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DRAFT ENVIRONMENTAL REPORT
ON
YEMEN
(YEMEN ARAB REPUBLIC)

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(Revised)

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THE UNITED STATES NATIONAL COMMITTEE FOR MAN AND THE BIOSPHERE
Department of State, IO/UCS
WASHINGTON, D. C. 20520

An Introductory Note on Draft Environmental Profiles:

The attached draft environmental report has been prepared under a contract between the U.S. Agency for International Development (AID), Bureau of Science and Technology (ST/FNR) and the U.S. Man and the Biosphere (MAB) Program. It is a preliminary review of information available in the United States on the status of the environment and the natural resources of the identified country and is one of a series of similar studies now underway on countries which receive U.S. bilateral assistance.

This report is the first step in a process to develop better information for the A.I.D. Mission, for host country officials, and others on the environmental situation in specific countries and begins to identify the most critical areas of concern. A more comprehensive study may be undertaken in each country by Regional Bureaus and/or A.I.D. Missions. These would involve local scientists in a more detailed examination of the actual situations as well as a better definition of issues, problems and priorities. Such "Phase II" studies would provide substance for the Agency's Country Development Strategy Statements as well as justifications for program initiatives in the areas of environment and natural resources.

Comments on the attached draft report would be welcomed by US MAB and ST/FNR and should be addressed to

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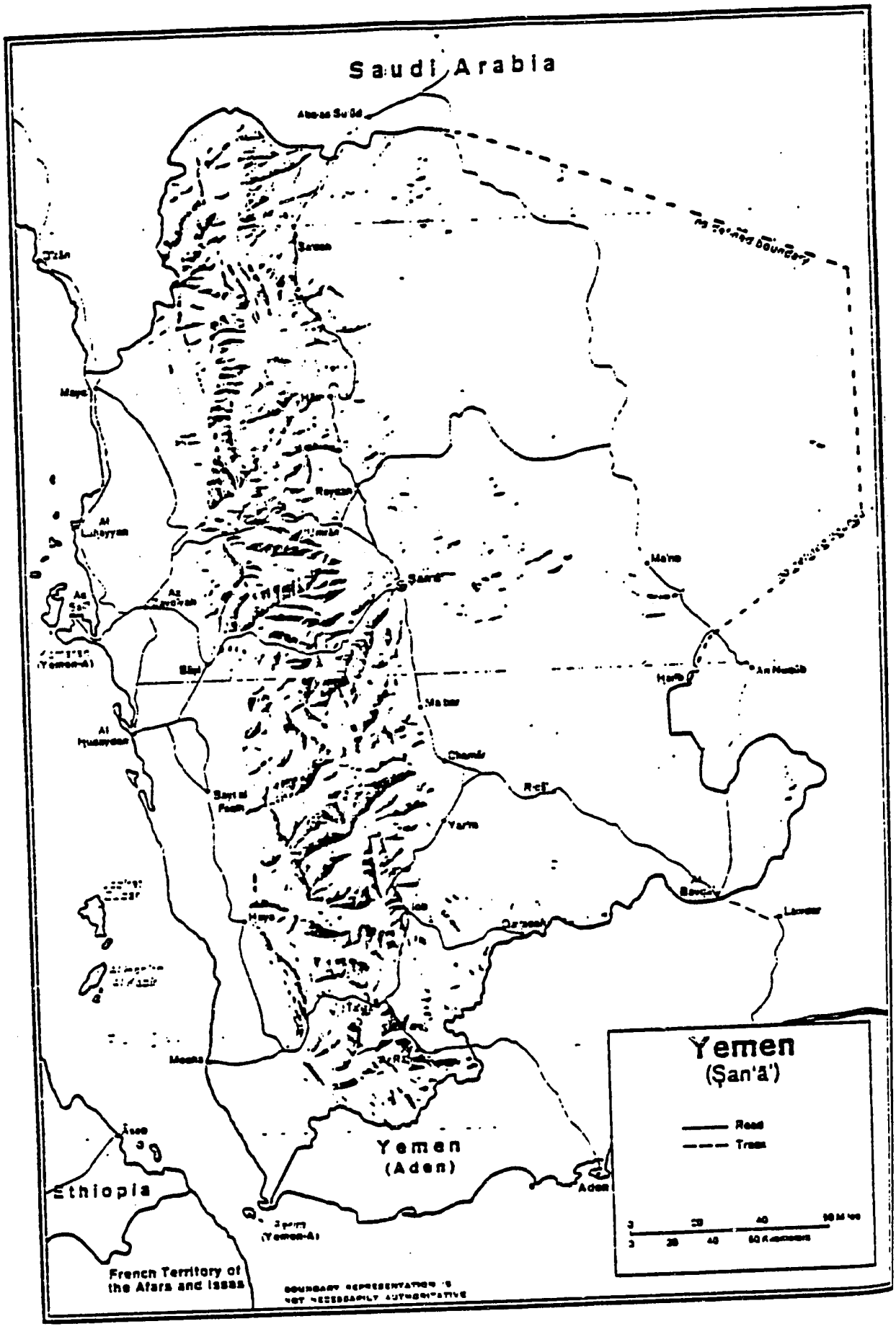
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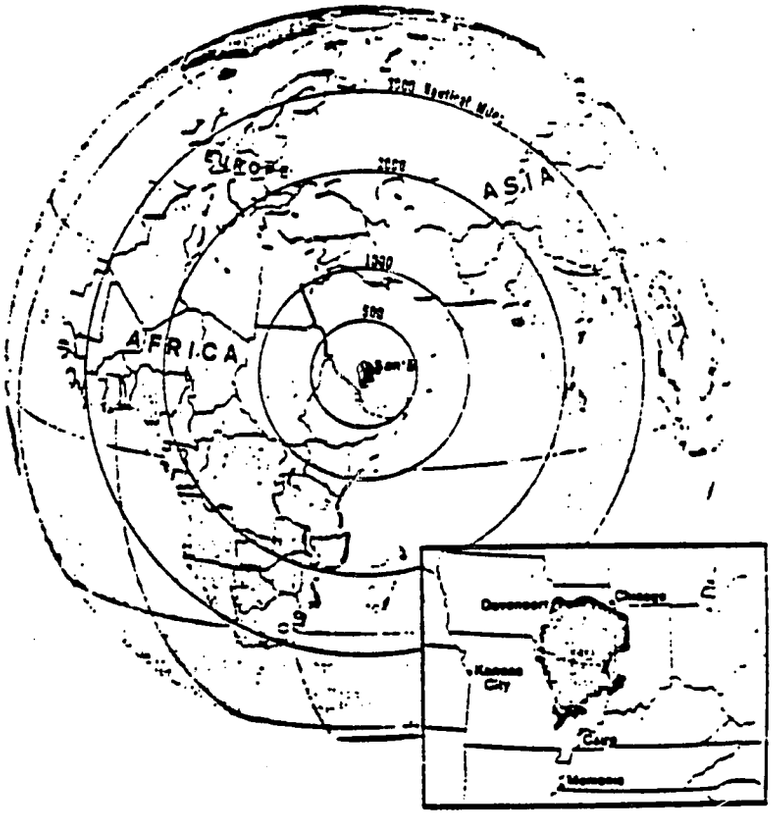

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SUMMARY

The Yemen Arab Republic (YAR) is one of the least developed countries in the world. It is not blessed with any substantial mineral resources, so that its primary resource is its agricultural and range lands. Even these are not extensive. In general, the YAR has not yet addressed most environmental problems. Implementation of any action for identified problems has not usually occurred. The government is hampered by a lack of data on nearly every aspect of the country's resources and environment.

Major environmental problems in the YAR are nearly all tied to aspects of water or agriculture, or both. These problems include:

1) Pollution of drinking water. This is a serious problem, both in rural and in urban areas. Most drinking water is obtained from shallow wells, and is easily contaminated. The normal lack of sewage and waste disposal systems in both rural and urban areas compounds the problem.

2) Water shortages. Most of Yemen suffers from scant rainfall and little surface water. Thus groundwater is the major source of water for household use. Increases in this use and in groundwater irrigation are rapidly lowering the water table in many areas.

3) Soil erosion. Wadi areas have always been subject to unexpectedly heavy floods which can destroy irrigation systems and wash away much soil. Now, as labor leaves rural areas and terraces deteriorate, erosion is becoming serious in highland agricultural areas as well. The depletion of plant cover in range and woodland areas has made soil erosion a problem even in nonagricultural areas.

4) Soil salinization. This is a particular problem in the Tihama, where irrigation with groundwater, which can be quite saline in the coastal plains, is increasing rapidly.

5) A number of other problems exist which are not yet as critical or are more local in nature. These include spreading sand dunes in the Tihama, overgrazing and depletion of range plant cover (cf no. 3), soil depletion, and problems associated with rapid urbanization.

The best researched aspect covered herein is the water resources of the YAR, and even in this area data is very inadequate for any kind of comprehensive planning. Any future research on any aspect of natural resources or the environment is not likely to duplicate much of the currently available knowledge, since there is so little. Several areas which are of critical importance and have almost no data are aspects of soil erosion, and of range and woodland management.

Mark Speece
Compiler

1.0 Introduction

This revised draft environmental report summarizes information available in the United States on the natural resources and environment of the Yemen Arab Republic. The report reviews the major environmental problems of Yemen and the impact of the development process upon resources and the environment. This report represents the first step in developing an environmental profile for use by the U.S. Agency for International Development (U.S. AID) and Yemeni government officials. The next step in this process should be a field study to evaluate the information presented here, obtain additional information, and define the issues, problems, and priorities in greater detail. This entire process should help provide direction in future efforts to deal with the management, conservation, and rehabilitation of the environment and natural resources.

The information and interpretations in this report are preliminary and are not intended to attain the detail and accuracy required for development planning. The YAR is still in the beginning stages of development, and detailed information is often not available. Thus, the content of this report itself is a fairly accurate guide to the extent of current knowledge and data available on the YAR. The report represents a cooperative effort by the Man and the Biosphere (MAB) project staff of the Arid Lands Information Center (ALIC). The primary research, writing, and analysis of the original report, as well as of this revision, were done by Mark Speece, through the resources of ALIC and the University of Arizona Library. James Silliman edited this revised version. Particular thanks are extended to Dr. Michael Bonine for the use of materials obtained in Yemen, and to Dr. Edmund Weber for access to documents of the Yemen Title XII Program. The cooperation of James Corson, AID/MAB Project Coordinator, and other AID personnel is gratefully acknowledged.

2.0 General Description

2.1 Geography and Climate[1]

The area known as Yemen lies in the southwestern corner of the Arabian Peninsula. Politically, Yemen has been divided in modern times into two states: the Peoples Democratic Republic of Yemen (PDRY), often called South Yemen or Yemen (Aden); and the Yemen Arab Republic (YAR), usually called North Yemen or Yemen (Sana).

The Yemen Arab Republic covers approximately 200,000 square kilometers (75,000 square miles). The Red Sea provides the western boundry. Saudi Arabia borders the YAR on the north and northeast, and the PDRY borders on the southeast and south. The YAR's easternmost borders with its two neighbors are not yet demarcated.

Discussions of the Yemen Arab Republic's geography are occasionally based on division of the country into three major hydrographic regions (Bernhardt et al. 1980, Swiss Technical Co-operation Service 1978; see Appendix I, Fig. 1). Detailed climatological data based on these divisions is presented in Appendix I. However, usually two major geographical regions are recognized in the YAR (Fig. 1.1): The Tihama, or coastal plain, and the mountainous interior. Often the eastern part of the country, which slopes down from the mountains and fades into central Arabia and the Rub al Khali, is also called a separate region.

2.1.1 The Tihama

The coastal plain of the YAR extends nearly 600 km from the Bab al Mandab in the south to the border of Saudi Arabia. Geographically it continues into Saudi Arabia, as do the other regions. This 30 to 60 km wide region ranges in elevation from sea level on the coast to about 200 m in the foothills. Annual rainfall for the Tihama ranges between 50 and 300 mm, and falls quite

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[1] Sources: Council of Arab Economic Unity. 1977.
Faroughy. 1947.
Nyrop et al. 1977.
World Bank. 1979.

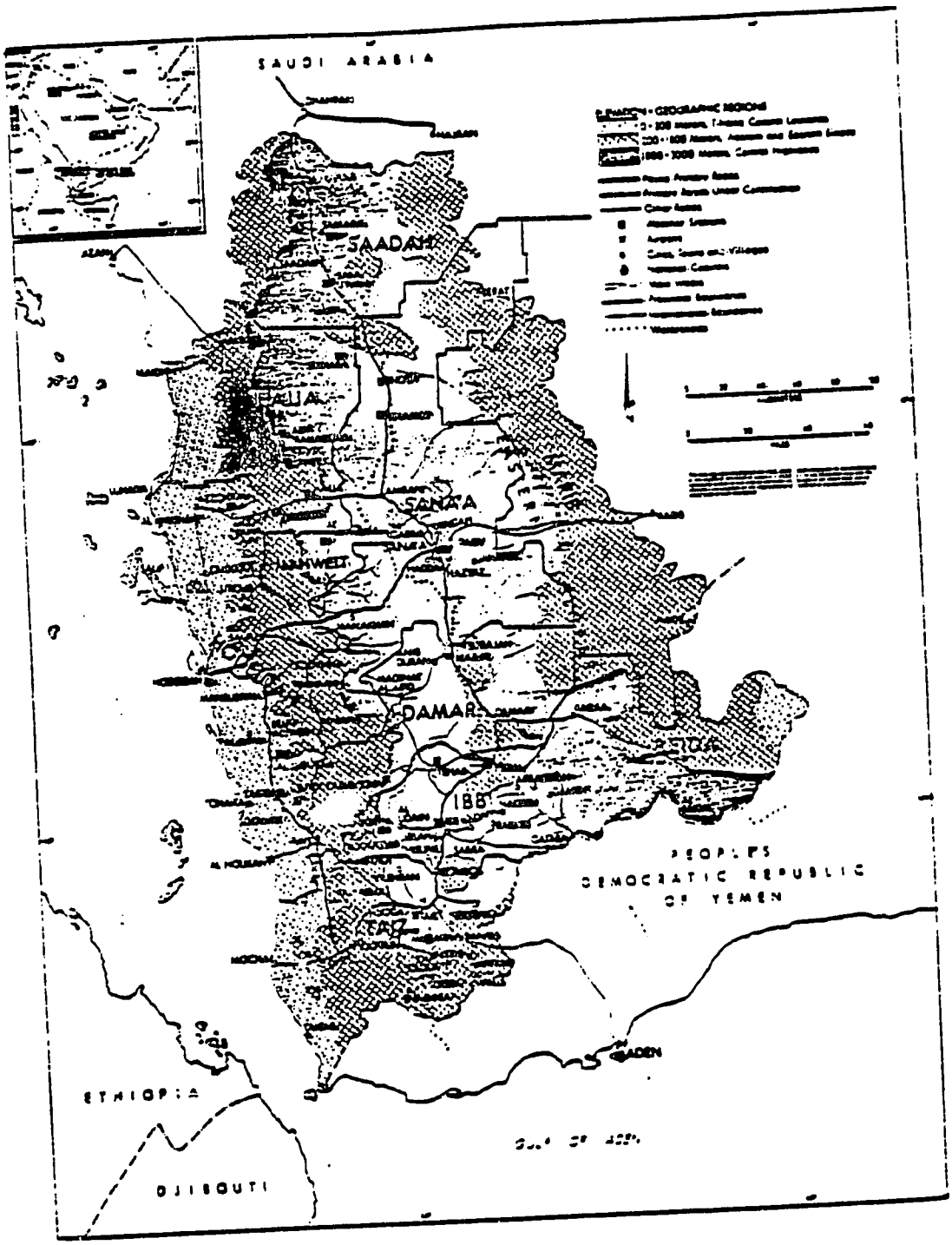

Figure 1.1 Physical Regions and Hydrography

Source: World Bank. 1979.

erratically. Average temperatures are quite high year round (Hodeida, 1974: low 19°C, high 38.8°C), often climbing over 54°C. Humidity is usually between 50 and 70 percent. High winds often come in from the sea, causing sandstorms and soil erosion. Dryland farming can only be practiced under these semidesert conditions in years of exceptional rainfall, but about 70,000 ha are cultivated under spate irrigation and another 25,000 ha under well irrigation.

2.1.2 The Interior Highlands

In the interior of the country elevation climbs from the area of the western foothills (200 to 1500 m) to peaks exceeding 3000 m in the central highlands. Seven major wadis run out of the highlands to the Red Sea, three run to the east and two major ones flow southwards. Most of these are perennial in the upper reaches, but rarely reach the sea except at high flood times. Rainfall varies considerably in the interior. Generally it becomes wetter from north to south and from lower to higher elevation. Lower levels of the western foothills may get 250-300 mm annually. Annual averages in the northernmost areas of the highlands may be as low as 100 mm, while the figure for Ta'izz province is over 600 mm. Ibb recorded an annual average for 1970-73 of 1100 mm. Temperatures in the highlands are quite comfortable, with average summer highs of ca 21°C and lows in winter around 4°C. The interior is traditionally the major agricultural area of the Yemen Arab Republic. Most cultivation must be practiced on terraced land, and most is rainfed rather than irrigated.

2.1.3 The Eastern Slopes

This approximately 80,000 sq km region slopes gently eastward into the Rub al-Khali. Very little climatic data is available on the area beyond the general observation that it may be classed as varying from semi-desert to desert. Little agriculture is practiced here; rather it is primarily an area of nomadic herding.

2.2 Demographic Characteristics[2/]

2.2.1 Population

Population estimates for the Yemen Arab Republic vary widely, even when they are supposedly based on the same source. Population may have reached almost 6 million in 1980. Only 11 percent of this population lives in settlements of greater than 2,000 inhabitants. The largest cities/towns (1976) are the present capital, San'a (134,588); Hodeida (80,314); and Ta'izz (78,642). The only other towns of any size are Dhamar (19,167) and Ibb (19,066). Population densities are highest in the general area within the San'a-Hodeida-Taizz triangle, and are quite low elsewhere, especially in the northern Tihama and in the eastern foothills and desert. Net annual population increase has been variously estimated at between 1.86 and 2.2 percent, surprisingly low for a developing country.

2.2.2 Composition

Although the Yemen Arab Republic is almost completely Arab and Arabic speaking there are a number of divisions in the society which continue even now to cause some difficulties. One major division is along religious lines. About 60 percent of the population of the YAR is Sunni of the Shafi'i school. In general they inhabit the Tihama and western foothills, and the southern highlands around Ibb and Ta'izz. The other 40 percent are of the Zaidi branch of Shi'ism. Though a minority, the government was Zaidi until the 1962 revolution. Zaidis are concentrated in the central and northern highlands. Tribalism also serves to divide Yemeni society. Although the vast majority of Yemenis are sedentary cultivators, tribalism remains firmly entrenched, particularly in Zaidi areas. This can have effects on rural development schemes. For example, lineage groups rather than individuals may hold certain land or water rights.

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[2] Sources: Middle East Economic Digest. 21 December 1979.
Nyrop et al. 1977.
Socknet and Sinclair. 1978.
Swiss Technical Co-operation Service. 1978.
World Bank. 1979.

2.2.3 Migration

Approximately 50 percent of the population of Yemen is under 15 years of age. The population pyramid for ages above 15 is quite distorted on the male side because of extensive migration out of the country for employment. An estimated 1.5 million Yemenis, mostly males, live outside of Yemen. While remittances from their earnings help alleviate foreign exchange problems and help to raise the standard of living somewhat, this trend has led to severe manpower shortages within Yemen, especially in the agricultural sector. Rural to urban migration within the YAR is also occurring, but is not well documented.

2.2.4 Public Health

Health conditions of the population are still quite poor. The death rate is nearly 29 per thousand, and life expectancy at birth averages about 37 years. Major reasons for the low standards of public health include inadequate nutrition, poor and overcrowded housing, lack of personal hygiene, and an acute shortage of medical personnel. Average daily per capita caloric consumption between 1972-74 fluctuated around 2000, about 83 percent of the estimated daily requirement. Shortage of medical personnel is compounded by the uneven distribution: 87 percent of the 234 physicians are in the provinces of the three major cities which contain 52 percent of the population and most of these are in the three cities themselves. Environmental problems have a direct effect on these health problems. For example, use of polluted water and lack of effective sewage disposal create favorable conditions for endemic diseases. The government began to tabulate diseases in 1975, when the following number of cases were reported (Nyrop et al. 1977):

gastroenteritis	17,909
malaria	8,118
amoebiasis	6,289
bilharzia	3,932
typhoid	3,705

Incidences of certain diseases are estimated as follows (Swiss Technical Co-operation Service 1978):

bilharcia schistomasias	97 per 1,000 inhabitants
tuberculosis	25 per 1,000
malaria	20 per 1,000
intestinal parasites and dysenteries	850 per 1,000

The actual incidence must be assumed to be much higher. Many other diseases are known in the YAR, including tuberculosis, trachoma, helminthiasis, cholera, hepatitis, and bacillary dysentery.

2.3 Economic Characteristics[3]

The economy of the YAR is heavily oriented toward agriculture. By World Bank figures 45 percent of the GDP in 1975/6 was accounted for by agriculture, fishing, and forestry. It is more common to find estimates of over 60 percent for agriculture's share. Seventy-three percent of the workforce is employed by agriculture, and 85 percent of export earnings were for raw agricultural goods in 1976/77. Processed agricultural products accounted for another 11 percent of exports by percent value.

Yemeni agriculture is still predominately subsistence, though in recent years cash cropping has increased. Only about 8 percent of Yemen's land area was cultivated in 1976, and another 10 percent was classified as marginally cultivatable. Of the 1,515,000 hectares cultivated, 85 percent were dependent on rainfall. Sorghum and millet are the major crops. Maize, wheat and barley are also extensively planted, as are vegetables and fruits. The main cash crops are cotton and qat, a shrub very popular in Yemen for its narcotic leaves.

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[3] Sources: Nyrop et al. 1977.
Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens, Annual Supplement. 1979.
Socknet and Sinclair. 1978.
U.S. AID Project Design Information (INQUIRE). 1980.
U.S. AID All Data. 1979.
World Bank. 1979.

Agriculture in Yemen has been declining in recent years. A major factor in this has been the vast migration out of rural areas, especially abroad, which has led to serious labor shortages. Remittances sent back from abroad also reduce incentive to keep farming marginal land. Domestic popularity of qat has led to a decline in production of coffee, with which qat competes ecologically. Thus, the YAR is not self-sufficient in agriculture at the present, and prospects seem to be worsening.

The government hopes to reverse this, and in the 5 year plan (1976/77-1980/81) is aiming to work towards self sufficiency in food production, reduce the trade deficit in agricultural goods, and improve the quality of agricultural products. About 14 percent of the total YR 16 billion budget for the plan is to be spent directly on agriculture.

Other sectors of the economy, in order of contribution to the GDP, are trade (24%), government (10%), industry, mining, and electricity (6%) and construction (4%). The major industries are light, such as textiles, food processing, and building materials. The investment in industry (including construction) under the five year plan is to be about 25 percent of the total expenditure, and nearly 31 percent is to go toward transport and communications.

The Yemen Arab Republic's ambitious five year plan is nearly 85 percent dependent on foreign aid. A good proportion of this aid is expected from various Arab sources, and the rest from the World Bank, the United Nations, and from the industrial nations, both east and west. U.S. AID in the late 1970s has been involved primarily in implementing and improving water systems in urban areas, and in several agricultural projects, particularly sorghum and millet improvement and poultry planning. A common problem in many of the projects has been the inability of the YAR to provide qualified Yemenis to take part.

3.0 Natural Resources

3.1 Geology and Mineral Resources

3.1.1 Geology

The USGS - ARAMCO Geologic Map of the Arabian Peninsula (1963) distinguishes 22 major geologic formations in southwest Arabia, as follows (Fig. 3.1 and Table 3.1):

Qe. Aeolian sand, which is commonly mobile, is found in large areas of the eastern deserts.

Qu. Wadi terrace deposits, alluvial fans, gravel, sand, and silt, with numerous loess deposits particularly in the central plains. This formation predominates in the Tihama, where it may include coralline deposits below the 3 meter terrace. It also covers extensive areas of the eastern desert and occurs in patches in the highlands.

Qa. Consists of predominately basaltic lava and pyroclastics in lava flows and numerous scattered cones and craters. In places it is covered with tuff and volcanic bombs. Large patches occur near San'a, Dhamar, and Marib, with smaller patches scattered throughout the mountainous areas.

Qg_2. Consists of gravel, limestone, and other components forming dissected remnants unrelated to present or recent drainage. It occurs in the northeastern deserts along the borders with Saudi Arabia.

Ta. Hypabyssal andesite and diabase intrusives, commonly glomeroporphyritic and in dike swarms. In the YAR this formation is found only in small patches of the western foothills near the Saudi border.

Tla. These basaltic and granitic laccoliths occur only in small patches of the northern highlands. The largest are found just south of Sa'dah where the composition is granitic.

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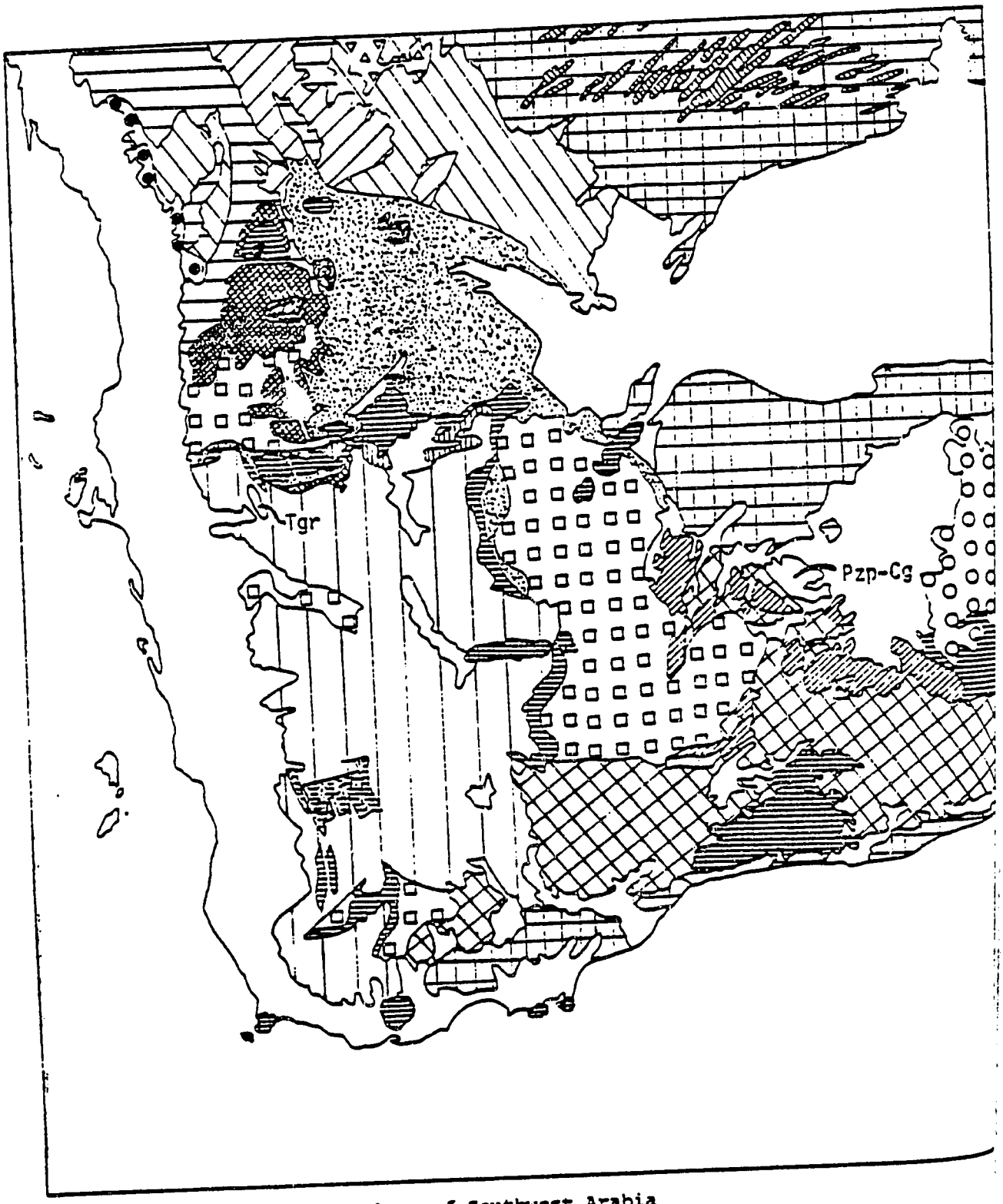

Figure 3.1. Geology of Southwest Arabia

Source: USGS - ARAMCO. 1963.

Table 3.1 Geologic Formations of Southwest Arabia

Quaternary	Qe		Eolian sand
	Qn		Alluvium and related surficial deposits
	Qa		Aden Volcanic Series
	Qg_2		Gravel
Tertiary	Ta		Andesite and diabase
	Tla		Laccoliths
	Tgr	*	Granite
	Tj Tu		Jeza Formation Umm-er-Radhuma Formation
	Tm		Medj-zir Series
Cretaceous	Tkt		Trap Series, in places overlies Tm
	Kt		Tawilah Group
Jurassic	Jam		Amran Series
	Jko		Kohlor Series
Permian or Older	Pw		Wajid Sandstone
Precambrian to Paleozoic	Pzp-Cg	*	Precambrian (?) synkinematic and Paleozoic postkinematic granite rocks
Precambrian	hr		Hybrid rocks
	ur		Precambrian rocks undivided
	mr		Precambrian metamorphic rocks
	gr		Calc-alkaline granite
	gg		Granite gneiss
	wh		Hali Schist

* Noted on map.

Source: USGS - ARAMCO. 1963.

Tgr. Small patches of leucocratic granite with some amphibole and tourmaline crystals occur in the highland areas, mostly between San'a and the coast.

Tm. Consists of crossbedded sandstone with locally fossiliferous, calcareous sandstone, and shale. Sandstone in the upper part may be locally rich in hematite. Small patches occur mainly in the highlands near San'a.

Tkt. Consists of basalt, rhyolite, andesite, trachyte, and pyroclastics with interbedded lenses of fluviatile and lacustrine sand, clay, and shale. Locally it may contain freshwater Oligocene-Miocene fossils. At least 1200 m in thickness, in places this formation overlies Tm. This is the most common highland formation and occurs throughout the central and southern mountains.

Kt. This is continental coarse crossbedded sandstone with lenses of conglomerate and gravel, and interbedded shale and sandstone in the lower part. It overlies rocks of Jurassic age or basement complex. Bands of this formation are found around the fringes of Tkt, especially west of San'a, along the eastern foothills, and southwest of Ta'izz. Small patches also occur just southwest of Sa'dah.

Jam. This formation of limestone, marl, and shale is the predominant type in the northern highlands and northeastern foothills. Local areas include detrital beds in the lower part. The series is overlain by a less widespread Upper Jurassic transition zone of gypsum, clay, marl, shale, sandstone, and some limestones.

Jko. Consists of green shale with sandstone and conglomeratic bands in the lower part, sandstone and some conglomerates in the upper part. The formation is common in the northwestern highlands.

Pw. Consisting of partially crossbedded, locally conglomeratic sandstone, the formation also includes common quartz granule and pebble zones. It is common in southwest Saudi Arabia and occurs in the YAR near the northern interior border with that country.

Pzp-Cg. Predominantly granitic rock of Precambrian age, but includes some younger Paleozoic granite. The formation occurs in small patches in the southeast interior, near the PDRY border.

hr. Hybrid rocks affected by variable and generally intense granitic invasion and feldspathization. They occur in small patches in the southeast interior near the PDRY.

ur. Predominantly granite, gneiss and mica schist with subordinate quartzite, syenite, and hornblende schist, the formation locally includes marble with ilmenite mineralization. It is common throughout the southeastern interior, in the northwestern highlands, and occurs in patches throughout the highlands. Sometimes considered equivalent to mr, Pzp-Cg, and hr.

mr. This formation consists of metamorphic rocks, schist, gneiss, quartzite, chert, crystalline limestone, and granulite. It occurs throughout the southern highlands and foothills, and is particularly common in the PDRY.

gr. Consists of gray and pink hornblende granite, which is generally massive and weathers into bornhardts. It occurs in the YAR near the Saudi border north of Sa'dah.

gg. This formation consists of gray granite with many inclusions and xenoliths. It weathers into pits and caves. Found in northern foothills areas, on both sides of the mountains near the Saudi border.

wh. Consists of chlorite-sericite schist, amphibolite schist, graphitic schist, marble quartzite, slate, jaspilite, conglomerate, and interbedded greenstone derived from basalt. It occurs in the northern highlands near the Saudi border.

Figures 3.2 through 3.6 show geological cross-sections from several areas in the YAR.

