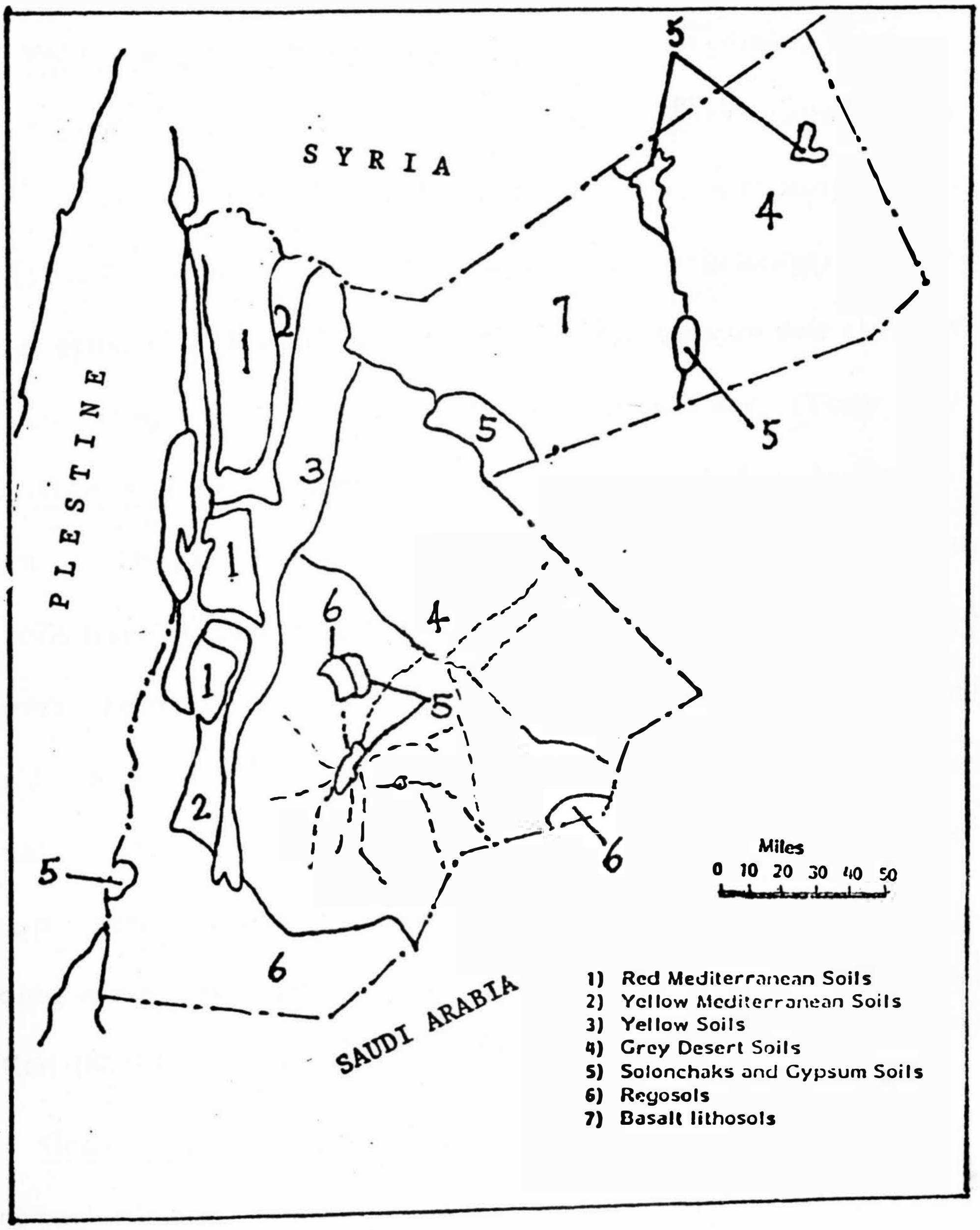
The soil groups are:

Red Mediterranean Soils: These soils are typical of areas with greater than 11 inches (275 mm) of rainfall. This soil is usually derived from calcareous rocks, and occassionally from basalt and sandstone. Most of the land used for agricultural purposes on the Jordanian Plateau belong to this group. The soil is deep and fertile and serves as excellent crop land. Natural fertility is relatively high, which is proved by the cultivation of these soils for thousands of years without the addition of any appreciable amount of fertilizer (Aresvik 1976: 23).

Yellow Mediterranean Soils: These soils are found in some parts of the highlands on the scarps and in the rift valley. The parent material is the same as for the Yellow Soils and it can be regarded as a transitional soil between the Red Mediterranean Soil and Yellow Soils. Wheat and barley are usually grown in these soils if water is available

MAP 2.7

SOIL REGIONS OF JORDAN



SOURCE: Report on Jordan, U.S. Department of State, 1979.

for irrigation (U.S. Department of State 1979: 53).

Yellow or Steppe Soils: These soils vary in origin, from weathered limestone and chalk to colluvial loess. These soils are found in the steppe region that suffered from degradation, uprooting of shrubs for fuel, excessive plowing, trampling, overgrazing, and wind and water erosion. This group forms the most extensive soil cover in Jordan, covering at least 40 percent of the total land area (Tony 1969: 13).

Alluvial Soils: These soils have a very wide distribution in the country. They are derived from either limestone or basalt or both. These soils have accumulated through periodic water deposition. There are alluvial sedimentary soils of flood water or marshy origin such as those of the areas alongside streams in the Jordan Valley. The deposits are usually deep, heavy in texture, have a high water-holding capacity, and are productive. These soils areas are cultivated intensively,[3] producing winter and summer field crops both under dry farming and irrigation (Nuttonson 1947: 450).

Grey Soils: These soils cover the eastern half of Jordan (desert region) with the surface usually covered with flints, pebbles,

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3. A high percentage of these soils have been salinized through centuries of irrigation without adequate drainage so that they are artificial solanchaks.

stones, or even boulders. Productivity of these soils is low due to their high salinity content. They represent areas used mainly for grazing. Agricultural activities are possible where underground water is available for irrigation. In some areas the salinity level has been reduced from 17 percent to 1 percent by washing soils and use of modern technology (Aresvik 1976: 23).

Soil Problems

Soils in Jordan have suffered from many problems. They include: 1) Soil erosion, which leads to a reduction of cultivatable areas. Soil erosion results from several causes such as: run-off on slopes, overgrazing, deforestation, and improper farming practices[4] (Atkinson 1969: 146). Soil erosion may cause siltation in reservoirs. In the catchment area for the King Talal Reservoir, for example, about 95 percent of the area will be affected seriously if nothing is done about siltation (U.S. Department of State 1979: 54).

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4. Four-fifths of the cultivated land area is devoted to monoculture of cereals (wheat and barley) and some other crops (tomatoes, lentils and chick peas). The most serious effect of this cultivation pattern is that the ground surface is bare of vegetation during the winter months when precipitation totals are highest thus causing soil erosion.

2) Increases of soil salinity in the irrigated area of the Jordan Valley, resulting from salty water or bad drainage or irrigation water. Irrigation is essential for the crops and the leaching of salts must be performed recurrently in order to keep the salt level low (U.S. Department of State 1979: 55).

Soil Conservation

The Soil Conservation Department in Jordan passed legislation designed to control soil erosion by several ways: 1) prohibiting grazing and cutting of trees on certain types of land, 2) contour walls and terraces were built on slopes, 3) reforestation of uncultivated lands with a slope in excess of 25 percent, 4) encouraging people to replace goats with sheep (the government has forbidden the raising of goats in some areas), and 5) the use of proper farming practices (Atkinson 1969: 147).

In summary, there are three different topographic regions in Jordan, the Ghor, desert, and mountains. Each of these topographic regions include types of soils that are not present in the other regions. The soils in the Ghor and in the desert are different from the soils in the mountain because each region has its own physical condition which includes variations in vegetation, type of rocks, and climate. Natural vegetation is also different in these regions. There are forests in the mountains, shrubs in the desert, and a mixture of trees and shrubs in the Ghor district. All of these differences affect the type of agricultural plants and crops. Agriculture crops in the Ghor district can not grow in the mountains and in the desert districts because of the variation of the climate conditions in those regions. Therefore, the study of climate is essential to illustrate its relation with agriculture.

CHAPTER THREE

CLIMATE

The climate of Jordan is generally Mediterranean subtropical, characterized by dry summers. This climate occurs mainly in the areas around the Mediterranean Sea. The climatic conditions range from almost arid tropical to nearly temperate climates. It is hot and dry in the summer and mild and rainy in the winter (Critchfield 1966: 179). Differences in Jordan's climatic conditions are apparent between north and south and between west and east. According to the Koppen classification,[1] Jordan is divided into three climatic types: Low Latitude Desert (Bwh), Low Latitude Steppe (Bsh), and Dry Summer Subtropical (Mediterranean) Climates (Cs) (Map 3.1).

Low Latitude Desert (Bwh) climates are located in the deserts, and are among the most arid regions of the earth. The average rainfall is less than 5 inches (125 mm) per year. Rainfall is not only small in amount, but also unreliable in terms of its frequency. The sudden

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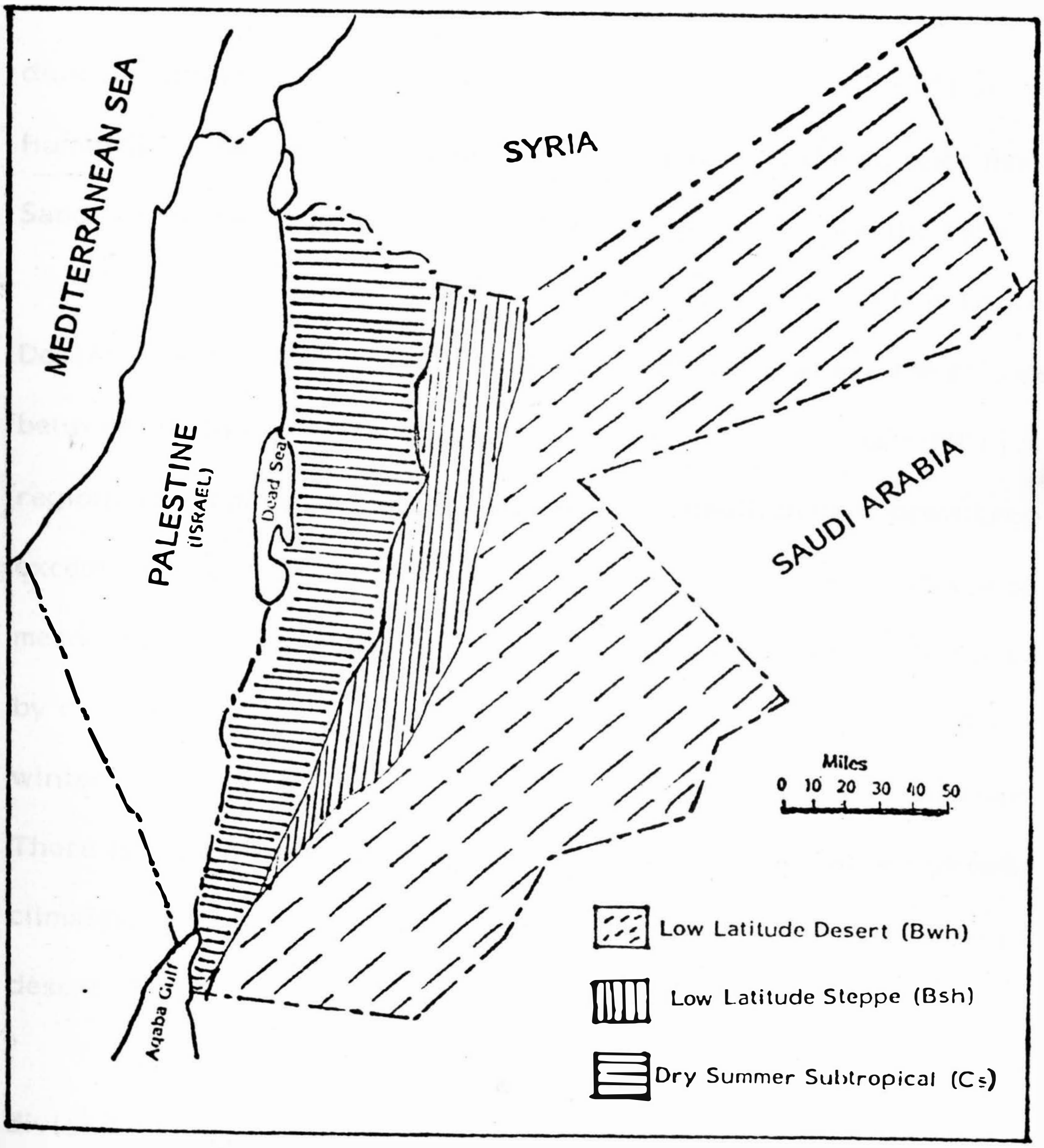
1. Koppen's classification is based upon annual and monthly means of temperature and precipitation. Native vegetation is considered as the best expression of the totality of climate, the boundaries of climatic regions are selected with vegetation consideration.

MAP 3.1

CLIMATE REGIONS OF JORDAN



SOURCE: <u>An Introduction to Climate</u>, Trewartha, 1954.
<u>Crossroads</u>, Cressey, 1960.

rainfall that occurs in these climates, results in sudden "flash floods" that cause damage to buildings and plants. A large percentage of the rainwater evaporates quickly because of the hot dry air. Temperature averages range from 85° to 95°F (30° to 35°C), and often experience diuernal extremes of 110°F (43°C) in mid-day and 75°F (24°C) at night. Humidity in these regions is low, especially during the summer months. Sandstorms are frequent in these climate regions (Trewartha 1954: 273).

Low Latitude Steppe (Bsh) climates surround the Low Latitude Desert Climates (Bwh) except on the western side, where the climate is between the Desert and the Subtropical Climates (Cs). Rainfall in these regions is variable and uncertain, and it is insufficient to grow crops except in oases. Grass is the dominant vegetation found in this area. The mean rainfall in the steppe is 12 inches (300 mm) most of which is caused by cyclonic storms. Evaporation during the summer is higher than in winter because of the high temperature and low humidity in summer. There is little difference in temperature between the steepe and desert climates, whereas the humidity is higher in the steppe region than in the desert (Trewartha 1954: 279).

The Dry Summer Subtropical climate (Mediterranean, Cs) is divided into two climates based on the degree of summer heat: 1) a cool summer (Csb) climate is located near the cool coastal waters, and 2) a warm or hot summer (Csa) climate which is located further inland and includes the highlands of Jordan. A low pressure center forms over the Mediterranean Sea during the winter, and becomes the route of many eastward moving cyclones that bring rainfall to the interior area. The rainfall amount is generally between 15 to 25 inches (375-625 mm) per year, decreasing from the coasts eastward toward the interior except in the mountainous areas. Snow and frost rarely occur in the mountain district. Frost does occur occassionally and it has a damaging affect on many forms of plant life. The average temperatures differ seasonally; in winter the average is between 40^{o} and 50^{o}F (4.5^{o} - 10^{o}C), whereas in the summer it is between 70^{o} and 80^{o}F (21^{o} - 27^{o}C). Relative humidity in this climate is lower in summer and higher in winter (Trewartha 1954: 291-296).

Jordan can be divided into three different climate districts as suggested by Taha (1981: 208):

1) The Jordan Highlands. The Jordan highlands district is located to the East of Jordan Rift Valley. Its altitude ranges from 1,600 to 3,300 feet (500 to 1,000 meters) with peaks reaching more than 5,000 feet (1,500 meters) in the southeastern mountains. The mountains belt generally has cooler summers and colder winters, than are perceived in other districts. The area is an attractive summer resort such as that found in the vicinity of Ajlun.

2) The Ghor District. This district includes the area with an average width of 10 miles (16 kilometers) located near the Jordan River and the Dead Sea. Its elevation ranges from 640 to 1,310 feet (-192 to 396 meters) below sea level. This district is characterized by warm winters and very hot, dry summers with many days experiencing very dry sirocco winds. This area serves as a winter resort.

3) The Jordan Desert. This area is situated to the east of the highland district. It forms a part of the Arabian desert and plateau. The district has an arid desert climate, hot and dry in summers and cool, almost rainless winters. There is very little life in this district except in the oases.

Weather Seasons

Spring and autumn are considered the transitional seasons between winter and summer. Each of the four seasons has its own climate conditions which differ relatively from the other seasons.

Summer season includes the three hottest months: July, August, and September. There are no significant changes from day to day in the summer. The main characteristics of summer are: drought, brilliant sunshine with a high daytime temperature, low relative humidity, and the occurrence of sandstorms in the desert and Ghor regions.

Autumn includes the three transitional months of October, November, and December. The weather conditions change gradually toward winter characteristics. In autumn, cloud cover and rain appear. Dust storms decrease gradually with the increase of precipitation. Temperature is still relatively high, but there is an increase in the relative humidity. The daily weather in autumn becomes more uncertain.

Winter, the coldest season, includes the months of January, February, and March. The important characteristics of winter include an increase in the frequency and strength of cyclones, increased precipitation, lower temperatures, and occasional snowfall and frost.

Spring is the transitional season (April, May, and June) between winter and summer. The season is characterized by the formation of low-pressure systems which originate in the arid northwest of Africa, and move eastward to the Arabian desert. Passing cyclones begin to occur in the end of this season. Spring is a delightful season that is rather warm, but cooler than autumn. The harvest period for many grains begins in the spring. Dry winds (sirocco) occur in this season bringing with them high temperatures and low humidity.

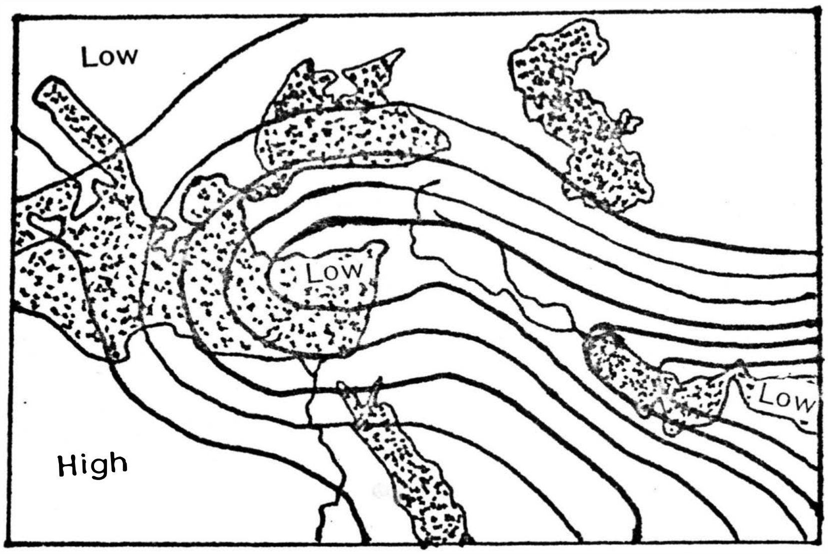
Pressure

Available studies pertaining to pressure systems generally encompass large areas. Information for Jordan is likewise combined with in such an area. Jordan is affected by low and high pressure systems that originate in central and south Asia, Europe and in north Africa. These pressure systems vary seasonally from winter to summer, and with their passage comes a variety of weather conditions.