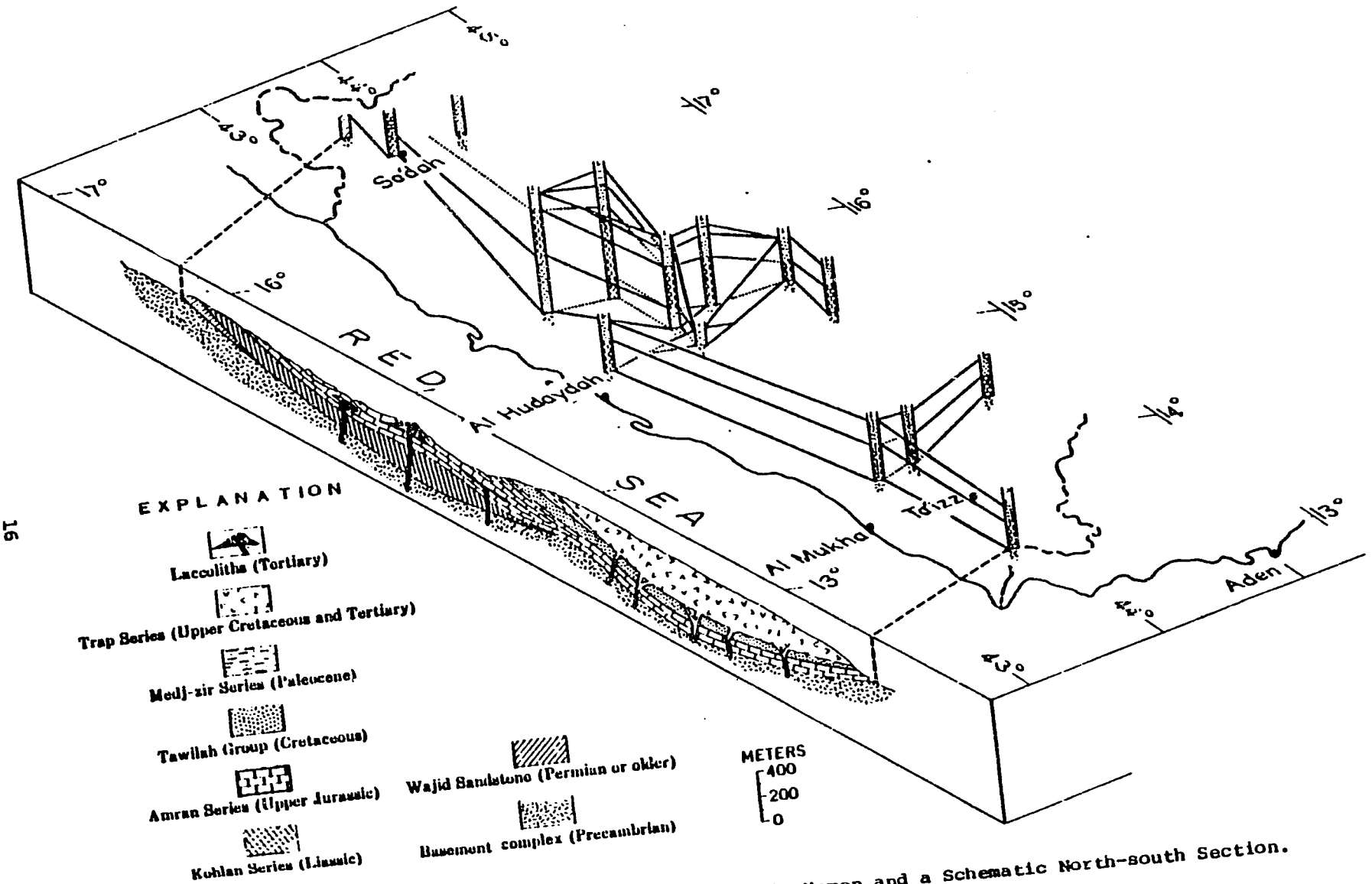

Figure 3.2 Block Diagram Showing Sedimentary Units in Yemen and a Schematic North-south Section.

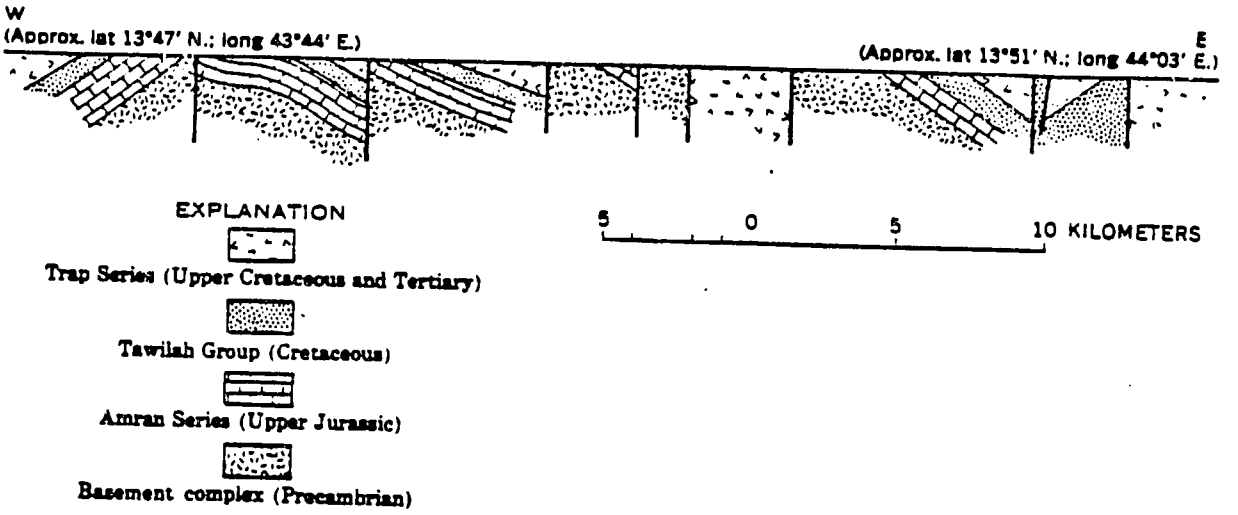

Figure 3.3. Schematic Profile of North of Ta'izz Showing Horst Through Tran Series.

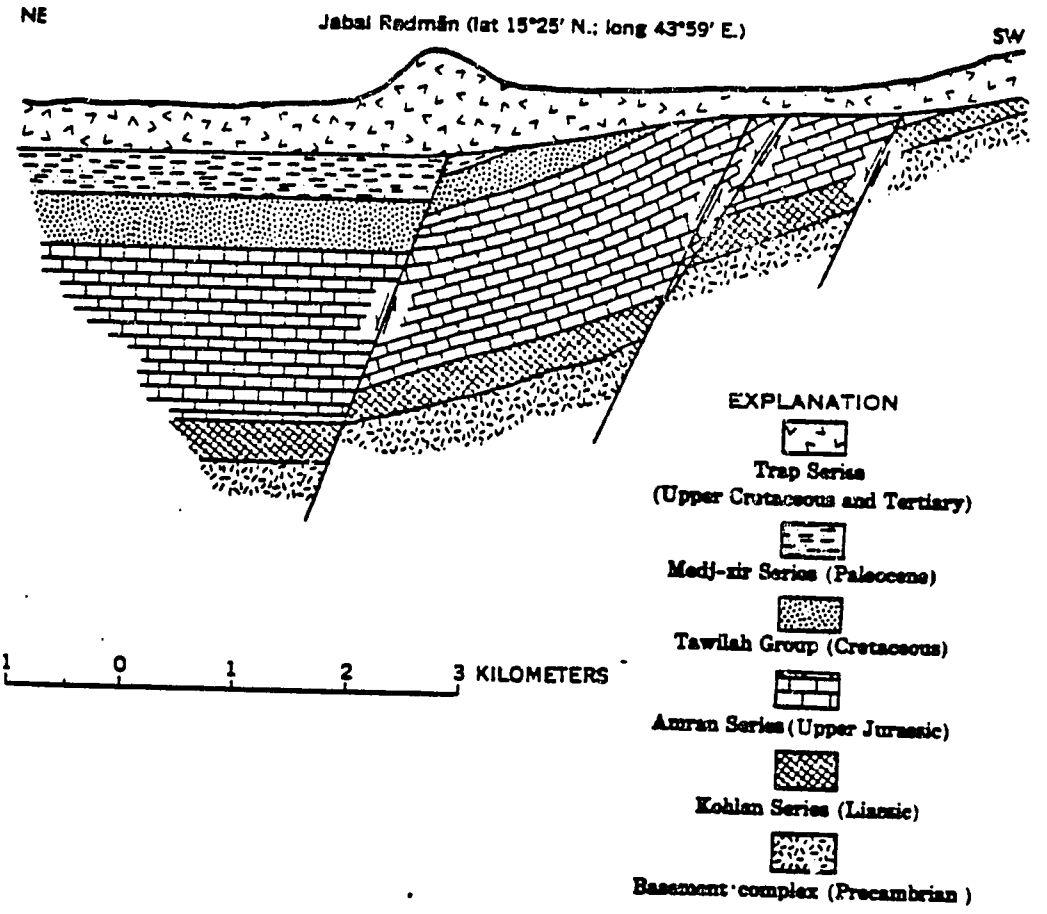

Figure 3.4 Structure Section in Vicinity of Jabal Radman (West of San'a).

Source: Geukens. 1966.

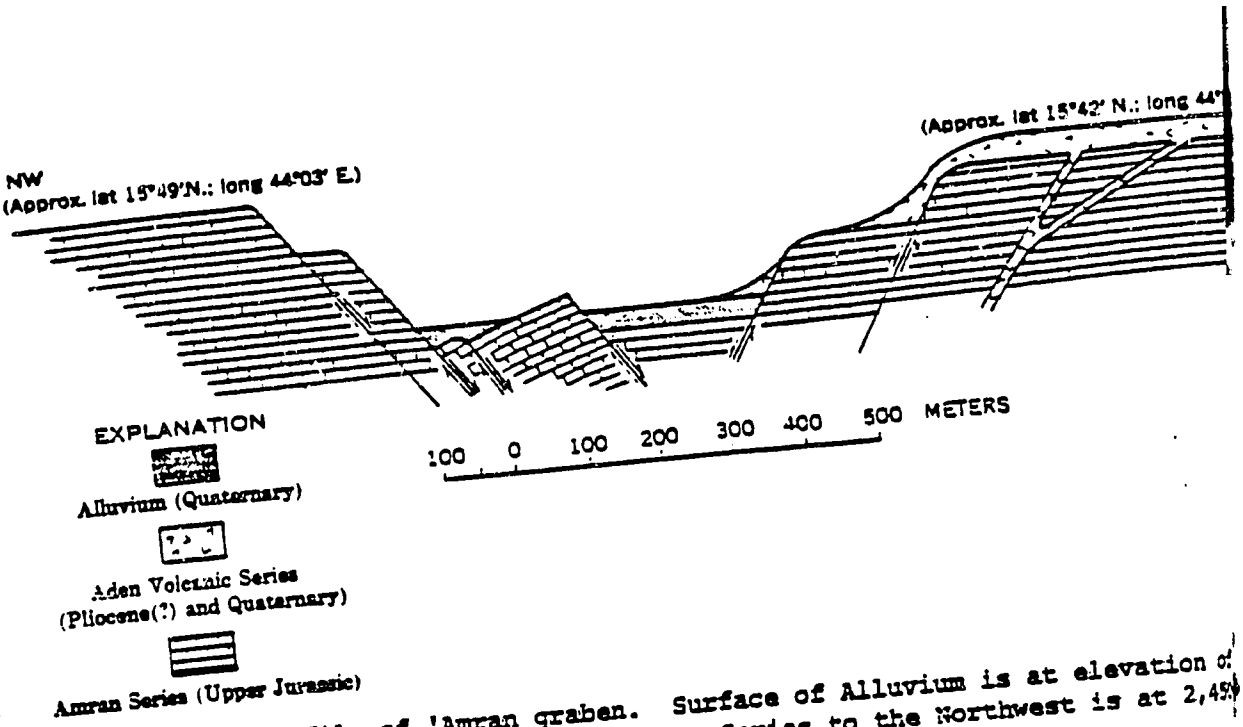

Figure 3.5: Profile of 'Amran graben. Surface of Alluvium is at elevation of 2,100 m; surface of the Amran Series to the Northwest is at 2,45

Source: Geukens. 1966.

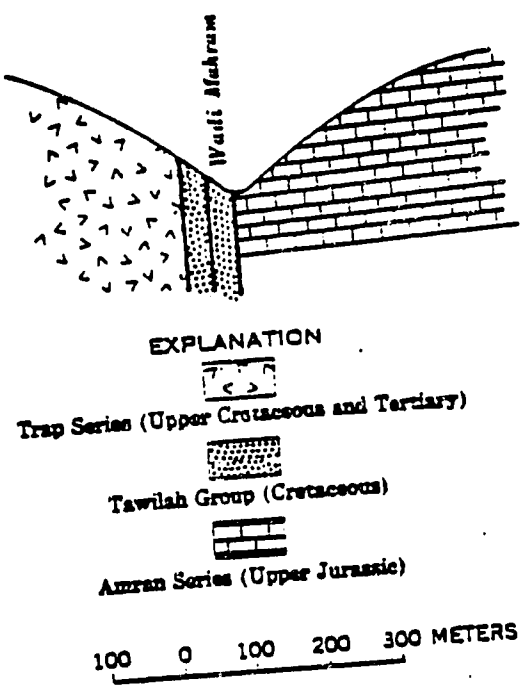

Figure 3.6: Profile of Wadi Mahram (lat 15°20'N.; long 43°55'E.) showing Fault Contacts of Trap Series, Tawilah Group, and Amran Series.

Source: Geukens. 1966.

3.1.2 Mineral Resources[4/]

The Yemen Arab Republic seems to have very few mineral resources which could aid economic development, although medieval writers regarded the area as rather rich in minerals. The only minerals currently being exploited are rock salt and building materials such as gypsum and limestone. The Yemen Salt Mining Corporation, the only large mining company in the YAR, is currently producing rock salt in the area of Salif (75 km north of Hodeida). Capacity is about 1 million tons per year of salt grading 98.2 percent NaCl. Proven reserves at Salif are about 72 million tons if mined to a depth of 50 m, or 115 million tons mined to 80 m. Rock salt has also been discovered in the eastern interior (Fig. 3.7) near Marib, but it is not currently being mined.

Gypsum and gypsiferous beds are associated with the rock salt deposits near Salif, and about 2300 tons are produced annually for the cement plant at Bajil (about 100 km southeast of Salif, 60 km east of Hodeida). Another few thousand tons are consumed locally for construction from the deposits around San'a, Ta'izz, and Heis (between Ta'izz and Hodeida). Alabaster is quarried in small amounts in the eastern foothills west of Marib. Other industrial minerals such as graphite, mica, marble, chalk, limestone and dolomitic limestone, sandstone suitable for the glass industry, sulfur, saltpeter, and coal occur in various areas. They are not currently being exploited and there is some question of whether any are present in sufficient quantity to make exploitation economically worthwhile.

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[4] Sources: Faroughi. 1947.
Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens, Annual Supplement. 1979.
el-Shatouri and al-Eryani. 1979.
UNESCO. 1976.
U.S. Dept. of the Interior. Bureau of Mines. 1976.
U.S. Dept. of the Interior. Bureau of Mines. 1979.

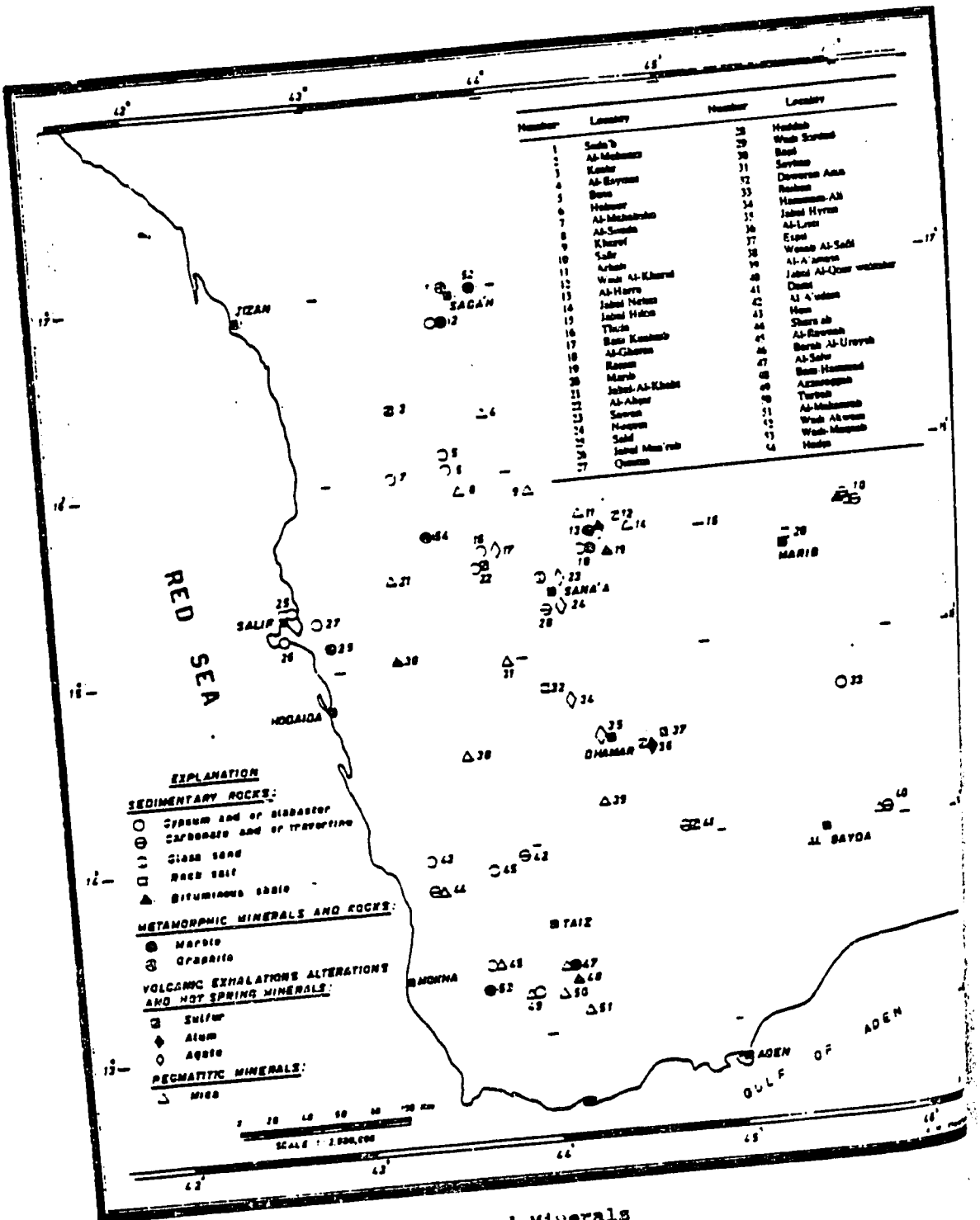

Figure 3.7: Industrial Rocks and Minerals

Source: el-Shatouri and al-Eryani. 1979.

Metalliferous deposits in the YAR are classed into seven associations: 1) copper-cobalt-nickel, 2) copper-lead-zinc (cadmium), 3) copper-(silver-gold), 4) lead-(zinc), 5) iron, 6) tin, and 7) uranium - (thorium) (el-Shatouri and al-Eryani 1979). One of the major Cu-Co-Ni areas is located about 40 km southeast of Ta'izz (Fig. 3.8). Analyses of four samples from al-Hamura (within the Cu-Co-Ni area) are presented in Table 3.2. Other samples have reported to assay at up to 19 percent Cu. At another location in the same area analysis showed 45.0 percent Fe, 10.0 percent Cu, 2.0 percent Ni, and 1.5 percent Co.

Table 3.2 Mineral Analyses from al-Hamura and Marib

	% of element in sample				
			Al-Hamura		Marib (?)
Element	1	2	3	4	5
Si	3-10	3-10	3-10	3-10	n.d.
Al	0.50	0.13	0.60	10.00	n.d.
Fe	n.d.	n.d.	n.d.	n.d.	15.0
Ca	0.2	0.2	0.3	1.3	15.0
Mg	0.2	0.2	0.4	0.7	3.0
Ti	0.08	0.08	0.20	0.01	0.03
Cu	10	10	1	10	2
Zn	0.03	0.04	0.02	0.03	1
Co	1.00	2.30	0.03	0.60	0.05
Ni	1.0	3.0	0.3	1.0	0.015
Pb	0.015	0.015	0.015	0.015	2
Ca	n.d.	n.d.	n.d.	n.d.	0.05
Cr	0.030	0.005	0.001	0.003	n.d.
Sn	n.d.	n.d.	n.d.	n.d.	0.03
Ag	n.d.	n.d.	n.d.	n.d.	0.07
Bi	n.d.	n.d.	n.d.	n.d.	0.03
Ba	n.d.	n.d.	n.d.	n.d.	0.5
Sb	n.d.	n.d.	n.d.	n.d.	0.3
Sr	n.d.	n.d.	n.d.	n.d.	0.15

Source: el-Shatouri and al-Eryani. 1979.

Table 3.2 also includes data on a sample from the Cu-Pb-Zn (Ag-An) area near Marib. The actual values of Cu, Pb, and Zu are much higher than indicated, due to limitations in the methods of spectrographic determination. Data on the other associations is not readily available. As with most industrial minerals, metals are not currently being exploited and may not be present in sufficient quantities for economic exploitation. Oil has been and is currently being prospected, particularly off-shore in the Red Sea, but without success so far.

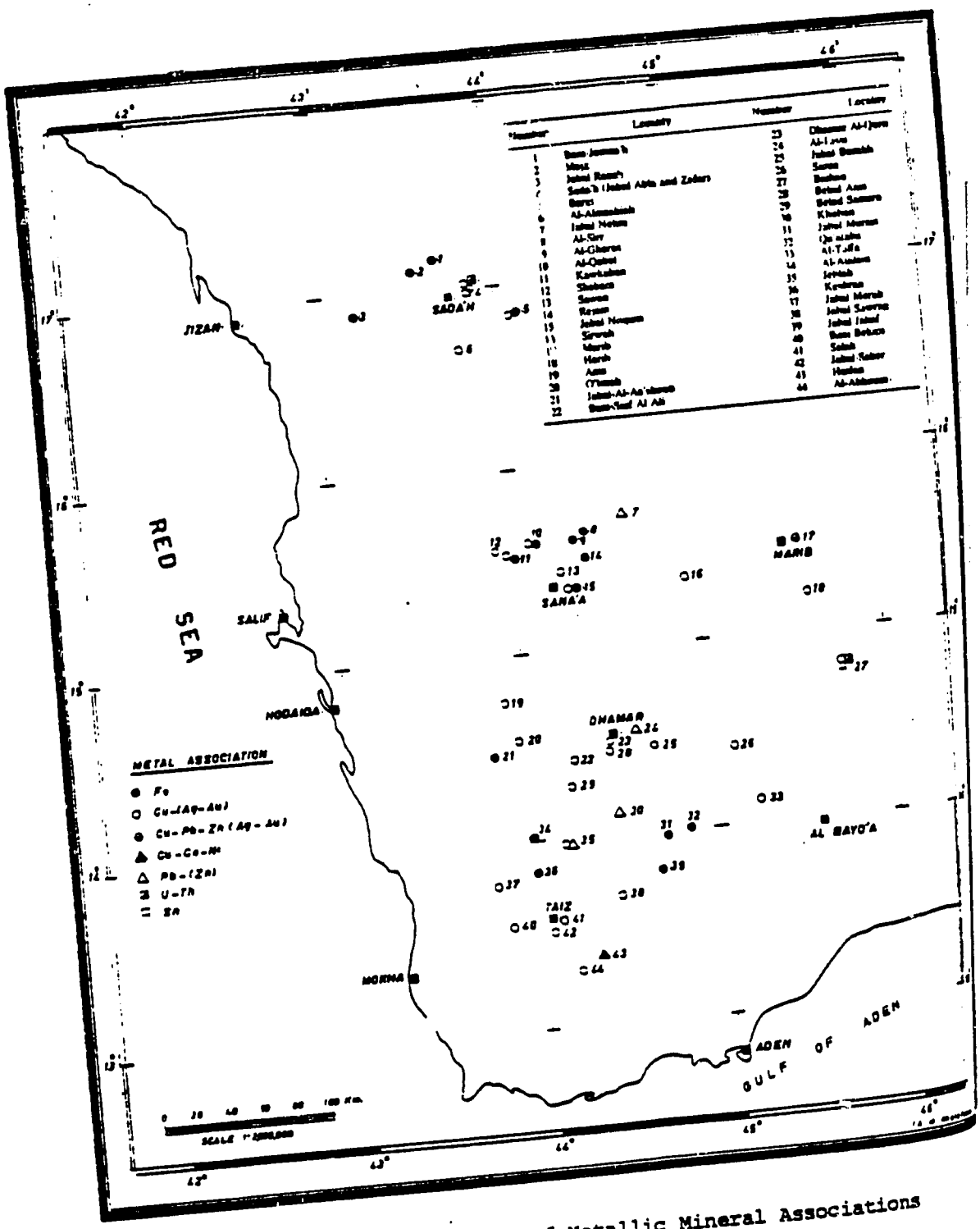

Figure 3.8: Spatial Distribution of Metallic Mineral Associations

Source: el-Shalouri and al-Eryani. 1979.

3.2 Water Resources

3.2.1 Surface Water[5/]

Compared with the rest of the Arabian Peninsula, Yemen receives a large amount of rainfall. Rains come in two distinct periods: March through May, and July through September, which is the heavier rainfall season. Since the rains come from the Indian Ocean monsoon system, the most well watered provence is Ibb, where 1468 mm was the average at the town between 1970-1976. In general, rainfall drops off with increasing distance from Ibb. For example, at Ta'izz, southwest of Ibb, a 24 year average ending 1976 was 580 mm; at Yarim, to the northeast, it was 497 mm (1970-76). As far north as San'a, this six year average was only 181 mm, and at Zabid, in the Tihama, 140 mm. However, rainfall can be quite erratic, and an extended drought such as the one between 1967-73 may severely damage agriculture in all but the most heavily watered areas around Ibb.

Most agriculture is either directly dependent upon rainfall, as in the highlands, or indirectly utilizes rainfall by irrigating with surface runoff, as in the Tihama. Agricultural areas in lowland regions are therefore generally confined to land near wadis. Seven major wadis drain into the Red Sea, two to the Gulf of Aden, and a number drain the eastern slopes. Figure 3.9 shows the major wadis, and Table 3.3 gives catchment areas for most of them. Topographic profiles of representative wadis are shown in Figure 3.10. Hydrometeorological data and streamflow data are presented in Tables 3.4 and 3.5 respectively. Figures for streamflow are usually taken at a point near the base of the mountains.

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[5] Sources: Bernhardt et al. 1980.
al-Eryani. 1979.
Escher. 1976.
Nyrop et al. 1977.
Pratt. 1977.
Swiss Technical Co-operation Service. 1978.
U.S. AID. 1977.
World Bank. 1979.

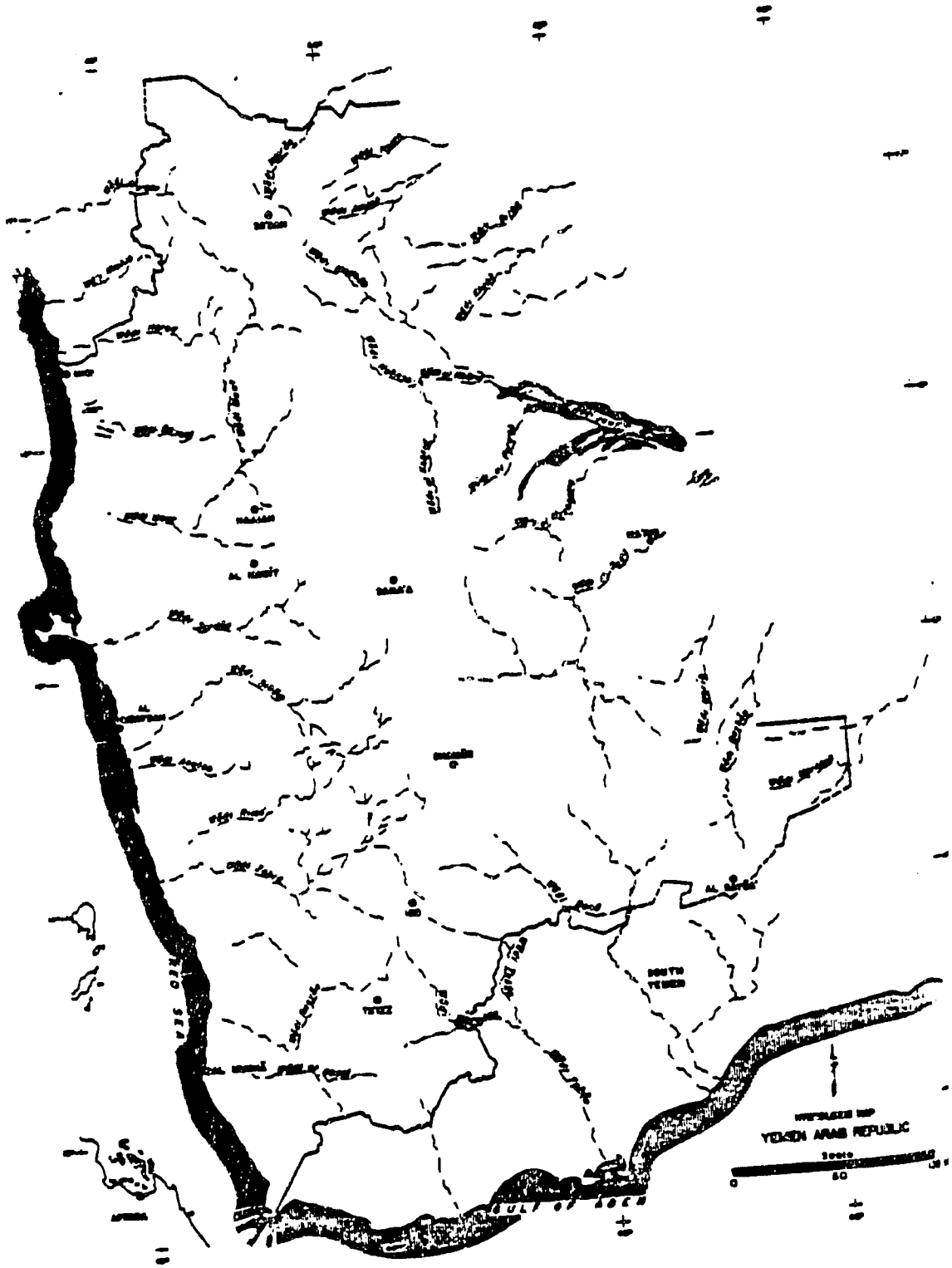

Figure 3.9: Major Wadis

Source: Bernhardt et al. 1980.

Table 3.3 Drainage Areas of Major Wadi Courses

WESTERN ESCARPMENT	
Wādi Mawr	7.500 sq km
Wādi Surdud	2.450 sq km
Wādi Siham	3.200 sq km
Wādi Rima'	2.450 sq km
Wādi Zabid	4.500 sq km
Wādi Rasyan	1.700 sq km
Wādi Mawza'	1.300 sq km
Total	[illegible].150 sq km

SOUTHERN ESCARPMENT	
Wādi Tuban	3.550 sq km
Wādi Bana	5.900 sq km
Total	9.450 sq km

EASTERN ESCARPMENT	
Wādi Amiah	1.000 sq km
Wādi Khabo	1.400 sq km
Wādi Awban	800 sq km
Wādi Madhab	2.700 sq km
Wādi Hirrsa	3.000 sq km
Wādi Kharid	3.100 - 7.000 sq km
Wādi Saba'	8.900 - 11.300 sq km
Wādi Harib	1.000 sq km
Wādi Bayhān	2.450 sq km
Total	30.650 sq km

Source: Bornhardt et al. 1980.

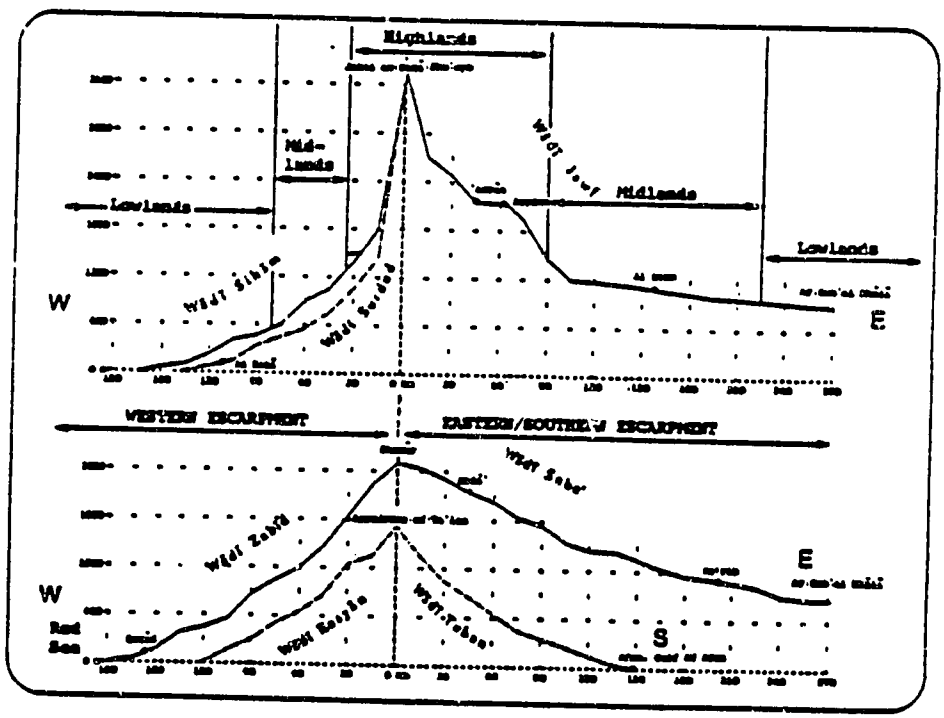

Figure 3.10: Topographic Profiles along Seven Selected Wadi Courses

Source: Swiss Technical Co-operation Service. 1978.

Table 3.4 Hydrometeorological Data for Major Wadis

Wadi	Catchment Area (km^2)	Median Annual Rainfall (mm)	Median Annual Volume of Rainfall (MCM)	Median Annual Runoff (MCM)
Mawr	7912	524	4144	237
Rima	6420	460	2953	167
Bayah	5164	350	1807	235
Tuhom	5060	460	2328	200
Zabid	4338	665	2885	199
Itwad	1554	163	253	32
Liyyah	1293	266	344	38
Jizan	1100	480	528	58
Dhamad	1084	346	375	37
Khulah	869	500	435	63
Sabya	843	275	232	30

Source: al-Eryani. 1979.

Table 3.5 Summary of Available Streamflow and Relevant Data at Wadis Mawr, Surdud, Rima, and Zabid.

Wadi	Year	Average Rainfall (mm)	Rainfall Volume (MCM)	Runoff Volume (MCM)	Runoff/Rainfall (%)
Mawr	1975	493	3901	162.1[a]	4.2
	1976	438	3469	183.5	5.3
	1977	—	—	215.6	—
	1978	—	—	344.4	—
Surdud	1965	—	—	27.0	—
	1966	—	—	7.1	—
	1967	—	—	82.6	—
Rima	1975	—	—	97.9	—
	1976	—	—	99.9	—
Zabid	1970	551	2420	117.7	4.6
	1971	573	2485	125.3	5.0
	1972	469	2035	124.0	6.1
	1973	377	1637	120.1	7.3
	1974	410	1780	145.9	8.2
	1975	644	2794	230.4	8.2
	1976	562	2440	138.6	5.7

[a]Includes an estimate of surface flow prior to March 1975.

Source: al-Eryani. 1979.

Wadi Mawr is one of the best researched wadis of the Tihama, and may be viewed as fairly typical even though flow figures in Table 3.5 are somewhat greater than for other wadis in normal years. Under normal conditions none of the water in Wadi Mawr will reach as far as Luhayyah on the coast. Not only will the extremely dry soils of the Tihama absorb any water that reaches it, but also every effort is made to harvest as much as possible for agriculture. In general, surface water is available all year only in the highland areas in the major wadis.

3.2.2 Groundwater[6/]

Groundwater is in most cases the only year-round reliable source of water. Unfortunately, the aquifers in the YAR have not yet been studied extensively. The Tihama groundwater regime has received a certain amount of attention (al-Eryani 1979), where groundwater is generally under water table conditions rather than confined. Depth to water varies from as much as 85 m near the base of the mountains to as little as 5 m near the coast or under wadi beds. In a few areas swampy conditions may exist. Direct recharge of the Tihama aquifer through rainfall is negligible. Indirect recharge comes through seepage from streamflow in wadi channels and irrigation canals; deep percolation losses from irrigated land; underflow through streams cross-sections at the point of exit from the mountains; and possibly underflow through the mountain front east of the Tihama. Estimates for these figures appear in Table 3.6.

Additional data on water resources in the Tihama may be found in Appendix IV.

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[6] Sources: al-Eryani. 1979.
Escher. 1976.
Nyrop et al. 1977.
U.S. AID. 1977.
World Bank. 1979.

Table 3.6 Recharge from Surface Water (as Percentage of Annual Inflow), from Ground Water (as Percentage of Annual Ground Water Pumpage), and the Total Estimated Ground Water Recharge during 1975.

	w. Mawr		w. Serdud		w. Rima		w. Zabid	
Total Surface Inflow (MCM)	162.1		(100)		97.9		230.4 (164.3)	
Total Ground Water Pumpage (MCM)	12.6		16		43			
Recharge	%	Volume (MCM)	%	Volume (MCM)	%	Volume (MCM)	%	Volume (MCM)
Recharge through streambed and irrigation canals	2.7	4.4	49	49.0	31	30.3	69	159
Recharge through infiltration on surface water irrigated lands	4.4	7.1	4.7	4.7	7.5	7.3	17	39.2
Recharge through infiltration on ground water irrigated lands	10.0	1.3	13.0	2.1	3.1	1.3	50	82.2
Wadi cross-section underflow	—	4.7	—	12.8	—	0.1	—	5.0
Mountain front underflow	—	—	—	—	—	—	—	—
Totals		17.5		68.6		39.1		285.3
Grand Total	Approximately 410.0 MCM							

Source: al-Eryani. 1979.

Total annual recharge is estimated to be around 410 million cubic m, while total estimated withdrawal through pumping is increasing rapidly and was estimated at around 300 million cubic m in 1979 (al-Eryani 1979). This is already causing lowered water tables. Salvage of the groundwater lost to natural discharge into the sea (an estimated 60 percent before wide spread pumping began in 1969) depends upon lowering the hydraulic gradient. However, preliminary computations indicate that lowering this gradient by as much as 10 percent would divert less than 4 percent of natural discharge. The danger is that lowering the gradient enough to make a significant impact would foster sea water intrusion, which has in fact already been reported in a number of coastal areas.

Much less data is currently available on groundwater in highland areas, and only general information can be presented here. The area around Sana'a is estimated to have a groundwater potential of about 26.5 million cubic meters per year, which is estimated by ITALCONSULT to be sufficient until about the year 2000. Others consider the figure of groundwater availability overly optimistic. In the area of Ta'izz it is estimated that a potential of

12.6 million cubic feet per year could be developed from presently known sources. Projected annual water demand for 1995 in million cubic meters is 17.6 at Sana'a and 14.4 at Taizz. Obviously, if these figures prove to be relatively accurate, water supply for Taizz will soon become crucial and Sana'a will be having problems by the beginning of the 21st century. Table 3.7 forecasts Sana'a's water use through 1985.

Table 3.7 Forecast of Population and Water Consumption

Year	Total Population	Population Connected	Piped Supply % Population Served	Number of Connections	Water Consumption M^3 x M^3/Year Domestic	Industrial	Public	Total	Production M^3/Year	Number of Connections	Population Connected	% Population Connected
1976	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,637	[illegible]	[illegible]	-	-	-
1977	[illegible]	[illegible]	[illegible]	[illegible]	1,335	947	[illegible]	[illegible]	[illegible]	-	-	-
1978	[illegible]	[illegible]	[illegible]	[illegible]	1,490	1,711	[illegible]	4,177	[illegible]	-	-	-
1979	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-
1980	[illegible]	[illegible]	[illegible]	[illegible]	1,637	2,117	[illegible]	[illegible]	7,434	-	-	-
1981	[illegible]	[illegible]	[illegible]	[illegible]	4,238	2,397	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1982	[illegible]	[illegible]	[illegible]	[illegible]	4,878	2,474	[illegible]	7,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1983	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,646	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1984	[illegible]	[illegible]	[illegible]	[illegible]	6,378	[illegible]	[illegible]	[illegible]	11,784	[illegible]	[illegible]	[illegible]
1985	[illegible]	[illegible]	[illegible]	[illegible]	7,043	3,053	274	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Source: AID Project Assistance Paper: Yemen Water Supply Systems Management

3.2.3 Water Quality[7]

Surface water quality in the Tihama is generally considered to be fairly good, with medium salinity, low sodium, and slight alkalinity in some cases. Test analyses in wadis Rima and Zabid showed total dissolved solids (TDS) around 290 mg/l and 500 mg/l respectively. Electrical conductivity was 455 and 740 micromhos (at 25°C) respectively. These values are probably representative for the Tihama, but no data is readily available for highlands areas.

Groundwater quality in the Tihama is quite variable. It can be fairly good, as in wadis Rima and Zabid (Table 3.8), but more commonly Tihama groundwater tends toward high salinity. Often this is attributed to the existence

[7] Sources: al-Eryani. 1979.
Lateef. 1978.
Pratt. 1977.

of salt deposits underlying the aquifer in many areas. Data on quality of irrigation water may be found in Table 7 Appendix IV.

Table 3.8 Groundwater Quality in the Tihama

Total Dissolved Solids		Electrical Conductivity		Location
Range	Average	Range	Average	
520 - 2700	1000	800 - 3000	1600	Wadi Surdud
<1300 - >2600	775	<2000 - >4000[a]	<1000	Wadi Siham
1661 - 6507	3730	<1000 - 4000	3350	Wadi Rima
400 - 700	500 - 650	1500 - 6150		Wadi Mawr
		700 - 1550		Wadi Zabid

Source: al-Eryani. 1979.
[a]Pratt. 1977.

Lateef (1970) reports on water supply of two Tihama coastal cities. His summary is presented here, and detailed data may be found in Appendix IV, Tables 7 and 8.

Hodeida Area. This is the second largest city and the principal seaport in Yemen. It depends, for its domestic water, on the Town Water Supply with sources of water from four drilled wells in Baydah, about 11 kilometers northeast of the city. Water from these wells has nitrates, chloride salt, calcium and magnesium far beyond acceptable levels for human consumption as listed by WHO.

Al-Mokha Area. This seaport town depends on two drilled wells for its water supply. The water has chlorides, sulphates, nitrates and a salt content above the maximum permissable levels for human consumption.

Also, experiment stations, established, or to be established at Gomeisha, Ausseifera and Zabid have sources of water high in nitrates and are used for the irrigation of vegetables. The use of this water causes concentrations of nitrates in parts of the plant, usually consumed by humans. This additional intake of nitrates, through vegetables, aggravates the problem of high intake of nitrates taken through the drinking water.

Taizz Area. This city has its domestic water supply from the Town Water Supply and from natural springs from Jabal Sabar and Salah. The Town Water Supply has six wells in the Haugla area drilled by USAID during the sixties. Sample analyses of these waters are listed in Appendix VI, Table 8. Their nitrate content is extremely high and range from 50 to 200 parts per million as compared to 45 parts per million, considered the maximum permissable level for drinking purposes. Similarly, the salt content is 2000 PPM as compared to the maximum permissable level of 1500 PPM.

Water from Jabel Salah is relatively acceptable although it has 16 PPM of nitrates and high levels of fluoride respectively. Yet there is considerable demand for this water although the supply fails to meet the demand. Therefore, over 90 percent of the population depends on the less desirable Town Water Supply for drinking and domestic use.

Ibb Area. This city has its source of water from three wells drilled in Queensland near Ibb. The quality of water is in excess of the maximum permissable limits in calcium, chloride and nitrates.

Sana Area. This is the capital city and depends on deep wells dug to a maximum depth of 200 meters. The wells are dug in a cretaceous sandstone acquifer northeast and northwest of the city. Shallow wells are dug into the alluvium which overlie layers of basalt rock. Although this is probably the best water in Yemen, it is considered below acceptable standards for human consumption.

3.2.4 Water Law[8]

The YAR has no comprehensive system of law in the modern sense concerning water resources. According to the 1970 constitution, the Shari'ah is the source of all laws; in practice this means that in the absence of modern legislation on water, the Shari'ah governs all aspects. While it was developed to suit the needs of a pre-modern society, because of its case by case approach Shari'ah can often be adapted to modern situations. In general, water is

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[8] Sources: Caponera. 1973.
U.S. AID. 1977.

regarded as part of the public domain. In practice, many conventions, such as ownership of a well but not the water, may seem to confer de facto (private) ownership of water. However, there is ample legal precedent for the community to step in, if need be, to protect the public interest in water. For example, since groundwater resources extend beyond the property of a well owner, Islamic law would not allow the owner to pollute the well. To prevent misuse of areas around water resources, the principle of harim, protected area, may be invoked. Thus, while traditional Islamic law has not directly addressed many modern water problems, it certainly can provide the legal basis for modern legislation.

Yemen has taken a first step in this direction with Law No. 13, 1973, which set up the Water and Sewage Public Corporation, now called the National Water and Sewerage Authority (NWASA). Agricultural uses of water remain outside the domain of this office's power, but it is charged with developing water for domestic use and providi for sewage. NWASA has been given legal powers over many aspects of water to insure that it can function properly. The definition of duties tends to restrict NWASA to the immediate vicinity of the major cities.

3.2.5 Rural Water Use and Management[9/]

Traditional water management practice naturally varies widely with area and according to whether the water is i rural or urban areas. In the highlands, a centuries old elaborate system of terracing on mountain slopes is able to trap runoff in millions of small plots containing a deep soil layer.

The village of al-Qasim between San'a and Sa'dah provide a good example of water use in the highlands. The rains bring a layer of new soil to many terraces, which must be re-levelled. The first rains usually come in mid-February. This two-month season is not as wet or as reliable as the late summer rains, and not all plots an cultivated in the early part of the year. Al-Qasim dos

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[9] Sources: Caponera. 1973.
ECWA/FAO Joint Agricultural Division. 1978
Escher. 1976.
Kopp. 1977b.
Nyrop et al. 1977.
Speece. 1980.
World Bank. 1978.

have a few small spate-irrigated plots for vegetables at the bottom of a nearby wadi. However, because this activity is so insignificant, there do not seem to be any elaborately-developed institutions for regulating irrigation. There is no shaykh al-sharigah (watermaster, see below), no priority rights, and no elaborate division of water shares. Each ten Libnah (ca. .05 ha.) of land gets one day of water when the wadi is running. The village does have an 'aqil to oversee a fair determination of the order of use, which is reset every cycle. The village cistern, which catches runoff for washing and and for animals, has been under waqf (religious endowment) administration for at least a century. Drinking water is carried by the women from a spring about 15 minutes walk from the village (Kopp 1977b).

In the wadi floors, networks of dams and weirs divert spate flood water into irrigation channels wherever there is available land. These traditional methods have been very efficient in harvesting whatever surface water is available for agriculture. For example, of an estimated annual yield of 150 million cubic meters of water in Wadi Zabid, the traditional system can capture about 60 million cubic meters for irrigation.

The irrigated area of wadi Zabid is divided into 3 sections. The upper delta has six canals which branch off the wadi. For the period between 18 October - 29 March the base flow of the wadi is allotted to these six canals. From 29 March to 3 August, these canals get part of the water on the basis of upstream priority. The rest goes to the next area. The middle delta gets the peak flow during the rainy season, from 3 August to 13 September. Upstream priority within this middle region is again the basis for division between its seven canals. The lower delta has four canals, and these are entitled to the flow from 14 September to 18 October. The only exception to this canal upstream priority rule is that one family with land downstream from all of these divisions gets five days of flood flow. This family traditionally supplied the shaykh al Sharige, (local official responsible for administering water distribution) and these water rights were partial payment for services rendered (Caponera 1978).

In the Wadi Mawr area (Escher 1976), the watermaster is called wakil al 'aqm. His duties are not different from the shaykh al Sharige and only the title varies locally. His authority varies within the region. The wakil al 'aqm may be responsible only for overseeing irrigation water

distribution, or he may act as a representative of a landlo and choose the renter of the land. He normally ascertains that farmers contribute animal and human labor for upkeep of the irrigation system. The wakil al 'aqm receives about 8 percent of the yield as payment, but often pays for the materials needed in maintenance out of this portion.

In theory, upstream priority holds in Wadi Mawr. In practice, it is sometimes not followed for various reasons. The diversion system is not build for particular strong floods, and may sometimes be washed out, making normal water division impossible. Also, well-off families are sometimes able to influence a wakil al 'aqm to their own benefit. In cases where all fields along a canal are owned by the same family, priority rights are not needed.

Just as the maintenance of the elaborate terracing in the highlands is labor intensive, so are the complex irrigatio systems of the Tihama wadis. In Wadi Mawr dams are constr in the wadi bed during the dry season to divert flood waters into the canals. There are 38 of these major diversionary canals along the wadi. In minor floods, water will never reach the canals furthest downstream. In the largest floods, the upper dams will be washed out, and water cannot be diverted. It is rare when all land can be irrigated by the same flood.

The major canals run parallel to the wadi in the alluvi soils. To water fields, the dam marking the field from the canal is breached, and the field is flooded to the t of the boundary dam. Usually this is enough to allow water to remain standing on the field for 24 hours, and this suffices for one planting cycle. Fields are plowed and planted about a week after such irrigation.

Drinking water in rural areas is usually obtained from wells, surface flows of wadis, or directly from rainwat In the Ta'izz - Ibb region, 27 percent of the rural pop uses wells, 41 percent uses wadis, and 30 percent uses rainwater (el-Omari 1979).

In recent years the use of pumps has increased dramatic especially in the Tihama, and groundwater is now being extensively used for irrigation. In the area of Wadi Zabid again, pumping is now extracting another 62 milli cubic meters of water from the aquifer annually.

Water resources are one of the most crucial factors fo the YAR, and various aspects of water are receiving hi

priority in the 5 year plan. Appendix VII gives some indication of the kinds of projects and of the aid the YAR is receiving in this field. As in most other fields, progress is often hampered because of lack of the proper administrative and managerial structure, and due to an acute shortage of qualified personnel for nearly every aspect of implementation.

3.3 Soils and Land Use[10/]

3.3.1 Soils

There have been no systematic soil surveys covering the whole of the Yemen Arab Republic. Saad (1979) and Checchi and Company (1978) offer general observations on soils, upon which the following summary is based.

Highland Soils. More than half the area in the highlands is steep, rugged, rocky and stony to the extent that agriculture is impossible. The most widespread soils are light colored calcareous silt loams and silty clay loams. These bear a strong resemblance to loess, and are found on gentle slopes. On steeper slopes, stony colluvial soils predominate; these are brown to red-brown and have a high clay content. They are formed on the weathering products of the rock, mostly basalts and volcanic tuffs. Soils in wadi basins contain transported elements of both of these soils, transformed by high water tables in places to form hydromorphic soils.

Saad's observations (1979) are similar, but she is concerned primarily with agricultural soils in the terraces. Terrace soils show moderately well developed profiles and are mostly lithosols and yermosols. Yermosols are mostly lithic and stony because truncation by erosion has gone on more rapidly than soil formation or accumulation. Saad classifies terraces into categories by soil type which correspond to the three rough divisions noted by Checchi and Company on the slopes.

The first category has calcareous loess-like soils, with characteristics as noted above. They are usually well drained, and they occupy extensive areas of the southern highlands.

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[10] Sources: Checchi and Company. 1978.
Saad. 1979.
UNESCO - FAO. 1977.
University of Arizona, Department of Plant Sciences. 1981.

The second category of terraces is a mixture of the soils of the calcareous loess-like soils and colluvial soils washed down from the slopes, as noted by Checchi and Company. These soils in terraces are moderately to very deep, and are found particularly in the central highlands.

Third are the agricultural soils of the wadi bottoms, which are generally young, moderately to very deep, well drained, and gravelly coarse to medium in texture. They are quite susceptible to flooding. Checchi and Company notes the tendency toward hydromorphic soils in areas with high water table, and Saad classifies these separately. They are very deep, poorly drained, and often have accumulated salts due to evaporation from the soil surface.

Intermontane Plains and other Fluviatile Valleys. These areas range from 1500 to 3000 m in elevation. Characteristic soils include a wide variety of xerosols, lithosols, yermosols, and fluvisols. Stony and lithic phases are common, and extensive lava fields occur in some areas. These soils are generally quite deep, well drained, medium alkaline, and consist of calcareous silt loams to silty clay loams. Hydromorphic soils occur occasionally in some poorly drained local areas. The montane plains contain some of the most important agricultural areas in the YAR, particularly in areas of relatively high rainfall. Analyses of soils from highland sites are presented in Table 3.8.

Tihama Plains. Soils on low dunes and sand sheets are mostly coarse textured regosols, while gravelly fluvisols occupy most areas of the southern plains. Along the Red Sea coast, narrow strips of various solonchaks occur. Five major groups of soils can be distinguished (Saad 19

1. Alluvial-fan soils. These occur in the upper catchments of the main wadis, and are the result of transportation and redeposition of alluvial materials from the highlands. Most of these soils are shallow and show little profile development, but deep soils occur in some areas with some clay and calcium carbonate accumulation. These soils are mostly dry, and cultivation generally can be practiced only where wadi flow, spring, or well water is available.

2. Alluvial-eolian soils. These occur in the eastern part of the Tihama and are made up of the coarser alluvial material brought down from the highlands. They are mostly arid soils with high infiltration rates, deep, coarse to medium texture, calcareous, and show weak to moderate profile development. Alluvial-eolian soils are not usually cultivated except in a few areas where sufficient rainfall supports cultivation for grazing purposes.

Table 3.8 Soil Structure and Chemical Analyses from Highland Sites

Test Location No.	Soil Structure				Soil Chemistry				
	Fine Sand %	Silt %	Clay %	Organic Matter %	pH	Available/ppm P_2O_5	Available/ppm K_2O	Total N	E.C. mmho*
OR 78-1	60	30	10	tr	7.9	5.75	390	0.015	1.15
OR 78-2	40	20	40	tr	7.8	2.30	360	0.017	0.96
OR 78-3	95	—	5	tr	8.1	7.59	840	0.071	1.16
OR 78-4	60	25	15	tr	7.7	1.15	420	0.055	1.53
OR 78-5	25	45	30	tr	8.0	3.91	840	0.050	1.03
OR 78-6	80	15	5	tr	7.8	1.15	258	0.046	1.04
OR 78-7	13	40	45	2	7.6	2.3	240	0.118	1.16
OR 78-9	90	10	—	tr	8.0	1.61	138	0.042	1.14
OR 78-10	—	95	5	tr	7.7	5.75	264	0.008	1.01
OR 78-11	5	95	0	tr	7.8	3.91	540	0.038	1.05
OR 78-12	87	10	3	tr	7.9	8.74	396	0.029	0.35
	—	—	—	—	8.1	2.07	420	0.038	0.44

*Electrical Conductivity—millimhos.

Legend for Table 3.8

Test Location No.	Closest Village	Distance from Sana'a (kms)	Approx. Elevation (meters)
OR78-1	Badram	50 NE	2424
OR78-2	May Moon	34 NW	2270
OR78-3	Hiryam	17 S	2242
OR78-4	Dubra Sunham	27 S	2424
OR78-5	Maf-Dan	43 SW	3000
OR78-6	Yamle	35 SW	2424
OR78-7	Batina	148 NW	1100
OR78-8[a]			
OR78-9	Sa'Dah	240 N	1818
OR78-10	Khayman	140 NE	1830
OR78-11	Bilsin	101 NE	436
OR78-12	Rawdah	68 NE	636

Source: University of Arizona, Department of Plant Sciences. 1981.

3. Alluvial soils of the valleys. These are the most common soils of the Tihama, and were formed by the movement and deposition of alluvial materials through the plain flood action which takes place annually. They are stratified soils, generally young with little or no profile. The alluvial soils of the valleys can be divided into 2 categories: (a) the soils that are affected by spate irrigation are very deep, relatively coarse textured, sandy loam with no profile development. They have high levels (earth beds) built around them leaving two openings, one as an inlet and the other as an outlet for water. (b) soils not affected by spate irrigation are generally very deep, silt loam to fine and sandy loam with weak to moderate profile development.

Agriculturally, this is the most important group of soils in the Tihama. Cultivated lands are irrigated either by wells or by wadi water through a network of irrigation channels, or directly by spate irrigation.

4. Saline and/or alkaline soils. These are located mainly along the sea coast and in other local areas of the Tihama where poor quality water has been used for irrigation without appropriate water management practices. Two examples of the latter soils are: (a) the Gumaisha area, 16 km east of Hodeidah, where typical alkalinity pan (mostly caliche) have developed in the medium to coarse texture soil profiles of the experimental farm; and (b) The Lawia area about 50 km southeast of Hodeidah. Soils near the coast are not usually cultivated except in local areas at wadi mouths.

Since leaching requirements are seldom met, salt-affected soils are extending in area and the severity of the problem in the already salt-affected areas is increasing.

5. Miscellaneous soil types. These include: (a) rough broken lands which are severely eroded and have no soil cover (rock outcrops), and (b) large areas of sand dunes in the areas around wadis Zabid, Siham, and Rasyan. The desert sand areas are practically bare, with very deep coarse sand profiles.

Beyond these summaries, very little current data is readily available on soils. The FAO-UNESCO soil survey of south Asia (UNESCO-FAO 1977) does include Yemen, and distinguishes the following broad categories (Table 3.9 and Fig. 3.11):

Table 3.9 Dominant Soil Types and Associated Soils

Map Symbol[d] (dominant soil)	Associated soils (>20%)	Inclusions (<20%)	Phase	Approx. Area in Oman (1000 ha)
I-Y-bc			Stony	4,846
I-Yh-Yk-1/2b			Stony	6,148
I-Yk-2ab			Stony	433
Je61-2a		Zo		406
Qc46-1/2ab	I,Y	R	Lithic/ Stony	270
Rc30-1ab	Qc,Yk	Z	Shifting Sand	902
Yh22-1ab	Qc,Yk	Rc,Jc,Z		2,464
Yk25-1/2a	I,Yl	Jc,Z	Lithic/ Stony	1,956
Yk26-1ab	Qc		Petro/ calcic	a
Yk28-1a	Rc	I	Stony	1,424
Yk29-1/2a	Rc	Z	Stony	b
Yl19-3ab	I,Yk	Rc	Stony	654
Zg3-2/3a	Zo			c

[a]Yemen is not listed under this soil type, but there may be pockets along the northern interior boundry with Saudi Arabia.

[b]Yemen is not listed under this soil type, but there is a small pocket shown on the map east of San'a.

[c]Yemen is not listed under this soil type, but there may be small pockets on the coast near the northern border.

[d]In the example Qc46-1/2ab, Qc refers to soil type Cambic Arenosol. The number immediately following the soil type (46) is an arbitrary classification for tabulation purposes on the UNESCO - FAO map. Numbers following the hyphen (1/2) are textural class (coarse to medium). Small letters at the end (ab) refer to slope class.

INTERPRETATIONS OF SYMBOLS

Soil Types	Textural Class	Slope Class
I. Lithosols	1. coarse	a. level to gently undulating
Jc. Calcaric Fluvisols	2. medium	b. rolling to hilly
Je. Eutric Fluvisols	3. fine	c. strongly dissected to mountainous
Qc. Cambic Arenosols		
R. Regosols		
Rc. Calcaric Regosols		
Y. Yermosols		
Yh. Haplic Yermosols		
Yk. Calcic Yermosols		
Yl. Luvic Yermosols		
Z. Solonchaks		
Zg. Gleyic Solonchaks		
Zo. Orthic Solonchaks		

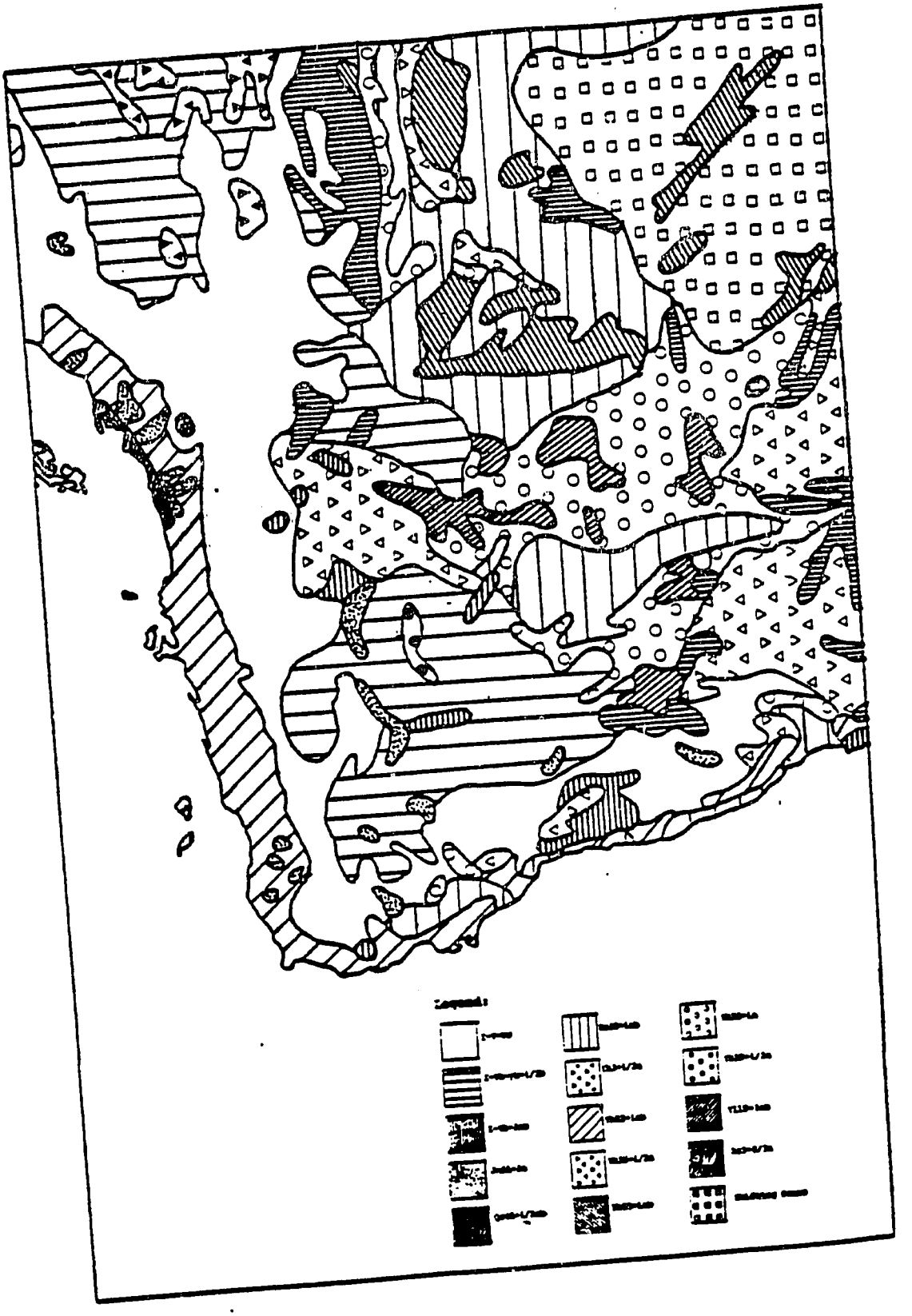

Figure 3.11. Soils of Southwest Arabia

Source: UNESCO - FAO. 1977

Lithosol Yermosol Association. The majority of Yemen's soils are composed of lithosols intermixed with various yermosols. The lithosols tend to be in steep rocky areas, on mountains or rock outcrops. They are usually shallow, stony, and very prone to water or wind erosion. These characteristics normally make lithosols unsuitable for cultivation. Undifferentiated yermosols (I-Y-bc) are intermixed with the lithosols in most of the western foothills and in the foothills area along the border with the PDRY. The yermosols occur on peneplains and alluvial terraces. Like the lithosols, they are usually shallow, stony, prone to erosion, and not particularly suited to agriculture. Both of these soils may be cultivated in small local areas where patches of deep soil have accumulated, either naturally or through terracing.

The southern highlands and portions of the central and northern highlands consist primarily of lithosols intermixed with haplic and calcic yermosols (I-Yh-Yk-1/2b). Calcic yermosols, especially those with petrocalcic horizons at shallow depth, are generally unsuitable for cropping and may be utilized only as rangeland. Haplic yermosols on the other hand, can be very productive under irrigation. Small patches of lithosols in association with just calcic yermosols (I-Yk-2ab) may also be found scattered throughout the highlands.

Eutric Fluvisols (Je61-2a). Small patches of this soil are found in the southern Tihama and the southern and central highlands. They are also quite common in the coastal plain of neighboring Asir and may occur in the Tihama near the northern border. Eutric fluvisols are quite good soils for agriculture.

Cambic Arenosols (Qc46-1/2ab) and Calcaric Regosols (Rc30-1ab). These are common soils of the interior Arabian deserts such as the Rub al-Khali. In Yemen they are found in the eastern desert region with a few patches in the northern highlands along the border with Saudi Arabia. The arenosols are mostly shallow and stony, while regosols are characteristically found on dunes and sand ridges.

Yermosol Associations. Several varieties of yermosols predominate in large areas of Yemen. Haplic yermosols (Yh22-1ab) are the major soil type through the Tihama coastal plain. These can be quite productive under irrigation. Cambic arenosols and calcic yermosols are the major associates. Calcic yermosols (Yk25-1/2a, Yk26-1ab, Yk28-1a, Yk29-1/2a), which differ in their associates (Table 3.8), are found throughout the northern highlands and the eastern desert regions. These soils in the desert regions are usually unsuited for agriculture.