During summer, there are two major low pressure systems in the Middle East. The monsoonal low pressure system of India centers over the Gulf of Oman and extends to the Persian Gulf and Iran. This pressure system results from the intensive heating of the southern part of Asia and develops into a wind system that affects almost all of the Middle East (Figure 3.1). Other low pressure systems also develop over or

FIGURE 3.1

PRESSURE DISTRIBUTION IN SUMMER



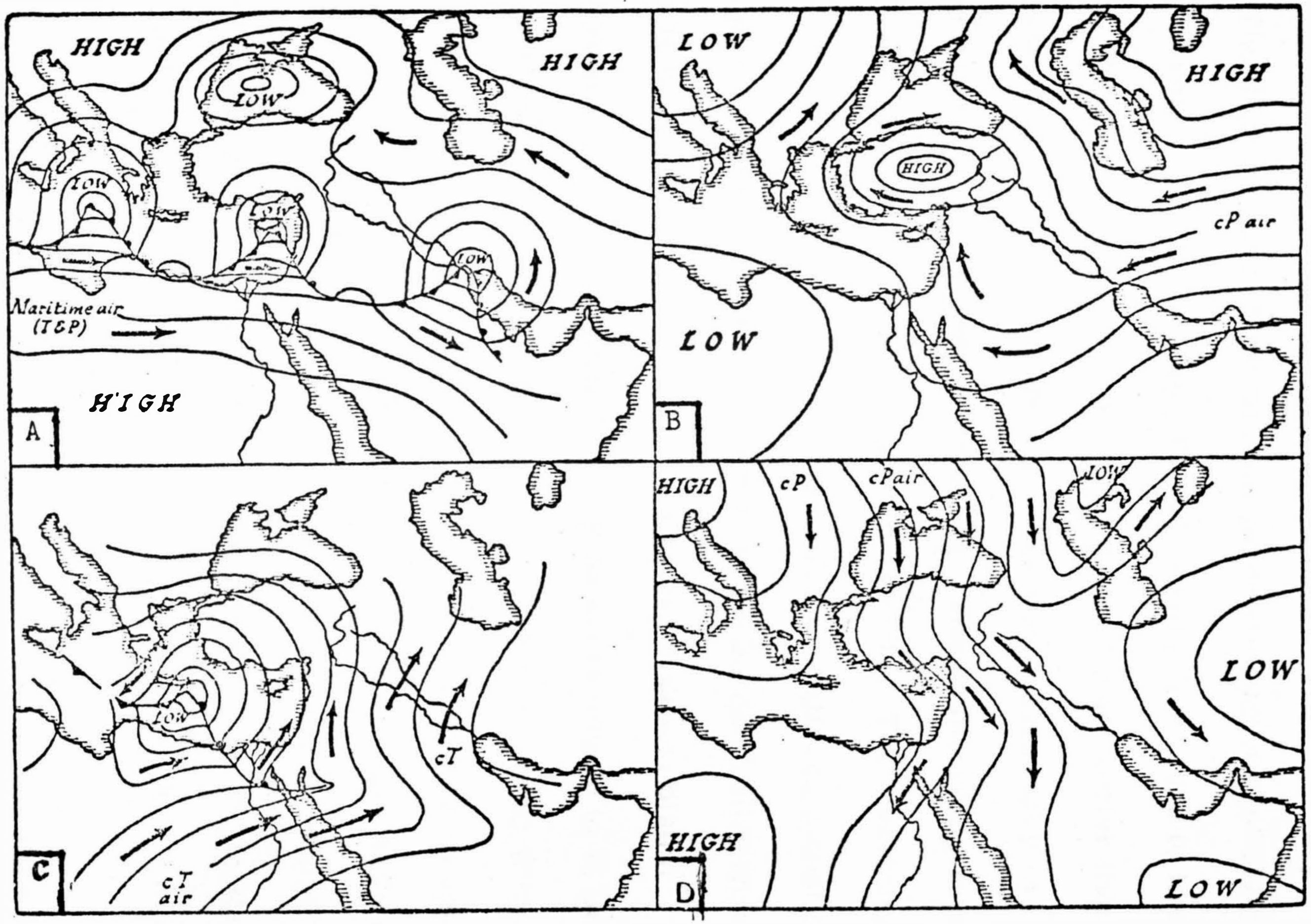
SOURCE: The Middle East, Fisher, 1963.

near the Island of Cyprus; these cyclonic systems affect the seasonal flow of wind in the Middle East. The low pressure area of Cyprus results from the unequal heating of sea and land, developed as a result of temperatures in the interior of Cyprus during the summer months. These pressure systems are semi-permanent from late May or June until September. Minor variations of pressure occur from time to time, but the general pressure systems remain unchanged (Fisher 1963: 36-37).

During the winter pressure conditions over the Middle East are variable (Figure 3.2). High pressure develops over the interior of Asia and extends as far as Iran. This is a minor feature because it disappears completely from time to time as depressions advance eastward across the Mediterranean or the Black Seas. Atlantic depressions arrive over the Middle East from southwest Europe or northwest Africa, and are rejuvenated by their contact with the Mediterranean pressures as they continue as far eastward as Iran. Frequently, low pressure systems develop within the Mediterranean area. Low pressure system regions are developed chiefly over Italy and move southeastward into the eastern Mediterranean region. Other low pressure systems develop south of the Atlas mountains, move into the central Mediterranean, and often reach the Persian Gulf (Fisher 1963: 39-41).

FIGURE 3.2

PRESSURE SITUATION IN WINTER



SOURCE: The Middle East, Fisher, 1963.

Surface Winds

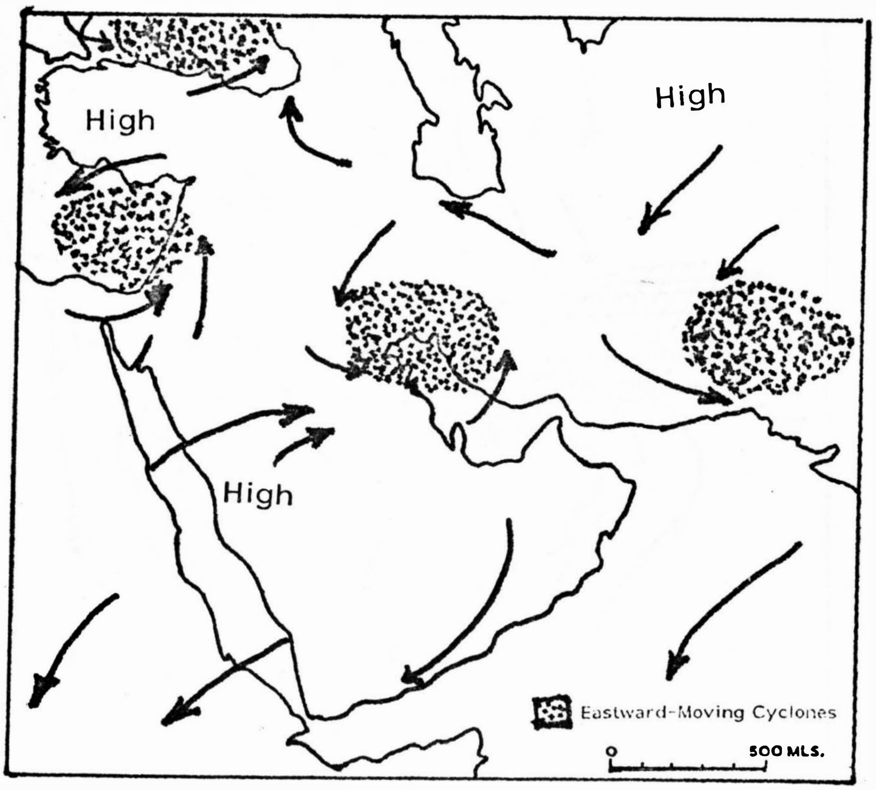
The distribution of high and low pressure systems influence the direction of winds. Wind generally flows from high pressure to low pressure. Winds that flow from northwest generally are cooler than the winds from east or south. Winds in Jordan vary seasonally in response to changing patterns in barometric pressure. The southwest to west winds blow during winter and they vary in velocity. Their velocity averages 14 - 21 miles per hour (22 - 33 km/hour) with occasional gales in the highland district, from 8 to 15 knots in the Jordan Valley district, and from 10 to 15 knots with occasional gales in the desert district. These winds generally diminish in intensity to calms averaging 20 to 45 percent of their peak daytime velocity during night and early morning (Figure 3.3). During the summer, northwest winds flow regularly with velocities which range from 8 to 15 knots in general, with stronger afternoon winds (20-25 knots) (Figure 3.4). Generally, winds blow from southwest to northwest in the hilly district, northerly winds prevail in the Jordan Valley district, and westerly to northwesterly winds blow in the desert district (Taha 1981: 210).

There are many types of surface winds that flow into Jordan. They are:

The Shamal (North) Winds. North winds blow regularly

FIGURE 3.3

WEATHER SITUATION IN THE WINTER MONTHS

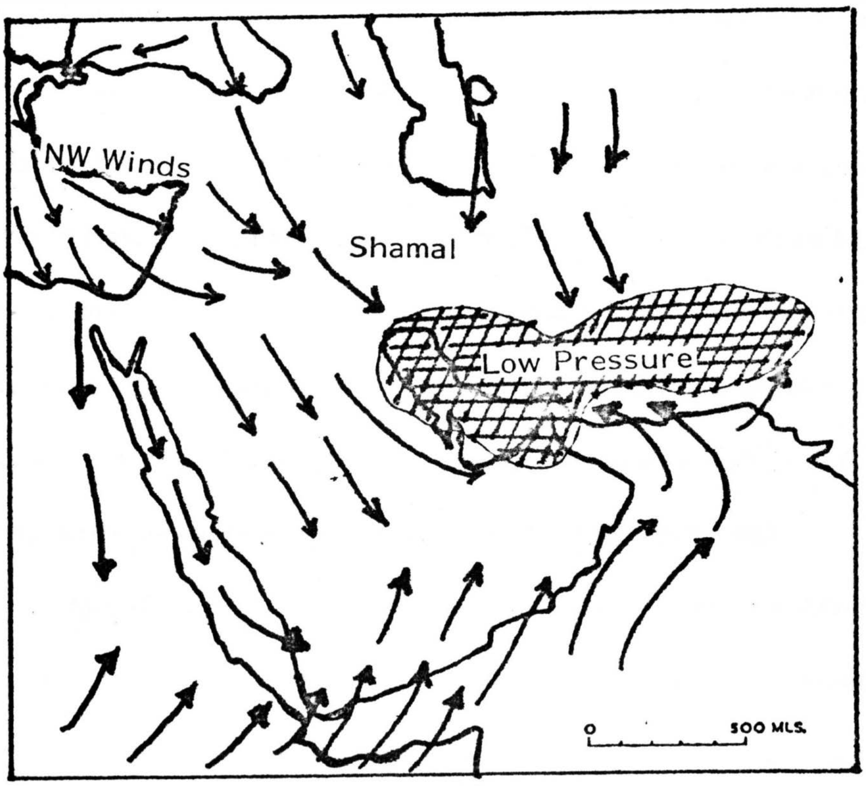


SOURCE: South-West Asia, Brice, 1966.

throughout the summer months from May until late September, blowing often nine days out of ten. These winds are strong during the daytime and usually lulls to a breeze at night. These winds, in principle, are part of the trade winds system that blows from the north of the Black Sea and Caspean Sea as far as the south of the Arabian and the Red Seas (Brice 1966: 44).

FIGURE 3.4

THE WIND SYSTEMS OF SUMMER



SOURCE: South-West Asia, Brice, 1966.

Sirocco Winds (Tropical Continental Air). Sirocco winds are well known in the Middle East. Different local names have been given to these winds such as Khamsin in Egypt, Gibli in Libya and Shlouq or Splitter in the Levant. The sirocco is a dry and dusty wind that frequently blows from the south and southeast in the summer (Figure 3.2-C). In many places the sirocco may bring the highest temperatures of the year, even as early as March or as late as October. As the winds increase in velocity, reaching gale force, they often develop violent sandstorms. The sirocco begins shortly after sunrise, reaches its maximum in the early afternoon and ceases toward evening. When well developed, this wind may blow for three or four days. Velocities of over 50 miles (80 kilometers) per hour have been recorded. With the sirocco, relative humidity drops to less than 10 percent and temperatures usually exceed 100^{o}F (38^{o}C). As the depression passes on, cool winds from northwest replace the sirocco, causing temperatures to drop as much as 59^{o}F (16^{o}C) in two hours, with an increase in humidity (Fisher 1963: 46).

Maritime Air. These winds originate over the Atlantic and arrive to the Mediterranean region either by way of southwest Europe (Iberian Penninsula) or northwest Africa. Maritime air currents generally blow from the west and penetrate the entire Middle East region between October and May (Figure 3.2-A). There are differences in the air mass itself, depending upon its point of origin. Some masses are polar and others are tropical in origin. The inflow of maritime air is interrupted from time to time by the sirocco and polar continental air.

Polar Continental Air. In winter and spring waves of cold air flow southward and westward from the intensely cold interior of Eurasia (Figure 3.2-B). There are two types of these winds. The first originates in south central Asia and flows westward reaching the Mediterranean Sea, and the second is from central and eastern Europe. During February and March, air masses originating in the Atlantic result in heavy precipitation which decreases from the Mediterranean coasts eastward. Northwest winds originating in Europe flow in winter (Figure 3.2-D).

Weather Phenomena

Dust storms are associated with strong gusty winds and broad land surfaces covered with loose material such as sand or river silt. Only with high velocity and turbulence are sand particles lifted more than a few inches or carried long distances. Sand dunes advance by surface action. These sandstorms are less frequent after rainy periods when the ground is wet. Dust storms and dust risings are very frequent in the Ghor and desert districts (during summer) with an average occurrence of 25 to 60 days annually (Taha 1981: 210).

Thunderstorms result from a vigorous instability of the atmosphere that occurs in the winter and to an lesser extent in the spring and autumn. Their annual frequency over the western hills and the Jordan Valley is greater than that which occurs over the eastern hills and the desert districts (Table 3.1). Thunderstorms occur on an average of about ten

TABLE 3.1

DAYS WITH THUNDERSTORMS

JORDAN	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
Aqaba Airport	0 57	0.59	0.14	0.43	1.00	0.14	0.00	0.00	0.06	0.86	0.38	0.29	4.10
Amman Airport	1.10	0.40	0.70	0.80	0.70	0.03	0.00	0.03	0.22	0.70	0.80	0.40	5.88
H.4	0.40	0.60	0.40	1.20	1.00	0.40	0.00	0.00	0.00	1.40	0.80	0.40	6.60
Mafraq	0.77	0.11	0.60	1.30	0.30	0.00	0.00	0.00	0.11	0.78	0.67	0.56	5.20
Ma'an Airport	0.17	0.17	0.33	1.00	0.67	0.00	0.00	0.07	0.57	0.43	0.72	0.40	4.46

SOURCE: World Survey of Climatology, Volume 9, 1981.

days per year in the mountain region and approximately five days per year in the desert region.

Fog and Mist occurs mainly in the hilly district with an average annual frequency of 5 to 20 days per year (Table 3.2).

Precipitation

Precipitation falls mainly during winter months, beginning in October or November and ending in April. The largest amount of precipitation falls in January and February. Precipitation total in Jordan declines from west to east and also from north to south. There are three mechanisms that cause precipitation in Jordan:

1) Orographic precipiatation caused by mountains which force air to rise and cool which, in turn, results in precipitation. Jordan highlands are located in the rainshadow of the Palestine mountains, and the amount of rainfall that they receive is lower than that in West Bank mountains (Figure 3.5).

2) Cyclonic precipitation results when the warm air rises slowly along the mildly inclined surfaces of colder and more dense air. The resulting precipitation is less violent than in thunderstorms, but it continues longer. The cyclonic storms occur over the lowlands several times a month during the winter.

TABLE 3.2

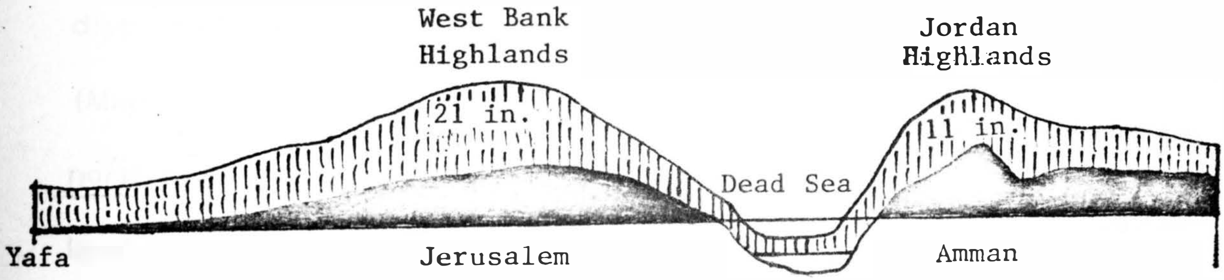
DAYS OF FOG (1,000 m)

JORDAN	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
Aqaba Airport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.43	0.57
Amman Airport	1.72	1.02	0.58	0.16	0.12	0.00	0.02	0.02	0.00	0.12	0.59	1.16	5.51
H.4	1.60	0.60	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.20	0.60	0.60	3.80
Mafraq	5.44	3.00	1.20	1.20	0.60	0.20	1.20	1.91	2.10	1.10	1.40	2.40	21.75
Ma'an Airport	0.33	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.43	1.21

SOURCE: World Survey of Climatology, Volume 9, 1981.

FIGURE 3.5

TOPOGRAPHY AND PRECIPITATION



Rainfall matches elevation in this section from Yafa into Jordan where land above sea level is shown in black and the amount of rainfall is shaded.

SOURCE: Crossroads, Land and Life in Southwest Asia, Cressey, B., 1960.

3) Convectional precipitation occurs when a column of warm surface air is replaced by cooler and heavier air. Precipitation occurs when the air rises enough to become saturated and condensed. Thunderstorms and hail may occur under such conditions because they are triggered by heat (Trewartha 1954: 137).

Precipitation in Jordan occurs in different forms which includes rain, snow, and hail.

Rainfall

Most rain in Jordan falls in winter. The rainy season usually starts in late October and continues through March or April, with the heaviest rainfall amount occurring in January (an average of 11 to 14 days of actual rain) and February (Table 3.3). It is apparent that the rainfall distribution concides with relief because of the orographic precipitation (Map 3.2). Rainfall generally decreases from west to east and also from north to south. Rainfall is higher on the windward slopes of the highlands than on the leeward slopes.[2] The highland districts have an average rainfall of 16 inches (400 mm) per year, but this varies with relief from 8 to 24 inches (200-600 mm) per year. The heavies rainfall up to 28 inches (700 mm), occurs in the northern highlands (Ajlun and West Amman). The southern highlands receive less rainfall than do similar elevations in the north.[3] The rift valley district, which is located within the rain shadow of the West Bank mountains, has an average of only 8 inches (200 mm) per year, varying from 16 inches (400 mm) in the northern part to less than 4 inches (100 mm) per year in the desert district. In the southern part of Jordan, the desert district which constitutes the bulk of

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2. Windward slopes and the highlands force the wind to rise resulting in condensation and rainfall more than the leeward slopes.

3. The northwest of Jordan may be regarded as the foreland of the Lebanon ranges, while southern Jordan is not far from the Sahara, Arabia desert belt.

TABLE 3.3

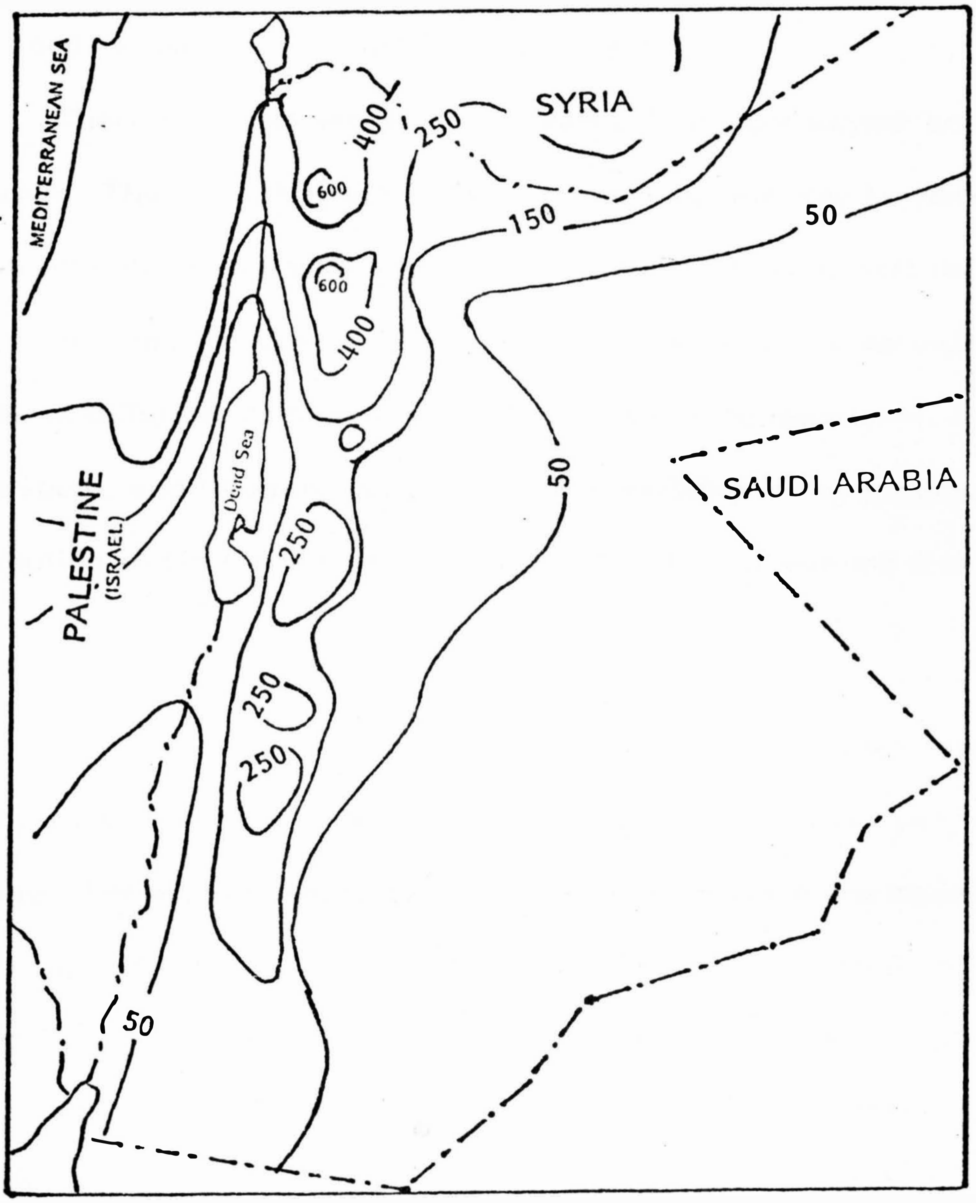
TOTAL AMOUNT OF RAINFALL (mm.)

JORDAN	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
Wadi Ziglab	92.6	59.9	49.6	25.6	10.6	0.0	0.0	0.0	0.0	11.4	43.3	97.1	390.1
Deir Alla	63.4	59.4	37.5	19.0	5.9	0.0	0.0	0.0	0.4	5.2	38.4	62.2	291.4
Shouneh South	48.3	27.7	22.6	8.0	3.0	0.0	0.0	0.0	0.0	3.1	13.4	41.6	158.1
Aqaba Airport	3.4	4.6	4.4	4.7	0.1	trace	0.0	0.0	trace	0.4	3.1	8.2	28.9
Amman Airport	63.7	67.3	36.8	14.7	4.3	trace	trace	trace	0.5	5.1	30.0	43.5	271.9
Shounak	72.2	70.2	66.1	18.4	6.5	0.0	0.0	0.0	0.0	1.9	22.8	76.1	325.2
H.4	8.7	12.9	10.5	11.3	7.5	0.0	0.0	0.0	0.0	2.9	9.7	13.9	77.4
Mafraq	35.5	33.4	20.5	8.6	3.4	0.0	0.0	0.0	0.4	3.1	16.2	29.1	150.2

SOURCE: World Survey of Climatology, Volume 9, 1981.

MAP 3.2

RAINFALL DISTRIBUTION OF JORDAN



SOURCE: The Agricultural Development of Jordan, Aresvik, 1976.

the country's territory, less than 6 inches (150 mm) of rain fall per year, with monthly averages of less than one inch (25 mm) through the winter months. Thunderstorms occasionally occur in the desert district causing flash floods which destroy buildings and crops.

There are great variations in rainfall from year to year and season to season. The variability of rainfall from year to year may be more than 50 percent between the total in wet and dry years; in the desert the derivation from norm is even greater. Table 3.4 shows the variation of rainfall in different stations in Jordan: Amman in the mountains, Ma'an in the south, and H4 in the east. Rainfall is variable in the seasonal distribution and in the winter months is higher than in autumn and spring.

Snow

Snow is rare and is limited to high terrain during the winter season in January and February when it may fall one to two days per year on the average. The maximum number of days with snow fall in one month was 7 days in the Amman area (Table 3.5). The amount of snowfall and accumulation is generally low. At Shoubak, 4,950 feet (1,500 meters) altitude in the southern highlands, the snow cover may remain for several days. Ground frost forms frequently during winter in the hilly and desert districts.

TABLE 3.4

ANNUAL VARIATIONS OF PRECIPITATION IN THREE STATIONS IN JORDAN (mm.)

	1974			1976			1978			1980		
	H.4	Amman Airport	Ma'an	H.4	Amman Airport	Ma'an	H.4	Amman Airport	Ma'an	H.4	Amman Airport	Ma'an
January	22	235	22	0	29	0	9	77	2	1	40	1
February	42	100	14	23	43	1	11	76	28	8	28	1
March	12	12	13	36	69	11	9	78	10	1	67	6
April	3	21	2	8	11	0	1	16	0	0	6	0
May	0	0	0	6	7	2	0	0	0	0	0	0
June	0	0	0	0	1	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	1	1	0	2	0	0	2	3
November	17	36	7	12	11	0	0	7	0	1	1	0
December	12	25	8	3	1	0	48	173	41	6	43	8
TOTAL	108	429	66	88	173	15	69	429	81	17	187	19

Source: Monthly Climatic Data for the World, 1974, 1976, 1978 and 1980.

TABLE 3.5

MEAN NUMBER OF DAYS WITH SNOW

JORDAN	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
Aqaba Airport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Amman Airport	0.51	0.95	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	1.83
H.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20
Mafraq	0.11	0.11	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
Ma'an Airport	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.47

SOURCE: World Survey of Climatology, Volume 9, 1981.

Temperature

The distribution of temperatures over Jordan actually varies due to differences in elevation and the nature of the earth's surface.[4] Temperature variations are not as great as those of rainfall. Temperature increases toward the interior (from west to east), decreases with elevation, and increases from north to south. The normal decrease in temperature with increasing altitude is 3.3°F per 1,000 feet (6°C per 1,000 meters). The difference between Amman at elevation of 3,300 feet (1,000 meters) above sea level, and the Dead Sea at elevation of 1,310 feet (396 meters) below sea level is 14°F (8°C) because of the differences in elevation. Table 3.6 shows the temperature variation between Amman in the north and Ma'an in the south. Seasonal differences are related to the intensity of sunshine during the seasons. In the clear skies of summer the sun appears everyday with almost a vertical line of rays, whereas during cloudy winter days the sun appears less than in summer and the rays are seasonally inclined. Hence, temperatures in summer are higher than in winter. The spring and autumn seasons have a medium situation of sunshine days between summer and winter (Table 3.7). There are also diurnal temperature variations. It is cool in the morning and at night and relatively

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4. Jordan has mountains desert which include different types of surface cover such as sand, vegetation, rock and bare areas, and different soil groups.

TABLE 3.6

THE TEMPERATURE VARIATIONS BETWEEN AMMAN AND AQABA

MONTH	AMMAN		AQABA	
January	8.1	(46.5)	15.6	(60.0)
February	9.0	(49.2)	17.0	(62.6)
March	11.8	(53.2)	20.1	(68.2)
April	16.0	(60.8)	24.3	(75.7)
May	20.7	(69.3)	28.4	(83.1)
June	23.7	(74.6)	31.8	(89.2)
July	25.1	(77.2)	32.5	(90.0)
August	25.6	(78.0)	33.0	(91.4)
September	23.5	(74.3)	30.4	(86.7)
October	20.6	(69.0)	27.1	(80.7)
November	15.3	(59.5)	22.1	(71.7)
December	10.0	(50.0)	17.2	(62.9)

Centigrade (Fahrenheit)

SOURCE: Jordan, Summer, 1979.

TABLE 3.7

DURATION OF SUNSHINE

(PERCENT)

JORDAN	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Deir Alla	63.2	67.3	62.5	72.1	86.4	92.6	95.5	95.3	87.7	85.0	74.3	65.3
Aqaba Airport	72.8	80.2	77.1	75.2	91.9	88.0	96.0	95.0	94.6	88.6	85.4	77.3
Amman Airport	64.7	66.1	72.8	78.1	85.3	93.6	94.9	96.2	93.4	87.5	76.2	65.0
H.4	61.9	75.2	71.7	74.4	87.5	98.3	93.9	90.5	94.1	85.2	74.7	70.5
Mafraq	58.8	67.0	70.7	70.9	83.8	87.1	91.4	91.7	85.8	83.0	79.0	63.0
Ma'an Airport	69.6	82.2	80.0	75.0	91.6	90.4	94.7	91.0	94.1	86.4	81.6	76.0

SOURCE: World Survey of Climatology, Volume 9, 1981.

hot from noon to late afternoon. Summer diurnal variations are less pronounced than during the winter months (Fisher 1954: 51).

During winter, the temperature is pleasant in the Ghor district with a daily mean of approximately 59°F (15°C). In the hilly and desert districts, the temperature is relatively low with a daily mean of 46°F to 54°F (8° - 12°C). The minimum temperature average is 48°F (9°C) in the Jordan Valley district, 39° - 47°F (4° - 8°C) in the hilly district and 35.5° - 39°F (2° - 4°C) in the desert district. January is the coldest month of the year throughout Jordan (Table 3.8). During summer, the temperature generally is high in all of Jordan. The averages of daily temperatures in the hilly, Ghor and desert districts are approximately 77°F (25°C), 88°F (31°C), and 84°F (29°C), respectively. Summer temperature is little influenced by latitude, the maximum temperature average in the hilly district is 90°F (32°C), in the Ghor is 102°F (39°C) and 95°F (35°C) in the desert district.

Evaporation

Evaporation is influenced mainly by the solar heat which is high in summer and low in winter. The evaporation of moisture is important because it affects soils, vegetation, and surface water. The variation of average annual potential evaporation decreases with increased elevation; near the Dead Sea it amounts to a loss of 58 inches (1,450 mm) per year,

TABLE 3.8

MEAN DAILY TEMPERATURE (C°) [3]

JORDAN	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Wadi Ziglab	13.5	14.2	16.8	20.8	26.0	28.7	30.2	31.0	29.4	26.3	21.1	15.8
Wadi Yabis	12.8	13.9	16.3	20.5	26.0	28.1	30.3	30.7	29.2	24.8	20.3	15.1
Deir Alla	14.6	15.5	17.9	21.8	26.3	29.0	30.5	31.1	29.8	26.6	22.3	16.9
Shouneh South	15.1	15.9	18.8	23.3	27.8	30.6	31.9	32.7	30.7	27.7	22.3	17.4
Wadi Husban	14.5	15.6	17.6	22.2	26.3	28.8	30.2	30.9	29.6	26.9	22.5	17.3
Aqaba Airport	15.6	17.0	20.1	24.3	28.4	31.8	32.5	33.0	30.4	27.1	22.1	17.2
Amman Airport	8.1	9.0	11.8	16.0	20.7	23.7	25.1	25.6	23.5	20.6	15.3	10.0
Shoubak	4.7	5.2	8.5	12.7	14.5	18.1	20.7	20.7	17.7	15.3	11.1	6.8
H.4	8.6	10.5	14.2	18.5	23.8	26.7	28.7	28.8	25.6	21.4	15.6	10.7
Mafraq	7.4	8.7	11.6	15.9	20.2	22.7	24.0	24.4	22.2	19.3	14.0	9.3
Shoumary	9.1	10.2	13.8	18.5	22.7	27.2	27.9	27.7	25.2	21.0	15.9	10.5
Ma'an Airport	8.5	9.7	13.0	17.2	21.5	24.6	25.9	26.4	23.8	20.2	14.6	10.2

SOURCE: World Survey of Climatology, Volume 9, 1981.

whereas the potential loss in the highlands drops to about 32 inches (800 mm) per year (Cressey 1960). Evaporation in Jordan varies from district to district. The mean evaptranspiration in Jordan is 55.5 inches (1,385 mm) per year which correspondes to an annual average rainfall of 10.8 inches (270 mm) (Table 3.9). In Ghor and the desert districts average evaporation is higher than in the highlands because of the temperature differences between these districts. The highest rate of evaporation occurs over the Dead Sea, with nearly one half inch (12 mm) per day during the summer months (Fisher 1963: 414).

Humidity

In general humidity is affected by temperature and precipitation. Humidity in the desert district is low because of the high temperatures and low moisture. The mean monthly range of humidity in Jordan is between 25 to 76 percent. Relative humidity has diurnal and seasonal variations. It is lower during the summer than in winter. During summer months, humidity averages about 50 percent in the highland district, 35 percent in the desert district, and 22 percent in the Ghor district. During winter, the relative humidity averages ranges between 66 percent and 70 percent in all of Jordan except in the Aqaba city at the Red Sea and the desert district where it ranges between 47 percent and 53 percent. The diurnal range of humidity varies through the day; at noon it is lower than at night

TABLE 3.9

Daily and Annual Values of Potential Evapotranspiration Compared with Monthly and Annual Values of Precipitation in Several Stations in Jordan

1) Monthly and Yearly Averages and 2) Average Daily Value

		JAN		FEB		MAR		APRIL		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC		YEAR		
		P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	P	ETP	ETP - P
Deir Alla	1)	57	56	59	64	45	99	17	141	5	186		230		238		226		183	5	143	44	96	60	68		1730	1438
	2)		1.8		2.3		3.2		4.7		6.0		7.7		7.7		7.3		6.1		4.6		3.2		2.2		4.7	
Amman	1)	68	34	62	50	41	87	12	135	4	170		200		208		189		144	4	108	32	60	48	43		1428	1157
	2)		1.1		1.8		2.8		4.5		5.5		6.7		6.7		6.1		4.8		3.5		2.0		1.4		3.9	
Irbid	1)	115	4.0	91	56	90	80	29	111	8	161		186		198		182		135	13	108	82	60	74	50		1364	882
	2)		1.3		2.0		2.6		3.7		5.2		6.2		6.4		5.9		4.5		3.5		2.0		1.6		3.7	
Mafraq	1)	36	34	32	50	29	87	11	135	5	170		198		210		189		141	6	108	21	80	33	45		1427	1254
	2)		1.1		1.8		2.8		4.5		5.5		6.6		6.8		6.1		4.7		3.5		9.0		1.5		3.9	

SOURCE: A Study of Agroclimatological in Semi-Arid and Arid Zones of the Near East, G. Perrin de Brichambaut and C. C. Wallen, 1963.

or in the morning because of the diurnal variation of temperature. The relative humidity in winter is above 80 percent most of the night and during the early morning hours, and it may reach 100 percent for many hours (Taha 1981: 209).

Dew

On clear nights the cooling of the ground by radiation can cause the surface temperature to fall below the dew point of the air with the result that condensation occurs. Dew in Jordan accounts for 25 percent of the total moisture available for plant growth in the Ghor district. Winds are the main factor that influences the amount of dew. The total amount of dew fall on a clear night is higher than on windy nights (Fisher 1963: 412).

The Impact of the Dead Sea

The Dead Sea is large enough to develop the sea and land breezes, especially at its northern and southern end. The effect is due to the intense heating of the arid lands under the summer sun; the surface soil temperature often being as high as 130^{o}F (55^{o}C). The sea breeze is developed by the temperature differences between land and sea water. During daytime the land is heated more than the water and a cool breeze is formed that flows to the neighboring lands from the Dead Sea, causing a sudden change in both temperature and humidity. Everyday there is a sudden change in both temperature and humidity in the afternoon. There is also a daily drop of several degrees, because of the cool breeze from the sea. Land breezes occur at night because the land looses more heat and is cooler than the sea.[5] The sea breeze reaches as far as 15 miles (25 kilometers) toward the north, 9 miles (15 kilometers) toward the west, 6 miles (10 kilometers) toward the south, and about 9 miles (15 kilometers) toward the east (Ashbel 1939: 187).

Mediterranean breezes reach the Jordan Valley in the afternoon as a very dry and hot wind that is often full of dust. The increase of its temperature occurs over the Lebanon and Jerusalem mountains and also while it flows down from the mountain to the Dead Sea (its temperature rises 12^{o} - 14^{o}C because of its descent in elevation) (Ashbel 1939: 188).