The highland calcic yermosols may become productive under irrigation, although they are not as good as haplic yermosols. Small patches of luvic yermosols (Y119-3ab) occur on the eastern slopes and in the eastern desert regions.

3.3.2 Land Use and Cropping Patterns[11/]

Only about 8 percent of the total land area of the YAR is cultivable, while another 10 percent is classified as marginal, but possibly usable in wet years (Table 3.10). Eighty-five percent of the normally cultivated land depends upon rainfall (Table 3.11). Most of this land is in the highlands and consists of terraced fields (Figure 3.12).

Field and cropping patterns, like most other aspects of Yemeni agriculture, can vary widely, depending on topography, climate, altitude, water, soil, and frost frequency. These patterns may also be affected by a number of social and economic factors, such as the needs of the producer, labor availability, land tenure, access to market and credit, and the customary planting history of the field. In general, fields are small, and even when a landowner holds a large total acreage, his land may be in a number of small plots scattered over a wide area. Most large plots are in the Tihama.

Sorghum and millet are the major crops and these crops in 1975-76 accounted for 78 percent of the area planted (Table 3.12).

Sorghum and millet are primarily subsistence crops and about 70 percent of the total per capita daily food intake is from these two grains. They also provide for a number of other needs, such as fodder for animals. The stalks are also used for fodder, as well as for hous

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[11/] Sources: Birks and Sinclair. 1979.
Checchi and Company. 1978.
Escher. 1976.
Kopp. 1977b.
Nyrop et al. 1977.
Speece. 1980.
Tutwiler et al. 1976.
World Bank. 1979.

Table 3.10 Major Land Use by Governorates ('000 hectares)

Governorate	Total Area	Cultivated Land	Marginal Agriculture	Forest and Shrubs	Other
Sana'a	8,000	400	600	100	6,900
Hodeida	3,500	235	500	450	2,315
Ta'izz	1,200	250	100	500	350
Ibb	1,300	300	50	400	550
Hajja	1,700	130	250	50	1,270
Sa'ada	1,800	60	200	-	1,540
Dhamar	1,000	100	200	100	600
Beida	1,500	40	100	-	1,360
	20,000	1,515	2,000	1,600	14,885

Source: World Bank. 1979.

Table 3.11 Cultivated Land and Irrigation by Source of Water ('000 hectares)

Governorate	Cultivated Land	Rainfed	Spate flood Irrigated	Perennial	Wells
Sana'a	400	375	-	20	5
Hodeida	235	105	100	5	25
Ta'iz	250	221	10	18	1
Ibb	300	279	-	20	1
Hajja	130	115	10	5	-
Sa'ada	60	60	-	-	-
Dhamar	100	92	-	5	3
Beida	40	38	-	-	2
	1,515	1,285	120	73	37

Source: World Bank. 1979.

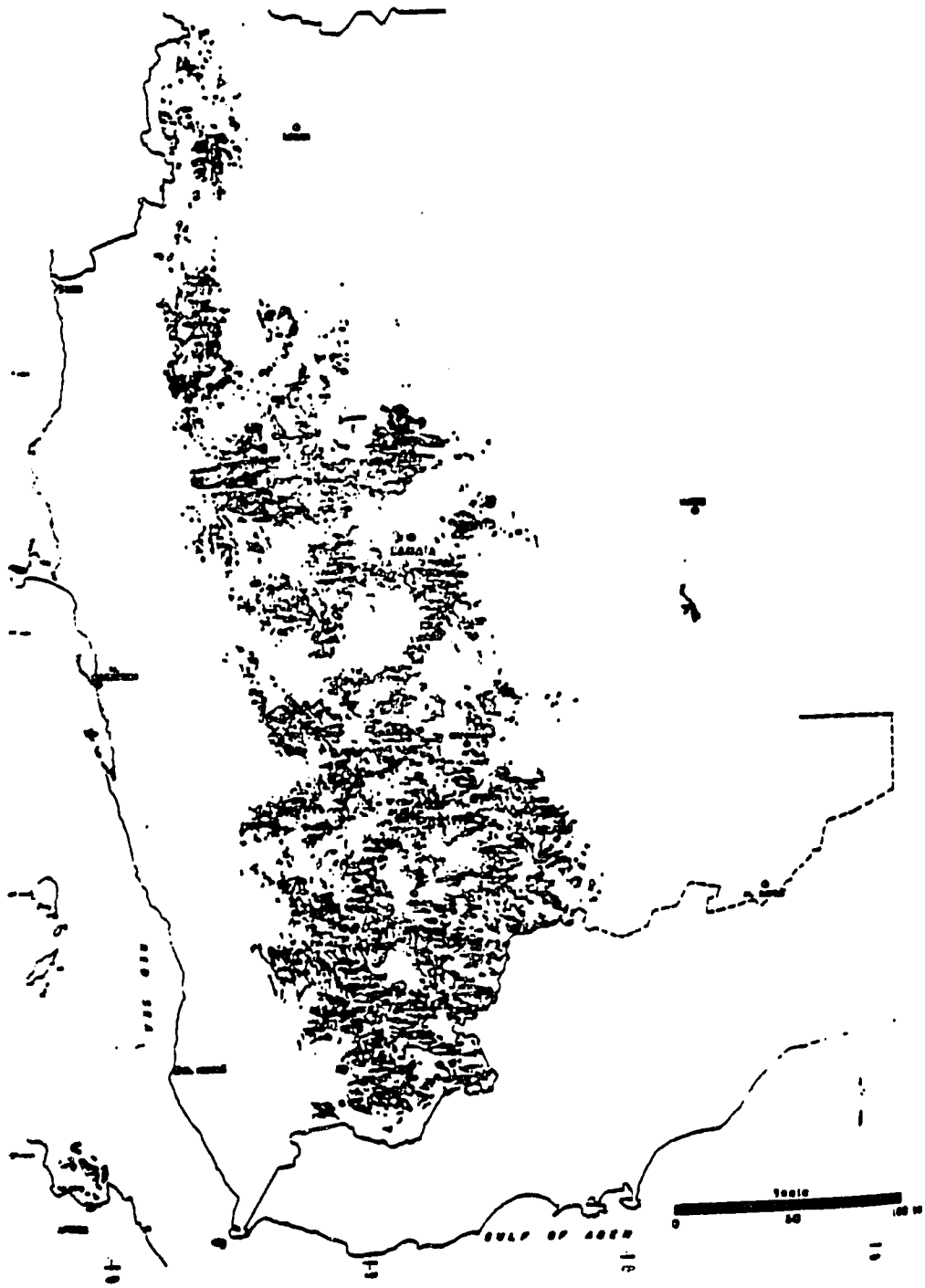

Figure 3.12 Terraced Rainfed Agricultural Lands

Source: Bernhardt et al. 1980.

Table 3.12 Area and Production of Main Agricultural Crops (area: '000 hectares, production: '000 tons)

Crop	1969/70		1970/71		1971/72		1972/73		1973/74		1974/75		1975/76	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
Cereals														
Sorghum & millet	886	610	973	730	920	627	1080	809	952	639	1215	1008	1145	859
Maize	4	8	16	30	20	16	50	70	52	80	50	79	50	72
Wheat	35	16	30	33	25	25	50	50	70	71	50	56	50	52
Barley	145	160	140	154	125	140	110	120	77	85	73	80	68	75
Legumes, Vegetables														
Legumes	50	50	50	60	60	60	60	56	65	64	71	71	76	76
Green vegetables	8	50	10	100	15	137	17	150	16	150	18	168	20	181
Potatoes	4	20	6	55	5	58	6	64	6	64	7	71	7	76
Fruits, tree crops														
Fruits	4	23	5	25	5	28	10	60	10	60	12	60	12	65
Grapes	4	10	7	30	8	35	8	35	8	31	9	40	9	42
Dates	-	3	-	5	-	5	-	5	-	5	-	5	-	5
Coffee	5	4	5	4	5	4	5	4	5	4	4	3	4	3
Industrial Crops														
Cotton	5	2	10	10	15	15	20	19	20	20	28	27	14	13
Tobacco	4	2	4	3	4	5	4	5	4	5	4	5	5	6
Sesame	4	2	8	4	8	5	8	4	8	4	9	5	10	6

Source: World Bank. 1979.

construction or fuel. The crops are not normally produced for the market. In general, even though they can occasionally be found in markets, the cash value of sorghum and millet does not cover production costs, nor will people buy it when they have cash to spend on food. Wheat, potatoes and canned goods are preferred.

Maize, wheat, and barley, which together accounted for about 11 percent of the planted area in 1975-76, are the other major grains. Vegetables and fruits, though occupying less than 10 percent of the planted area, are important crops in terms of food value. Vegetables and fruits are grown for both subsistence and cash crops. However, the major cash crops are cotton, tobacco, coffee and qat. As seen in Table 3.13, raw cotton accounted for over 49 percent of Yemen's exports by value, and cotton products added more than another percentage point to this. Coffee made up over 20 percent of the exports by value.

All of these cash crops are important in the domestic market, but the predominant one is qat. Qat growing and use is usually condemned by outside observers, while its many beneficial effects are often overlooked. Qat is an indigenous plant which is well adapted to climatic conditions of the highlands, and it is more drought resistant and requires less care than competing crops. Thus, with much less work than for other crops, the peasant can produce a cash crop worth much more. This is particularly important in light of increasing labor shortages.

Even a peasant with very small holdings can gain some income, for although qat marketing can have elaborate structures, it may also be sold by individual farmers in small amounts. Laborers on qat fields receive a much better wage, usually about 25 YR per day compared to about 8 YR on a millet field. Most Yemenis who do not chew qat suffer from deficiencies of vitamin A. All of these aspects can be be compensated for if programs to eradicate qat growing and use are implemented. However, it is important to remember that any such program will be resisted and probably will fail if these factors are not considered.

Figure 3.13 shows general areas of primary crop production. Grains tend to be more important in the highlands, around Ibb - Ta'izz and north of San'a. Sorghum and millet are the major lowland grains but the highlands also produce wheat, barley, and maize. The cash crops, cotton and tobacco are found mainly in the Tihama, and qat and coffee in the highlands.

Table 3.13 Commodity Composition of Recorded Exports (YR thousands)

Fiscal Years ending June 30	71/72	72/73	73/74	74/75	75/76	76/77
Agricultural Raw Materials	22,703	23,691	51,648	41,982	41,582	43,205
Cotton	10,799	12,871	37,053	30,954	24,583	24,953
Cotton Lint	(9,912)	(10,785)	(35,180)	(28,188)	(24,221)	(24,593)
Cotton Seeds	(887)	(2,036)	(1,873)	(2,766)	(362)	(-)
Coffee	5,534	5,469	6,461	4,972	7,588	10,223
Hides & Skins	3,271	3,325	6,241	4,404	8,040	6,129
Dried Fish	58	382	781	736	325	56
Live Animals	341	768	643	443	6	-
Potatoes	239	394	195	141	135	17
Fruits	66	274	143	116	164	26
Tobacco	25	44	74	172	382	668
Others	2,370	266	57	44	359	1,133
Processed Agricultural Products	100	1,143	1,896	3,453	4,322	5,640
Cotton Products	100	317	325	1,590	1,384	637
Fabrics	-	-	-	(1,193)	(775)	(165)
Sheets	(100)	(317)	(325)	(257)	(609)	(472)
Yarn	-	-	-	(140)	..	(-)
Biscuits	-	636	1,315	1,131	2,093	3,156
Confectionery	-	119	54	582	845	724
Oil Seed Cakes		71	202	150	-	1,123
Non-Agricultural Exports	1,898	433	1,838	7,531	4,159	1,689
Salt	1,412	27	26	-	1	-
Metal Scrap	247	102	356	9	343	-
Others	239	304	1,456	7,522	3,815	1,689
TOTAL	24,701	25,269	55,382	52,966	50,063	50,534

Source: World Bank. 1979.

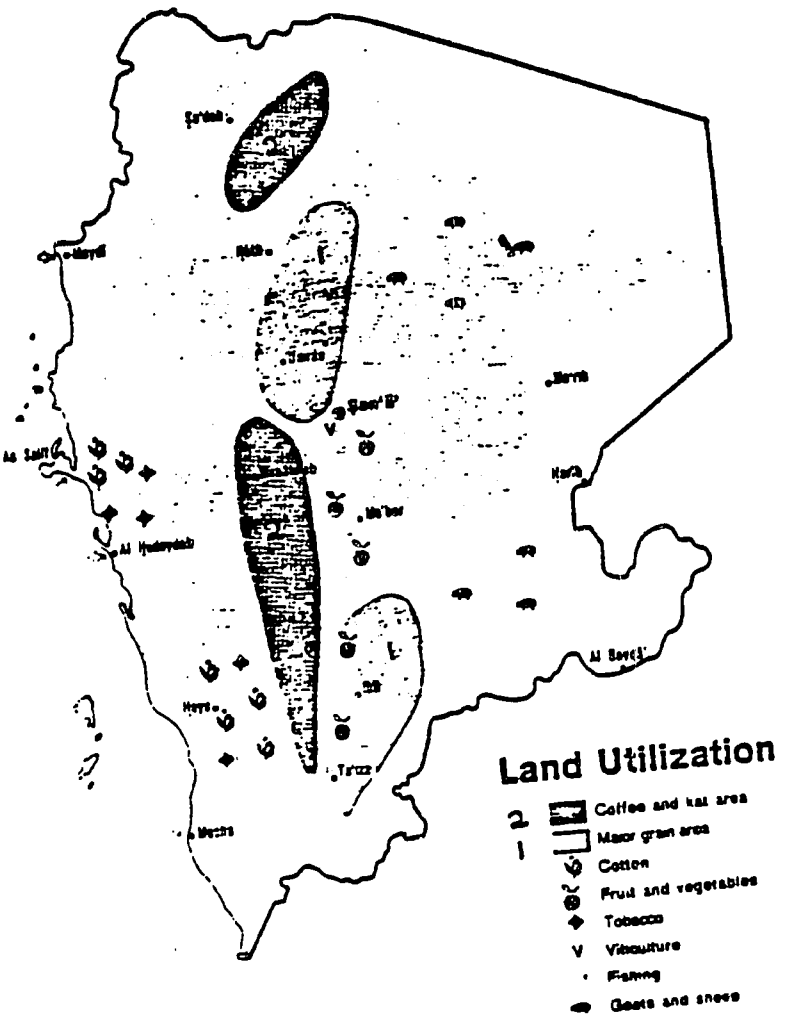

Figure 3.13 Major Crop Areas

Source: Available from U.S. GPO, Map 501036 2-73 Yemen (Sana'a

Several surveys show crop distribution patterns on the local level. In Wadi Mawr, a survey of farmers whose holdings covered 2 percent of the cultivated area showed that sorghum was planted on 76 percent of the irrigated land and 70 percent of the dryland cultivated area. Cotton was planted on 21 percent of the irrigated land, while in the dryland fields millet was sown in another 26 percent (Table 3.14; cf also Fig. 3.17). Total production of sorghum and millet in the Wadi Mawr region (1973-74) was about 25,000 tons, of which 15,000 were consumed locally. Total production of cotton was about 2250 tons, nearly all of which was sold after taxes and debts were settled in kind (Escher 1976). Additional data on cropping in Wadi Mawr is presented in Appendix V. Data is also available on land use in Wadi Rima, although not for specific crops (Table 3.15, Fig. 3.14).

Table 3.14 Crop Coverage in Wadi Mawr (Winter 1973/74)

Crop	Cultivated Area ha	%	% of Wadi, or Khabt (Rainfed)
Irrigated			
Sorghum	351	25	76
Sesame	16	1	3
Cotton	96	7	21
Total Wadi	463	33	100
Rainfed			
Sorghum	664	47	70
Millet	249	18	26
Sesame	36	2	4
Total Khabt	949	67	100
TOTAL	1,412	100	
As a percentage of the total project area (cf. Fig. 3.17)		2	

Source: Escher. 1976.

Table 3.15 Population and Farm Statistics in Relation to Land Use in Wadi Rima

Land use category 3/	Area (km^2)1/			Population				Access to farmland			Cropping intensity		Livestock holding		Net farm income 2/	
	Map total	Adjusted total	Actual cult.	Total (*000)	Density/km^2 Total (No.)	Density/km^2 Cult. (No.)	Absent men (%)	Landless families (%)	Land area sharecropped (%)	Farm size (ha)	Crops/year (No.)	(km^2)	No./km^2	No./family	TL/yr (*000)	$/yr (*000)
Cropland (A-F)																
A Pump irrigation Less 60 km^2 E,F&L	103	43	37	9.8	95	265	6	-	85	35	3.9	2.2	81	105	7	8.2	1.8
B Perennial wadi irrigation	42		7	3.2	320	457	11	50	80	2.5	3.0	81	482	11	8.9	2.0
Regular spate irrigation Less 2 km^2 H		40	25	7.2	225	288	21	35	65	3.0	2.0	50			6.4	1.4
C Irregular spate irrigation Less 7 km^2 H	67	60	48	12.7	190	265	20	35	30	3.5	1.3	62	151	8	8.6	0.6
D Hill front runoff	22	22	18	3.6	164	200	17	15	80	3.5	1.5	87	195	7	8.7	0.6
E Rainfed + runoff Plus 39 km^2 from A-C	91	130	73 31	5.2	57	71	26	10	30	10.0	0.6 0.6	44 19	130	18	1.2	0.3
F Opportunistic planting Plus 20 km^2 from A	21	41	7 7	(land users mostly resident in other areas)							0.2	8	(included elsewhere)		-	-
Date plantation (G-H) (+ Rephaim)	18	18	9	1.3	108	144	41	50	(tree crop)		(tree crop)		120	5	-	-
Rangelands (J-L) Plus 10 km^2 from A	177	187	all all	1.0	6	all	18	(not applicable)			all	all	4	7	-	-
Barren land (M-P)	108	108	all	all	(not applicable)			(not applicable)			all	all	all	all	-	-
Total	641	641	248	44.0	-	-	-	-	-	-	-	318		-	-	-
Base	-	-	-	-	68	177	18	30	40	3.0	1.8	-	90	8	3.6	1.3

1/ Where mapped units are known to contain elements of other units, their areas have been adjusted accordingly. In addition, to arrive at estimates of areas actually cultivated, allowance has been made (15% in pump irrigated areas and 30% elsewhere) for land occupied by villages, tracks and irrigation earthworks.

2/ Income figures are indicative; they are derived from gross margins for typical cropping patterns and livestock holdings, less the main fixed costs, and relate to farm units of average size before sharecropping fees are met.

3/ See Figure 3.14

Source: Pratt. 1977.

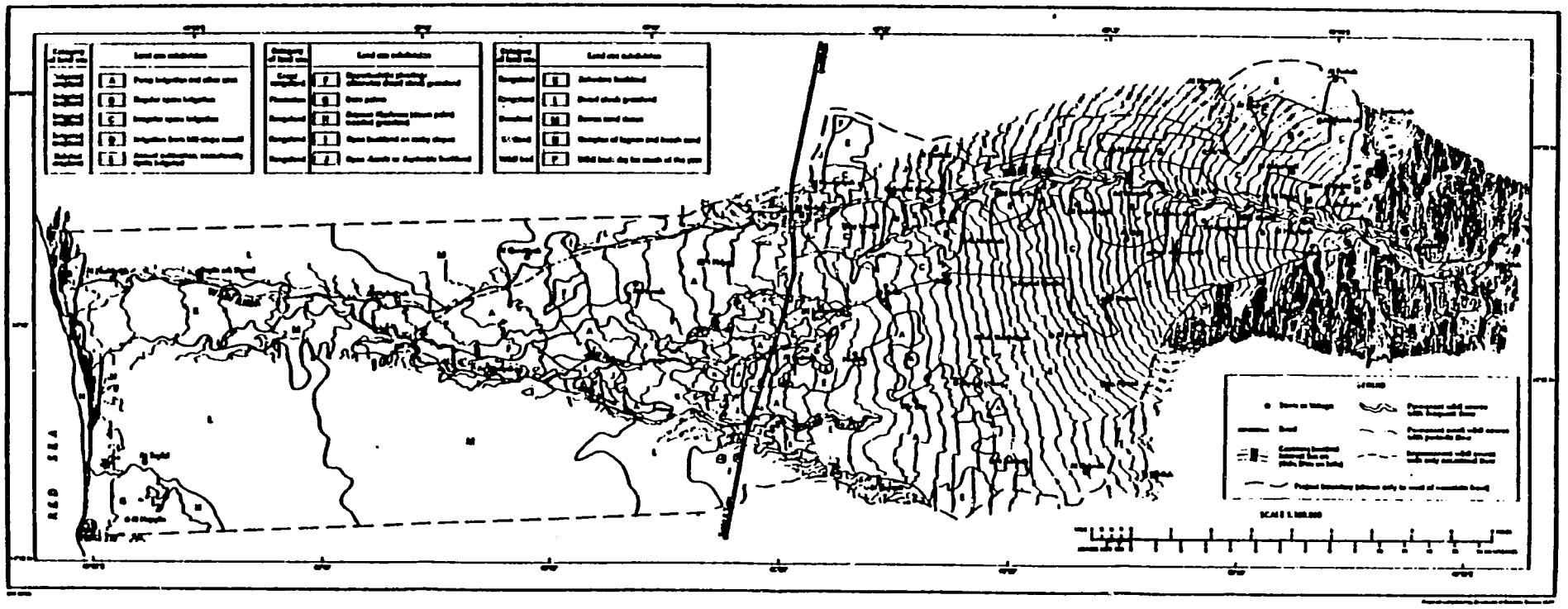

Figure 3.14 Land Use in Wadi Rima, 1975-76.

Source: Pratt. 1977.

Al-Qasim is in an area where all agriculture is terraced or in small level areas between mountain peaks. Land holdings by family as well as cropping patterns on the terraces are very fragmented. Most of the area planted is in wheat and barley or sorghum. Quite a bit of land is used for qat, but in al-Qasim there have been no new plantings of qat for several decades. The quality is not as good as in other areas of Yemen, and production is mostly for personal use, not for sale. Small terraces along the wadi bed are planted with vegetables (Kopp 1977b).

Figures 3.15 and 3.16 show this kind of fragmentation in two highland coffee areas. Hajjah is located about 50 km NW of San'a, and Udayn is about 20 km W of Ibb. Tables 3.16 and 3.17 show cropped area, production, and yields of a number of crops in the Ta'izz - Ibb region.

3.3.3 Land Tenure System[12/]

Only about 1.5 million hectares, or 8 percent of the total area of Yemen, is cultivable under normal conditions. Another 10 percent (2 million hectares) is classified as marginal and could potentially be cultivated in years of exceptional rainfall. This is essentially all of the land that comes into consideration when discussing ownership and tenure patterns.

All aspects of Yemeni law, including land tenure systems and peasant-landlord relationships, are theoretically governed by the Shari'a. In practice, tribal law and custom have remained intact from pre-Islamic times, and supplement or supplant Shari'a law. Since agriculture is and always has been the basis of Yemen's economy, as

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[12] Sources: Caponera. 1973.
Checchi and Company. 1978.
CID. 1979.
Dostal. 1974.
ECWA/FAO Joint Agricultural Division. 1978.
Escher. 1976.
Kopp. 1977b.
Nyrop et al. 1977.
Speece. 1980.
Stookey. 1978.
Tutwiler et al. 1976.
World Bank. 1977.

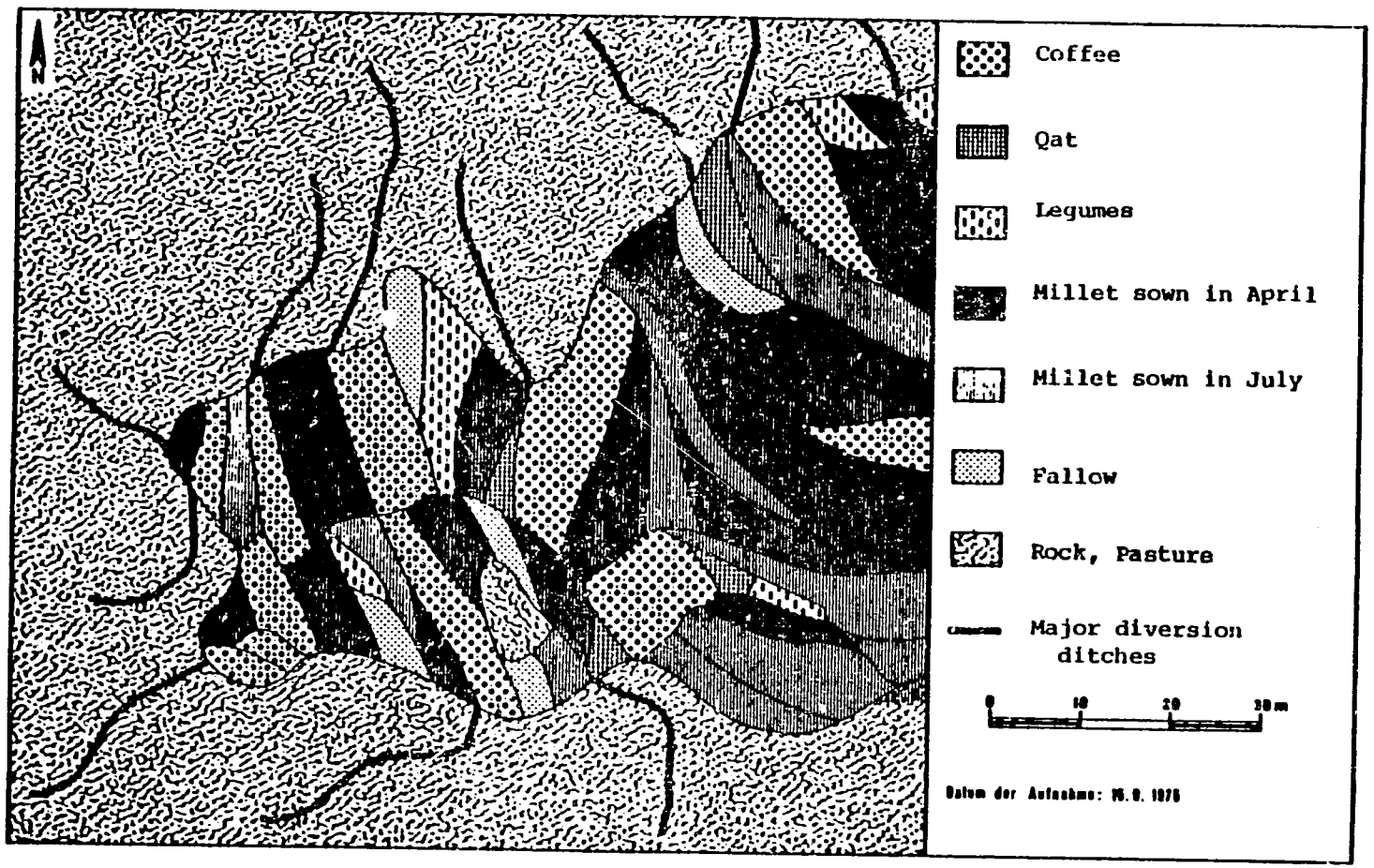

Figure 3.15 Cropping Patterns at Hajjah (1975)

Source: Becker et al. 1979.

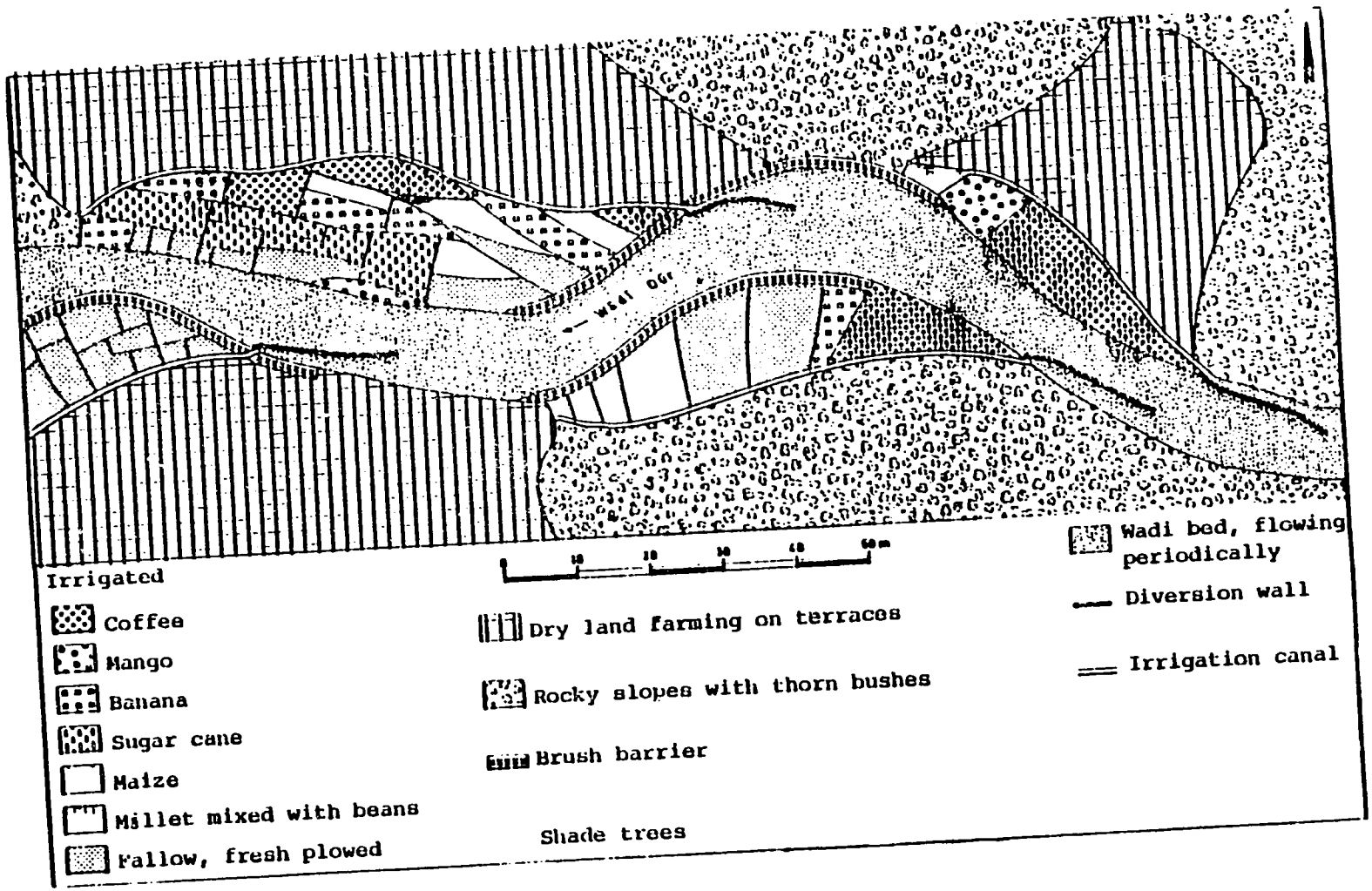

Figure 3.16 Cropping Patterns at Udayn, 1975.

Table 3.16 Area and Production of Crops in Ta'izz, Ibb, and YAR, 1976/77 (area = '000 ha; production = '000 metric tons)

Crop	Ta'izz		Ibb		YAR	
	Area	Production	Area	Production	Area	Production
Sorghum and Millet	117.0	140.0	120.0	156.0	786.0	660.0
Maize	26.0	46.8	32.0	51.2	67.0	111.0
Wheat	3.0	2.4	18.1	22.1	55.0	51.0
Barley	4.0	4.0	12.8	15.4	60.0	54.0
Sesame	2.2	1.5	1.1	0.8	10.2	6.4
Pulses	10.0	15.0	27.0	40.5	72.0	82.0
Potatoes	2.0	22.0	8.0	96.0	10.8	124.0
Vegetables	6.0	60.0	9.3	93.0	25.0	239.0
Cotton	0.6	0.5	-	-	5.2	5.1
Tobacco	0.2	1.5	-	-	5.3	6.4
Fruits	4.5	26.5	3.0	15.0	15.0	84.0
Grapes	-	-	-	-	10.0	47.1
Coffee	0.5	0.2	1.7	0.9	7.5	3.4
Dates	150	0.8	-	-	1250.0	6.3

Source: el-Omari. 1979.

Table 3.17 Yields of Major Crops in the Ta'izz and Ibb Governates (kg/ha)

Season	Sorghum		Barley		Wheat		Maize		Potatoes		Dates[a]
	Ta'izz	Ibb	Ta'izz	Ibb	Ta'izz	Ibb	Ta'izz	Ibb	Ta'izz	Ibb	Ta'izz
1975/76	1.05	2.26	-	-	.90	1.15	2.49	2.74	11.0	13.0	11.7
1976/77	1.68	2.54	-	1.1	.92	1.29	2.49	3.25	16.0	19.5	11.7
1977/78	1.57	3.12	-	1.2	.87	1.37	3.25	3.75	15.7	18.2	11.7

[a]yields for dates in kg/tree

Source: el-Omari. 1979.

government in power has always concerned itself with agriculture. Units for the measurement of land areas were first standardized by legislation in the 13th century. At this time, the Rasulid rulers also legislated the basic terms for landlord tenant relations. They initiated land reclamation projects, and eased taxes on peasants to encourage production. However, most agricultural legislation had as its goals increased revenue or the procurement of some other benefit for the government, rather than the peasant's welfare. The same Rasulid rulers made extensive use of fief-granting (iqta). Originally, the iqta was neither hereditary, nor privately owned, but simply entitled the holder to the state revenue of the grant in return for the military service he provided to the state.