Climatic Change

There is evidence that points to changes of climate in the region. Generally climatic change is related to a decrease of rainfall in the Middle East. It is said that various parts of the interior of the Middle East once

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5. This depends on the depth of water; the northern basin of the Dead Sea is deeper than the southern basin. Therefore the southern basin is hotter than the northern basin. The difference between the land temperature and the northern basin is greater than it is with the southern basin.

supported a much larger population than at present. There were more forests in the hills. As late as 3,000 B.C. a fully Mediterranean flora extended as far as the Tibestia highlands (the present Lebanon cedar covered larger areas in the past).

There is also geomorphogical evidence to indicate that the rain must have been heavier thousands of years ago. Indications include:

1) Geomorphological phenomean such as the extensive occurrence of fluviatile deposits in now arid areas; strand lines, both marine and continental; and the misfit and attenuated river systems of the present day in relation to land forms.

2) The existence of "fossil soils" in regions now too-dry to produce comparable development.

3) The occurrence of surface depressions (closed basins) in Libya, Egypt, and the Arabian Desert which show some signs of original erosion by water (Fisher 1963: 60-61).

Buried dams, empty channels, and dry wells which are located where there is not obvious water suppiy shows that surface water has decreased and is now scarce. In Jordan certain wells were cleared, but most of them remained dry, and a number of Roman channels were repaired near the Gulf of Aqaba (Fisher 1963: 61). The climatic changes within the recent millennia have caused the Dead Sea to shrink; these fluctuations are apparent in a series of ancient terraces and deltas, with elevation up to several hundred feet above the present water level (Cressey 1960).

Jordan has three climatic regions, in descending order of precipitation amounts and reliability they are: Mountain climate, steppe, and desert. Each of these regions has different climatic characteristics of rainfall, humidity, temperature, wind, and potential evapotranspiration. There also is a slight difference in the temperature between these regions, with the mountain climate region being cooler than the other climatic regions due to elevation. Differences in rainfall are greater than are those of temperature and wind. Rainfall averages range from 4 inches (100 mm) in the desert region to about 16 inches (400 mm) in the mountain region. These differences in rainfall from region-to-region result in the variable amounts of water resources available in Jordan. Rivers, for example, flow all the year in the mountain region, whereas the desert (east and south) climate region has rivers that flow only during and immediately after periods of rainfall. The next chapter is devoted to the water resources available in Jordan.

CHAPTER FOUR

WATER RESOURCES

Water resources are limited in Jordan. The total available water is estimated to be about 1,100 million cubic meters (MCM) per year, 880 MCM of which are from surface resources and the rest from groundwater. The majority of this water comes from the northern part of Jordan. Water utilization in Jordan is estimated to be about 450 MCM per year. About 90 percent of the water is used for agricultural irrigation, 8 percent for domestic use, and 2 percent for industrial purposes (U.S. Department of State 1979: 34). The increase of population and the growth of industries and agriculture through irrigation demand more water and better management of existing water resources. Available water resources are from three sources, precipitation, surface water, and groundwater.

Precipitation

Rainfed agriculture which amounts to only 4.2 percent of Jordan's total, depends mainly on the annual amount of rain which is small in amount and variable in space and time (Table 4.1). Jordan receives an average annual total precipitation of about 700 MCM, but most of which is lost by evaporation. Precipitation forms a large percentage of the available surface

TABLE 4.1

ANNUAL AVERAGE RAINFALL FOR VARIOUS

AREAS OF JORDAN

Rainfall (mm.)	Area (sq. km)	Quantity Rain Water MCM
Less than 50	59,327	1,483.2
50-100	13,851	1,038.2
100-150	7,293	911.6
150-200	4,102	717.9
200-250	2,145	482.6
250-300	1,803	495.8
300-400	1,781	625.8
400-500	1,253	563.9
500-600	777	427.3
More than 600	212	137.8
TOTAL	92,551	6,884.7

SOURCE: The Agricultural Development of Jordan, Aresvik, 1976.

water during winter months, and amounts to little or nothing during the rainless summer. Jordan, generally, is divided into three climatological and hydrological regions each with its own distinguishing characteristics. They are: 1) the Jordan Valley which receives about 44 MCM rain water, 2) the Jordan highlands which receive 2,530 MCM, and 3) the Desert plateau which receives about 3,400 MCM (Aresvik 1976: 109 and U.S. Department of State 1979: 36).

Surface Water

Surface water, which includes rivers, streams, wadis, springs, and reservoirs, is estimated at 850 MCM to 880 MCM per year. The northern part of Jordan, the densest district in terms of population, has the majority of agricultural and industrial development, and has the largest amount of surface water, which is estimated to be 683 MCM per year. Not all of the surface water is available for the economic sectors, however, only 550 MCM of surface water being available per average year (U.S. Department of State 1979: 37).

Rivers

The total amount of water flow in Jordan rivers is about 880 MCM per year. The Yarmouk River brings 400 MCM per year from its basin in Syria, and the remainder is from Jordanian territory. Rivers are fed by both rainfall and groundwater discharges. Rainwater forms 10 percent of the total flow while groundwater forms 90 percent. The Jordan river basins receive an annual average of rainfall of about 8,065 MCM, of which 75 percent is actually within Jordan territory (U.S. Department of State 1979: 37). The major part of rainwater is collected by the major rivers: the Zarqa, Wadi Mujib, and Wadi el-Hasa.

Rivers in Jordan flow either westward to the Jordan River, the Dead Sea, or Wadi Araba, or to the east into the Jordan depressions, Sirhan, Azraq, and H4. Many of these rivers flow in the winter and are dry during the summer. Due to the distributional characteristics of rainfall, rivers flowing eastward are drier than those flowing westward. There are fifteen tributaries that collect water from mountains and plateaus and discharge their water directly or indirectly into the Dead Sea. The annual base flow of rivers in Jordan is about 420 MCM per year, while the annual discharge of floods in the rivers is about 380 MCM (Aresvik 1976: 114). Rivers in Jordan are divided into three basins (Table 4.2):

Jordan River Basin. The Jordan is a short river with total length of 110 miles (175 km) flowing from Mount Hermon to the Dead Sea. Its source is the snowcover on Mount Hermon in Lebanon, from which the largest tributary, the Hasbany, flows southward to connect with other tributaries, the Banias, Laddan, and Bareighit, to form the Jordan River. The length of the river in Jordanian territory is 65 miles (110 km), flowing

TABLE 4.2

AVERAGE DISCHARGE OF JORDAN RIVERS AND WADIS

River/Wadi	Average Annual Flow (MCM)	Catchment Area Sq. Km.	Catchment Area Sq. Miles
Jordan River Basin			
Yarmouk River	387.0	6,805	2,628
Wadi Arab	28.8	254	98
Wadi Ziglab	10.2	131	50
Wadi Jurum	11.0	119	56
Wadi Yabis	3.5	107	41
Wadi Kufrinia	6.0	27	10
Wadi Rajib	4.3	80	31
Zarqa River	67.1	3,440	1,328
Wadi Shueib	7.9	90	35
Wadi Kafrein	14.3	161	62
Dead Sea Basin			
Wadi Zarqa Main	20.3*	300	116
Wadi Mujib	102.9	6,510	2,537
Wadi Karak	5.3*	----	----
Wadi Hasa	48.8	3,500	965
Red Sea Basin			
Wadi Yutum	2.0	----	----

*Estimate Flow

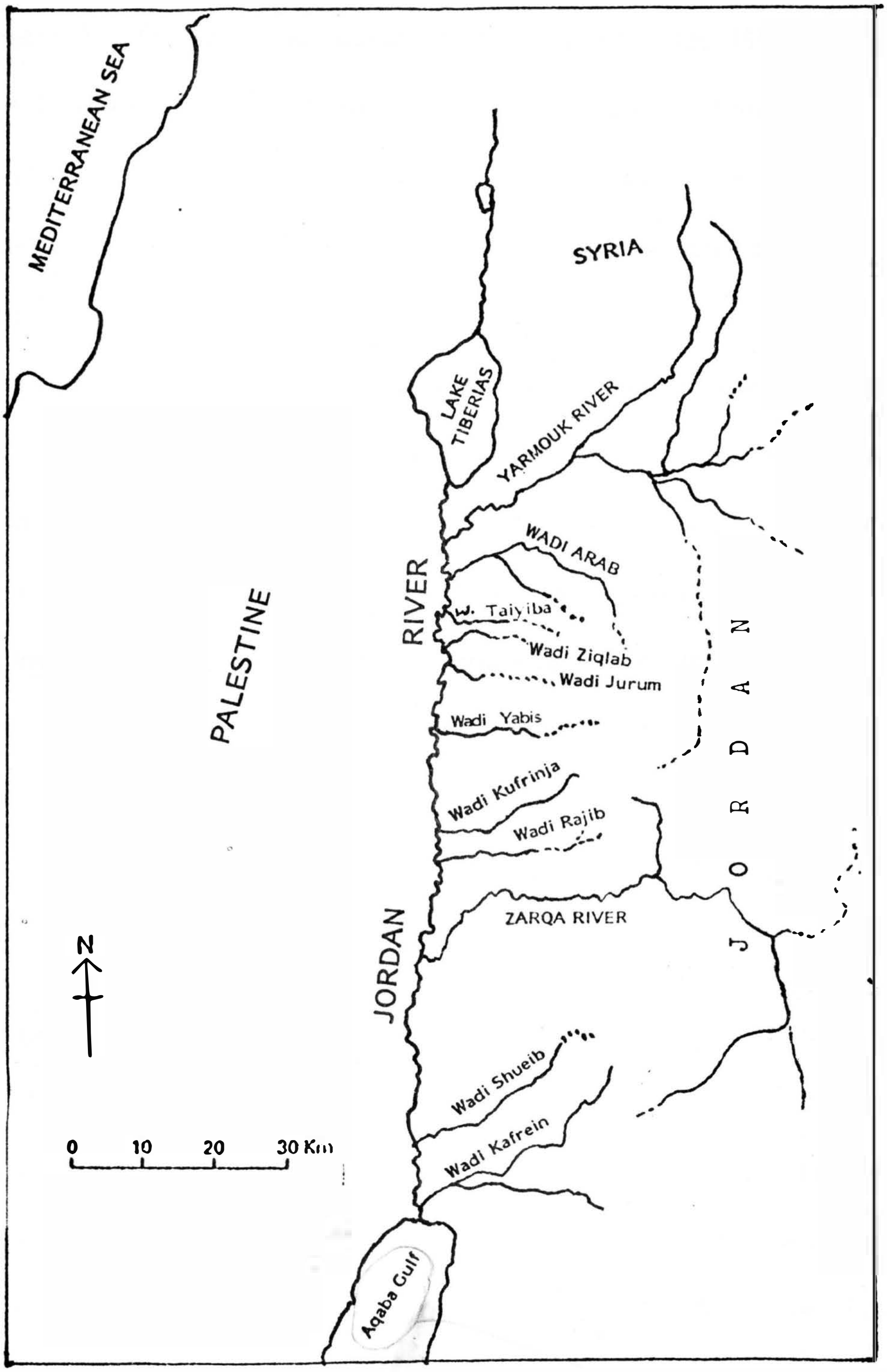
SOURCE: Report on Jordan, U.S. Department of State, 1979 from Lake Tiberias to the Dead Sea. The river's average width is 100 feet (30 meters), and depth 3 to 10 feet (1-3 meters) during most of the year. Jordan River and its tributaries fall from 9,235 feet (3,000 meters) at Mount Hermon to 1,310 feet (396 meters) below sea level at the Dead Sea. In the Jordan, the river course is entirely below the sea level, starting at 72 feet (22 meters) below sea level at the southern end of Lake Tiberias (north border) to the Dead Sea. Length of the Jordan River has increased due to its meandering. The linear distance of Jordan River to its mouth in the Dead Sea is only 65 miles (110 km), but the meandering channel of the river measures 200 miles (320 km) (Cressey 1960: 131) (Map 4.1).

Water from the Jordan River covers a total of 2,320 square miles (6,000 sq. km). This area includes eleven tributary basins that collect the major part of the run-off in the northern part of Jordan. The most important tributary is the Yarmouk River that has a length of 66 miles (110 km). Its normal flow nearly equals the Jordan River's flow and contributes about a third of the water which enters the Dead Sea. The discharge in winter increases and decreases in summer in response to available precipitation. Generally, these tributaries have a discharge which is seasonally variable.

Dead Sea Basin. The Dead Sea occupies the central part of the rift valley and is the lowest land elevation in the world at 1,310 feet

MAP 4.1

THE JORDAN RIVER BASIN



SOURCE: The Jordan Valley, Khouri, 1981.

(396 meters) below sea level. (It has a maximum depth of some 1,320 feet or 401 meters). The Dead Sea occupies 370 square miles (950 sq. km), with a total length of about 48 miles (76 km) and width 10 miles (16 km). The Dead Sea water is useless because of its salinity which is the highest of the world seas with an average of 24 percent, or seven times that of the ocean.

There are four rivers that discharge directly in the Dead Sea (Map 4.2). They are: Wadi Zarqa Main, Wadi Mujib, Wadi Karak, and Wadi Hasa. The total catchment area of these wadis is 4,312 square miles (11,170 sq. km), with a total of 85 MCM per year (Table 4.2).

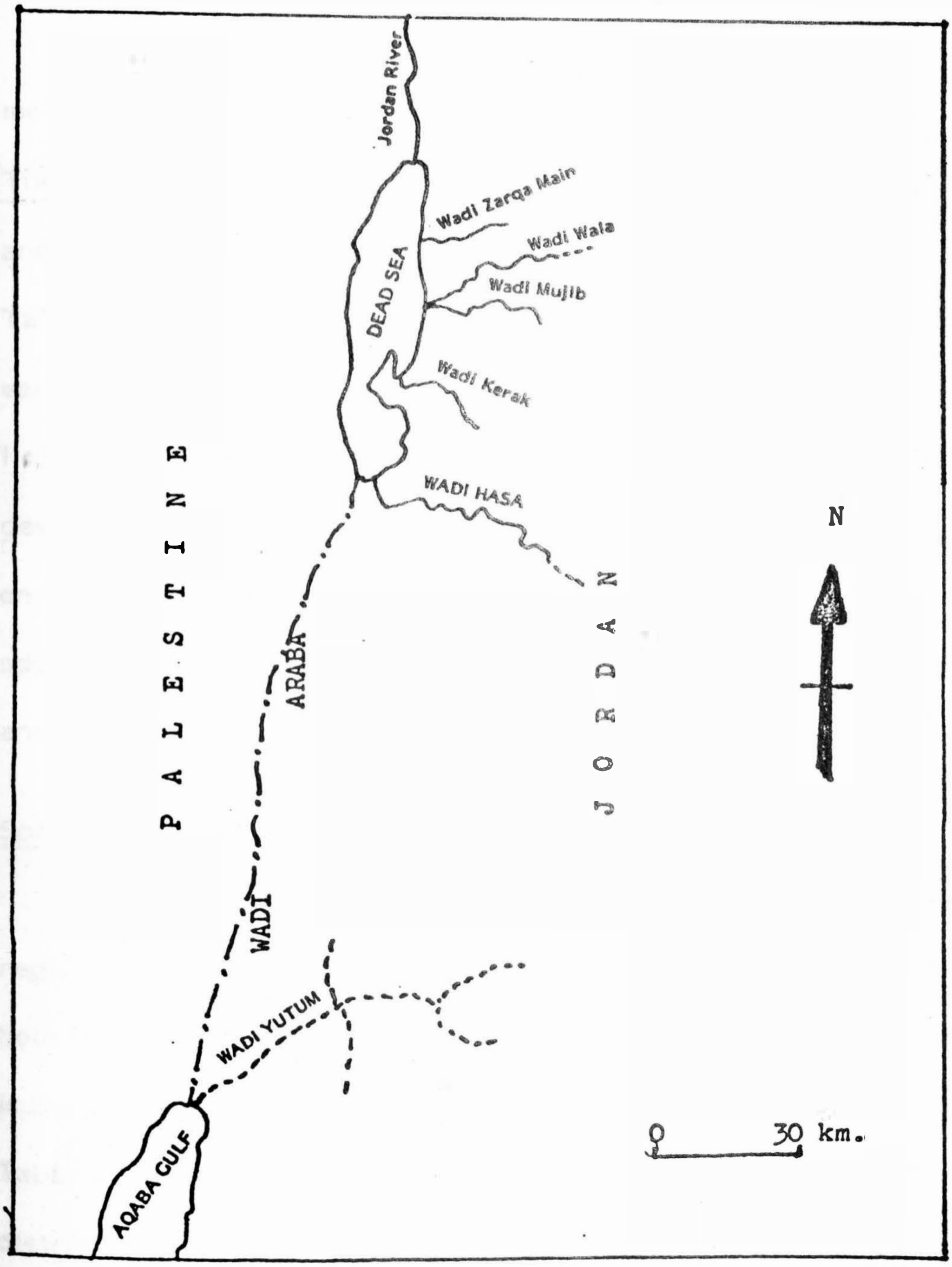
Red Sea Basin. Jordan has a small 16 miles (26 km) coastline facing the Aqaba Gulf. There is one non-perennial river that discharges southward to the Red Sea. This river is known as Wadi Yutum. Wadi Yutum is dry most of the year and flows only with the occassional winter rain that occurs (Map 4.2).

The East Ghor Canal

The East Ghor Canal was designed in 1955 for the purpose of agricultural development in the east and west banks of the Jordan River. The canal flows from Yarmouk River in the north to the Dead Sea, and has a length of 60 miles (96 km). Construction of the first 43.5 miles (70 km) began in July 1958 and was completed in July 1966. The Canal has been

MAP 4.2

DEAD SEA AND RED SEA BASINS



SOURCE: Report on Jordan, U.S. Department of State, 1979.

expanded twice. The first extension was 12 miles (18 km), and the second time it was expanded by an additional 5 miles (8 km). Both were implemented in the 1970s (Map 4.3).

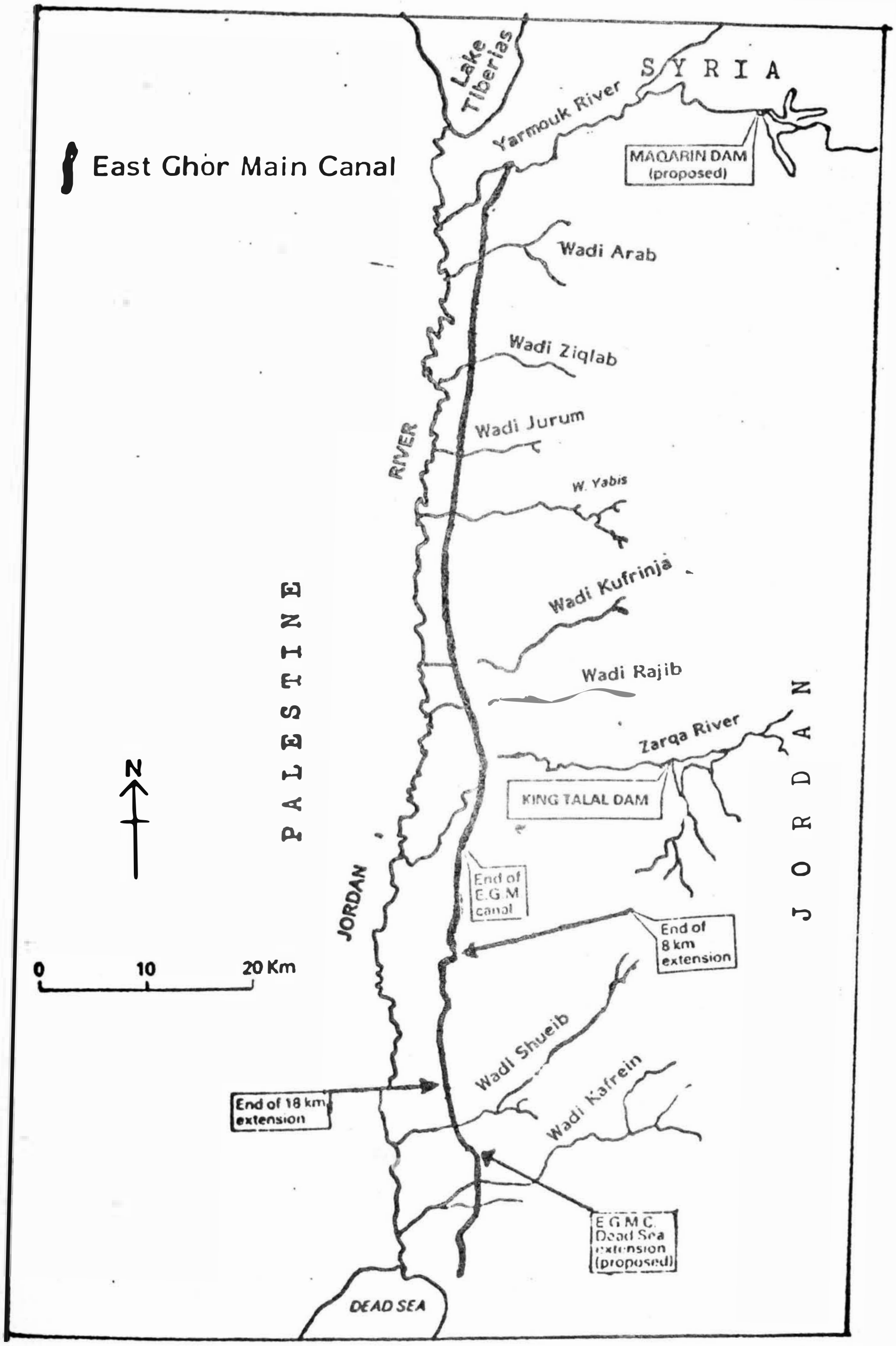
The main canal originally had a volumetric capacity of 10 cubic meters per second; this later was raised to 20 cubic meters per second. The canal is designed to be fed both by gravity from the Yarmouk River and several other streams, and by pumps from dams such as the King Tala Dam. The construction of the canal included construction of two earthen dams on the side wadis of Shueib and Kafrein. These were finished in 1968. The East Ghor Canal is the major project for irrigation development of agricultural lands in Jordan. Work is still being done on the system in order to increase the irrigated land. Water is being added from other sources such as Wadis Rajib, Kufrainjeh and Yabis, and from new dams such as the Maqarin (Khouri 1981).

Springs

Many small springs flow from the mountain slopes in more humid regions of Jordan. Springs are an important source of water in Jordan both for agriculture and domestic use. A total of 75 MCM of spring water is used annually for irrigation purposes, and 180 MCM for domestic use. Table 4.3 below shows the average discharge of springs in different districts of Jordan.

MAP 4.3

EAST GHOR CANAL



SOURCE: The Jordan Valley, Khouri, 1981.

TABLE 4.3

TOTAL DISCHARGE OF JORDAN SPRINGS

BY DISTRICTS

District	Average Annual Total MCM
Irbid	102
Amman	62
Balqa	38
Karak	46
Ma'an	7
TOTAL	255

SOURCE: The Agricultural Development of Jordan, Aresvik, 1976.

Dams

Early in the 1960s, Jordan's government started to utilize flood-waters by building dams on wadis. The Sultani, Qatroni, Wadi Shueib, Wadi Kufrien, and other dams have been constructed. The total capacity of these dams is about 70 MCM. The capacity of these dams will increase to about 533 MCM with the construction of the proposed dams such as Maqarin, Khaled, Wadi Araba and Wadi Hasa dams (Table 4.4). Construction of these dams should be completed in the mid 1980s. The two largest dams in Jordan are the King Tala and Maqarin Dams. The largest, King Tala, was completed in 1978 on the Zarqa River. It has a storage capacity

TABLE 4.4

DAMS CONSTRUCTED OR UNDER CONSTRUCTION

Dam	Capacity (MCM)
Kufrein	4.30
Shu'eib	2.30
Zialab	4.30
Sultani	1.25
Qatrani	4.20
Sama Sdud	1.70
King Talal	52.00
Um Jimal	1.80
TOTAL	71.85
Proposed Dams	
Maqarin and Khaled	400.00
Wadi Araba	20.00
Wadi Hasa	12.00
Rumell	30.00
TOTAL	462.00

SOURCE: The Agricultural Development of Jordan, Aresvik, 1976.

of 48 MCM to 52 MCM. This dam provides water for the East Ghor Canal and for irrigation purposes on the land lying near the dam.

The Maqarin Dam on the Yarmouk River is in its final stage of construction, with completion scheduled for 1983-84. The capacity of the reservoir is expected to be 250 MCM. This dam will provide water to the East Ghor Canal and for irrigation to be used for agricultural purposes in the southern tip of the Jordan Valley (U.S. Department of State 1979: 41).

Groundwater

Groundwater in Jordan is encountered in three types of environmental settings: 1) alluvium and wadi deposits in the Jordan Valley and other major wadis, 2) fractured rocks of basalt, limestone and sandstone in the southern part of Jordan, and 3) in restricted areas in central Jordan. Drilling for deep water wells started in Jordan Valley district in 1936. The total number of productive artesian wells in 1973 was 854. Of these, only 274 were suitable for the purposes of irrigation. The remainder of the wells were not used for agricultural purposes due to their salinity (Table 4.5). The number of deep wells is increasing every year, especially for domestic use in the more heavily populated urban areas in the northern part of Jordan. The annual groundwater resources in Jordan are estimated to be about 100 MCM and 77 MCM in

TABLE 4.5

Number of Agricultural Productive Wells, Irrigated Area, Increase in Percentage, and Average Size of Irrigated Area by Single Well

	1971	1972	1973
Agricultural productive wells	162	256	274
Percentage (increase)	---	58.02+	69.13+
Irrigated area (in dunums)	32,570	35,491	52,991
Percentage (increase)	---	18.96+	62.70+
Average size of irrigated area by single well (in dunums)	201.05	138.64	193.40

SOURCE: The Agricultural Development of Jordan, Aresvik, 1976.

the northern part of Jordan (U.S. Department of State 1979: 43).

Groundwater has different qualities on its suitability for agricultural and domestic use. Water quality depends upon the frequent replenishment of water and water supplies. Groundwater with a high rate of annual replenishment is of good quality, while groundwater stored in deep aquifers is generally unsuitable for use, due to its salinity. Many wells in the Jordan Valley region have been closed due to their salinity, which results from the overuse of fresh water, until the lower saline water appears. To protect the wells in Jordan, the Natural Resources Authority only permits drilling of new wells under specified conditions and in certain areas. Drilling of wells without a permit is prohibited (Aresvik 1976: 113). The groundwater quality in Azraq is good[1], as it is in Amman, Kerak - Ras En-Naqb, and other small areas. Ground water of poor quality is found in the Jordan Valley, Wadi Araba, and in the eastern desert region (U.S. Department of State 1979: 44).

Water resources are affected by climate conditions, primarily precipitation and evaporation, and also by topography and the type of rocks or soils. The demand for water has increased not only for domestic

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1. The amount of fresh water springs is about 1,200 cubic meters per hour. This water comes from the vein which falls from the Jebel El-Druze in Syria.

use but also for agricultural use. A large amount of Jordan's water is wasted due to evaporation and by discharge into the saline Jordan River or the Dead Sea. Projects are being implemented to utilize some of the water that is presently lost. Dams, reservoirs, and canals have been constructed, and wells drilled, to save water, and to have more water available for domestic and agricultural use. The availability of good water determines the distribution of cultivated lands.

CHAPTER FIVE

AGRICULTURE

Agriculture has been practiced in certain areas of the Jordan Valley (Ghor) district for some 10,000 years. This arable land in Jordan has been used for ten millenia, yet the soils are still suitable for agricultural purposes. Jordanian farms usually are located beside wadis, springs, and wells, in order to obtain the necessary water for irrigation. Livestock grazing is found mainly in the steppe regions, where herds are moved seasonally between the mountains and desert districts in a practice known as Transhumance. Jordan's agricultural development has taken place mainly in the Ghor district. Acreage has increased during recent decades due to the construction of canals and dams, and the increased use of water available from springs, wells, and wadis. These developments result in the expansion of arable land, increased production and yields per dunums, and the growing of new crops such as dates, sugar beets, and rice.

Throughout the early 1930s, agriculture in Jordan was basically subsistance farming. Wheat and barley were the main crops in the high-lands, whereas livestock production was adopted primarily by the nomadic and semi-nomadic tribes. Agriculture produces only enough to supply the immediately surrounding area. The construction of roads in the 1940s connecting Jordan with Palestine and other roads connecting the Jordan Valley district (Ghor) extended from Irbid to North-Shuneh, contributed significantly to the gradual transformation from subsistance farming to a marketing-type of agriculture. In the late 1940s the Palestinian refugees brought new crops and new agricultural methods to Jordan, thereby improving the country's agricultural production. In the 1950s the construction of the East Ghor Canal was started. This project brought about 26,429 acres (107,000 dunums) of land in the northern section of Jordan Valley under irrigation. Since the 1950s, the government has concentrated its efforts on the Jordan Valley region, which is the area of greatest potential for agricultural development (Aresvik 1976: 106).

Irrigation projects in the Jordan Valley receive more attention and financial support than do projects involving dry land agriculture or livestock production. The East Ghor Canal was constructed to expand irrigated agriculture in the Jordan Valley. The construction of dams and diversion canals was scheduled for completion in 1968. Unfortunately, the project was delayed due to the 1967 Middle East War. The war destroyed 65 percent of the construction already completed.

In 1972, when peace was restored to the area, the government prepared a three-year plan, the "1973-75 Plan," for completion of this phase of irrigation development in Jordan Valley. Those projects unfinished during the 1973-75 Plan were completed during the 1975-82 Plan, which tripled the irrigated area in Jordan Valley. The main project of the 1975-1982 Plan was the building of the Maqarin Dam on the Yarmouk River. The Maqarin Dam ultimately will provide irrigation for 37,050 acres (150,000 dunums) or about 42 percent of the 1975-1982 Plan in total area of irrigation (Mazur 1979: 180). The main purposes of the East Ghor Canal Projects are the following (Hazleton 1979: 260):

1) To provide farmers in the area with water for full irrigation potential on their lands.

2) To provide assistance to farmers for the development and modernization of the farms, including technical, financial, and marketing services.

3) To increase agricultural production.

4) To raise the standard of living of the families residing in the projected areas.

Agriculture Situation

The agriculture sector in Jordan has a low growth ratio compared to other sectors in Jordan. The annual growth rate of agricultural sectors is 7.0 percent, whereas it is 16.8 percent for industry and mining, 16.3 percent for electricity, and 9.3 percent for water and construction (Kasrawi 1982: 13). There has been some improvement in this economic sector, but the current agricultural production still does not satisfy the country's need of food. Jordan still imports crops such as wheat, barley, potatoes, onions, applies and pears. Cultivation in Jordan is on any land that is available, no matter the size, as long as there is soil and a sufficient supply of water to enable crops to grow. The cultivated land currently amounts to about 1,610,000 acres (6,510,000 dunums), which is about nine percent of the total area of Jordan. Forest cover is about .04 percent and the rest of the area is steppe or desert (Figure 5.1). In 1973, the cultivation area was distributed as follows:

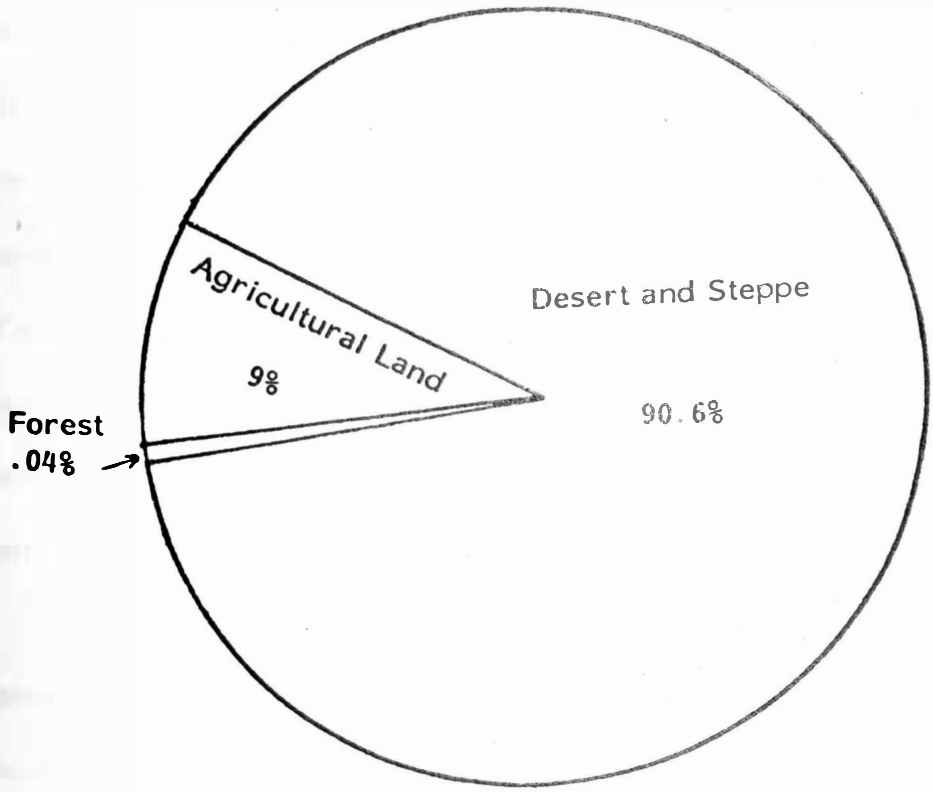
TYPE OF LAND	AREA IN ACRES
Fallow	435,420
Uncultivated Land	231,362
Cultivated Land	943,097
Land under field crop cultivation	816,928
Land under vegetable crop cultivation	33,837
Land under fruit tree cultivation	92,354

SOURCE: The Agricultural Development of Jordan, Aresvik, 1976.

FIGURE 5.1

LAND USE IN JORDAN

TOTAL AREA: 35,734 SQUARE MILES (92,552 sq. km.)



SOURCE: Report on Jordan, Department of State, 1979.

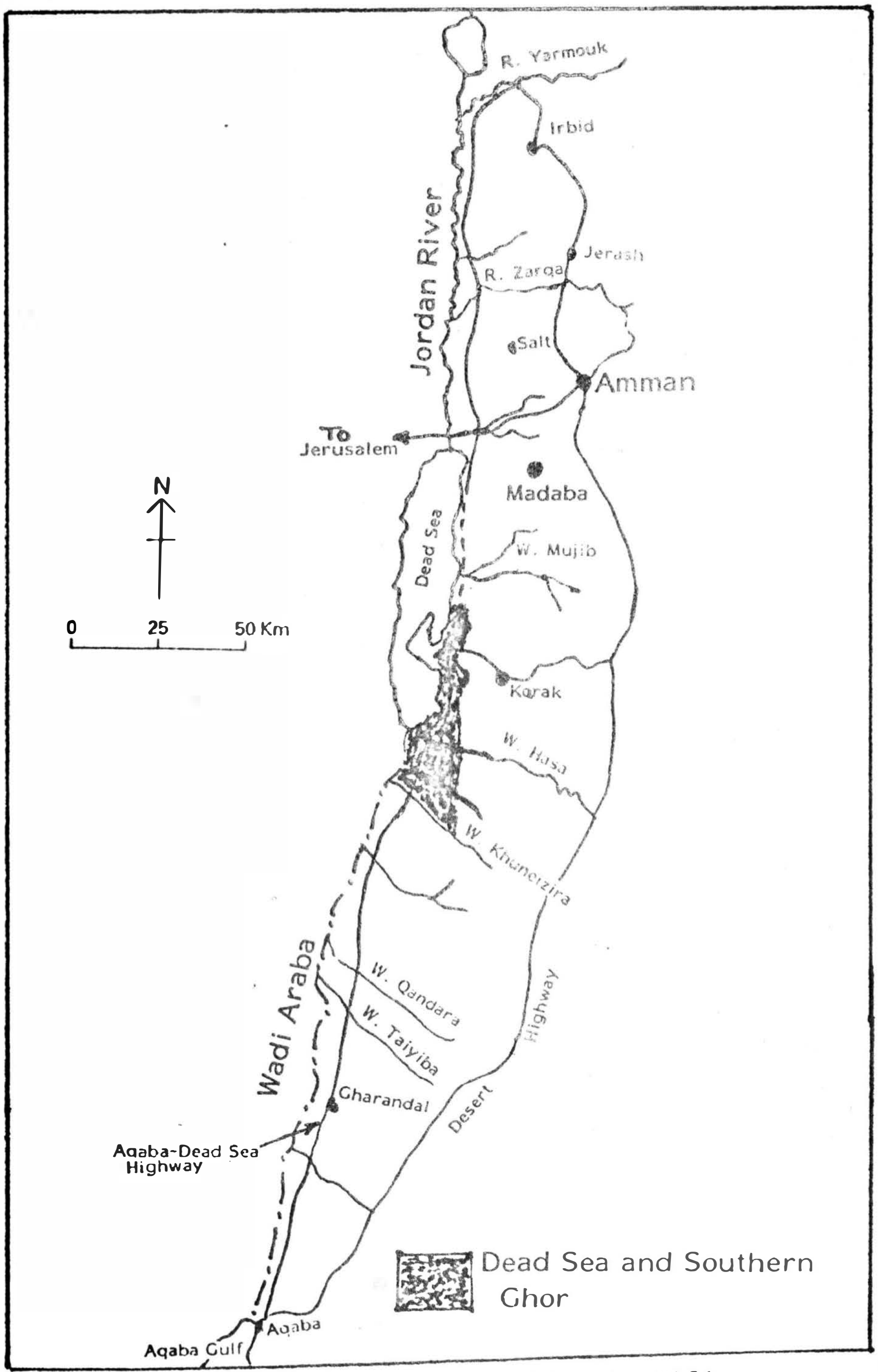
Arable land in Jordan is divided into five agricultural zones, each of which is based upon the climatological pattern and the changes in these patterns with altitude, and the frequency in distribution of the minimum average annual rainfall. According to Aresvik (1976: 107) these five zones are:

1) The Ghor. This zone lies between Yarmouk River in the north and Gharandal in the south, with the Dead Sea in the middle (Map 5.1). It is located at between 665 to 1,165 feet (200-350 meters) below the sea level, and experiences hot summers and warm winters. Water is available for irrigation in this zone and alluvial soil is found here. The Ghor has high production potential because of cropping intensity. Three and four crops may be produced annually in many parts of the Ghor. The area is suitable for improving the production of summer and winter crops and some industrial crops such as sugerbeets and oil seed.