Tax collection was not always as equitable as Rasulid legislation may have intended. Tihama date production, for example, declined because the tax collectors were demanding more tax on date palms than the value yielded by the crop. Not surprisingly, peasants fled the agricultural areas to escape taxes. These demands continued until the revolution of 1962. Earlier in that year, farmers refused to plant winter crops because taxes were too high to provide any incentive. Many farmers were selling animals because taxes on them were too high to leave any profit from stock-raising.

Current land ownership and tenure is still primarily traditional. Land reform had not been attempted as of mid-1976, except for a government takeover of the former Imam's holdings. Iqta, which in the modern sense means privately-owned large landholdings usually leased on a share-cropping basis, made up 60 to 70 percent of all arable land, based on 1965 data. Privately-owned small farms, ("milk"), constituted 4-10 percent of arable land, and state farms constituted 2-3 percent. Collectively-owned land held by extended families (mushaa) and by villages (huma), comprised 1-3 percent, but about 90 percent of all pasture land was in this category.

Waqf land accounts for about 15-20 percent of the arable land in Yemen and there are a number of types of waqf. Waqf al-dakhli and waqf al-Sawafi, internal and clear waqf respectively, are the usual types, with direct and undisputed ownership by religious institutions. Today this land is owned and operated by the Ministry of Waqf, a department of the Yemeni government. Waqf al-wasay, willed waqf, remain under full ownership of the donor's family and are operated by the head of that family. Only a specified portion of the income goes to a pious purpose; the rest

remains with the family, except for a 2 1/2 percen tax on the income for state services in record keeping, dispute arbitration, and similar situatio Waqf al-muthallath, three-tenths waqf, give 3/10 o the income to the state, divided into 2/10 for the Ministry of Waqf and 1/10 for Zakat. A subcategor this type, called waqf al muthallath al-Haramin, i divided the same, except that the 2/10 portion goe Mecca and Madina.

According to one estimate, approximately 90 percen all arable land was leased on sharecropping arrangements (Checchi and Company 1978). Another estimate places this figure much lower, at about o third of the total cultivable land. Tenancy is lo in the highlands according to this estimate, at ab 15-20 percent, and rises to 40-50 percent in the Tihama (CID 1979). Arrangements differ according region and especially according to whether or not land is irrigated. The tenant might expect to rec anywhere from 1/2 to 3/4 of the crop if he engaged dryland farming, and between 1/3 to 1/2 if the lan was irrigated. Detailed arrangements depend on exactly what resources the landlord supplied. In general, the privately owned and worked land compr small plots in highland areas, while the lowlands t to be larger ownings that are leased.

Several studies show the application of these gener observations on local levels. In wadi Mawr, about percent of the population is directly dependent on agriculture (Escher 1976). Approximately 87,000 ha agricultural land is available, of which 70 percent dry farmed, and another 9 percent is irrigated only occasionally in wet years. Figure 3.17 shows distribution of irrigated and dry farmed lands in t wadi.

Forms of land holding include privately owned and worked (milk), state owned (miri), waqf, and leased land (sh'arak). Some land, mostly that unusable fo cultivation, is unowned by any person or instituion. Of a sample of 161 peasants working for themselves wadi Mawr, 55 percent work only their own land, 22 percent work land of their own but also lease, and percent work only leased land. Another 43 persons (21% of the total sample of 202) do not work any lan for themselves. A few of these are traders or craftsmen, but most do agricultural work for wages. Table 3.18 shows distribution of these ownership categories by irrigated or dry farmed land. Size distribution of holdings is very uneven. Two percen of the sample own 50 percent of the land covered in the sample. The bottom 50 percent of the sample

controls only 5 percent of the land (Table 3.19). At the time of the survey, there were no absentee landlords in wadi Mawr.

Table 3.18 Land Tenure in Wadi Mawr

Tenure Form	No. of Farmers	%	No. of Farmers	%	No. of Farmers	%	No. of Farmers	%
Only owners	9	10	27	31	52	59	88	100
Owners and lessees	2	6	24[1)]	69	9	25	35	100
Only lessees	19	50	8	21	11	29	38	100
Total	30	19	59	37	72	44	161	100

Source: Escher. 1976.

Table 3.19 Size of Land Holdings in Wadi Mawr (Winter 1973/74)

Area (ha)		<.5	.5	.5-2	2-5	6-10	11-15	16-20	21-25	26-50	50-100	100-250	250-500	>500	Area	N	NA	Min.	Max.	Avg.
Owned			3	12	25	19	13	10	12	16	8	2	1	2	5950	123		1.0	1470	49
of which irrigated			3	11	13	9	3	3	0	4	0	2			695	49	1	0.5	168	14
Leased			7	18	20	16	7	1	1	3					531	73		0.5	30	7
of which irrigated			6	15	16	9	3	0	1						232	51	1	1.0	21	4
A		4[1)]	6	18	22	32	20	12	16	19	8	3	0	1	3790	161		0.5	840	24
of which cultivated		8[2)]	13	20	29	34	18	7	10	14	2	1	1		1990	161	4	0.5	220	12

1) lease-all land
2) 4 lease all land; 4 do not cultivate at all
N: No. of farmers
NA: No answer in survey
A - Land owned & land leased (in) - land leased out
of 123 farmers, 89 only own, 35 own and lease
of 73 lessees, 38 only lease, 35 own and lease

Source: Escher. 1976.

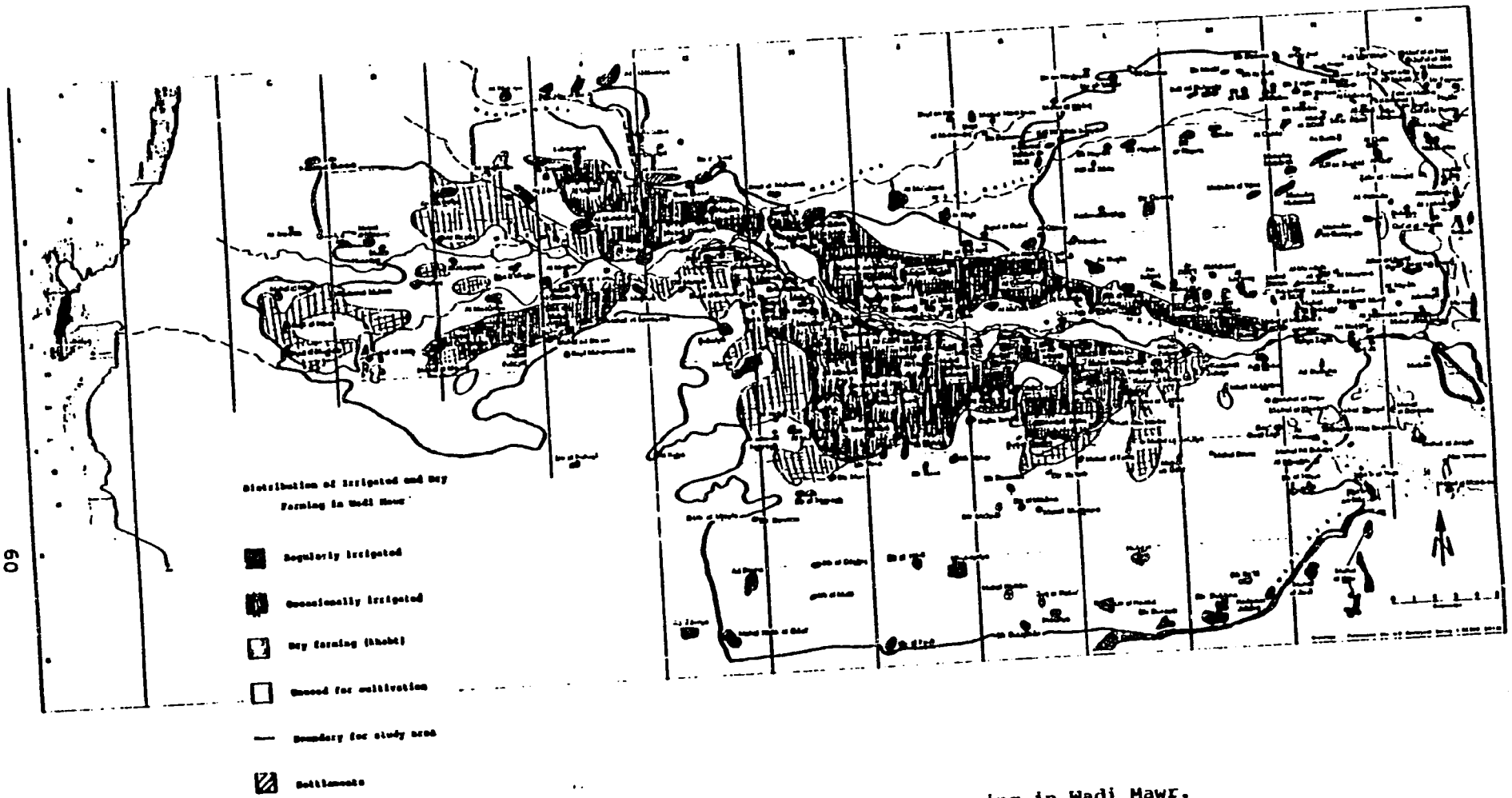

Figure 3.17. Distribution of Irrigated and Dry Farming in Wadi Mawr.

Source: Escher. 1976.

Land can be leased from private holdings, miri, or from waqf land, and the basic terms are the same. Owners of land in the wadi, where irrigation is facilitated, are in a strong position because of the greater demand for their land. In general, landowners provide only the land and no other resources. Only about 10 percent of the sample which leased land said the landlord bore production costs. The lessee must usually pay for or supply all labor, animals, tools, seed, and any fertilizer needed. Several fees are deducted from the yield before division between the landlord and the sharecropper. Ten percent of the yield goes to Zakat, 8 percent to the wakil al-aqm (water master), and 5 percent is for the threshing fee. The yield is then divided half and half under normal circumstances. If the landlord has provided a motorpump for irrigation he may get 2/3 to 3/4 after taxes and fees. Terms of a lease may be for many years. Nineteen percent of the sharecroppers had leases for 1-3 years, 27 percent for 4-10 years, 37 percent for 11-20, and 17 percent for over 20 years.

The relative standards of living of various agricultural classes in the Tihama is shown by a survey from wadi Zabid. A total of about 19,000 hectares is cultivated and nearly all of this is irrigated. About 10,000 families inhabit the area, and about 8,000 of these are dependent on agriculture. Of these, 4,400 represent day laborers, 2,000 are small landowners who work their own land, and 1,400 and 160 are sharecroppers on private land and state land respectively. One percent of the owners control 60 percent of the land, and 60 percent of the owners control only 10 percent of the land. Average annual income for day laborers is about 84 YR, small owners 1,000 YR, for private tenants 1,400 YR, and for state tenants 2,250 YR. Income for the 175 absentee landlords was not available, but the average annual income of the representatives that oversee their holdings was 25,000 YR. Most of these landlords live in Zabid town or in Hodeida. (ECWA/FAO Joint Agricultural Division 1978).

Two surveys are also available showing patterns in the highlands. One is of the village of al-Qasim, with about 180-200 inhabitants, which lies in the highlands about halfway between Sana'a and Sa'dah (Kopp 1977b). Theoretically, the agricultural land around al-Qasim is sabil, tribally owned. Milk land consists of sabil land which is individually cultivated. The milk is supposed to be usufruct only, not ownership, and it is use of the land, not the land itself, which may be owned. The topography, combined with Islamic inheritance law, has led to extreme fragmentation of

holdings. The average holding of cultivable land is 1-3 hectares. However, many of the elite also own some land in other parts of Yemen, and most families have some income from non-agricultural sources.

In al-Qasim landowners will normally work their own land. Only if they are unable to do so is it leased out. When it is leased, the contract specifying the plots and the terms is agreed upon before witnesses. From the yield, Zakat and next year's seed is taken out and the rest is split half and half. If the landlord supplied animals, a separate lease is drawn up for them.

In extreme cases, a peasant may have to sell his land (technically, his usufruct of the tribes land). Priority of purchase goes first to relatives, then to owners of neighboring plots, then other peasants of the same tribe, and only after several other possibilities is the peasant free to choose the buyer. In general both sale and leasing of one's land is regarded as undesirable, and attempts will be made to hire labor first.

Finally, a survey by CID (1979) in the southern highlands further shows that the highlands are primarily an area of small holdings worked by the owners. The vast majority of farmers in the sample surveyed cultivate their own land. There are an insignificant number of landless agricultural laborers. Laborers might be imported from neighboring areas in particularly good years. In the survey of randomly-selected peasant households, 71 farmers cultivated their own land. Three cultivated their own land plus some leased land, two cultivated only rented land, and one was an agricultural laborer.

3.3.4 Land Use Problems[13]

Migration has also had numerous effects on agricultural land. Migrant remittances often go into land acquisition, reinforcing the pattern of large holdings by a few people. Labor shortages have caused more marginal land to be abandoned; without upkeep, the terraces decline and become susceptible to erosion. On the other hand, the value of agricultural labor has risen.

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[13]Source: Checchi and Company. 1978.
World Bank. 1979

A number of the problems associated with land could be solved by increased training or the implementation of specific programs. Proper instruction in the use of tractors would prevent plowing too deep and the resulting loss of soil moisture. Afforestation of the marginal terraces could be used to prevent further soil deterioration, and to provide windbreaks to prevent crop damage and soil erosion from wind. Local problems with spreading sand dunes in the Tihama could also be dealt with by tree plantings. Fertilizers could increase yields given sufficient water.

Other problems are more serious in that no quick or even relatively quick solutions are available. The YAR is still in the beginning stages of developing its agricultural infrastructure. It simply does not have the resources or personnel to make any sweeping changes in rural areas. The traditional land tenure system is also somewhat of a problem. Sharecroppers do not often have the means or the incentive to make improvements, and landholdings are often so fragmented that modern methods cannot be economically applied. Labor shortages are not likely to decline either, even as the YAR develops, because many of its close neighbors are developing much more rapidly. In fact, as the YAR develops, internal migration to urban areas is likely to increase, further aggravating the shortage of rural labor.

3.4 Vegetation

3.4.1 Native Flora

Vegetation zones of a broad region distinguished as the "Mediterranean Zone" have been mapped by UNESCO-FAO (1970). In the Yemen Arab Republic ten divisions are represented as follows (Fig. 3.18):

1. Formations with a tropical bias. Acacia tortilis and Maerua crassifolia are found in the foothills, Panicum turgidum, Lasiurus hirsutus in the sandy plains. Bush steppe contains Acacia spp. and Commiphora spp. A number of sub-categories are mapped in Yemen without further definition. The zone is found throughout the lowlands and foothills on both sides of the Yemen highlands.

2. Introduced or transformed vegetation. Pockets of this oasis vegetation are found in the lower reaches of wadis along the coast. The vegetation is sustained by springs, artesian wells and sometimes by intense atmospheric humidity.

3. Bush shrub, tree pseudosteppe, savannah and thickets. This foothills transition zone is found fringing the mountains on the western, southern, and eastern sides. It consists of thorny scrub characterized by Euphorbia amac and Themeda triandra. Sub-categories are mapped but are not defined by UNESCO-FAO.

4. Shrub or tree pseudosteppe and savannah, thickets and open forest. This highland vegetation occurs in the western and southern areas of the Yemeni mountains. It consists of fairly open dry forests with Olea chrysophylla and Dodonea viscosa.

5. Savannah-woodland formations. Characteristic vegetation of this highland vegetation is more or less dense Juniperus procera from 1,800 m, and Podocarpus gracilior.

6. Forest formations occur in patches throughout the highlands and are characterized by Juniperus procera.

7. Perennial formations with or without ephemerophytes in accentuated desert climates. This desert steppe with Artemisia herba-alba and Stipa tortilis is fairly common in southwestern Saudi Arabia and may occur in interior Yemen near the Saudi border.

8. Ephemerophyte-dominated formations, with Haloxylon salicornicum, Rhanterium eppaposum, and Salsola spp. in the depressions. This desert vegetation is found in the eastern desert.

9. Sparse ephemerophyte formations or no vegetation. Representative vegetation includes Calligonum comosum, C. torophytes, and ephemeral forms of Aristida spp., Tribulus spp., and Fagonia spp. after rain. This is typical of the Rub al-Khali and occurs in the northeastern interior of the YAR.

10. Sands with Calligonum vegetation, found in the southeastern interior desert regions of the YAR.

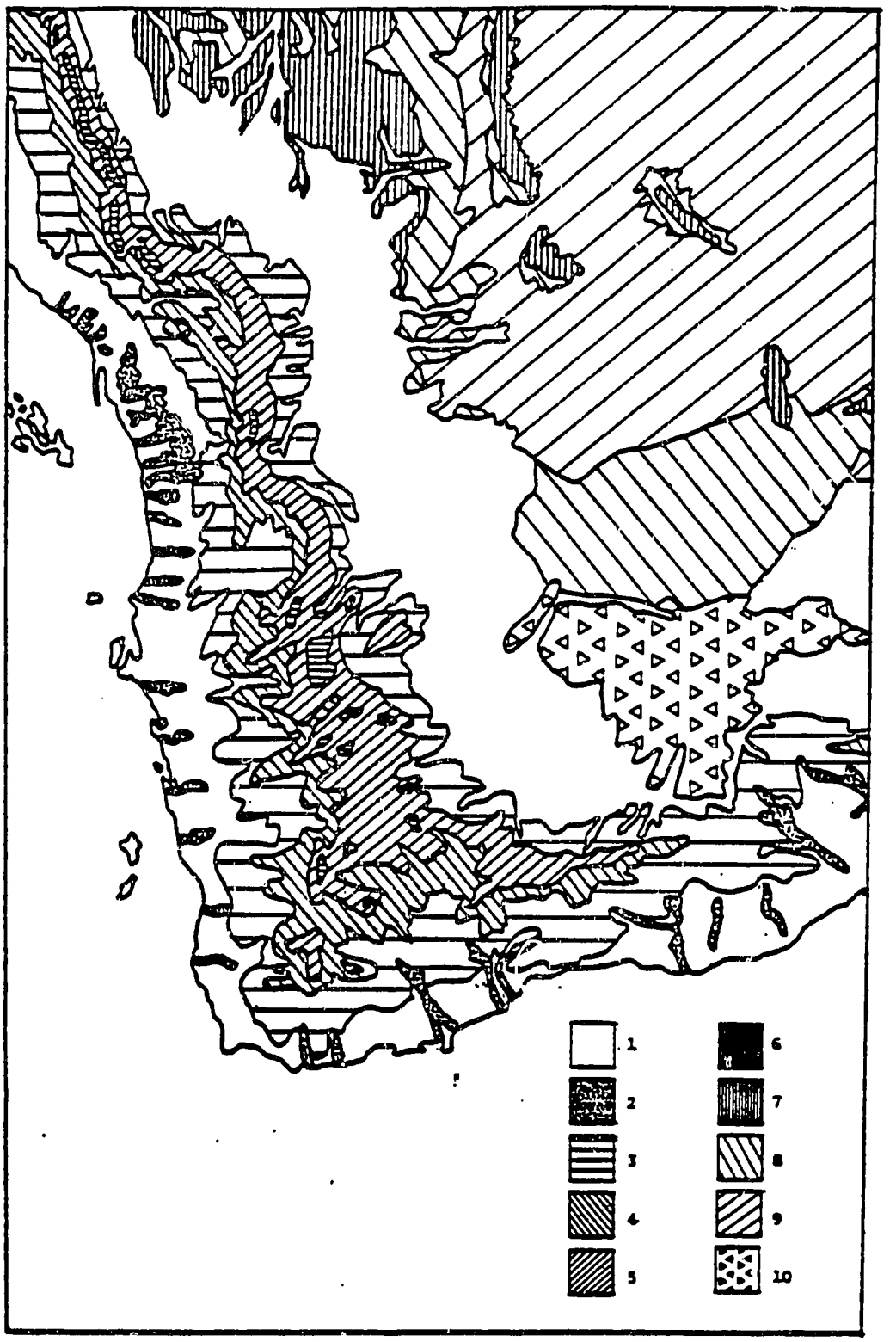

Figure 3.18. Vegetation of Southwest Arabia

Source: UNESCO-FAO. 1970.

Woodlands

The World Bank (1979) uses slightly different criteria, and considers only woodlands. The YAR has no forest in the strict sense, but large areas, about 8 percent of the total area, are covered by sparse woody vegetation. These woodlands may be grouped into 5 types:

1. Mangroves of the coastal belts that occupy the saline coastal marshes from Hodeida northward to the Saudi border.

2. Savannah-type woodlands that run close to the western foothills. Acacia species are dominant, growing in gravelly or sandy sediments.

3. Trees growing on the large fans of the big wadis that open onto the Tihama.

4. Acacia scrub woodlands in the foothills and highlands. These extend over large areas of the western and southern slopes of the central mountain range.

5. Wadi bottom vegetation, which includes the *Ficus* species that provide some lumber for construction of local buildings.

This woody vegetation is for the most part so sparse that it is of very little importance beyond the local level. Acacia is used as a fuel, and some wood is used in construction. Because of these kinds of local uses, it is thought that these resources are being depleted at a rapid rate. However, there is very little current data available on any aspect of these resources.

Rangelands

Most of the area of the YAR, including many areas which are sometimes called woodlands, can be more accurately classified as rangeland. Very little data is available on rangeland in most areas of Yemen, but very detailed studies have been carried out in the Rada' district in the southeastern interior desert (Westinga and Thaden 1980?). The following classification is taken from this study, as is the more detailed data in Appendix VI.

1. Slope vegetation types

The vegetation on the slopes can be classified in two main groups. The dwarf shrublands with scattered *Acacia* trees and shrubs: (AS1, AS2 and AS3) in the

East and the dwarf shrublands without trees (S1, S2, S3, S4 and AS4) in the West (Fig. 3.19a). These types are:

AS1 Acacia caupoptila - Acacia nubica type
AS2 Acacia millifera - Aloe inermis type
AS3 Acacia nilotica spp. kraussiana - Barleria parviflora type
AS4 Hypoestes paniculata - Acacia negrii type

S1 Lantana petitiana - Hyparrhenia hirta type
S2 Euphorbia inarticulata - Caralluna spec. type
S3 Chrysopogon plumulosus - Blepharis ciliaris 'rich' type
S4 Chrysopogon plumulosus - Blepharis ciliaris 'poor' type

2. Wadi vegetation types

The wadi vegetation types can be divided into Tamarix 'forests' (TAM 2) and four types of Acacia pachyceras 'forests' (W1, W2, W3 and W4). The distribution of the types is shown in Fig. 3.19b. All wadi types are characterized by the occurrence of Acacia pachyceras, Solanum incanum, Calotropis procera and Cynodon dactylon. The types are:

W1 Acacia pachyceras - Solanum incanum + Salvadora persica type
W2 Acacia pachyceras - Solanum incanum + Ephedra aphylla type
W3 Acacia pachyceras - Solanum incanum + Solanum sepicola type
W4 Acacia pachyceras - Solanum incanum + Withania somnifera type

TAM2 Tamarix nilotica - Pluchea dioscoriodes types

3. Non-saline valley vegetation types

Two valley types (V1 and V2) were found to be distinctly different from the other, mostly halophytic, types in the plains and valleys. They are floristically rather closely related to the slope and wadi types listed above. They are:

V1 Salsola spinescens - Euphorbia cuneata type
V2 Acacia pachyceras - Acacia nilotica spp. kraussiana type

4. Halophytic plain and valley types

The vegetation of distinctly saline areas (Fig. 3.19b) can be divided into four types: the halophytic

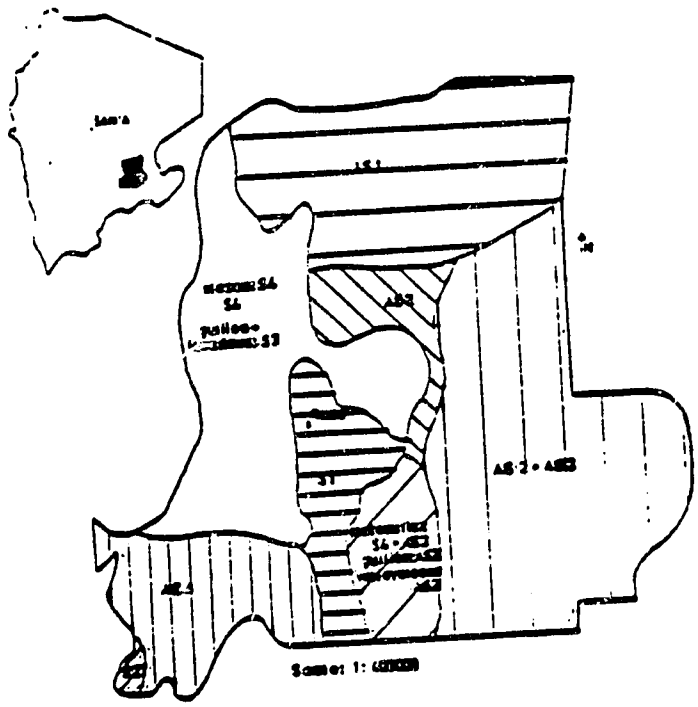

Figure 3.19a. Distribution of the Slope Vegetation Types in the Rada District.

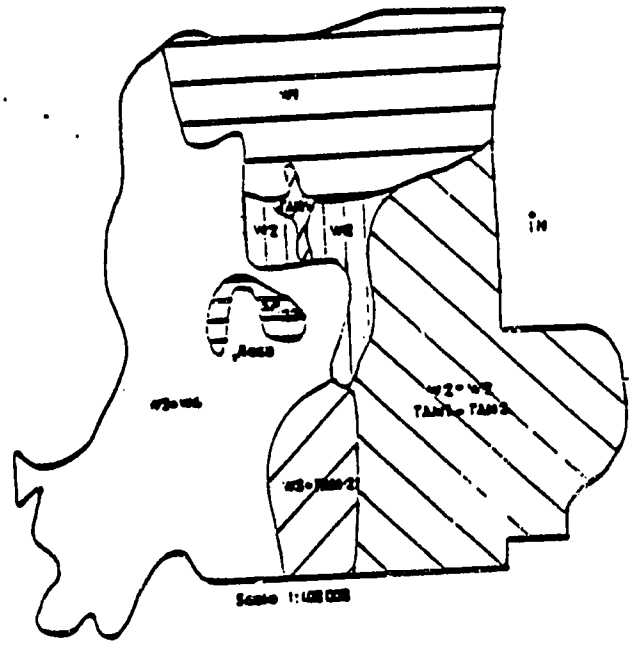

Figure 3.19b. Distribution of the Wadi and Halophytic Vegetation Types in the Rada District.

Source: Westinga and Thalen. 1980 ? .

Tamarix bush 'forest' (TAM1) and the halophytic plain types SP1, SP2, and SP3, fully named as follows:

TAM1 Tamarix nilotica - Schanginia hortensis type

SP1 Aeluropus lagopoides - Atriplex leucoclada type
SP2 Juncus heldreichianus - Dichanthium annulatum type
SP3 Sporobolus iocladon - Centaurea pallescens type

5. Types of cultivated and fallow lands

Only two units have been distinguished:

FAL Xanthium spinosum - Laggeria garieppina type (fallow land)
AGR Convolvulus arvensis - Erucastrum arabicum type (cultivated land).

6. Vegetation types of drainage ways and marshland

The vegetation found in permanently wet places, where springs occur and water accumulates at or near the surface, has been divided in two types: DW Drainage ways and MP Marshy places:

DW Apium nodiflorum - Agrostis semiverticillata type
MP Paspalum vaginatum - Juncus oxycarpus type

3.4.2 Range Use[14]

Livestock populations were estimated for 1973 as follows:

sheep & goats	9,500,000	(11.6 million 1965)
cattle	800,000	(1.3 million 1965)
donkeys	600,000	(500,000 1965)
camels	100,000	(55,000 1965)

Figures for sheep, goats, and cattle are declining, as are the numbers reported slaughtered from 1972 to 1975.

Severe erosion and depletion of plant cover is becoming a problem, and may be one cause for these declines in animals. These problems were perhaps brought on by the drought between 1967-73, as figures for 1974 show slight improvements. The World Bank has suggested that these arid to semi-arid rangelands

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[14]Sources: Nyrop et al. 1977.
World Bank. 1979.

could be restored to some extent, but no projects are being carried out to do so at present.

No data is available breaking down the animal population according to whether they are herded by nomads or kept by villagers. Most of the eastern part of the YAR is inhabited by nomads, but their total population is small. In general, most animals are owned by villagers and grazed communally near the village, so that any programs must start with these villages. The IDA is planning several pilot Village Development Associations and a Range Improvement Center which may be able to address some of the problems of the rangelands.

3.5 Fauna[15]

The Yemen Arab Republic is part of the Ethiopian zoogeographic region, which covers southern Arabia and central and southern Africa. Current information is almost non-existent on fauna in Yemen. No current literature even mentions wildlife as being of any importance in the economy or daily life of the population, except for fishes.

Crop threatening insects have been investigated to some extent (University of Arizona 1981). Swarms of desert locusts (Schistocerca gregaria) have been reported in the Tihama, and may have migrated from across the Red Sea, where they cause extensive damage. Surveys in the San'a and northern mountain areas observed the migratory grasshopper (Locusta migratoria), but not the desert locust. Appendix V, Table 7 provides detailed data on insects identified as the most serious sorghum and millet pests, as well as several beneficial insects.

3.5.1. Rare and Endangered Species

The Red Data Book lists only three species in Yemen as being threatened, which the IUCN defines as being in its endangered, vulnerable, rare or indeterminate categories. These are as follows:

Panthera pardus nimr	South Arabian Leopard
Dugong dugon	Dugong
Gazella gazella arabica	Arabian Gazelle

Details on these animals, taken from IUCN (1978) are included in Appendex VII. Countries near the YAR are listed for comparison as many of these species may also be in the YAR.

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[15]Sources: IUCN. 1976.
Scott. 1939.

ETHIOPIA

Canis simensis simensis	Northern simien fox
Lycaon pictus	African wild dog
Panthera pardus	Leopard
Acinonyx jubatus	Cheetah
Dugong dugon	Dugong
Equus asinus	African wild ass
Equus grevyi	Grevy's zebra
Diceros bicornis	Black rhinoceros
Alcelaphus buselaphus tora	Tora hartebeest
Alcelaphus buselaphus swaynei	Swayne's hartebeest
Dorcatragus megalotis	Beira antelope
Ammodorcas clarkei	Dibatag
Capra ibex walie	Walia ibex

SOMALIA

Lycaon pictus	African wild dog
Panthera pardus	Leopard
Acinonyx jubatus	Cheetah
Dugong dugon	Dugong
Equus asinus	African wild ass
Equus grevyi	Grevy's zebra
Diceros bicornis	Black rhinoceros
Damaliscus hunteri	Hunter's hartebeest
Ammodorcas clarkei	Dibatag
Gazella dorcas pelzelni	Pelzein's gazelle
Dorcatragus megalotis	Beira antelope
Gazelle spekei	Speke's gazelle

SAUDI ARABIA

Canis lupus	Wolf
Panthera pardus nimr	South Arabian leopard
Panthera pardus jarvisi	Sinai leopard
Acinonyx jubatus venaticus	Asiatic cheetah
Dugong dugon	Dugong
Gazella subgutturosa marica	Sand gazelle
Gazella dorcas saudiya	Saudi Arabian dorcas gazelle
Gazella gazella arabica	Arabian gazelle

OMAN

Panthera pardus nimr	South Arabian leopard
Dugong dugon	Dugong
Oryx leucoryx	Arabian oryx
Gazella gazella arabica	Arabian gazelle
Hemitragus jayakari	Arabian tahr

SOUTH ARABIAN FEDERATION

Gazella gazella arabica	Arabian gazelle

SOUTH YEMEN

Panthera pardus nimr	South Arabian leopard

3.5.2 Fishing[16]

The estimated catch in 1976 of all fish from Yemen waters was 17,000 metric tons. The potential is estimated to be about 25,000 metric tons per year. This includes some fish types which are not now eaten by the local population. The main fish resources presently exploited by the artisanal fisherman are pelagic in habit; i.e., they are fast-moving and live in open waters. These species include the Indian mackerel, which makes up the largest part of the catch, the king mackerel, tuna, black cobia, large jacks, sharks and barracuda.

The highly prized shrimp and lobster resources are substantial, but not as great as once assumed. Based on production potentials off West Africa of 3 metric tons per square mile, and a maximum of 500 square miles of shrimp grounds off Yemen, the production potential indicated would thus be 1,500 metric tons per year. On the basis of the latest surveys, however, it has been found that the shrimp areas are mainly in the coastal waters, especially north of Hodeida around Kamaran Island. This area is not more than 250-300 square miles.