2) The Semi-Humid Zone. This is where the minimum average annual rainfall is between 20-32 inches (500-800 mm). This zone occupies small areas that are scattered between Irbid and Ajlun in the north, around Karak in the central part of the country, and around Salt which is located between the two foregoing regions. The major soil groups of this zone are the brown soils. The gently sloping lands are used for summer and winter crops, and especially for summer vegetable production. Areas

MAP 5.1

WESTERN JORDAN AREA



SOURCE: The Jordan Valley, R. Khouri, 1981.

with slopes between 9 and 25 percent are used primarily for the fruit tree production. Steep and rocky areas with slopes above 25 percent are used as woodlands.

3) The Semi-Arid Zone. This zone has a minimum average annual rainfall of more than 14 inches (350 mm) and a maximum annual rainfall of less than 20 inches (500 mm). It occupies about 1.5 percent of the total area of Jordan. The major area of this zone is located between the Yarmouk River in the north and Madaba in the south and between the northern Ghor in the west and Jerash and Amman in the east. The second part of this zone is the area surrounding Karak. Red Mediterranean Soils constitute the major soil groups in this area. This gentle slopping area is good for wheat and other crops grown in rotation with summer crops. Planting of trees is done in areas of 9 to 25 percent slope, and many of the hilly areas with slopes above 25 percent support a forest cover.

4) The Marginal Zone. Minimum average annual rainfall is greater than 8 inches (200 mm) and the maximum average rainfall is less than 14 inches (350 mm). This zone occupies about 6 percent of the total area of the country. It occupies areas between the Semi-arid Zone and the Arid Zone. The main soil groups of this zone are the Yellow Mediterranean Soils. Areas with a slope of less than 9 percent are utilized for barley and wheat. Areas with slopes from 9 to 25 percent are suitable for fruit trees, and areas with a slope of above 25 percent are suitable

for forest cover.

5) The Arid Zone. Average annual rainfall is less than 8 inches (200 mm). This zone occupies 91 percent of the total area of Jordan. It lies east of the highlands toward Iraq and Saudi Arabia. Much of this zone is comprised of rocky out-crops, vast expanses of stone and gravel, and in the southern extreme there is sandy desert. Some areas of this zone are used for grazing. Natural vegetation is limited to scattered scrubs and bushes. Cultivation of crops is found only in the oases where there is enough water for irrigation.

Cultivated land is not capable of producing enough food for Jordan's population. Also, cultivation in the rainfed area can not be expanded because all available land already is used. The solution for increasing yields depends on improving irrigation agriculture mainly in the Jordan Valley, rather than depending on the rainfed agriculture. Therefore, any increase in cultivation land should occur in the irrigated areas. Increases in the annual production of crops depends mainly on increased yield per dunum (International Bank for Reconstruction and Development 1961: 78).

Rainfed Agriculture

Rainfed agriculture occurs throughout those areas which receive enough rain for cultivation. These areas are found mainly in the mountains and steppe regions. The improvement of rainfed land depends upon many factors. They include: the average amount of precipitation, the type and depth of soil, and its topography, and other social and cultural factors such as inherited agricultural methods. Crop production in the rainfed area is smaller than on irrigated lands. Increased agricultural production can be achieved by proper utilization of agricultural machinery, technology, and fertilizers. Increased yields can be achieved by using the land to its fullest potential and utilizing the best type of crops suitable for that land. The only way to expand rainfed land is to use the grazing land to grow crops such as legumes (Aresvik 1976: 118). The main crops in rainfed areas now are wheat, barley, olives, vines, fig, and some vegetables.

Irrigation Agriculture

The irrigated area in Jordan covers only 8 percent of cultivated land, 65 percent of which is in the Jordan Valley. Implementing of the proposed reclamation projects would increase the irrigated area to 4,940 acres (20,000 dunums) (U.S. Department of State 1979: 79). Irrigated lands in Jordan are distributed in all agricultural regions: the Jordan Valley, highlands and desert regions. The area of land under irrigation increases every year as a result of development and land improvement, especially in the Jordan Valley district. Table 5.1 compares the land area under irrigation in 1978 and 1985.

TABLE 5.1

IRRIGATION AREA IN 1978 AND 1985

(Acres)

Region	1978	1985
Jordan Valley	52,000	62,500
South Ghor	9,250	15,500
Highlands and Desert	35,250	7,250
TOTAL	96,500	85,250*

*Additional areas or a total irrigated area of 181,750 acres (735,830 dunums)

SOURCE: Jordan, Winter 1980 (Ministry of Information and Central Bank of Jordan), Statistical Bulletin, August, 1979.

The total irrigated land in Jordan is 43,210 acres (174,979 dunums) distributed as the following:

1) East Ghor Canal project is 28,310 acres (114,609 dunums), or 65.5 percent.

2) Side wadis and springs consist of 7,008 acres (28,373 dunums), or 16.2 percent.

3) Land irrigated by underground wells is 3,562 acres (14,420

dunums), or 8.2 percent.

4) Land irrigated by pumped water from Jordan River is 373 acres (1,059 dunums), which is 0.9 percent.

5) Rainfed areas have 3,969 acres (16,068 dunums), which is 9.2 percent. (Khouri 1981: 138).

Greater potential exists for crop improvement on irrigated land than on rainfed land. By the mid-1950s, it was recognized that further agricultural development would depend upon irrigation, especially in the Jordan Valley region, using the Jordan River and its tributaries. During the last three decades extensive areas have been under improvement by introducing new crops, incorporating better farming techniques and better irrigation methods, resulting in a high level of commercial agriculture (Hazleton 1979: 259-260). Production increases by leveling the land and shaping it to a smooth plane with a slight slope for water distribution and drainage, and expanding the use of modern irrigation methods.

Machinery, Fertilizers, and Chemicals

The development of agriculture, the expansion of cultivated areas and increasing of crop yields depends on the correct use of techniques of machinery, fertilizers, and chemicals. Advanced forms of technology used in farming has some negative points too. The negative side-effects result from the improper use of agriculture technology without first studying their potential impact, especially the impact upon the soils in the dryland areas. In spite of the increased use of machinery, fertilizers, and chemicals during the last two decades, the use of advanced forms of technology in Jordan is low in comparision with other countries in the Middle East. There are many possible reasons to explain why the adoption of new technology is limited in Jordan, particularly in the dryland areas (Mazur 1979: 160).

1) New technology has not been developed in Jordan.

2) New technology has not been adapted to Jordanian conditions.

3) Even if adopted, agricultural production in Jordan might not justify the cost by making it profitable.

4) Farmers are often reluctant to adopt new technology because of personal characteristics, such as the illiteracy of Jordan's farmers, or inadequacies in the system of delivering new technology to the farmer (farm input suppliers, agricultural extension, agricultural cooperatives).

Machinery. The traditional methods of soil tillage, planting, and harvest, are still used in some areas of Jordan. Most of the farming, however, is dependent on modern machinery, such as tractors, drills, combines, sprayers, and plows. Mechanization has taken place during recent decades, and has spread quite rapidly since the early 1960s. The number of tractors increased from 1,000 in 1950 to 3,748 in 1975. Also growing in use are disc plows, disc drillers, and harvesters (U.S. Department of State 1979: 80).

In Jordan the use of tractors is not encouraged by a labor shortage, but because of the need for a higher degree of weed control and the superior standard of cultivation that is obtained by its use. Modern agricultural equipment is used more frequently on open land where the soil is deep. Traditional farming methods are still being used extensively in the rocky areas and those with rugged terrain. Approximately 20 percent of the farmers in the rainfed areas use their own tractors for plowing; 65 percent hire tractors and 15 percent use draft animals (Aresvik 1976: 91).

One result of using modern equipment for agricultural purposes in recent years has been an increase in the rate of erosion. The introduction of farm mechanization was not accompanied by educational programs to train farmers in the correct choice of implements and their proper use with reference to soil and climatic conditions. Many areas in Jordan have been seriously effected by soil erosion resulting in declining productivity of the land. The widespread of tractors, for example, has led to plowing of submarginal land in the dry areas. Such land should have been left for grazing (Aresvik 1976: 91).

Fertilizers and Chemicals. The use of chemical fertilizers is relatively new in Jordan. As yet, chemicals and fertilizers are not widely used because of their cost and the lack of knowledge on proper use. Many farmers in the rainfed areas prefer to minimize risk rather than maximize profits. In the irrigated areas, the availability of irrigation water encouraged farmers to use chemicals and fertilizers to increase land yields. The majority of farmers in the irrigated areas use fertilizers for vegetables and fruit trees; whereas in the rainfed areas the use of fertilizers is infrequent. There are different kinds of fertilizers used in Jordan such as phosphate and nitrogen. Table 5.2 shows the total amount of fertilizers that has been sold in Jordan from 1960 to 1976. With regard to the application of fertilizer per hectare of arable land, Jordan ranks the lowest of all Near East countries, with only 0.6 kilogram of nitrogen and 1.1 kilogram of phosphate per hectare (U.S. Department of State 1979: 80). Modern agriculture requires diverse kinds of chemicals as part of improving technology to control weeds, insects, and plant diseases for higher yields. Table 5.3 shows the total amount of agricultural chemicals used in Jordan in 1976.

Land Tenure

The average size of agricultural land holdings varys according to location. In the Jordan Valley, which contains a third of the country's

TABLE 5.2

INORGANIC FERTILIZERS SOLD TO FARMERS DURING 1960 TO 1976 (Tons)

Year	Phosphatic	Nitrogenous	Other	Total
1960	377.0	1,728.0	282.0	2,347.0
1961	316.0	2,188.0	364.0	2,868.0
1962	414.0	2,230.0	444.0	3,088.0
1963	694.0	5,519.0	1,070.0	7,283.0
1964	585.0	5,319.0	1,358.0	7,262.0
1965	754.0	5,237.0	1,860.0	7,851.0
1966	1,255.0	6,517.0	2,460.0	10,232.0
1967	325.0	1,364.0	1,200.0	2,881.0
1968	303.9	1,343.4	1,179.2	2,826.5
1969	376.3	1,722.3	1,211.8	3,310.4
1970	1,516.0	875.0	1,111.0	3,502.0
1971	3,546.0	6,544.0	390.0	10,408.0
1972	72.0	2,999.0	736.0	3,807.0
1973	NA	1,222.0	1,570.0	NA
1974	NA	820.0	280.0	NA
1975	NA	200.0	801.0	NA
1976	397.0	450.0	NA	NA

SOURCE: Report on Jordan, Department of State, 1979.

The Agricultural Development of Jordan, Aresvik, 1976.

TABLE 5.3

AGRICULTURAL CHEMICALS SOLD DURING 1976

(Tons)

Plant Chemicals:	
Tree Washer	0.232
Fungicides	13.967
Greases for tree band	0.113
Mercury Compounds:	
Phosphatic compounds	4.583
Sulphuric compounds	33.728
Copper compounds	48.950
Yellow sulphur	4.000
Bentine Hexachloride	4.000
Others	4.710
Veterinary Medicines	6.000
Cases	0.595
TOTAL	133.025

SOURCE: Report on Jordan, Department of State, 1979.

economically active population, the average land holding is under 5 acres (20 dunums) per person. In the highland region, yields are lower due to terrain and the farms tend to be larger with some exceeding 500 acres (2,000 dunums) (Fisher 1977: 457).

Land holdings in the rainfed area varys in size from those of the irrigated areas. Ten percent of the land owners with the largest ownership, in the rainfed region have 35 to 45 percent of the land area, while the 75 percent of land owners with the smallest ownership have about 30 to 40 percent of the land area. The area in the Jordan Valley irrigated by the East Ghor Canal has a more equitable distribution of ownership than is found in the rainfed farming areas. Six percent of land owners with the largest holdings own only 14 percent of the total area (Table 5.4) (Mazur 1979: 151).

The size of land holdings in the irrigated area has changed in the last two decades. In 1962, the government passed a legislation on land holdings for the irrigated areas. The initial legislation (before 1962) provided for a maximum holding of 75 acres (300 dunums). This was increased to 125 acres (500 dunums) in 1960, and was reduced to 50 acres (200 dunums) in 1962. Under the 1962 legislation, holdings of 7.5 to 12.4 acres (30-50 dunums) were to be allotted in full; those who had holdings of 12.5 to 25 acres (51-100 dunums) were allotted 12.4 acres (50 dunums) plus 25 percent of the additional area; persons with holdings

TABLE 5.4

SIZE DISTRIBUTION OF AGRICULTURAL

LAND HOLDINGS IN JORDAN IN 1975

Size Class (Dunums)	Number of Holdings (Percent of Total	Area of Holdings (Percent of Total)
Less than 10	24.4	1.1
10 - 29	24.2	5.6
30 - 49	15.1	7.3
50 - 99	17.0	14.3
100 - 199	10.7	18.3
200 - 499	6.6	24.2
500 - 999	1.4	11.4
over 1,000	.7	17.0

SOURCE: Economic Growth and Development in Jordan, M. Mazur, 1979.

of 25.1 to 123.5 acres (101-500 dunums) were allotted 15.3 acres (62 dunums) plus 17 percent of the additional area; those persons having holdings of 123.6 to 247 acres (501-1,000 dunums) were allotted 32 acres (130 dunums) plus 17 percent of the additional area; and those persons with holdings in excess of 247 acres (1,000 dunums) were allotted 50 acres (200 dunums) (Hazleton 1979: 261).

Land tenure in Jordan is of three types: 1) three-fourths of the agricultural holdings are entirely owned by farmers, 2) 15 to 20 percent are rented holdings, and 3) the remaining are partially owned and partially rented (Mazur 1979: 155).

Ownership holdings on the whole, are greater in the dryland areas of Jordan. In 1975, 49 percent of the total number of holdings were in single parcels; the other 51 percent of holdings averaged three parcels per holding. For the two groups combined, the overall average is about 2.3 parcels per holding. In the Jordan Valley region the average is 1.2 parcels per holding because of the development and redistribution of land (Mazur 1979: 154-155).

Climate, soil, and topography are the main factors that affect agricultural production in Jordan. There are other factors, however, that limit Jordan's agricultural production. They are:

1) Water needs. The possibility for increasing water supplies for agriculture is constrained by the limited availability of water.

2) The size and nature of agriculture holdings.

3) Inefficient farming methods.

4) The loss of a substantial portion of the agricultural work force as farmers are attracted to higher paying jobs in other Arab countries (U.S. Department of State 1979: 72).

As a result of developments in Jordan, in agriculture, the country has begun exporting crops to the surrounding Arabian countries. Increased production yields vary from one crop to the other. Wheat and vegetable production have increased more than other field crops have or fruit. These variations are due primarily to the Jordan Valley area development, which is very suitable for the growing of vegetables. In the next chapter, agriculture production of crops, vegetables, fruits, and livestock will be discussed.

CHAPTER SIX

AGRICULTURAL PRODUCTS

This chapter investigates agricultural products, and environmental factors influencing crop yields in Jordan. A variety of field crops, fruit trees, and vegetables are grown in Jordan. Generally field crops are planted in the rainfed areas, fruit trees in the upland regions, and vegetables in both rainfed and irrigated areas. The successful production of these agricultural products is influenced by weather and climate, soil, terrain, moisture, and water resources. As a result, the distribution, of agricultural products among the agricultural regions of Jordan reflect the influence of environmental factors as growth and production.

Field Crops

There are a variety of agricultural crops produced in Jordan (Table 6.1). Most of the field crops are grown in the rainfed area which provide fertile conditions without significant additional costs. Crop yields and production in the rainfed area are influenced by environmental elements. The rainfed area is characterized by a large rainfall fluctuation,

TABLE 6.1

MAJOR FIELD CROP PRODUCTION AND AREA 1973-1977

(Area in thousands of acres, production in thousands of tons)

	1973		1974		1975		1976		1977	
Crop	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
Wheat	514.8	50.4	608.1	244.5	292.2	50.0	338.2	66.6	312.5	62.5
Barley	131.4	5.9	159.3	40.2	130.7	11.8	132.5	13.2	114.4	12.0
Lentils	60.0	4.8	53.4	29.5	36.8	5.2	56.7	9.4	33.3	6.0
Kersenneh	20.0	2.3	19.7	6.6	10.4	1.9	11.7	0.8	10.9	1.9
Maize	0.5	0.2	0.7	0.4	1.5	0.7	1.3	0.6	0.5	0.3
Sesame	1.7	0.1	2.6	0.1	0.7	0.1	0.7	0.1	----	----
Chick Peas	18.0	1.9	30.9	8.3	0.1	0.1	4.0	0.4	3.5	0.6
Broad Beans	0.7	0.1	1.2	0.7	----	----	0.8	0.2	1.0	0.4
	747.1	65.7	875.9	330.3	472.4	69.8	545.9	91.3	476.1	83.7

SOURCE: Report on Jordan, U.S. Department of State, 1979.

The Middle East and North Africa, W. B. Fisher, Europa Publication Limited, 24th Edition, 1977.

and shallow poor soils. This is particularly true on the mountain slopes that are affected also by erosion.