Another potentially exploitable marine resource is the crayfish or spiny lobster of the coral reef area. There is undoubtedly considerable suitable habitat for spiny lobsters fringing the reefs, but additional exploratory fishing trials need to be undertaken to estimate the quantities that might be exploitable.

The bivalve mollusca located in the shallow littoral regions along the beaches are another potential marine resource. The local clams have a hard consistency but are quite delicious and are already exploited to a small degree by the foreign community in Hodeida. Development of this resource as a canned export is a possibility. However, further work on stock is neccessary.

An estimated 4,000 fishermen earn a meager livelihood from artisanal fishing. The estimated number of fishing vessels now in operation is: 100 large motorized boats (sambuks), 140 small motorized boats (houris), 640 medium-sized boats (houris), and roughly 100 small rafts. Most of the local catch of fish is sold in the immediate coastal region. However, increasing amounts of fresh fish are reaching the

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[16] Source: World Bank. 1979.

urban centers of Sana'a and Ta'izz. A large part of the fish landed is salted and dried for transport to interior markets as well as for export.

Fishermen get relatively low prices for their catch at the village landing centers. In addition, the price fluctuates widely with availability and season. If their catches are too large there may not be a market at any price.

3.5.3 Parks, Reserves, Protected Areas[17]

This section is inserted only to note that nothing is being done in the field. The lack of current data on wildlife, and the fact that wildlife is not part of the traditional or modern economy, indicates no governmental or popular awareness or action in the sphere of parks or reserves. The IUCN in 1971 had no listings of national parks or equivalent reserves, and noted:

> "No response yet received from the authorities at San'a, but private information suggests that no areas exist with the necessary qualifications for inclusion in the list."

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[17]Source: IUCN. 1971.

4.0 Environmental Problems and Impacts

The Yemen Arab Republic is hardly even in the beginning stages of awareness of environmental problems or developing the ability to deal with them. In fact, Yemen is so undeveloped that many modern environmental problems simply do not exist and are not likely to become even a minor concern for years to come. However, even if industrial pollution, air pollution, and excessive noise levels do not exist, there are some major problems to be faced in the areas of water and land resources.

4.1 Legal and Administrative Background[18]

The YAR is still governed essentially under Shari'ah, or Islamic law, combined with customary law. There is very little modern legislation that addresses any aspect of the environment directly. Because Islamic law is basically concerned with the well-being of the community, and because it tends to approach problems on a case by case basis, there is certainly ample legal justification should the government need to step in on a specific case. Islamic law has already addressed many cases of water pollution, proper water management, and similar problems which have come up in traditional settings. However, as the YAR continues to develop, one of its needs will be some kind of comprehensive program to deal with such problems on a nationwide scale, rather than case by case.

A few institutions are beginning to appear which have been given powers to deal with some aspects of environmental problems on a restricted scale. For example, the National Water and Sewerage Authority (NAWSA) was set up in 1973 (Section 3.2.4) and given power over most aspects of urban water supplies and sewage. In particular, NAWSA's mandate gives it full power to take any steps necessary to protect the undergound and surface waters under its authority from pollution. This mandate has also been interpreted to include control over agricultural water usage within established protected zones around urban areas. The Tihama Development Authority, charged with responsibility for irrigation schemes and integrated rural development, may similarly concern itself with various environmental problems in the rural Tihama. A network of Local Development Associations is being established throughout the YAR. Many projects of this successful self-help program deal with environmental problems on a local level.

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[18] Sources: Caponera. 1973.
Quarterly Econ. Rev. 1979.
U.S. AID. 1972.
World Bank. 1979.

4.2 Water Supplies and Water Related Disease

Water is the single most crucial element in the YAR's efforts to develop, and it is not surprising that the most pressing environmental problems concern various aspects of water.

4.2.1 Rural Water[19]

Drinking water in rural areas is usually obtained from shallow wells which are often contaminated. A number of projects, including a U.S. AID Rural Water Supply project, have been constructing new village water systems, upgrading old ones, and providing training in maintaining the systems. In many cases, pumps are being installed for obtaining both drinking water and irrigation water.

Greatly increased use of pumps, especially for agriculture, is leading to serious depletion of the water table in many areas. Natural groundwater discharge of the coastal aquifers is declining rapidly due to pumping. Groundwater discharge at wadi Zabid, for example, has declined from 130 million cubic meters (mcm) in 1971 and 104 mcm in 1973 to 82 mcm in 1976. During this period pumping in the area increased from 130 mcm in 1973 to 165 mcm in 1975 (al-Eryani 1979). This increased pumping does salvage groundwater which would otherwise be discharged into the Red Sea. However, as water tables drop, seawater intrusion becomes a major problem. Several observers have cited the occurrence of seawater intrusion, but no data are available.

Increased pumping has also led to problems with soil salinity, especially in the Tihama where groundwater can be quite saline. Increases in surface water irrigation also are contributing to salinity problems. If expansion of irrigation continues according to plan (Table 4.1), these problems are likely to increase.

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[19]Sources: al-Eryani. 1979.
Nyrop et al. 1977.
U.S. AID. 1980.
U.S. Department of State. 1979.
World Bank. 1979.

Table 4.1 Long-Range Irrigation Targets

Plan Period	Flood Irrigation	Perennial Irrigation	Well Irrigation
	1,000 ha		
Present irrigation	120	73	37
1st 5-Year (1976/81)	134	79	83
2nd 5-Year (1981/86)	148	89	144
3rd 5-Year (1986/91)	158	96	194

Source: World Bank. 1979.

4.2.2 Urban Water Problems[20/]

Urban water supplies, also primarily from groundwater, are being depleted. Recharge of aquifers is not keeping pace with increases in demand. The cities of Sana'a and Ta'izz are primarily affected by this, and projections expect demand to far exceed the resources by the end of the century (Section 3.2.2).

Inadequate urban sewage systems are a major problem also. Waste water in Sana'a often drains directly into the gutter, and eventually reaches the aquifer under the city. Sewage is usually disposed of in pit latrines or cesspools; only occasionally are septic tanks available. Ta'izz is the only city to have a limited sewage collection system as of 1975, but this served only about 2,000 people. Otherwise, problems are similar to Sana'a.

In Hodeida the situation is similar. However, while the country's high altitude and low humidity somewhat check the resulting health problems, Hodeida does not have such mitigating factors. In addition, the water table is high in the area, and low-lying areas may not absorb wastewater at all. Stagnant pools greatly increase the transmission of typhoid, paratyphoid, cholera, parasites, infectious hepatitus, hookworm, and bacillary dysentary. In coastal areas such as Hodeida, solving water shortage problems without first installing sewage systems will only make conditions worse.

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[20] Sources: Nyrop et al. 1977.
U.S. AID. 1972.
World Bank. 1979.

4.3 Other Rural Problems[21]

Several other problems in rural areas are also the indirect result of water management or lack of it. Soil erosion is a serious problem in the YAR. During exceptional floods, high water can wash away much of the irrigation network of a wadi, as well as substantial amounts of soil. Modern projects in wadi irrigation are beginning to solve this problem. However, abandonment of terraces in highland regions is increasing problems there. Erosion is getting worse as terraces deteriorate. In addition, downstream areas are subject to greater flooding and sedimentation because deteriorated terraces no longer hold soils or slow runoff. Little data other than simple observations are available on terrace deterioration.

Soil erosion is also serious in range areas, and is often caused by depletion of rangeland and woodland vegetative cover. Westinga and Thalen (1980?), for example, cite severe problems with both sheet and gully erosion in the Rada' district. Communal grazing leading to overgrazing is certainly a major cause, although Westinga and Thalen are noncommittal about the extent to which overgrazing contributes to erosion.

The widespread use of the scanty wood resources for fuel and poles is the second cause of devegetation. Westinga and Thalen (1980?) are more explicit in identifying this cause of vegetation depletion in Rada'. Improved transport and high firewood prices have encouraged widespread wood cutting. On the other hand, in some parts of Yemen, high wood prices and the use of trees as windbreaks for crops have encouraged farmers to begin planting trees. Tree planting projects are being considered in some parts of the country (le Houerou 1976) and may help alleviate the problems somewhat if they are carried out extensively.

Shifting sand dunes are still another problem which occurs both in the Tihama and in the interior deserts. It is most serious in the Tihama where large areas of agricultural land may be buried. Le Houerou (1976) notes that the dune areas around wadi Rima have expanded greatly since 1972 and by 1976 threatened the highway in the area as well as large stretches of cultivated land. Other roads in the region have already been buried. Le Houerou has proposed a stabilization program. However, data on progress of such programs and even on the extent of the problem are not available.

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[21]Sources: Bornhardt et al. 1980.
le Houerou. 1976.
Nyrop et al. 1977.
U.S. Department of State Telegram #6891.
Westinga and Thalen. 1980?
World Bank. 1979.

Soil depletion and low yields are also problems in rural areas. Fertilizers and insecticides have been shown capable of greatly improving this situation. Use of them is so recent and so restricted (Table 4.2) that there is not yet and will not be for many years any resulting environmental impact. The YAR is fortunate that it has a chance to address one potential problem before it becomes serious.

Table 4.2 Fertilizer and Insecticide Imports

Year	Fertilizers		Insecticides	
	Tons	CIF Value (YRLs 1,000)	Tons	CIF Value (YRLs 1,000)
1969/70	1,997	900	118	300
1970/71	3,153	200	135	300
1971/72	4,046	500	218	500
1972/73	1,799	800	382	800
1973/74	4,256	1,500	375	1,200
1974/75	3,869	1,700	717	2,100
1975/76	7,932	1,400	2,510	2,900

Source: World Bank. 1979.

Table 4.3 Comparison with Other Countries of Average Fertilizer Use Per Hectare of Arable Land and Land Under Permanent Crops; 1974.

Country	Nitrogen	Phosphate	Potash	Total
	kg per ha			
Y.A.R.	2.0	-	-	2.1
Libya	4.0	1.6	0.6	6.1
Syria	4.5	2.2	0.3	7.0
Sudan	8.4	-	-	8.4
Saudi Arabia	6.5	3.5	4.5	14.5
Bahrain	10.0	5.0	5.0	20.0
Egypt	126.1	22.8	1.9	150.8
Europe	78.4	55.6	57.2	191.2
The World	25.8	15.1	13.2	54.1

Source: World Bank. 1979.

4.4 Other Urban Problems[22]

Traditional Yemeni houses in urban areas have a latrine shaft which runs from the lavatory-bathroom on an upper floor of the house to the ground floor. Excrement is collected in a small room at the bottom of the shaft, and eventually used for fuel when dried. Liquids are led down a vertical drain on the outside of the building. At ground level they disappear into an underground drainage sump, which usually leads to the street gutter. The ground floor also usually has rooms used as stables for animals. A typical house plan is shown in Fig. 4.1. This system is essentially what exists at present, as modern urban sewage and water treatment facilities are still in the rudimentary stages.

Rapid urbanization has been taking place since about 1970, although the total urban population is still a small percentage of total population. The 332,077 inhabitants of the five main cities (1975) is nearly double the urban population at the end of the 1960s. This growth has proceeded almost without any planning. In addition to water and sewage problems, many others are worsening due to this trend. Inadequate housing springs up in suburb areas. Nearly one fourth of all urban housing is huts, tents, or other temprorary structures. There is also crowding; in 1975 about two-thirds of all living quarters had only one or two rooms. The average occupancy rate per room was 1.6 in San'a, 1.4 in Ta'izz, and 2.9 in Hodeida. Since 1975, population density in urban areas has greatly increased. Transportation, solid waste collection and access to electricity are all still very inadequate.

The Yeman Arab Republic cannot be said to be facing some of the major pollution problems of more developed countries. Industrial pollution is still practically non-existent, as is air pollution.

4.5 Public Health[23]

Beyond the incidences of disease noted in section 2.2.4, there is no current data on the state of public health beyond the mention of certain diseases being present. However, environmental conditions which foster these diseases have not changed much since a survey was taken in 1951, so that the

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[22]Sources: Museum of Mankind. 1976.
World Bank. 1979.

[23]Sources: Kuntz et al. 1953.
Mount. 1953.
Mount and Baranski. 1953.

YEMENI HOUSE PLAN

A Entrance hall
Aa Entrance hall upper level
B Lobby
C Court
Cc Court upper level
D Animal stall
E Sheep pens
F Excrement room
G Well
H Store
J Grain and fruit store
K Loading
L Grinding mills
M Personal room
N Living room
O Bathroom
P Mafraj
Q Diwán
R Kitchen
S Terrace
T Laundry terrace
U Shaft
V Rain water
W Water cooling box
X Women's room and wardrobe

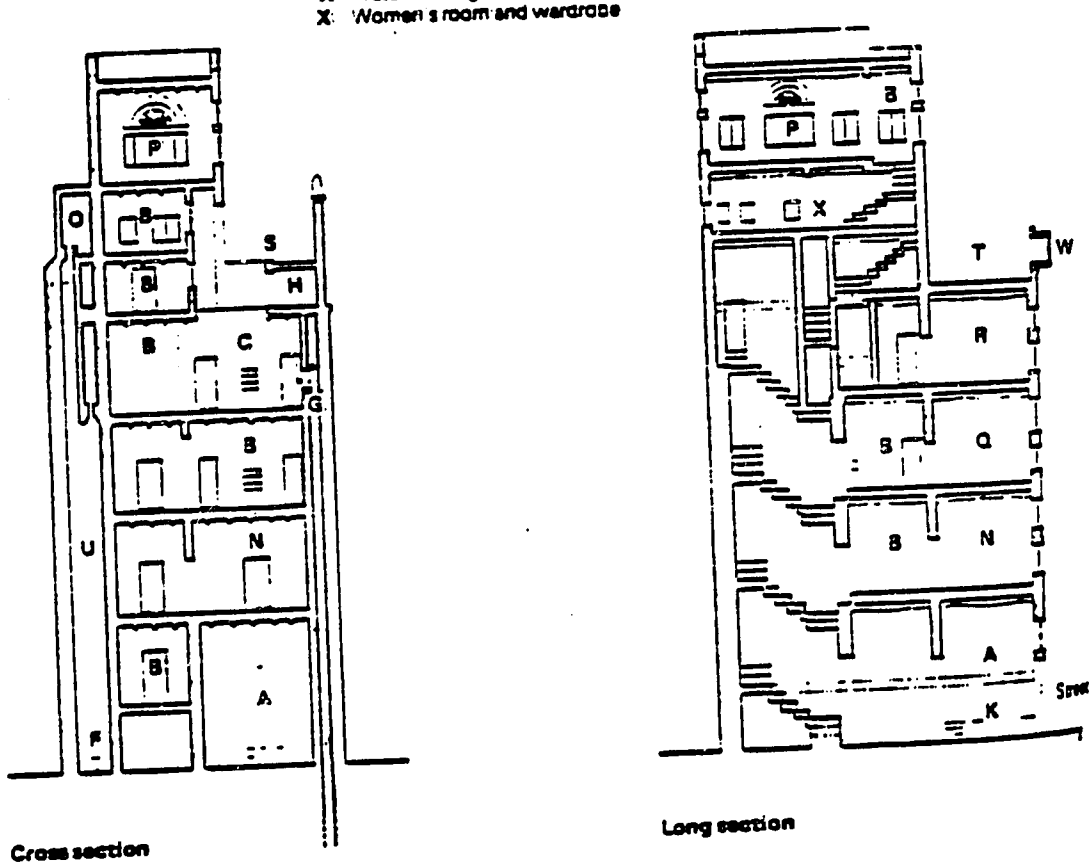

Figure 4.1. Yemeni House Plan.

Source: Museum of Mankind. 1976.

results may still give an idea of health conditions. Incidences of intestinal protozoa and helminth parasites are shown in Table 4.4.

Waterborne parasites such as Schistosoma mansoni, S. hametobium, as well as other diseases, were often transmitted via polluted water in ablution pools of mosques. Snail vectors were found in some mosques. Bacteriological and seriological sampling shows the incidences where typhoid, paratyphoid (from Salmonella) and bacillary dysentary (from Shigella) may be present (Tables 4.5, 4.6, 4.7).

4.6 Impact of Labor Migration[24]

One of the single most influential factors causing rapid change in the Yemeni agricultural sector in recent years has been rural labor migration. Many of the YAR's most serious environmental problems are directly related to the agricultural sector; therefore migration must be considered. Some migration is from one rural area to another. The Tihama wadi area may import some labor from the highlands, and to a certain extent the whole wadi may be regarded as an economic unit within which labor can be transferred. Of 126 farmers surveyed in wadi Mawr, 56 percent said they hired agricultural workers. Those working land in the irrigated wadi needed about 30 days of extra labor per hectare, and those dryland farming needed 5-10 days of extra labor. These extra needs are concentrated at plowing/sowing time in the summer and at harvest time in the fall. Many of the agricultural laborers are from the wadi Mawr region, but some also come from an area just to the north. However, only a few percent of the migrants go to other rural areas, and the sex ratio figures (Table 4.8) clearly show that the Hodeida Governorate (which includes most of the Tihama) is the only one not facing major out migration.

Internal rural-urban migration is a greater drain on the agricultural labor supply. Most of this internal movement is oriented toward the cities of San'a, Hodeida, and Ta'izz.

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[24]Sources: Birks and Sinclair. 1979.
Checchi and Company. 1978.
Cohen and Lewis. 1979.
Escher. 1976.
Halliday. 1977.
Kopp. 1977a.
Kopp. 1977b.
Socknat and Sinclair. 1978.
Speece. 1980.
Swanson. 1979.
Tutwiler et al. 1976.
World Bank. 1979.

Table 4.4 Percentage of People Infected with Intestinal Protozoa and Helminth Parasites (parasites identified from urine and fecal specimens, and perianal swabs)

PARASITES	LOCALITY			
	Hodeida	Ta'izz	Ma'bar	San'a
Intestinal protozoa				
Number of fecal specimens examined	72	100	26	24
Endamoeba histolytica	37*	33	65	37
Endamoeba coli	54	49	65	63
Endolimax nana	31	24	35	33
Iodamoeba bütschlii	19	31	42	75
Chilomastix mesnili	8	10	15	8
Giardia lamblia	19	11	0	13
Trichomonas hominis	4	2	0	0
Helminths				
No. fecal and urine specimens and perianal swabs examined	182	218	26	70
Ascaris lumbricoides	8	49	89	14
Enterobius vermicularis	7	14	21	26
Hymenolepis nana	18	4	4	10
Schistosoma haematobium	2	10	0	0
Schistosoma mansoni	7	56	4	18
Taenia saginata	0	0	16†	0
Trichuris trichiura	15	5	15	7

* Percentage infection is given as the nearest whole number.
† Two fecal specimens contained gravid proglottids as well as ova.

Source: Kuntz et al. 1953.

Table 4.5 The Percentage Distribution of Salmonella Non-specific "H" Agglutinins and S. typhi "O" Agglutinins by Age Group and Location in the Yemen

	PER CENT OF SERA AGGLUTINATING AT 1:20 OR ABOVE, BY AGE GROUP*				
Age in years	11-15	16-25	26-40	over 40	Total
No. sera from Ta'izz (number)	31	30	59	42	162 } 218
San'a "	14	31	4	7	56 }
Salmonella N.S.H (per cent)	13	13	22	8	15
Ta'izz "	13	12	24	10	16
San'a "	14	13	0	0	11
S. typhi "O"	70	84	51	63	67
Ta'izz "	58	93	47	60	61
San'a "	93	78	100	86	82

* Percentages are given as the nearest whole number.

Source: Mount and Baranski. 1953.

Table 4.6 Distribution by Age Groups of Shigella and Salmonella Types in the Yemen on the Basis of a Single Stool Culture

	AGE IN YEARS					TOTAL
	6-10	11-15	16-20	21-30	over 30	
No. examined	43	97	64	94	60	358
Per cent of pop. sample	12	27	18	26	17	100
Pos. for *Shigella*	6	12	12	10	11	51
Shigella						
ambigua					3	3
sonnei		2	5	5	6	18
flexneri						
I	2		1			3
II	1	2	2	1	1	7
III	1	1	2	1	1	6
IV		4	1	1		6
V	1	1		1		3
VI				1		1
VII	1	2				3
VIII			1			1
sachs	4	1	2	1		8
dispar						
Salmonella						
paratyphi						
A	1		1			2
B			1	1		2
C						
typhi	3	1				4
Total *Shigella* & *Salmonella*	10	13	14	11	11	59
Per cent pos. for enteric pathogens*	23	13	22	12	18	17

* Percentages are given as the nearest whole number.

Source: Mount and Baranski. 1953.

Table 4.7. Regional Distribution of Shigella and Salmonella Types in the Yemen on the Basis of a Single Stool Culture.

	Hodeida	Ta'izz	San'a	Totals
No. examined	150	160	39	358
No. positive for:				
Shigella	14	34	3	51
ambigua	1	2	0	3
sonnei	1	17	0	18
flexneri				
I	2	1	0	3
II	1	5	1	7
III	2	2	2	6
IV	0	0	0	0
V	1	5	0	6
VI	2	1	0	3
VII	0	0	0	0
VIII	0	1	0	1
sachs	3	0	0	3
dispar	1	0	0	1
Salmonella	5	1	2	8
paratyphi				
A	1	0	1	2
B	0	1	1	2
C	0	0	0	0
typhi	4	0	0	4
Total *Shigella* & *Salmonella*	19	35	5	59
Per cent found positive*	12	22	13	•

* Percentages are given as the nearest whole number.

Source: Mount and Baranski. 1953

Table 4.8 also shows that these cities have a large excess of males; most of this excess is due to men from rural areas who have come to the cities to find work. The estimated 70,000-80,000 such migrants (roughly 1.3% of the population) is substantial, but is nevertheless still a rather insignificant phenomenon compared to the magnitude of international labor migration.

Table 4.8 Enumerated Resident Population by Sex and Governorate (Preliminary Results of February 1975 Census)

Governorate	Governorate			Governorate Capital	
	Population (000)	Sex Ratio 1/ (percent)	Percent of Total Pop.	Population (000)	Sex Ratio 1/ (percent)
Sana'a	807,269	95.2	17.8	134,588	131.9
Damar	455,132	87.3	10.0	19,167	105.8
Ibb	789,518	88.4	17.4	19,066	116.1
Taizz	873,876	83.6	19.3	78,642	132.2
Hodeidah	676,693	102.2	15.0	80,314	145.0
Mahweet	174,639	85.7	3.9	2,421	109.2
Hajjah	396,578	95.8	8.7	5,813	107.3
Sa'adah	154,361	90.5	3.4	4,252	110.7
Marib	40,896	98.3	1.0	292	—
Beida	157,764	81.5	3.5	5,975	82.6
TOTAL	4,526,326	90.9	100.0	350,831	130.4

1/ Male/Female

Source: World Bank. 1979.

Estimates on the volume of international labor migration vary widely. The highest are about 1.5 million (Quarterly Economic Review 1979). The Yemeni government estimated 1,234,000 emigrants in its preliminary census results for 1975, but revised this estimate later to about 600,000 (World Bank 1979). This agrees with several other analyses (refs. in Birks and Sinclair 1979). World Bank (1979) estimates are about 500,000. The latest figures of the International Migration Project, which studied the problem extensively in a number of countries, show about 332,000 (Socknat and Sinclair 1978). This figure also agrees with several other estimates (Refs. in Birks and Sinclair 1979; Socknat and Sinclair 1978).

The lower estimates would seem to be more accurate, as they are based on more extensive research. Regardless of which figure is accepted, emigration is massive. Even 332,000, the lowest estimate, represents about 6.3 percent of the total

population. World Bank figures show that the total manpower potential in Yemen is about 3.5 million, and of this, only about 1.7 million are actually in the labor force (Table 4.9). The World Bank estimate of 600,000 emigrants represents 35.3 percent of the total labor force. When it is further realized that 73.2 percent of employment in Yemen is in agriculture, the impact of emigration on the agricultural sector can be fully appreciated.

Table 4.9. Population, Manpower and Labor Force, 1975
(in millions)

	Total	Male	Females
Total Population	5.3	2.7	2.6
of which Manpower Potential /a	3.5	1.8	1.7
of which People not seeking employment /b	1.8	.3	1.5
Migrants	.6	.5	.1
Resident Labor Force	1.1	1.0	.1

/a Age groups 10-69.
/b Including students and incapacitated.

Source: World Bank. 1979.

To some extent, this massive labor migration is causing changes in ownership patterns. The money earned abroad is sometimes invested in land, and this reinforces the patterns of large-holdings owned by relatively more well-off families. In general, though, investment in the agricultural sector is low on the list of priorities for returning migrants, and those who are interested in agricultural investment prefer larger projects in the Tihama. When the general reluctance to sell land is added to this, the net result is that very little rearrangement of ownership patterns is actually taking place except in the Tihama. Leasing patterns are changing to a greater extent. Some areas may have such labor shortages that no one can be found to lease, but other areas have seen great increases in share cropping. Labor is much more valuable, and thus the terms of these agreements are becoming more favorable to the leassee.

The major shifts caused by migration, however, are in land use and cropping patterns. Labor shortages are making it difficult to maintain marginal fields. Increased income is reducing the incentive, since these marginal areas are no

longer needed to support the family. A major shift toward qat is the result. Qat can be produced with very little labor input. At the same time, demand for qat has increased greatly, in large part due to more cash being available from remittances, and the price has risen. Coffee prices have fallen on the world market, and coffee, a labor intensive ecological competitor of qat, is being abandoned. Abandonment of marginal lands due to labor shortages is also one of the major factors behind the deterioration of terraces noted in Section 4.3.

Mechanization, still in the very early stages, is receiving a push because there is no longer sufficient labor for traditional methods. Tractors are often unsuited to conditions in Yemen, and the result is further deterioration of land, especially in highland areas. In lowland areas, which are physically the best suited for mechanization, the trend may drive a large pool of agricultural labor off the land in the only area not yet hit by such massive emigration. Remittances are also invested in pumps for irrigation, which can also be a mixed blessing. Short term production is improved, but often at the cost of increased soil salinity and declining water tables.

Finally, Yemeni migration abroad is overwhelmingly in unskilled and semi-skilled categories. However, in a country as short of highly trained personnel as the YAR, even the loss of a few trained people can impede implementation of development projects. Concern over a Yemeni "brain drain" may not seem justified in terms of the small numbers involved, and Yemen is certainly not similar to Jordan or Egypt in sending large numbers of educated or skilled personnel abroad. Still, the YAR is hurt by the loss of even a few of these people at this stage of its development.

4.7 Economic Development

The Yemen Arab Republic's initial Five-Year Dovelopment Plan (1976/77-1980/81) was the first attempt at comprehensive planning (Table 4.10). Previous development was simply a collection of individual projects. The basic economic objectives of the plan, as summarized by the World Bank (1979), were as follows:

(a) Mobilize human resources and improve their skills through education and vocational training;

(b) Expand the physical infrastructure, i.e., the transport network, telecommunications, and electricity, thus integrating the various regions of the country and breaking present bottlenecks in the supply of vital goods and services;

(c) Develop the productive sectors, i.e., agriculture and industry. Increase domestic food production;

Table 4.10. Five Year Plan: Investment by Sector

(YR mn; 1975/76 constant prices)

	1976/77	1977/78	1978/79	1979/80	1980/81	Total	% of total
Transport & communications	347	615	912	1,282	1,769	4,925	30.8
Industry	270	545	657	850	1,223	3,545	22.2
manufacturing	170	342	371	476	639	1,998	12.5
electricity & water	84	182	254	325	528	1,373	8.6
mining & quarrying	16	21	32	49	56	174	1.1
Agriculture	154	321	423	536	842	2,276	14.3
Housing	305	307	387	509	582	2,090	13.1
Services	90	194	364	564	751	1,963	12.3
Trade	50	95	116	168	199	628	3.9
Construction	32	73	83	116	147	451	2.8
Banking & finance	14	19	17	20	23	93	0.6
Total	1,262	2,169	2,959	4,045	5,536	15,971	100.0

Source: Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens, Annual Supplement. 1979.

develop agricultural supplies for export and local industry; establish viable manufacturing industries catering to domestic and foreign markets; and expand the capacity of the construction sector so that it can cope with the fast-rising investment volume; and

(d) Increase the level of national savings and mobilize financial resources through taxation and other means, to cover the expenditures of the public sector.

Besides these economic objectives the Plan also pursued social goals aimed at satisfying the basic needs of the population for food, drinking water, health care, elementary education, housing and other community services.

4.7.1 Agricultural Development

Agricultural development is the sector most likely to have direct immediate impact on the environment. In agriculture, the principal objectives as summarized by the World Bank were as follows:

(a) Work towards self-sufficiency in food production within economic limits;

(b) Provide raw materials for agro-industries already existing and those to be established during the Plan period;

(c) Reduce the widening trade deficit in agricultural commodities;

(d) Improve the quality of agricultural products;

(e) Provide special support to small farmers and create equitable and stable land tenure relations; and

(f) Limit the growing of qat.

These objectives were to be achieved through the following means:

(a) Continue the institution building and training of agricultural staff;

(b) Carry out a comprehensive survey of soil and water resources;

(c) Expand credit services to all main agricultural areas of the country;

(d) Establish farmer cooperatives suitable for Yemeni conditions;

(e) Provide storage capacities for agricultural products and extend the network of rural roads;

(f) Conduct an agricultural census to obtain reliable data for the sector; and

(g) Carry out studies on marketing, prices and taxation with a view of arriving at policies that would best promote agricultural development.

In addition, a great number of investment projects were to be carried out under the Plan with emphasis given to irrigation schemes, farm mechnaization, seed preparation, plant protection, livestock and poultry production, afforestation and integrated rural development.

Studies were to be made for the possible use of sewage water for irrigation. Also, investigations were planned for the location of dam sites in mountainous areas for the possible storage of surface flow for irrigation. The program of works envisages some construction of small dams for flood retardation and soil erosion prevention as well as water conservation. Other projects depend on groundwater. No legal protection is provided as yet against over-exploitation, although the plan did give recognition to the need for some government regulation of groundwater development.

In other aspects of environment, there is also a lack of means to deal with problems, and usually a lack of awareness. Even in the areas where the government recognizes the need, such as with afforestation, projects are only beginning to enter the implementation phase. Development of the industrial sector is not likely to bring about any additional immediate environmental problems.

Preliminary figures on the 1982-86 five year plan (Table 4.11) show no drastic changes in the government's priorities. Progress in the installation of transport and communications infrastructure has allowed the YAR to maintain a constant level of expenditure in this sector, so that the increased funding for the 1982-86 plan has been distributed only to other sectors.

Table 4.11 Second Five Year Plan (1982-1986)

Sectoral growth rate of gross domestic product 1982-86
(YR million, at 1981 constant prices)

Sector	Base-year 1981	Terminal 1986	Annual growth rate (%)
Agriculture	3,690	4,832	4.7
Mining	156	275	12.0
Manufacturing	770	1,357	12.0
Electricity and water	99	241	22.0
Construction	1,139	1,260	2.0
Trade	2,124	3,020	7.3
Restaurants and hotels	139	200	7.5
Transport and communications	463	702	7.8
Finance	1,013	1,495	8.1
Dwellings and real estate services	552	760	6.6
Government services	1,907	2,935	9.0
Other services	159	235	8.1
Imputed bank charges	−889	−1,348	8.7
Import duties	1,817	2,398	8.2
Total gross domestic product	12,949	18,182	7.0

Yemen (Sanaa) development plan (1982-86)
Fixed capital investment by sector (1982-86)
(YR million, at 1981 constant prices)

Sector	Total fixed investment	Percentage of total
Agriculture	4,430	16.2
Mining	905	3.3
Manufacturing	3,510	12.8
Electricity and water	2,040	7.4
Construction	640	2.3
Trade, restaurants and hotels	2,870	10.5
Transport and communications	4,640	16.9
Finance	100	0.4
Dwellings and real estate services	3,745	13.7
Government services	4,250	15.5
Other services	270	1.0
Total fixed investment	27,400	100.0
Changes in stock	1,496	
Total investment in the plan	28,896	
Of which: private sector	14,491	
government	14,405	

Source: Harvey. 1982.

4.8 Status of Environmental Problems

In general, there is in the Yemen Arab Republic very little action on environmental problems, either by the government or by private interests. The World Bank has made general recommendations concerning the environmental problems discussed in this report. It is likely to be some time before most of these are acted upon. The start of a few projects designed to cope with environmental deterioration show that the YAR is willing to recognize and deal with the problem once it is brought to attention. However, most development is still in the first stages.

There is little hard data on problems and even less on how development may affect them. The YAR is suffering from a lack of qualified personnel to implement projects. These and a host of other factors make it unlikely that in the near future the government will be able to devote very much attention to the environment except in those cases where problems directly and immediately affect the welfare of the population or the production of various sectors of the economy.

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APPENDIX I

Geography and Climate

Figure 1. Physiogeographic Regions

Figure 2. Location of Hydrometeorlogical Stations

Figure 3. Isoheyetal Map Suggested by Recent Precipitation Data

Figure 4. Monthly Rainfall Patterns

Figure 5. Provinces of Yemen Arab Republic

Figure 6. Ecological Zones, Principal Crops, Religious Divisions

Table 1. Areas of Physiogeographic Regions

Table 2. Major Climatic Zones

Table 3. Available Climatic Data in the Tihama

Table 4. Available Precipitation Data

Table 5. Mean, Maximum, and Minimum Monthly Rainfall at Selected Stations.

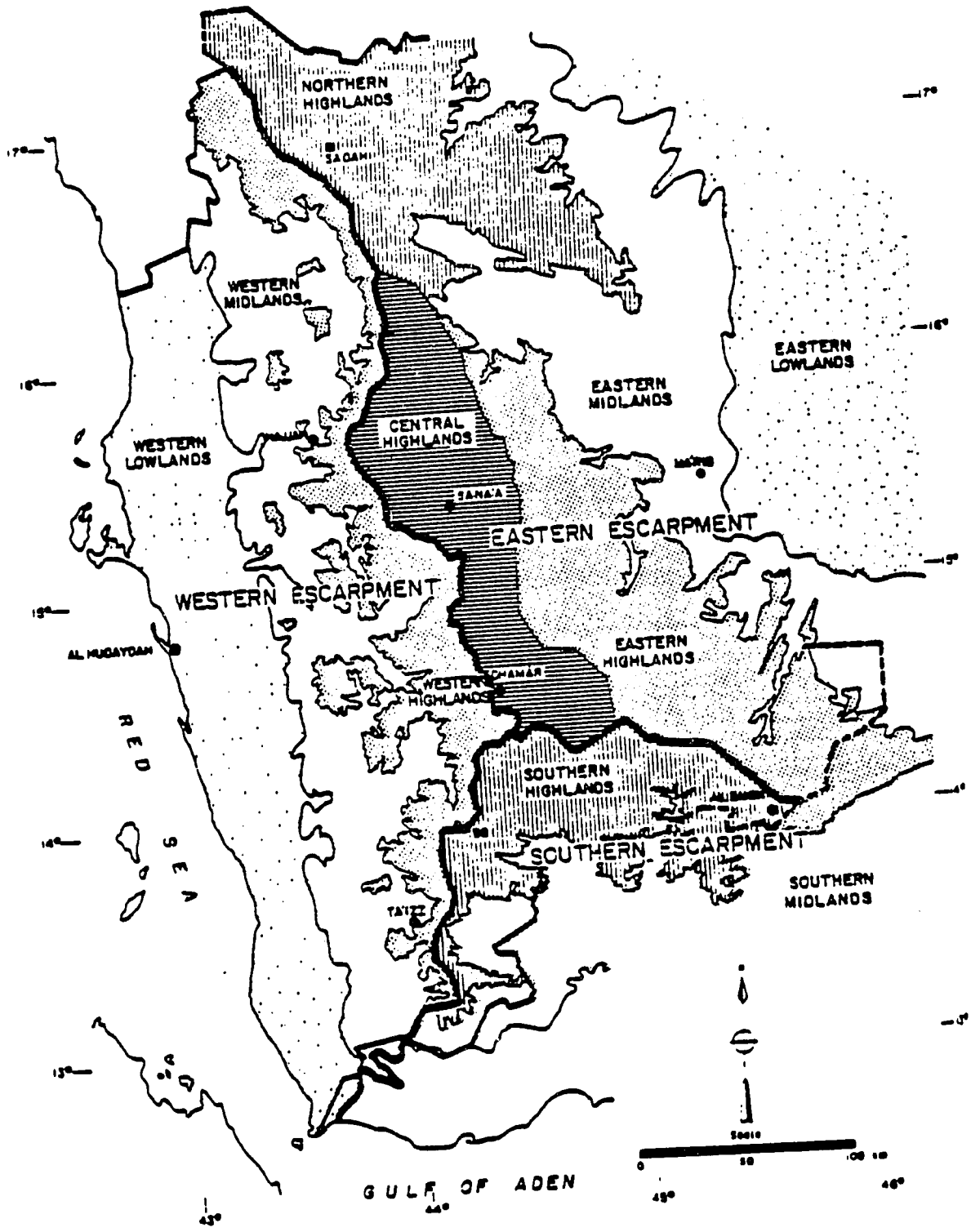

Figure 1. Physiographic Regions

Source: Bernhardt, et al. 1980.

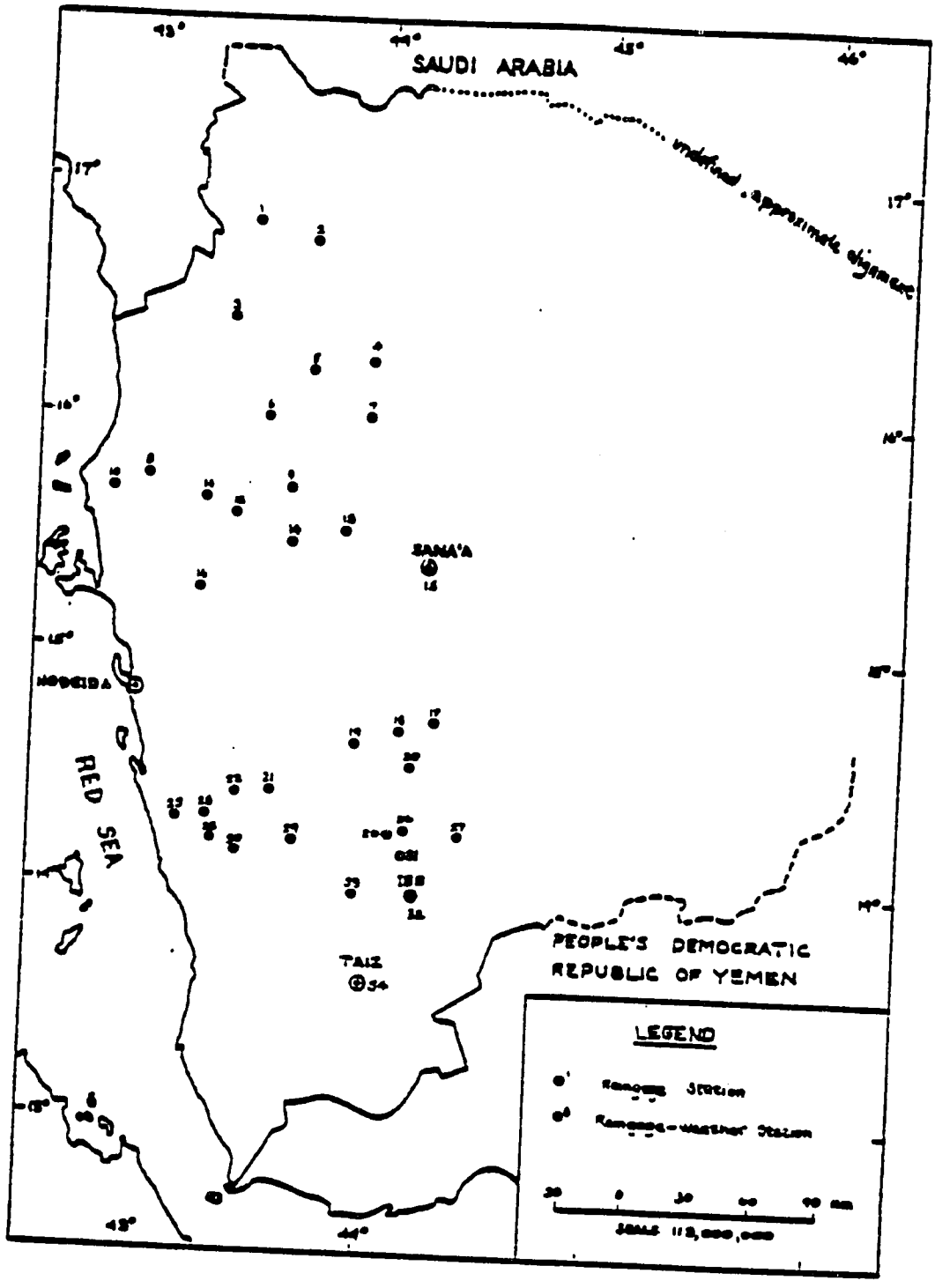

Figure 2. Location of Hydrometeorological Stations

Source: al-Eryani. 1979.

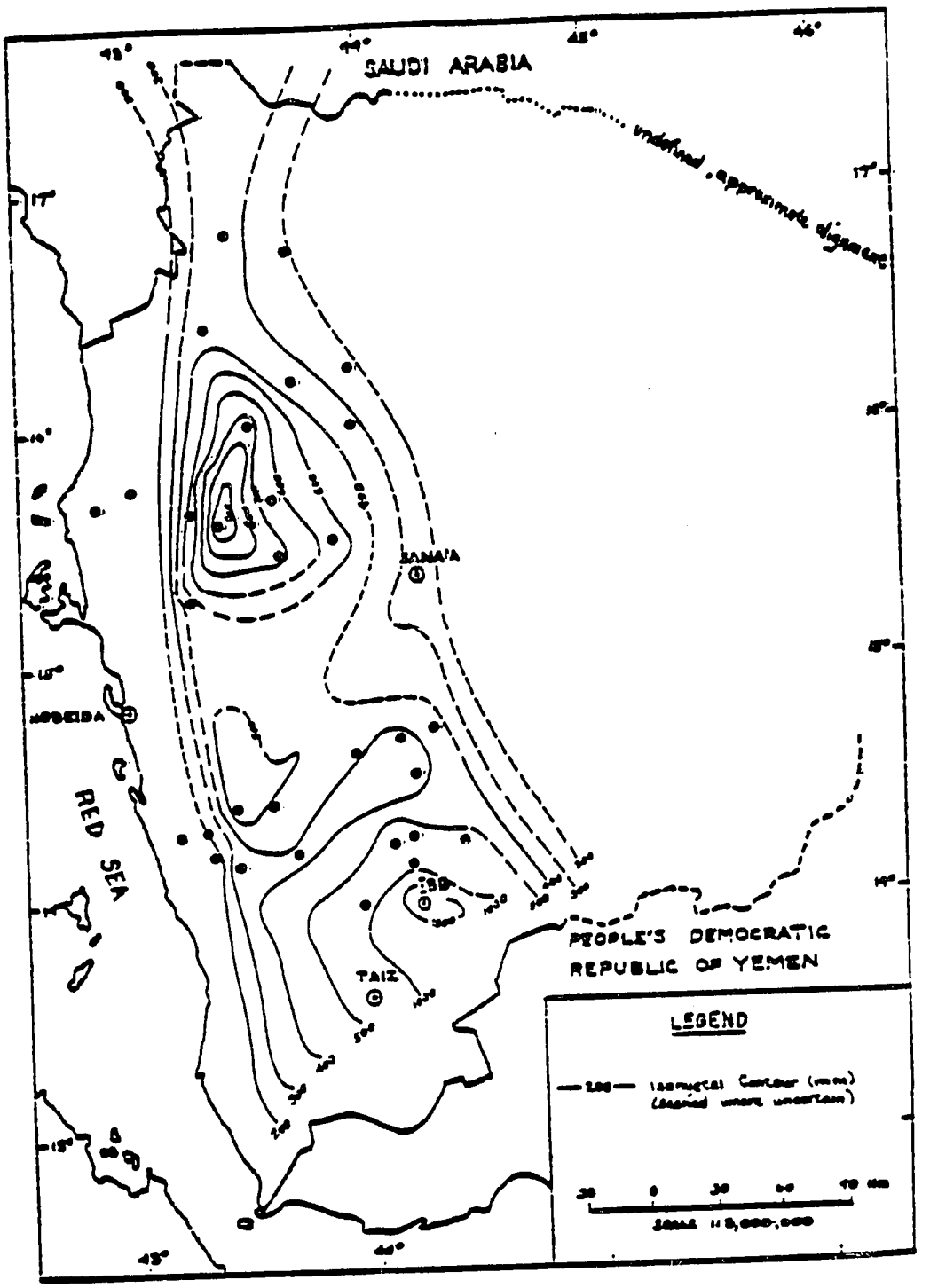

Figure 3. Isohyetal Map of Yemen Suggested by Recent Precipitation Data

Source: al-Eryani. 1978.

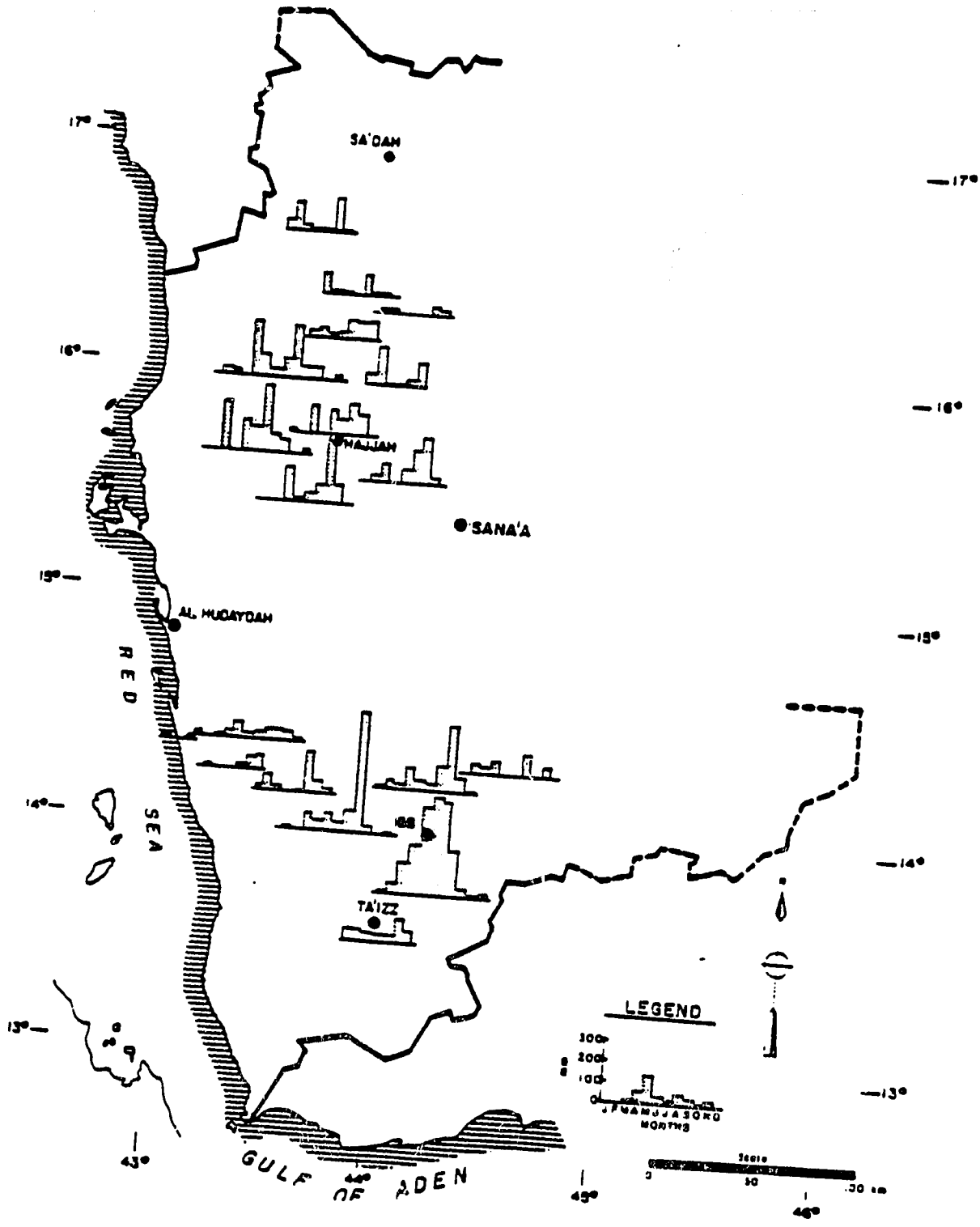

Figure 4. Monthly Rainfall Patterns

Source: Bernhardt et al. 1980.

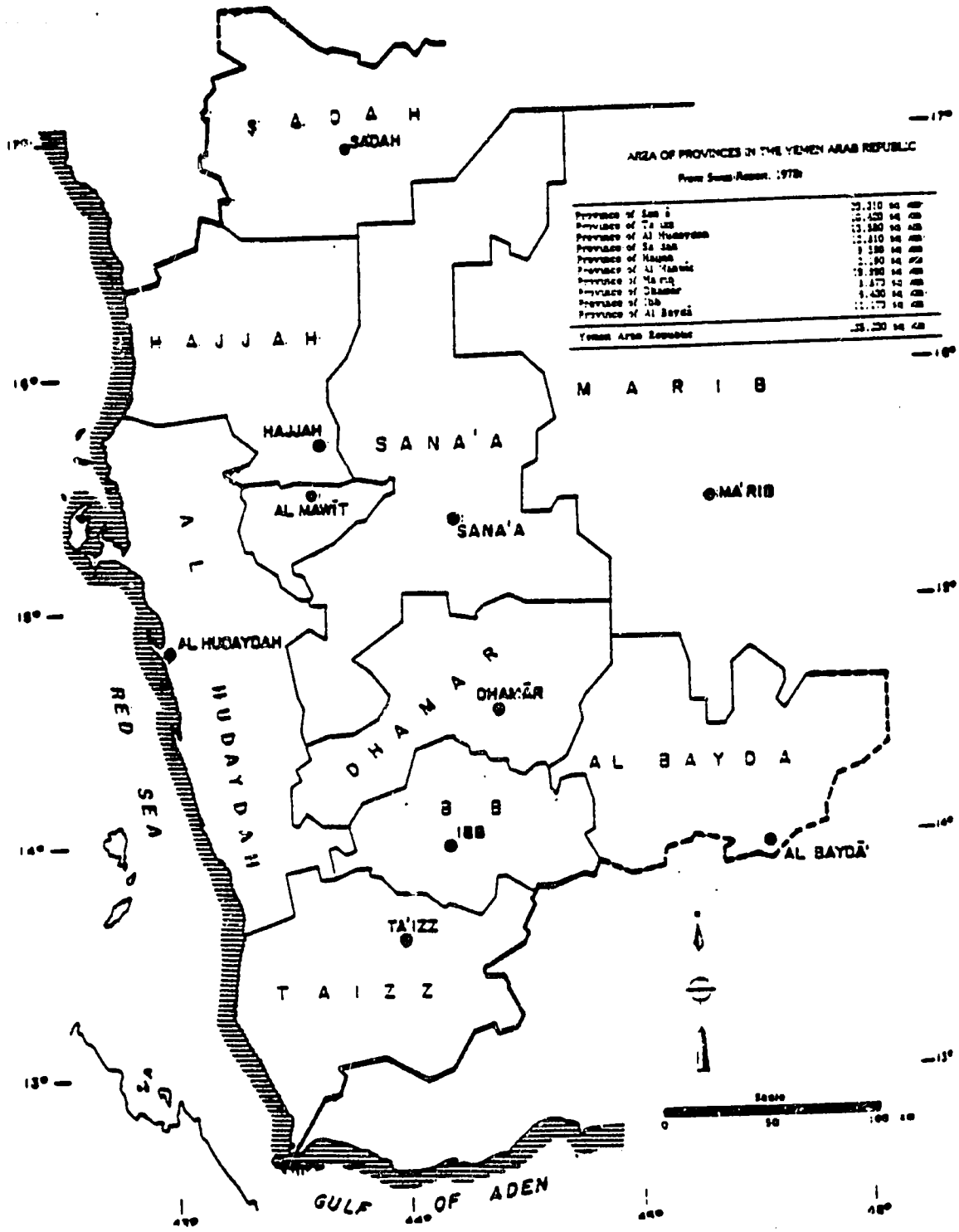

Figure 5. Provinces of Yemen Arab Republic

Source: Bernhardt et al. 1980.

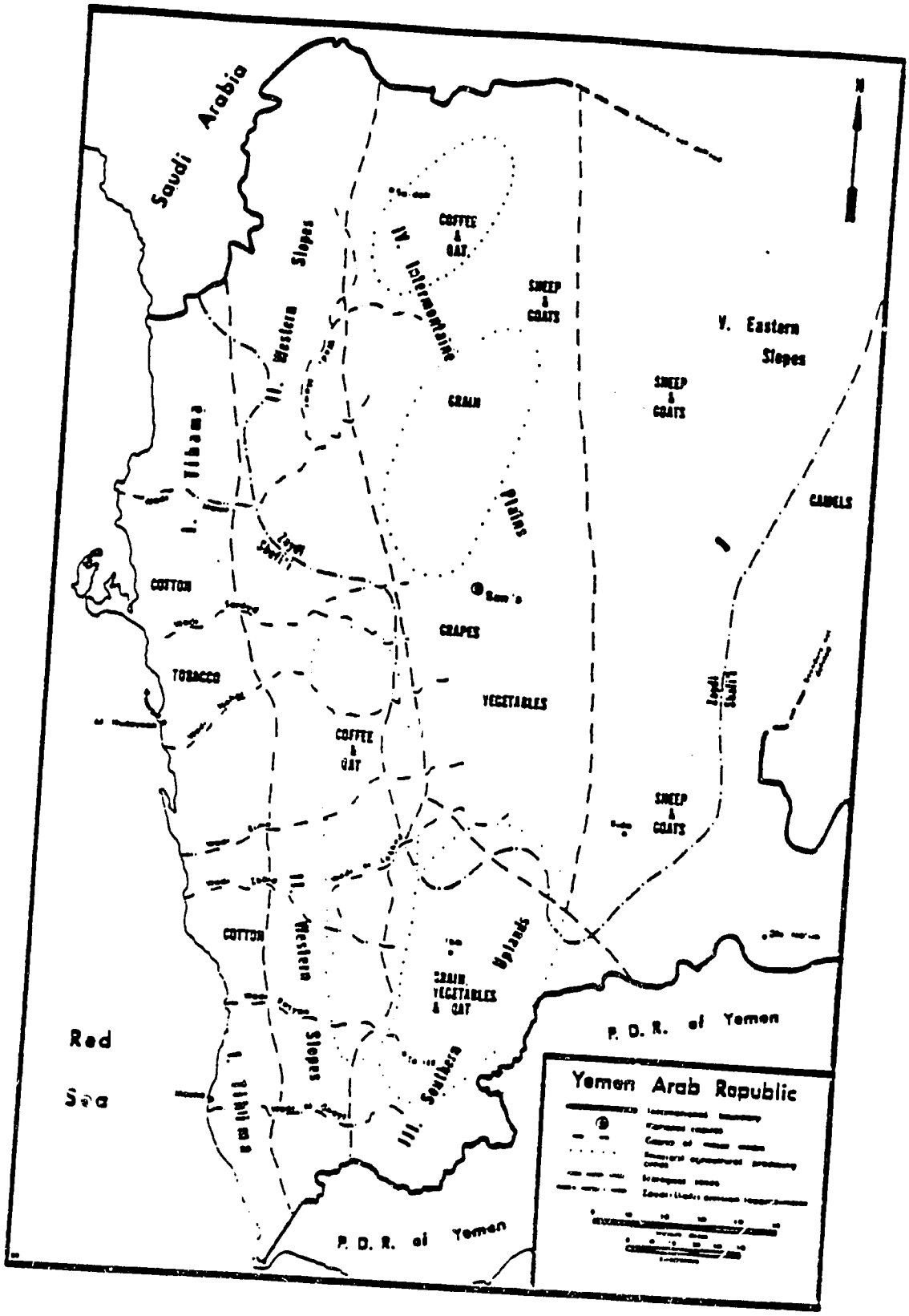

Figure 6. Ecological Zones, Principal Crops, and Religious Divisions

Source: Tutwiler et al. 1976.

Table 1. Areas of Physiogeographic Regions

Western Escarpment			
Western Highlands	over 1,500 m	11,500 sq km	
Western Midlands	500 - 1,500 m	19,100 sq km	
Western Lowlands	under 500 m	20,300 sq km	50,900 sq km
Eastern Escarpment			
Northern Highlands	over 1,500 m	10,500 sq km	
Central Highlands	over 1,500 m	10,500 sq km	
Eastern Highlands	over 1,500 m	15,100 sq km	
Eastern Midlands	1,000 - 1,500 m	20,100 sq km	
Eastern Lowlands	under 1,000 m	18,200 sq km	74,400 sq km
Southern Escarpment			
Southern Highlands	over 1,500 m	7,800 sq km	
Southern Midlands	1,000 - 1,500 m	2,100 sq km	9,900 sq km
TOTAL			135,200 sq km

Source: Bernhardt et al. 1980.

Table 2. Major Climatic Zones (cf. Fig. 1)

	ALTITUDE	CLIMATE CHARACTER.	MEAN MONTHLY TEMP. °C	AVERAGE ANNUAL RAINFALL
A TROPICAL TIHÂMAH ZONE				
Coastal Tihâmah plain with high atmospheric humidity and irregular low precipitation	0-50 m	tropical	25-25	0-80 mm
Central Tihâmah plain with low atmospheric humidity and irregular low precipitation	50-300 m	tropical	24-32	0-150 mm
Eastern mountain near Tihâmah plain with low to medium precipitation	300-500 m	tropical	22-32	
B TROPICAL TO SUBTROPICAL ZONE OF THE LOWER WESTERN ESCARPMENT ZONE				
Lower mountain slopes, frost-free zone with low precipitation	500-1,400 m	tropical	22-28	200-400 mm
Upper mountain slopes with medium rainfall	1,400-2,100 m	subtropical	15-24	300-600 mm
C TEMPERATE HIGHLAND ZONE				
Western, mountainous Highlands, with medium to abundant rainfall	2,100-3,700 m	temperate	10-18	600-1,800
Central Highlands, with medium rainfall	1,800-2,400 m	temperate	12-18	200-1,000
D SUBTROPICAL ZONE OF THE EASTERN ESCARPMENT				
Eastern mountain slopes with low, periodical rainfall	1,800-1,200 m	subtropical	16-24	100-400 mm
Eastern desert zones	1,200-800 m	subtropical	22-28	0-200 mm

Source: Bernhardt et al. 1980.

Table 3. Available Climatic Data in the Tihama

Station	Location	Elevation (m msl)	Climatic Parameter	Mean Monthly Value												Annual Mean	Annual Total	Years of Record
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Al Zuhra	15°44'N 43°01'E	70	Air Temperature (°C)	25.7	26.3	28.0	30.6	32.8	34.1	33.7	33.7	32.7	31.2	28.6	26.4	30.3	--	1972-74, 1975-76(6)
Gumaisha	15°15'N 43°15'E	210		24.6	25.4	26.2	29.4	31.5	32.5	33.2	31.3	31.0	29.5	26.4	24.7	28.8	--	1973-75(3)
Al Jarabah	14°19'N 43°26'E	230		25.0	26.5	28.2	29.9	31.5	33.0	33.0	31.1	30.9	29.3	27.5	25.7	29.3	--	1975-76(2)
Project Camp	14°09'N 43°26'E	240		24.9	26.0	28.1	30.8	32.4	33.3	33.1	31.7	30.7	29.4	26.0	25.3	29.4	--	1970-75(6)
Al Zuhra			Relative Humidity (%)	75	78	77	72	65	67	65	68	70	72	73	77	72	--	(6)
Gumaisha				83	84	83	73	72	66	64	72	74	73	74	78	75	--	1974-75(2)
Al Jarabah				--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Proj. Camp				60	65	62	56	57	56	54	62	68	67	65	69	62	--	1970-76(7)
Al Zuhra			Wind Velocity (km/hr)	7.6	8.3	8.6	7.9	7.9	8.3	10.1	9.0	6.0	6.5	6.0	7.6	8.0	--	(6)
Gumaisha				10.2	11.1	10.4	10.0	9.5	12.5	13.2	13.4	9.3	8.4	10.1	10.1	10.7	--	1974-75(2)
Al Jarabah				7.3	7.6	9.4	9.1	8.1	9.7	9.8	9.3	6.4	5.6	5.9	6.7	7.7	--	1975-76(2)
Proj. Camp				5.3	6.1	7.1	7.8	6.5	7.4	8.3	7.2	5.2	4.4	4.5	4.9	6.2	--	1970-72(3)
Al Zuhra			Pan Evaporation (mm/day)	192	179	217	264	319	315	329	313	285	245	213	202	256	3073	(6)
Gumaisha				285	210	243	300	311	387	403	358	296	320	230	206	289	3473	1973-74(2)
Al Jarabah				263	186	243	303	375	370	367	291	263	243	210	228	274	3236	1975-76(2)
Proj. Camp				175	185	237	288	311	302	313	264	236	216	186	173	239	2866	1970-76(7)

Source: al-Eryani. 1979.

Table 4. Available Precipitation Data

Sequence[a]	Station	Year									Annual[b] Average (mm)
		1970	1971	1972	1973	1974	1975	1976	1977	1978	
1.	Sahain	—	—	—	—	—	519	281	—	—	390
2.	Beni Umair	—	—	—	—	—	(231)[c]	189	—	—	220
3.	Mocha	—	—	—	—	—	—	(305)	—	—	305
4.	Hath	—	—	—	—	—	(173)	(187)	—	—	220
5.	Shehara	—	—	—	—	—	(468)	—	—	—	368
6.	Hababisha	—	—	—	—	—	990	872	(590)	—	794
7.	Khamir	—	—	—	—	—	(480)	294	—	—	394
8.	Zahra	—	—	(130)	40	38	—	(101)	(206)	(231)	164
9.	Hajjah	—	—	—	—	—	581	861	(580)	—	687
10.	Gabal Al Milh	—	—	—	—	—	(71)	(12)	(29)	—	56
11.	Al Mikrus	—	—	—	—	(183)	—	—	—	—	(183)
12.	At Tur	—	—	—	—	—	(949)	803	(1056)	—	948
13.	Shibam	—	—	—	—	—	(669)	470	(616)	—	577
14.	Mahwit	—	—	—	—	—	(795)	413	1606	—	717
15.	Sana'a	195	155	116	163	215	351	156	(412)	—	221
16.	Sarwah	—	—	(525)	409	(126)	—	(243)	—	—	470
17.	Mabar	—	—	—	—	—	435	370	—	—	413
18.	Hammam Ali	—	—	—	—	—	—	581	—	—	581
19.	Madinat Al Abidi	—	—	—	—	—	—	471	—	—	471
20.	Beit Al Jatni	303	397	270	119	(163)	(239)	(353)	394	(182)	366
21.	Misbrafah	—	—	—	—	—	—	543	—	—	543
22.	Al Jarubah	—	—	—	—	—	631	411	—	—	521
23.	Al Mahwit	—	—	—	—	—	—	38	—	—	38
24.	Rabar	—	—	—	—	—	615	643	—	—	629
25.	Al Mahamiyah	—	—	—	—	—	—	8	—	—	8
26.	Rihab	446	694	736	461	497	466	340	—	—	316
27.	Yarim	366	648	463	396	374	387	326	706	461	354
28.	Zabid	133	121	95	92	209	(193)	70	(290)	—	187
29.	Al Fulaih	624	516	—303	230	—	—	—	—	—	395
30.	Project Camp	379	246	226	315	547	437	282	416	—	346
31.	Samara	797	1219	1479	479	321	846	692	(574)	—	803
32.	Ibb	1050	1124	1300	1289	1500	1929	2193	2561	(834)	1624
33.	Udain	(450)	401	372	464	409	(639)	(524)	912	(271)	565
34.	Taiz	(222)	582	(215)	438	—	—	—	—	—	610

[a] See Fig. 2 for localities.

[b] Annual averages are the sum of average monthly precipitations. For stations with partial annual data, the annual averages are not equal to the average of the individual annual totals.

[c] ( ) = partial year data.

Source: al-Eryani. 1978.

Table 5. Mean, Maximum and Minimum Monthly Rainfall at Selected Stations

(mm)

Station/Years Record	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Taiz (24-yrs record)													
Mean	1.3	11.8	15.9	73.6	97.6	83.9	60.9	66.8	83.7	60.9	14.3	9.7	580.4
Maximum	15.2	84.6	60.9	138.6	213.4	149.8	134.7	141.7	137.1	130.0	53.9	36.5	831.4 (1966)
Minimum	0.0	0.0	0.0	0.0	30.4	22.8	10.2	25.4	25.4	5.6	0.0	0.0	308.9 (1976)
Zabid Camp (7 yrs 1970-76)													
Mean	5.0	0.7	5.4	21.9	29.1	4.4	35.7	80.7	128.4	36.9	2.4	1.6	352.2
Maximum	22.0	3.0	17.0	80.0	51.0	15.0	102.0	206.0	281.0	124.0	10.0	11.0	546.0 (1974)
Minimum	0.0	0.0	0.0	0.0	0.0	2.0	12.0	68.0	0.0	0.0	0.0	0.0	226.0 (1972)
Sana'a (7 yrs 1970-76)													
Mean	4.1	0.9	19.1	42.5	21.1	0.9	22.6	57.9	4.5	0.0	6.8	0.9	181.3
Maximum	23.9	3.0	35.8	109.4	89.1	3.0	84.5	102.0	13.8	0.0	31.5	3.0	350.6 (1975)
Minimum	0.0	0.0	0.5	5.6	0.2	0.0	0.0	3.7	0.0	0.0	0.0	0.0	111.3 (1972)
Yarim (7 yrs 1970-76)													
Mean	2.0	16.3	51.3	66.0	65.0	45.2	65.5	132.9	35.1	4.9	9.7	3.8	497.6
Maximum	9.1	37.2	104.6	202.1	178.3	109.5	114.5	242.3	65.2	23.4	48.6	14.5	667.9
Minimum	0.0	0.0	2.4	10.6	2.4	4.3	4.3	69.7	5.3	0.0	0.0	0.0	365.8
Ibb (7 yrs 1970-76)													
Mean	10.1	17.1	46.3	124.7	219.2	246.2	246.7	250.0	193.5	68.9	35.8	9.9	1,468.4
Maximum	43.4	42.9	76.6	291.0	402.0	367.0	414.3	426.3	335.9	174.8	120.5	33.6	2,228.6 (1970)
Minimum	0.0	0.0	0.0	44.6	77.5	185.5	174.2	199.2	109.8	15.5	0.0	0.0	1,050.1 (1976)

Source: World Bank. 1979.