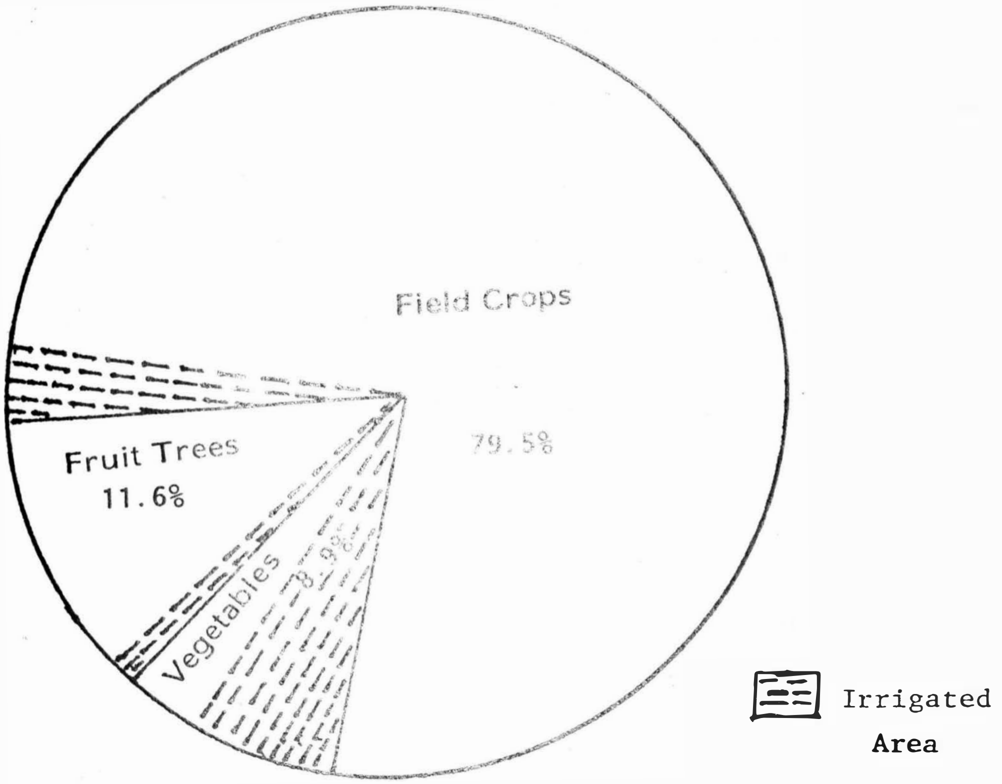
Field crop area in the rainfed area is approximately 79.5 percent of the total cultivated land (Figure 6.1). The cultivated area fluctuates from year to year depending on the climatic conditions. Table 6.1 shows the fluctuation of field crop area which was 875,900 acres (3,546,100 dunums) in 1974, 472,400 acres (1,912,500 dunums) in 1975, 545,900 acres (2,210,100 dunums) in 1976, and 476,100 acres (1,927,500 dunums) in 1977 respectively. The field crop area is distributed throughout all agricultural regions which include: 1) the desert area which receives an average annual rainfall of 6 to 10 inches (150 - 250 mm), 2) the eastern area that receives an average rainfall of 10 to 12 inches (250 - 300 mm), 3) the western plains that receives an average annual rainfall of 12 to 16 inches (300 - 400 mm), 4) the upland area which receives an annual average rainfall of more than 16 inches (400 mm), and 5) the Ghor area which depends entirely on irrigation from the East Ghor Canal and tributaries of the Jordan River.

Crop production fluctuates from year to year depending on environmental conditions and the cultivated area. Crop yields for each agricultural production also fluctuates from year to year, due to the amount and distribution of rainfall and soil quality. Wheat yield fluctuation, for

FIGURE 6.1

CULTIVATED LAND 1976

Total Area: 697,891 Acres (2,825,470 Dunums)



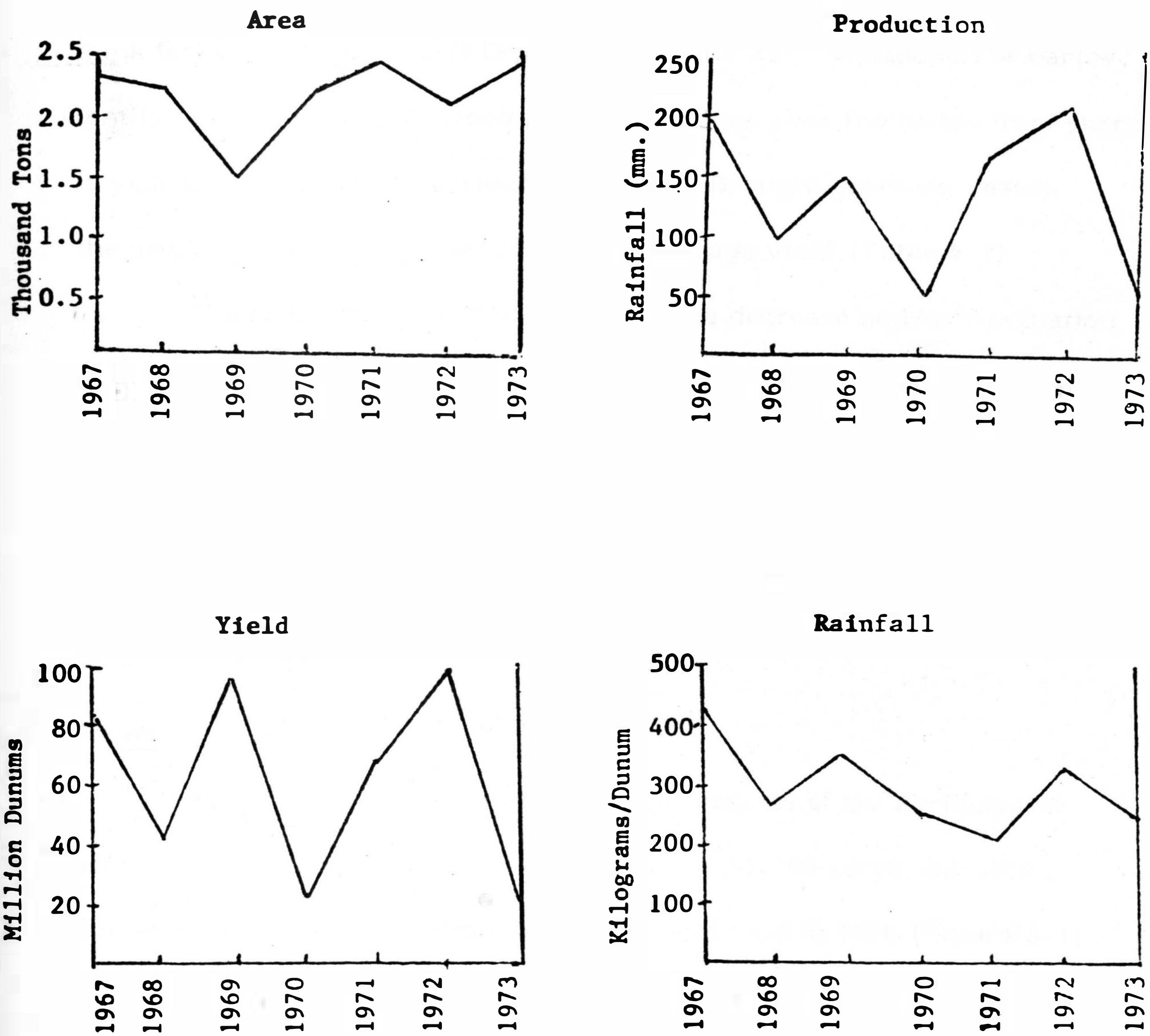
SOURCE: Report on Jordan, U.S. Department of State, 1979.

example, affected the production in 1973 compared to 1975. In 1973, 514,800 acres (2,084,200 dunums) produced 50,400 tons of wheat while in 1975 under better conditions only 292,200 acres (1,183,000 dunums) yielded 50,000 tons. The fluctuation of field crop production is demonstrated clearly in Table 6.1. The total production of major field crops in 1973 was 65,700 tons, 330,300 tons in 1974, 69,800 tons in 1975, 91,300 tons in 1976, and 83,700 tons in 1977.

The most important agricultural crop in Jordan is wheat, not only because of its economic value, but it is the primary means of food for the Jordanians. Wheat is planted in a wider area in Jordan than any other crop. Average wheat plantings from 1967 to 1973 was about 518,700 acres (2 million dunums), which is more than half of the cultivated area in Jordan. Wheat planting area decreased in 1973 to 1977 to 425,000 acres (1.7 million dunums). Wheat is now planted in the eastern region, western plains area, upland region, and the Ghor district, due to the suitability of soil and bountiful water. Wheat production fluctuates largely due to the fluctuation of rainfall. Production in Jordan with minimum and maximum rainfall conditions is about 86,000 tons and 228,000 tons, respectively (Aresvik, 1976: 137). Figure 6.2 shows the fluctuations of wheat production, yield and area, and the rainfall which illustrates the relationship between them.

FIGURE 6.2

AREA, YIELD, AND RAINFALL RELATIONSHIPS WITH WHEAT PRODUCTION



Barley is planted in the marginal areas surrounding the wheat growing regions. Barley matures earlier than wheat, therefore fair yields are produced with rainfall amounts that would be insufficient for wheat. In comparision to wheat, barley has a high tolerance for salt, which allows it to have relatively high yields under irrigated conditions (International Bank for Reconstruction and Development 1961: 85). Production of barley, lentils, maize, sorghum, broad beans, and chick peas fluctuates from year to year depending on the amount of rainfall. Drought years decreases the production to about 50 percent of the average yield (Table 6.1).

There are many factors that cause the decrease and/or fluctuation of field crop production. Factors such as: the fluctuation of rainfall, poor soil-moisture management, poorly prepared seed, the type of seed, hand seeding, fertilizer, and heavy weed infestation. The last four problems could be avoided by using modern agricultural machinery, fertilizers, and chemicals (Aresvik 1976: 145-146).

Fruits

Fruit production is one of the major aspects of the agricultural economy of Jordan. It occupies approximately 81,000 acres (328,000 dunums) or 11.6 percent of the total cultivated land in 1976 (Figure 6.1). The high variability of climate, elevation, and slope allows for the spread of a wide range of fruit trees from semi- and sub-tropical environments. Major fruit trees include: citrus, bananas, date plams, and deciduous fruit trees (U.S. Department of State 1979: 75). Fruit trees are grown on rough or hilly terrain that is unsuitable for other crops or vegetables. The fruit tree cultivated area is concentrated mainly in Irbid and Balqa followed by Amman and Karak district.

Fruit production fluctuates from year to year (Table 6.2) depending on weather conditions which are responsible for the low yields, especially in the rainfed areas. Besides climatic conditions, there are other problems that cause low production. Factors such as: shallow and poor soils in the mountain regions; failure to use fertilizers to increase fertility; the difficulty of using agricultural machines on the mountain slopes for tillage and cultivation; and the use of chemicals. Increasing fruit production can be achieved by improving the average yield per acre (dunum) and by expanding the cultivated area. The yields can be increased by the use of chemicals, fertilizers, and machinery. The expansion of hillside fruit cultivation can be achieved on the undeveloped hillsides utilizing land used for wheat and barley and in the forage crop, and grazing areas (International Bank for Reconstruction and Development 1961: 81).

Olive trees are the major tree type planted in the mountain

TABLE 6.2

PRODUCTION OF FRUIT IN JORDAN

(Thousands of tons)

FRUIT	1970	1971	1972	1973	1974	1975	1976	1977
Almond	0.5	1.2	1.0	0.2	0.8	1.0	0.6	0.4
Applies & Pears	0.8	0.6	2.9	0.4	4.0	1.4	0.7	1.2
Apricots	---	---	---	---	1.5	6.8	0.2	0.6
Citrus Fruits	3.8	8.9	20.9	15.4	33.6	12.8	16.5	36.5
Figs	3.0	2.9	2.2	1.0	1.2	0.1	0.3	0.6
Bananas	8.2	4.3	6.7	2.3	4.4	6.3	4.5	3.4
Plums & Peaches	0.5	0.3	0.1	---	0.3	0.3	0.4	0.8
Olives	3.0	18.5	35.0	5.2	40.5	4.7	22.5	---
Grapes	6.2	18.6	18.2	---	---	---	---	---

SOURCE: Report on Jordan, U.S. Department of State, 1979

The Agricultural Development of Jordan, Aresvik, 1976.

regions. Olive groves are planted on mountain slopes that receive an average annual rainfall of more than 12 inches (300 mm). The area in groves increased from 13,338 acres (54,000 dunums) in 1961 to 33,839 acres (137,000 dunums) in 1973. Grape arbors are also planted in the mountain region. Grape arbors have fluctuated around 17,290 acres (70,000 dunums) since 1961 (Aresvik 1976: 170).

Bananas and dates are planted in the Ghor district. Both demand hot climates, but bananas need more water than dates. Bananas are planted in the Ghor region where there is suitable soil and plentiful water. The banana production area has averaged around 1,235 acres (5,000 dunums) since 1968. Banana production fluctuates from year to year depending on the weather conditions (Table 6.2). Its production is affected largely by hot and dry winds. Banana production could be doubled just by using wind breaks around the groves. Date trees are planted in the Ghor, Dead Sea region and Desert region, in which the climate conditions is suitable (Aresvik 1976: 171).

Vegetables

Vegetables have gained importance in Jordanian agriculture, because of the expansion of irrigated areas. In fact, 90 percent of the irrigated lands are planted in fruits and vegetables. However, the area used for vegetables is small. Vegetable growing area amounts for only 8.9 percent of Jordan's total cultivated area, or about 61,750 acres (25,000 dunums) (Figure 6.1). The Jordan Valley is especially favorable for vegetable production due to the suitability of soil, weather conditions, and the availability of water for irrigation. Vegetables are also planted in the highlands district where slopes are not steep, and the soil is good. From year to year the vegetable area fluctuates depending on the weather conditions and the market demands. The area has increased from 60,370 acres (244,000 dunums) in 1971 to 70,000 acres (283,700 dunums) in 1972, and to 73,700 acres (298,500 dunums) in 1973 (Aresvik 1976: 154).

The value of vegetable production amounts to approximately 53 percent of the total production value of all crops. As a result they are important export items. Vegetable production value is high because they are produced throughout the year by utilizing plastic greenhouses. By using the plastic greenhouses weather conditions such as winds, temperature, evaporation, and moisture are controlled. The warm winter climate and the availability of water in the Ghor district have made it possible to produce early vegetables out-of-season. Vegetable production has reached the level of 1.4 million tons per year (Aresvik 1976: 154). Production of vegetables does fluctuate from year to year because of low yields due to weeds, diseases, and weather conditions such as frost, which could affect the greenhouse winter crop. These factors can reduce yields by up to 50 percent. The production of tomatoes, for example, fluctuated from 83,100 tons in 1973, to 133,300 tons in 1974, to 145,000 tons in 1975, to 87,900 tons in 1976, and 85,000 tons in 1977 (Table 6.3).

Tomatoes are the most important export vegetable crop for Jordan. Tomatoes are planted in the irrigated areas as well as in the dry-land areas. Tomato cultivated area is affected by weather conditions and mainly by the market demand which has been limited. Watermelons are the most important vegetable crop grown under dry-land farming conditions, covering a larger area than tomatoes (Aresvik 1976: 151). Other vegetables grown in Jordan are cucumbers, eggplant, cauliflower, cabbage, onions, garlic, peppers, green beans, and lettuce.

Livestock

Large parts of the country, particularly the steppe and desert regions that comprise the greater part of Jordan, are suitable only for nomadic or semi-nomadic animal husbandry. This economic activity is conducted principally by Bedouin people. Animals depend principally on natural growth in the spring and on fodder and cereal

TABLE 6.3

PRODUCTION OF VEGETABLES 1973-1977

(Production in thousands of metric tons)

Vegetables	1973	1974	1975	1976	1977
Tomatoes	83.1	133.3	145.0	87.9	85.7
Eggplants	14.7	32.4	39.6	42.8	24.6
Onions & Garlic	3.8	1.8	2.5	1.3	0.4
Cauliflower & Cabbage	10.4	15.9	8.7	7.7	6.3
Watermelons	56.0	46.6	50.4	23.1	28.1
Potatoes	9.4	3.9	5.1	13.0	13.0
Broadbeans (Green)	1.8	3.4	3.1	4.7	6.5
Cucumbers	10.4	17.5	18.0	12.9	13.6

SOURCE: Report on Jordan, U.S. Department of State, 1979.

products in the Summer. Animals are raised mainly in the steppe district, Zaraq-Amman, and also in the Jordan Valley district, where the climate conditions are more suitable than other districts.

Livestock products account for about a third of the total agricultural production in Jordan (U.S. Department of State 1979: 76). Generally, the number of animals (except sheep and poultry) have decreased in the period between 1961 and 1977 (Table 6.4). Rainfall amount affects the grazing area. In drought years, grazing is sparse resulting in the loss of many animals. Other factors influencing the production of animals are disease and the breed of animal. Principal agricultural animals include cattle, sheep, goats, camels, chickens, and turkeys.

Cattle are raised primarily for the production of milk, meat, and as draft animals. Cattle are well adapted to arid conditions and can survive under near starvation feeding conditions. Farmers in the rainfed areas keep cattle as draft animals in the traditional agricultural methods. Farmers have been encouraged to raise sheep instead of goats, particularly in the agricultural and forest areas. Goats are considered as dangerous animals in the cultivated areas. The government ruled that goats could be raised only in areas such as the mountains, that are not suitable for agriculture. Therefore, the number of goats decreased while the number

TABLE 6.4

DOMESTIC ANIMALS

(Thousands of heads)

	1961-65 Average	1974	1977
Cattle	61	47	36
Milk Cows	16	9	9
Sheep	752	792	820
Goats	592	399	490
Camels	17	16	19
Chickens	1,696	2,700	4,500
Turkeys	25	27	29

SOURCE: Report on Jordan, U.S. Department of State, 1979.

of sheep have increased. Sheep are raised in the eastern steppe grass lands and the southern brush vegetation regions. In the spring and in the summer the herds are moved to the uplands. During the winter and autumn sheep herds are moved to the eastern and southern desert (U.S. Department of State 1979: 77-78).

The main area for poultry production is in the Jordan Valley and the steppe district. Amman-Zarqa and Irbid are the main areas because of the climate conditions and locality near the markets. Poultry production is sufficient for Jordanians. Poultry units have increased from about 1.7 million heads in 1967 to 4.5 million heads in 1977 (Table 6.4).

Conclusion

Agricultural development in Jordan has been concentrated primarily on the improvement of crop and crop production. Generally, agricultural production has increased due to the new agricultural methods. Even with these developments, agriculture in Jordan is still on a low level compared to other countries in the world. Climate is the principal factor that affects agricultural production. Rainfall fluctuation and distribution is the main phenomenon that affects agricultural production on a wide scale. Other elements that affect agriculture are: winds, temperature, frost, and soil. The relationship between these factors are considered in the next chapter.

CHAPTER SEVEN

AGROCLIMATOLOGY

The study of relationship between climate and agriculture involve interrelations between atmosphere, water, soil, animals, and plants, as well as various cultural factors. Climatic elements affect agricultural crops and its production. Weather conditions may be suitable for particular plants and animals in most years, but occasional disastrous seasons may result in heavy losses. Weather condition variations result in large fluctuations of agricultural production, of which drought and flood cause the larges losses (Wiesner 1970: 92). Lack of adequate and reliable water is the primary factor limiting agriculture in Jordan. Rainfall is low and is characterized by considerable fluctuations from year-to-year. Other climatic factors such as frost and dry winds are also responsible for fluctuations in agricultural production. Wheat production, for example, was 211,000 tons in 1972; it declined to 50,000 tons in 1973, and increased to 213,000 tons in 1974 (U.S. Department of State 1979: 72).

The effects of weather on plants and animals can be reduced by adopting certain agricultural techniques that have been designed to avoid production losses resulting from weather conditions. By understanding the relationships between weather, crop yield, and animals, and employing modern agriculture methods (statistical and others), the agricultural climatologist may be able to predict crop yield in advance. Agroclimatologists also may provide information about the climatic potential of an area and how it best can be used to maximize productivity (Yao 1981: 189).

Moisture

Water is the major factor that limits the spatial distribution of agriculture and affects its production. Throughout most of Jordan, precipitation is the principal source of the soil moisture. The total amount and the intensity of precipitation both are important. Heavy rainfall produces water loss through run-off and extensive soil erosion, whereas light rainfall infiltrates the soil and is stored as moisture available for plant growth. The time, frequency and distribution of precipitation is important for agriculture.

Rainfall fluctuation is very noticeable throughout Jordan. Variations in amounts of annual rainfall differ throughout the country. In the southern and eastern parts of Jordan, annual rainfall variations range from 35 percent to more than 40 percent. Farmers in these two regions are more prone to crop failure; the percentage of variability decreases toward the north and northwest where rainfall is heavier and more reliable.

Farmers in these portions of the country can raise their crops with some confidence. Annual variations are responsible for considerable changes in agricultural output. Wheat production, for example, may be four or five times as great during a good year than a bad year (Mazur 1979: 148).

The distribution of precipitation throughout the rainy months is very important. The monthly amount of rainfall, that occurs during the growth season, and the time of its occurrence has an enormous effect on the total agricultural area and yields. Rainfall is divided into three periods, depending on its value for the plant growth. First, the "early" rains which occur in October and November, yielding one to five inches (25 - 125 mm), are important to agriculture since autumn plowing occurs after the early rains. Second, the main rains occur from December to February and yield 10 to 20 inches (250 - 500 mm). The value in these rains lie in the recharging of wells and springs. Third, the "late" rains occur in March and April and yield one to five inches (25 - 125 mm). These rains are important for the harvest (de Brichambout 1963: 18). In some years the total amount of rainfall during autumn and spring is less than average, but the heavy winter precipitation increases the total moisture available for plant growth so that it appears to be a wet year. Crop production during an unusually wet year would not be as good as during those years when the total amount of rainfall is normal and well distributed throughout the rainy seasons (Aresvik 1976: 134).

The importance of seasonal variations in rainfall can be illustrated by their effect on wheat (Table 7.1). The early rains are expected to fall at the end of October and early November, when wheat is sown. Seasonal rains are expected to fall in January and early February. If they are delayed or fail to come, however, the sown crops perish from lack of soil moisture needed to sustain the crops during this critical growth period. The late rains occurring in late February and March are important for the harvest. The best harvest in the rainfed areas is usually obtained when sufficient early and late rains occur over an extended period (Aresvik 1976: 135).

When heavy rains occur in Jordan, the average intensity seems to be around one inch (5 mm) per day. A maximum of 1.5 to 2 inches (40 - 50 mm) per day may occur once a year in the mountain region causing floods (de Brichambaut 1963: 9). It seems that two inches (50 mm) of rainfall, the minimum required during the active growth period for dry-land in Jordan, would be available during eight years out of ten. In Jordan, it has been determined that dry-land farming should not be established outside the isoline for 7 inches (180 mm) of annual precipitation in the area of regular rainfall (de Brichambaut 1963: 10).

TABLE 7.1

AREA (Million of dunums), YIELD (k.g./dunum)
AND PRODUCTION (Thousands of tons) OF WHEAT AND AVERAGE RAINFALL (mm.)
FOR JORDAN FROM 1967 - 1973

Year	Area	Production	Yield	Rainfall	Percentage Imports of Total Consumption
1967	2.3	196.1	85.0	425.8	48
1968	2.2	95.1	43.0	276.8	59
1969	1.5	159.3	96.0	342.4	28
1970	2.2	54.1	25.0	255.4	57
1971	2.4	168.1	68.0	217.7	45
1972	2.1	211.4	99.0	330.1	67
1973	2.4*	50.4	20.6	---	--

*Wheat-harvested area was 1.1 million dunums

SOURCE: The Agricultural Development of Jordan, Aresvik 1978.

Temperature

Temperature is one of the primary facotrs affecting plant growth and its geographical distribution is very important for agriculture. Inputs of solar energy raise the air temperature so that plants and animals benefit. There also is an exchange of energy between air, soil, plant and water, which gives a wide range of micro-climates. Extreme temperatures can cause death by either freezing or scorching. A sufficiently long period of favorable temperatures is necessary for plants to mature. Many plants have to experience a daily sequence of high temperatures in order to develop flowers and fruit. Tomato plants, for example, should experience night temperatures of 60^{o} to 70^{o}F (15.5^{o} - 21^{o}C) to set fruit. Generally, each specific crop has its own temperature limits for survival and optimum growth (Wiesner 1970: 108).

Fluctuation and distribution of rainfall determines the period in which crops develop. Winter and late spring temperatures also set limits to crop growth. The period of rapid plant growth in Jordan lies between late winter (late February) and early May, which is followed by high temperatures. Under a well distributed rainfall with amounts exceeding 14 to 16 inches (350 - 400 mm), the varieties of crops with relatively long periods of growth are more productive than are the varieties suited to dryer localities. Temperatures also affect the harvest time, in the Jordan Valley.[1] For example, the harvest time of cereals, fruits, and vegetables is more than a month ahead of the harvest in the mountain area. The greater the heat in an area, the earlier the date of maturity of crop species (Nuttonson 1947: 448).

Winds

Winds affect plants in many ways. They include: rapid water losses through evaporation and transpiration; mechanical damage; transport of pollen, insects, and diseases; and soil erosion. Dry winds often occurring in April and May affect agricultural crops and decreases production.[2] The combination of high temperatures and low humidity resulting from dessicating winds leads to excessive evaporation and transpiration, so that growing crops may be damaged, withered, or destroyed. Early ripening is highly dependent upon local conditions.

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1. Harvest time is affected by latitude and elevation. The growing season increases in length from polar to equatorial latitudes and decreases in length with increasing elevation.

2. Sirocco winds blow in summer, occasionally reaching gale force, and violent dust storms may develop. These winds have a very destructive affect on plants and decrease production.

Plants could be damaged by the hot sirocco winds in early May if they are caught during their "yellow-ripened" stage (Nuttonson 1947: 453). Some controls can be used against the wind, such as shelters and wind breaks.

Soils

Soil quality is very essential to plants growth, particularly moisture and essential nutrients. Soil type also plays an important role in determine the amount of moisture retained for plant growth. Extensive areas of Jordan are underlain by stable limestone or porous lava into which rainfall sinks quickly, thereby leaving the soil dry. The depth of soil is also important for agriculture. Deeper soils are preferred for wheat, whereas the lighter shallow soils can be used for barley crops.

Erosion is caused by poor cultivation methods, overgrazing, and the uncontrolled exploitation of forests on sloping terrain. The number of shrubs uprooted by nomads is estimated to be about 182 million plants per year (U.S. Department of State 1979: 78). Erosion causes soil fertility to be swept away; this leads to impoverished soils where the structure is progressively degraded. This major loss also results in flooding which further affects the arable area of the country.

Soil salinity is another problem in the Rift Valley and desert regions of Jordan. In the Ghor district, salt accumulation is due to the former presence of a higher level of water in the Dead Sea. Salt tends to be more concentrated away from the hills toward the Jordan river and away from the tributary valley crossing the Ghor, because these areas are washed by fresh waters running off the hills and along the wadis. Salinity also affects well water; most of the underground water away from the wadis and hills is saline. This affects agricultural areas by decreasing the irrigated area which depends on underground water (Davies 1958: 267). Soil temperatures affect the germination of seed and also influences the root development and the growth of the entire plant (Yao 1981: 206).

Topography

Topography also affects agriculture. The mountain district is more suitable for fruit trees than other crops. Cereals and vegetables are planted in the Jordan Valley and steppe districts. Irrigation for obvious reasons, is found in the flat, rather than in sloping areas. The lack of proper land leveling procedures prevailing in Jordan reduces water use efficiency and therefore yields to a high degree. Fields with undulating high and low spots can never give full yields. The low spots will be covered by too much water, and the high spots will get too little water, consequently yields will be reduced (Aresvik 1976: 117).

Climate Crops, and Soil

Each specific crop demands special climatic and soil characteristics for optimum growth. Generally, the performance of the locally grown field crops progressively is more satisfactory with greater amounts of yearly rainfall, with smaller yearly fluctuations in precipitation, greater percentage of "late" spring rains, higher relative humidity and amounts of dew collective, lower temperature, fewer days of dry desert winds and lower wind velocity, smaller water runoff, greater water absorption and greater water holding capacity of soil (Nuttonson 1947: 455).

Climate and soil characteristics are different for cereal crops. The heavier and deeper soils of the cereal growing areas are devoted to wheat, the lighter and shallower soils to barley. In the south, where the rainfall is lighter and the rainy season is shorter, barley is the leading crop. The best areas for wheat growing are the alluvial plains and valleys because of their deep and heavy soils and higher water holding capacity. Sesame requires more moisture than durra and is almost entirely confined to the nourthern part of the country where precipitation is more variable. Durra is grown in most of the agricultural areas receiving relatively low rainfall. Corn without irrigation is grown mainly in the northern part of the country (Nuttonson 1947: 455).

Agricultural rotation is used mainly to retain soil fertility. A two to three-year rotation method is used in growing cereals. A two-year rotation in which wheat or barley is followed by durra or sesame or by winter legumes or a three-year rotation is in which legumes are introduced as an additional winter crop between summer and winter cereals. Subtropical and tropical fruits and vegetables with high heat requirements are grown under irrigated condtions in the Jordan Valley district where the winters are warm and frostless and the summer is long and very hot (Nuttonson 1947: 453).

Olive trees which are well suited to heavy rocky soils are grown in the mountain regions without irrigation. Fig and almond trees are scattered throughout the countryside and are not irrigated. The relative low winter temperatures of the higher mountains provide better climatic conditions for deciduous fruits than do the milder winters of other regions in Jordan. Almonds with satisfactory production are grown at the lower elevations in mountains with elevation of about 300 feet (100 meters) above sea level where both relative humidity and dew are fairly high. Mountain climates also are suitable for the growing of some vegetables. The mountain region is better suited for growing cauliflower, cabbage, beets and carrots than are the regions with warmer winters (Nuttonson 1947: 454-455).

Animals

The affect of climate on animals is less harmfall than it is on crops. Temperature is the most important element affecting the performance of animals. For most kinds of livestock, there are optimal climatic conditions under which they will best develop and produce. The ideal temperature for most domestic species is generally within the range of $39^{o}F$ to $77^{o}F$ (4^{o} - $24^{o}C$) (Yao 1981: 257).

Conclusion

A country's climatic condition plays an important role in determining the types of crops that can be grown. Jordan's climate varies from region to region. The Jordan Valley climate differs from that of the mountain and desert regions. Therefore, some crops such as fruit trees grow better in the mountains, whereas vegetables grow better in the Jordan Valley (Ghor) district. With irrigation, many kinds of tropical and temperate zone crops are grown, particularly early vegetables, citrus fruits and bananas. Irrigation decreases the dependence upon rainfall. The main problems in the irrigated areas are frost, wind and diseases.

CHAPTER EIGHT

CONCLUSION

Jordan's land is quite poor in natural resources. The greatest part of the country's territory is desert, with only nine percent being arable and less than one percent being forested. The major problem confronting the country is insufficient water resources to meet both the domestic needs of its growing population and the demand for irrigation water to produce crops required to feed the population. Continuing degradation of soil resources through erosion, particularly in the mountain areas, also is a problem. Soil erosion results from overgrazing, deforestation, and the use of modern machinery on land unsuited for deep ploughing. There are additional environmental, social, and cultural problems that affect Jordan's agriculture. These incude: deterioration of agricultural land; deforestation; an arid climate; and ancient inherited agricultural methods that are still used on many farms.

The diversity of Jordan's topography is considerable, with extremes from the below sea level Rift Valley, to mountains, and the desert regions. Each of these regions presents its own distinct types of soils, natural vegetation, climatic conditions, and the amount of water available for agricultural use. Due to these environmental differences, crops must be selected which are best adapted to each regional ecosystem. Agricultural yields also are quite varied from region-to-region due to differences in soil fertility, available water and the use of modern agricultural technology.

The climate elements, precipitation, temperature, wind and humidity, are the main factors that affect agricultural production in Jordan. Climatic conditions are difficult to control, but the use of modern agricultural technology can minimize their effect. Understanding the relationships between climate and agriculture is extremely important if agricultural production in Jordan is to be increased. This understanding can be achieved by obtaining more accurate information about the local weather conditions from meteorological stations distributed throughout the agricultural regions in Jordan. Recording stations need to be increased in both number and distribution, particularly in the western and southern parts of the country, in order to provide more detailed information on rainfall, daily temperatures, and humidity. In addition to the normal weather data recording stations, there is a need for an increase in the number of stations making agrometeorological observations. There should be at least one additional agrometeorological observation station in each of the agricultural regions.

Through understanding the relationships between climate and agriculture and the affects of climate on soils, plants, and animals, it is possible to do one or more of the following in order to develop and to increase agricultural production according to Wiesner (1970: 93):

1) Determine the ideal climates for particular plants and those which give the highest yields.

2) Develop new species of plants to produce well in less favorable climates; plants less sensitive to climate might be bred and introduced into new regions.

3) Plan modifications to existing climates to more nearly meet the needs of plants such as the use of plastic greenhouses, the use of shelter belts, and in the control of water supply or irrigation.

The agricultural sector in Jordan has witnessed a rapid growth of agricultural production. This growth is mainly due to the expansion of irrigated acreage and shifts to higher value crops. The increase of agricultural production has occurred in crops such as wheat, barley, lentils and other legumes, and also in vegetables and fruits. There also is a great potential for increased production through the development of water resources and increasing yields. The use of new technology is required to increase production. If farming practices continue as in the past, little development can be expected. There is a need to know more about climate, soil, plants, animals and agricultural machines. Therefore, development can not occur by just investment, but the right kind of agricultural investment is required.

Despite the use of new technology, the production and yields of agriculture in Jordan remains low in comparision to many other countries. This is due to agricultural problems such as a traditional land tenure system and farm fragmentation, the risk factor associated with rainfed agriculture, the relative lack of credit and capital, the lack of well-tested and adopted improved technology, and climatic affects. There also are other important social and cultural problems. Some farmers, for example, are not able to use the new agricultural technology such as fertilizers, some machinery, and chemicals. Therefore, the Agricultural Ministry of Jordan issued "The Code of Agriculture of 1973" which states the main basis of government involvement in the organization of agricultural production. According to Aresvik (1976: 125), the "Code" carries the following functions:

1) To define areas for growing specific crops.

2) To organize the croping sequence at the level of the individual village or any other level.

3) To define the system of crop rotation.

4) To determine schedules for crop cultivation, harvest and

removal of residues

5) and to determine crop cultivation techniques including seeding rates, fertilizers, irrigation and services.

Most increases in production have resulted from irrigation, rather than from rainfed agriculture. Irrigated areas have expanded in the last two decades due to the development of water resources. Projects have been implemented to improve and manage irrigation water. These include canals (East Ghor Canal), dams, and other improvements in irrigation methods, and the use of fertilizers, machinery and chemicals to a much greater extent than they are used in the rainfed areas. These differences in production between irrigated and rainfed areas are due to the availability of a reliable water supply in the irrigation districts.

This study contains a survey of the physical aspects that influence agriculture such as topography, climate, soil, natural vegetation, and water resources. Social problems also influence agricultural production such as land tenure, traditions, and illiteracy in agricultural production. Understanding the relationships between these aspects and crops is important in order to improve and better develop the agricultural sector and to increase crop production without risk to the farmer. Physical aspects, especially climate are difficult to control, but their negative effects can be avoided by using the modern agricultural technology and obtaining more accurate information from the agricultural experiment stations distributed throughout Jordan. This study presents to the reader information about the agriculture in Jordan which can lead to better development toward increasing the agricultural production and help Jordan to become more self-sufficient in its need of food. Such development can be accomplished by:

1) An inventory of the cultivable land which would include soil types, climate, water, and topography.

2) Increase the number of agroclimatological stations in Jordan in order to collect more accurate information about moisture, wind, frost, temperature, humidity, and evaporation.

3) Improving crop seeds to tolerate Jordan's conditions and to adopt methods to decrease the climate effect on crop production.

4) Matching specific crops with areas suitable to their growing requirements which would produce higher yields.

and 5) Expand cultivated land, particularly in the irrigated areas, by implementing new projects such as the expansion of the East Ghor Canal area in order to have more land under irrigation.

VOCABULARY

1. Deforestation: The clearing of forests by natural or human causes.

2. Desert: An almost barren tract of land in which the precipitation is so scanty that it will not adequately support vegetation. Deserts are divided into: rock deserts, stony deserts, and sandy desert.

3. Dew: Water condensed onto plants and other objects on and near the ground.

4. Dew Point: The temperature at which air being cooled becomes saturated with water-vapor.

5. Ghor: The name el-Ghor is sometimes applied to the whole depression, but the term is more usually held to apply only to the part from Lake Tiberias to the Dead Sea, a region lying entirely below sea level.

6. Palestine: The country which is bounded with Lebanon from the north, Jordan from the east, Egypt from the south and the Mediterranean Sea from the west. It has become known as "Israel" since 1948.

7. Reforestation or Aforestation: Renewing of forest cover by seeding or planting.

8. Relative Humidity: The ratio of the air's vapor pressure to the saturation vapor pressure.

9. Run-off: The portion of the precipitation on an area that is discharged from the area through stream channels.

10. Wadi: The bed or valley of a stream in regions of south-western Asia and northern Africa that are dry except during the rainy season.

11. <u>Zore</u>: The Zore is the depression of the Jordan River. It is formed 200 yards (195 meters) to a mile (1,600 meters) wide and is lower than the Ghor of some 150 feet (45 meters).

The metric system is used in this study as well as the standard measuring system. Explaination of the two systems follow:

1. One mile = 1.61 kilometers

2. One square mile = 2.59 square kilometers

3. One foot = 0.3 meter

4. One yard = 0.91 meter

5. One inch = 2.54 centenmeters = 25.4 millimeter (mm.)

6. One ton = 1,000 kilograms

7. One kilogram = 2.2 pounds

8. Hectare = 10 dunums

9. Dunum = 0.247 Acre

10. $32^{o}F = 0^{o}C$ (To change Fahrenheit to Centigrade use the formula $C = (F-32)\,5/9$; or to change Centigrade to Fahrenheit use the formula $F = (C \times 9/5) + 32$.

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