APPENDIX II

Demographic Characteristics

Figure 1. Population Pyramid

Figure 2. Population Distribution

Table 1. Population Estimates, 1974-1979

Table 2. Population Projections

Table 3. Population of the Major Physiogeographic Regions

Table 4. Rural and Urban Populations by Province, 1978

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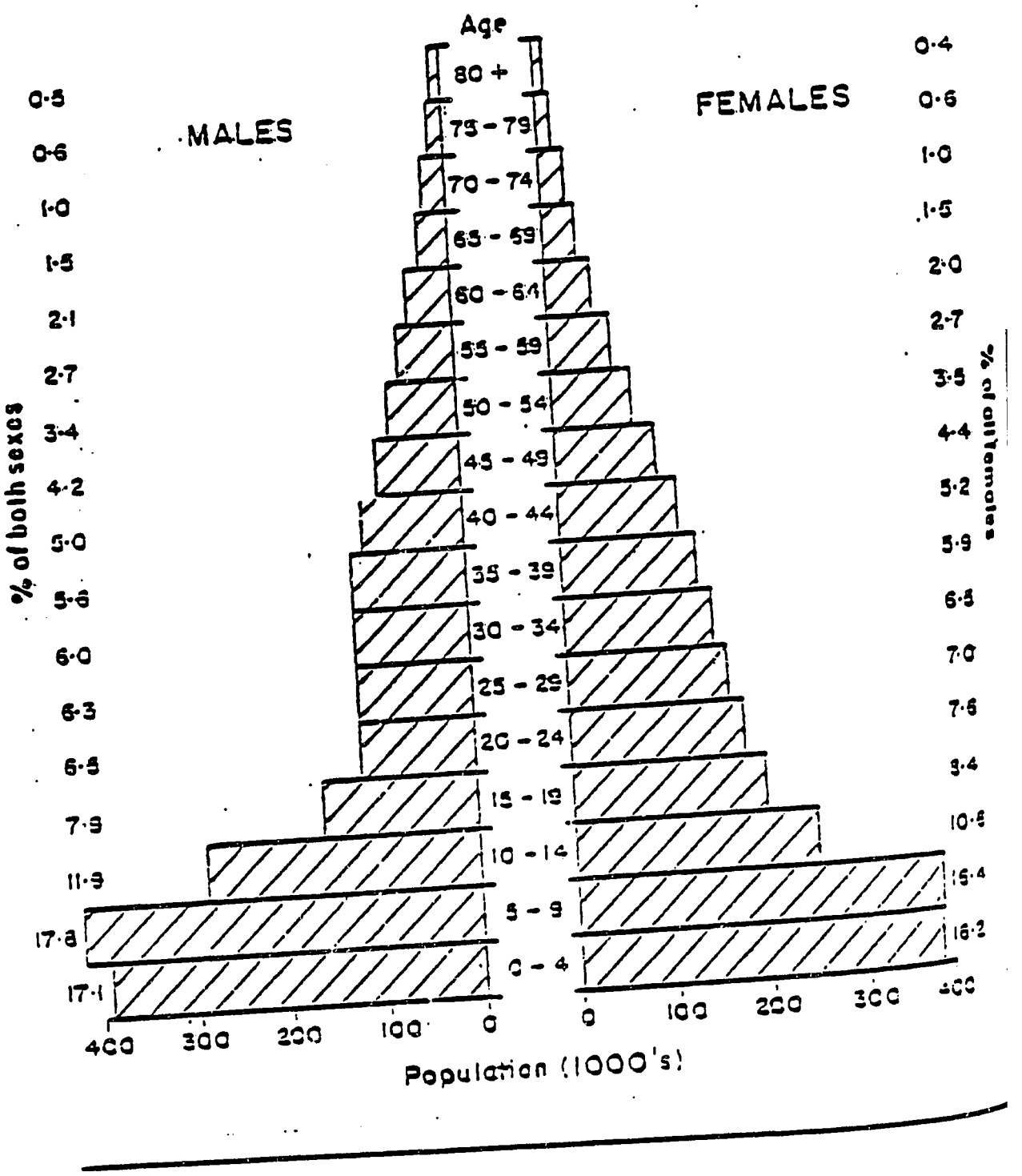

Figure 1. Population Pyramid

Source: Socknet and Sinclair. 1978.

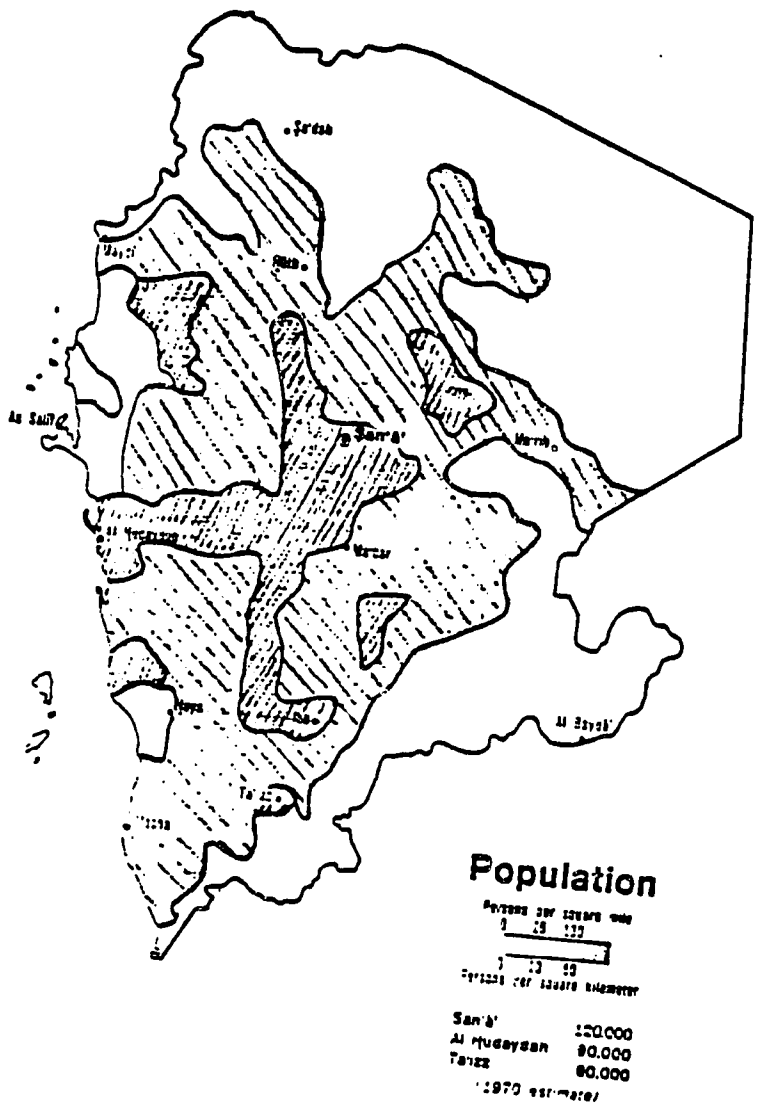

Figure 2. Population Map

Source: Adapted from a map available from the U.S. Government Printing Office (map #501036, 2/73)

Table 1. Population Estimates, 1974 - 1979 (millions)

Year	Population Est.	Source
1979	7.0 (+1.5 working out of country)	1
1978	5.804	2
end 1976	5.5	3
1974	6.365	4

1. Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. 1979.
2. U.S.A.I.D. 1979a.
3. World Bank. 1979.
4. Council of Arab Economic Unity. 1977.

Table 2. Population Projections (thousands)

	1975	1995	2010
Total Population	5,300	8,000	10,600
of which:			
Residents	4,720	n.a.	n.a.
Migrants	580	n.a.	n.a.

Source: World Bank. 1979.

Table 3. Population of the Major Physiographic Regions

	DE FACTO POPULATION 1975	Area	Population density (inhabitants/sq km)
Western Escarpment	2,970,000	50,900	58
Western Highlands	1,110,000	11,500	96
Western Midlands (1a)	1,130,000	19,100	59
Western Lowlands (1b)	730,000	20,300	36
Eastern Escarpment	1,055,000	74,400	14
Northern Highlands	112,000	10,000	11
Central Highlands (1c)	750,000	10,500	71
Eastern Highlands	133,000	15,100	9
Eastern Midlands	60,000	20,100	3
Eastern Lowlands		18,000	0
Southern Escarpment	680,000	9,900	69
Southern Highlands	595,000	7,900	75
Southern Midlands	85,000	2,100	40
Yemen Arab Republic	4,705,000	135,200	35

Source: Bernhardt et al. 1980.

Table 4. Rural and Urban Population by Province, 1978

PROVINCE	RURAL POPULATION		URBAN POPULATION			
			Province Center		Other urban settlements[1/]	
	Percent	Numbers	Percent	Numbers	Percent	Numbers
Al Hudaydah	78.2	523,379	11.9	82,724	12.9	89,528
San'ā'	80.2	665,383	16.7	138,525	3.3	27,941
Ta'izz	90.3	796,429	9.2	81,301	0.5	4,633
Al Bayḍā'	92.6	160,149	3.6	6,154	3.8	6,570
Ibb	94.5	769,412	2.3	19,638	3.2	26,153
Dhamār	95.7	448,735	4.3	20,051	-	-
Hajjah	96.5	399,148	1.4	5,988	2.0	8,238
Ma'rib	96.7	67,250	-	301	3.3	2,299
Sa'dah	97.5	172,228	2.5	4,380	-	-
Al Mahwīt	98.6	178,517	1.4	2,494	-	-
Yemen Arab Republic	80.9	4,180,628	7.7	381,356	3.4	163,352

1/ Includes persons living in settlements of over 2,000.

Source: Bernhardt et al. 1980.

Table 5. Population Distribution by Size of Settlement

Frequency, i.e. no. of settlements in each class		Settlement class		Total no. of inhabitants in each settlement class		
Absolute	Relative	Designation	No. of inhabitants	Absolute	Relative	
28,000	53.1 %	Dwelling groups	under 50	681,613	14.5 %	34.1 %
13,000	24.7 %		50 - 100	924,031	19.6 %	
9,000	17.1 %	Small settlements	100 - 250	1,395,041	29.6 %	52.5 %
2,000	3.8 %	Medium settlements	250 - 500	669,120	14.3 %	
600	1.1 %	Large settlements	500 - 1,000	403,098	8.6 %	
83	0.2 %	Small towns	1,000 - 2,000	110,026	2.3 %	7.0 %
34	0.1 %	Medium towns	2,000 - 5,000	99,723	2.1 %	
11	0.0 %		5,000 - 10,000	69,942	1.5 %	
3	0.0 %	Large towns	10,000 - 50,000	52,392	1.1 %	
3	0.0 %	Cities	over 50,000	303,350	6.4 %	6.4 %
52,734	100.0 %	Yemen, total February 1975		4,705,138	100.0 %	

Source: Swiss Technical Co-operation Service. 1978.

Table 6. Classification of Settlements by Size and Province, 1975

Settlement classes	Settlements of under 1,000 inhabitants		Small towns of 1,000-2,000 inhabitants		Medium towns of 2,000-10,000 inhabitants		Large towns & cities of over 10,000 inhabitants		Total of provinces no. of inhabitants	
Provinces	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative
Sana'a without city	639,471 (639,471)	72.0 % (91.2 %)	22,912 (22,912)	3.1 % (3.2 %)	27,941 (27,941)	3.2 % (4.0 %)	138,622 -	15.7 % -	831,949 (693,124)	100 % (100 %)
Ta'izz without city	788,113 (788,113)	89.1 % (99.1 %)	10,117 (10,117)	1.2 % (1.3 %)	4,633 (4,633)	0.5 % (0.6 %)	81,052 -	9.2 % -	882,043 (801,563)	100 % (100 %)
Al Hudaydah without city	488,002 (488,002)	70.1 % (79.6 %)	15,287 (15,287)	2.1 % (2.4 %)	76,825 (76,825)	11.1 % (12.5 %)	95,427 (12,703)	13.7 % (2.1 %)	695,631 (612,807)	100 % (100 %)
Ma'rib	63,037	98.3 %	4,314	6.5 %	2,299	3.3 %	-	-	69,648	100 %
Al Bayda'	159,388	92.0 %	1,031	0.6 %	12,734	7.4 %	-	-	173,673	100 %
Shabwah	421,913	92.1 %	18,833	2.6 %	-	-	38,052	4.3 %	458,765	100 %
Lahij	799,940	92.4 %	9,462	1.1 %	24,153	3.2 %	19,638	2.3 %	813,203	100 %
Ad'dali	168,319	99.3 %	1,387	2.2 %	4,100	2.5 %	-	-	170,606	100 %
Abyan	290,403	99.9 %	2,743	0.7 %	14,128	2.1 %	-	-	413,274	100 %
Al Mahrah	179,117	98.6 %	-	-	2,494	1.4 %	-	-	181,611	100 %
Y.A.R.	4,074,983	86.5 %	110,038	2.4 %	169,666	3.6 %	354,742	7.5 %	4,705,138	100 %

Source: Swiss Technical Co-operation Service. 1978.

Table 7. Growth in the Cities of Sana'a, al Hudayah and Ta'izz, 1970 - 1980

Year	San'ā'	Al Hudaydah	Ta'izz
1970	96,000	58,000	56,500
1971	103,000	52,000	52,500
1972	110,500	67,000	66,500
1973	119,000	72,000	71,000
1974	129,000	77,500	73,500
1975	138,000 census fig.	83,000 census fig.	81,000 census fig.
1976	148,500	89,500	86,500
1977	161,000	97,000	96,000
1978	175,500	106,000	103,000
1979	192,000	115,500	112,500
1980	210,000	127,000	123,000

Source: Bernhardt et al. 1980.

Table 8. Miscellaneous Demographic Statistics

Vital Statistics		Source
Population Density Per Sq. Km	28	4
Population Density Per Square m of Arable Land	300	1
% of Population in Urban Areas (defined as over (2000)	11%	1
Population Per Practicing Physician (1973)	20,440	2
Average Daily Caloric Consumption (1973)	2,017	2
% Literate (over 10 years of age)	10-13%	3
Per Capita Share of GNP (1978)	US$ 475	3

Sources:
1. Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. 1979.
2. U.S. AID. 1979a.
3. U.S. Dept. of State. 1980.
4. World Bank. 1979.

Table 9. Vital Statistics, 1970-1975

Crude birth rate	47.3
General fertility rate	217
Sex ratio at birth	104.3 (M/100 F)
Crude death rate	28.7
Life expectancy at birth	
Males	35.7 years
Females	38.3 years
Infant mortality rate	
Males	176
Females	142
Total	159
Net annual population increase 18.6 (per thousand)	

Source: Socknet and Sinclair. 1978.

Table 10. Population by Age and Sex, 1975
(Preliminary figures derived from a 3% random sample)

age groups (years)	total absolute	%	females absolute	%	males absolute	%
0 - 4	772,144	17	385,064	16	387,080	18
5 - 9	806,542	18	388,858	16	417,684	19
10 - 14	537,573	12	251,573	11	286,000	13
15 - 19	357,603	8	199,409	8	158,194	8
20 - 24	296,133	6	179,966	8	116,167	5.4
25 - 29	282,877	6	166,925	7	115,952	5.4
30 - 34	269,642	6	154,121	7	115,521	5
35 - 39	255,221	6	140.132	6	115,089	5
40 - 44	227,158	5	123,060	5	104,098	5
45 - 49	190,300	4	104,091	4	86,209	4
50 - 54	153,982	3	83,937	3	70,045	3
55 - 59	122,082	3	64,968	3	57,114	3
60 - 64	92,940	2	47,896	2	45,044	2
65 - 69	68,067	1.5	35,092	2	32,975	2
70 - 74	46,061	1	23,000	1	23,061	1
75 - 79	27,050	1	13,041	0.6	14,009	0.7
over 80	20,951	0.5	9,959	0.4	10,992	0.5
Total	4,526,326	100	2,371,092	100	2,155,234	100

Source: Swiss Technical Co-operation Service. 1978.

Table 11. Enumerated Population by Sex and Governorate, 1975
(Preliminary results of February 1975 census)

Governorate	Governorate: Population (000)	Governorate: Sex Ratio (percent)	Governorate: Percent of Total Pop.	Governorate Capital: Population (000)	Governorate Capital: Sex Ratio 1/ (percent)
Sana'a	807,269	95.2	17.8	134,588	131.9
Damar	455,132	87.3	10.0	19,167	105.8
Ibb	789,518	88.4	17.4	19,066	116.1
Taiz	873,876	83.6	19.3	78,642	132.2
Hodeidah	676,693	102.2	15.0	80,314	145.0
Mahweet	174,639	85.7	3.9	2,421	109.2
Hajjah	396,578	95.8	8.7	5,813	107.3
Sa'adah	154,361	90.5	3.4	4,252	110.7
Marib	40,896	98.3	1.0	292	—
Beida	157,764	81.5	3.5	5,975	82.6
TOTAL	4,526,326	90.9	100.0	350,831	130.4

Source: World Bank. 1979.

Table 12. Public Health Indicators, 1970 - 1976

	Total Number		Population per No.	
	1970	1976	1970	1976
Physicians	184	234	26,630	23,256
of which				
Yemenis	(102)	(124)		
Foreigners	(82)	(110)		
Medical Assistants	643	796	7,620	6,837
of which				
Yemenis	(601)	(653)		
Foreigners	(42)	(143)		
Hospital Beds	3,317	2,637	1,477	2,064

Source: World Bank. 1979.

Table 13. Educational Status of Labor Force (1975)

	Males	Females	Total
Illiterate	778,678	134,394	913,072
Unable to read and write	667,473	132,727	800,200
Can read only	111,205	1,667	112,872
Literate	219,277	3,378	222,655
Can read and write	198,882	1,943	200,825
Finished primary	4,766	86	4,852
Finished preparatory	4,367	194	4,561
Finished secondary	5,046	599	5,645
Finished university	4,342	319	4,661
Not Stated	1,874	237	2,111
TOTAL	997,955	137,772	1,135,727

Source: World Bank. 1979.

Table 14. Age Structure and Share Abroad of Labor Force Age Male Cohorts, 1975

Age Cohort	Male Inhabitants	Male/Female Ratio	Males Abroad Assuming Sex Ratio		Age Structure Males Abroad Assuming Sex Ratio		Males Abroad as share of Total Inhabitants plus Abroad Cohort	
			1.00	1.04	1.00	1.04	1.00	1.04
10-19	444,194	0.98	6,788	24,827	3%	8%	2%	5%
20-29	232,119	0.67	112,772	128,648	46%	41%	33%	36%
30-39	230,119	0.78	63,643	75,413	26%	24%	22%	25%
40-49	190,307	0.84	36,844	45,930	15%	15%	16%	19%
50-59	127,159	0.85	21,746	27,672	9%	9%	14%	18%
60-69	78,019	0.94	4,969	8,289	2%	3%	6%	10%
Total 10-69	1,302,408	0.84	246,762	310,779	100%	100%	16%	19%

Source: Socknet and Sinclair. 1978.

APPENDIX III

Economic Characteristics

Table 1. Gross Domestic Product at Current Prices

Table 2. Per Capita GNP and Remittances, 1970-1977

Table 3. Estimated Employment by Sector, January 31, 1975

Table 4. 1975 Structure of Manufacturing Industry

Table 5. Value of Agricultural Production

Table 6. Commodity Composition of Recorded Exports

Table 7. Composition of Imports By Value To YAR, 1970-1977

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Table 1: Gross Domestic Product at Current Prices

(YR Million)

	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76
Commodity Sectors	884	1,163	1,324	1,532	1,977	2,760	2,834
Agriculture, Fishing & Forestry	742	969	1,113	1,263	1,582	2,335	2,305
Industry, Mining & Electricity	66	87	109	142	213	249	302
Construction	76	87	102	127	182	176	227
Distribution Sectors	331	366	453	577	795	1,060	1,512
Trade	283	300	360	460	629	826	1,220
Finance & Banking	13	19	25	40	57	96	141
Transport & Communication	35	47	68	77	109	138	151
Services Sectors	184	237	314	405	488	654	835
Government	91	127	185	252	291	401	509
Housing	64	73	83	94	118	150	199
Other Services	29	37	46	59	79	103	127
GDP at Market Prices	1,399	1,746	2,091	2,514	3,260	4,474	5,181
Net Indirect Taxes	50	75	113	151	202	283	453
GDP at Factor Costs	1,349	1,671	1,978	2,363	3,058	4,191	4,728

Source: World Bank. 1979.

Table 2: Per Capita GNP and Remittances, 1970 - 1977

Calendar Year	Per Capital GNP	Fiscal Year	Per Capita Remittances	Approximate Relation of Remittances to GNP
1970	$69			
1971	$96			
1972	$111	1971/72	$13*	
1973	$147	1972/73	$25	17%
1974	$197	1973/74	$26	17%
1975	$225	1974/75	$44	18%
1976	n.a.	1975/76	$101	32%
1977	n.a.	1976/77	$203	

*1971/72 remittance figure is net private transfers; for all other years figures are gross private transfers. All prices are current.

Source: Socknet and Sinclair. 1978

Table 3: Estimated Employment by Sector, January 31, 1975

(in thousands)

Sector	
Agriculture (incl. forestry, livestock & fishing)	785
Manufacturing (incl. mining, quarrying, power and water)	39
Construction & Building	47
Trade, Restaurants & Hotels	72
Transport, Storage & Communication	26
Finance, Insurance, Real Estate & Business Services	2
Community, Social & Personal Services	101
	1,072

Source: World Bank. 1979.

Table 4: 1975 Structure of Manufacturing Industry

Sector	Countrywide industrial survey: No. of establishments	Countrywide industrial survey: Labourforce	Countrywide industrial survey: Turnover (TL million)	Significant operations estab. by end-197[illegible]: No. of Establishments	Significant operations estab. by end-197[illegible]: Labourforce	Significant operations estab. by end-197[illegible]: Turnover (TL million)	Cap[illegible] Lev[illegible] (TL
Food processing							
flour milling	6,104[b]	8,255	102.0[bc]	-	-	-	
bread	298	2,610	51.5	-	-	-	
biscuits and confectionery				2	444	22.7	
vegetable oils	403	528	7.9	-	-	-	
Total (incl. others)	6,808	11,440	192.7	4	461	23.7	
Soft drinks	6	207	12.7	4	160	10.0	
Tobacco and cigarettes	70	462	18.9	1	214	11.7	
Building materials							
cement	1	329	22.6	1	308	21.7	
bricks	32	123	3.0	-	-	-	
tiles and marble	13	122	4.4	-	-	-	
cement blocks	19	72	8.9	8	133	2.4	
Total (incl. others)	107[d]	743[d]	41.0[d]	9	441	24.1	
Textiles & related industries							
cotton ginning	1	553	28.9	1	138	34.5	
cotton textiles	55	1,995	25.2	2	1,890	16.9	
clothing	2,543	3,604	...	4	63	1.2	
Total (incl. others)	2,601	6,070	65.3[e]	7	2,091	52.7	
Metal products							
general workshops	782	1,948	...	-	-	-	
aluminium products	1	117	3.4	1	119	2.0	
jewellery	368	502	10.4	-	-	-	
Total (incl. others)	1,158	2,819	63.9	9	238	3.3	
Other manufacturing							
wood products	101	451	29.4	5	74	1.7	
printing/publishing	42	246	1.1	8	204	2.5	
pottery	170	283	4.5	-	-	-	
plastics[f]	4	229	14.7	4	201	7.0	
Total (incl. others)	337	1,331	72.4	22	528	14.1	
GRAND TOTAL	10,387	23,076	446.9[e]	56	4,135	139.5	

a includes most firms with more than 10 workers, and some smaller ones

b including coffee roasting

c estimated

d excluding the 780 employed in 250 small stone quarries (turnover 24.3 million TL)

e including only some clothing

f including artificial limbs

Source: World Bank. 1979.

Table 5. Value of Agricultural Production

(YEL million at 1971/72 constant prices)

	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76
Crops	676.6	871.2	821.1	1,024.9	920.8	1,186.2	1,090.5
Livestock	193.9	264.4	333.5	239.7	220.8	275.6	270.3
Fisheries	20.8	21.0	21.3	16.3	12.7	12.0	12.3
Forestry	45.9	44.6	43.3	42.0	40.7	39.5	38.3
Total	937.2	1,201.2	1,219.2	1,322.9	1,195.0	1,513.3	1,411.4

Source: World Bank. 1979.

Table 6. Commodity Composition of Recorded Exports

(YR thousands)

Fiscal Years ending June 30	71/72	72/73	73/74	74/75	75/76	76/77
Agricultural	22,703	23,693	51,648	41,982	41,582	43,205
Raw Materials						
Cotton	10,799	12,821	37,053	30,954	24,583	24,953
Cotton Lint	(9,912)	(10,785)	(35,180)	(28,188)	(24,221)	(24,593)
Cotton Seeds	(887)	(2,036)	(1,873)	(2,766)	(362)	(-)
Coffee	5,534	5,469	6,461	4.972	7,588	10,223
Hides & Skins	3,271	3,325	6,241	4,404	8,040	6,129
Dried Fish	58	,382	781	736	325	56
Live Animals	341	768	643	443	6	-
Potatoes	239	394	195	141	135	17
Fruits	66	224	143	116	164	26
Tobacco	25	44	74	172	382	668
Others	2,370	266	57	44	359	1,133
Processed Agricultural Products	100	1,143	1,896	3,453	4,322	5,640
Cotton Products	100	317	325	1,590	1,384	637
Fabrics	-	-	-	(1,193)	(775)	(165)
Shesta	(100)	(317)	(325)	(257)	(609)	(472)
Yarn	-	-	-	(140)	..	(-)
Biscuits	-	636	1,315	1,131	2,093	3,156
Confectionery	-	119	54	582	845	724
Oil Seed Cakes		71	202	150	-	1,123
Non-Agricultural Exports	1,898	433	1,838	7,531	4,159	1,689
Salt	1,412	27	26	-	1	-
Metal Scrap	247	102	356	9	343	-
Others	239	304	1,456	7,522	3,815	1,689
TOTAL	24,701	25,269	55,382	52,966	50,063	50,534

Table 7. Composition of Imports, by Value, to YAR 1970 - 1977

Item	1970	1971	1972	1973	1974	1975	1976	First Quarter 1977
Food Stuffs	65.2	44.2	50.1	51.3	49.8	45.3	41.1	30.6
Manufactured Products for Consumption	18.3	25.5	25.5	25.0	27.5	28.3	24.3	28.3
Fuel	3.5	6.3	4.8	5.0	3.8	5.0	3.4	1.6
Raw Materials	0.6	2.9	0.9	0.2	0.3	0.2	0.5	0.5
Chemicals	3.1	5.1	5.6	6.4	6.4	5.6	5.1	3.9
Machinery and Transportation Equipment	9.3	15.9	13.0	12.2	12.2	15.6	25.5	35.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Value of imports at current prices in YR millions	178.4	194.8	376.2	564.3	868.1	1,341.4	1,882.1	979.4
Index of growth 1970 = 100.0; 1977 @ First Quarter Rate	100.0	103.6	210.8	316.2	486.5	751.7	1,054.7	2,195.4

Source: Socknet and Sinclair. 1978

APPENDIX IV

Water Resources

Figure 1. Water Table Elevations in the Tihama, April 1976

Figure 2. Regional Flow Pattern of the Tihama

Figure 3. Contour Map of Hydraulic Conductivity, Wadi Mawr

Figure 4. Exploratory Wells, Wadi Rima

Figure 5. Salinity and Depth to Groundwater, Wadi Rima, May 1976

Table 1. Total Monthly Streamflow of Wadi Rima at Base of Mountains, Al Mishrafah Gaging Station

Table 2. Total Monthly Streamflow of Wadi Mawr at Base of Mountains, Shat Al Erg Gaging Station

Table 3. Flow Net Computations of Natural Groundwater Discharge

Table 4. Aquifer Parameters and Text Well Construction Data, Wadi Mawr

Table 5. Estimated Annual Well Discharge, Wadi Mawr, 1975-1976

Table 6. Aquifer Parameters, Wadi Rima

Table 7. Chemical Analysis of Irrigation Water from Ausseifera Farm, Ta'izz; Gomaisha Farm, Hodeida, Zabid Farm, Zabid

Table 8. Chemical Analysis of Drinking Water, Various Towns

Table 9. Water Resources Information Summary

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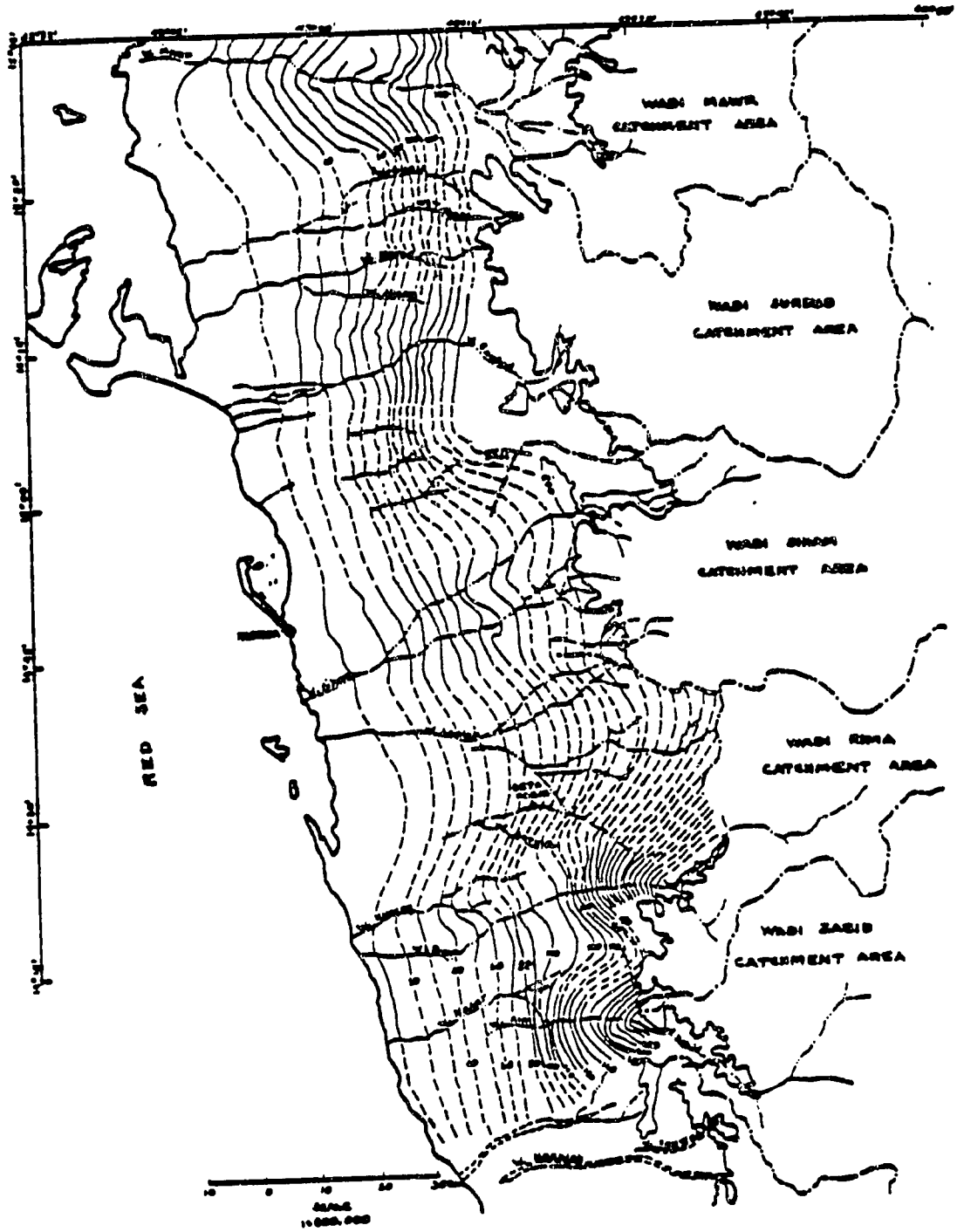

Figure 1. Water Table Elevation in the Tihama, April 1976

Source: al-Eryani. 1978.

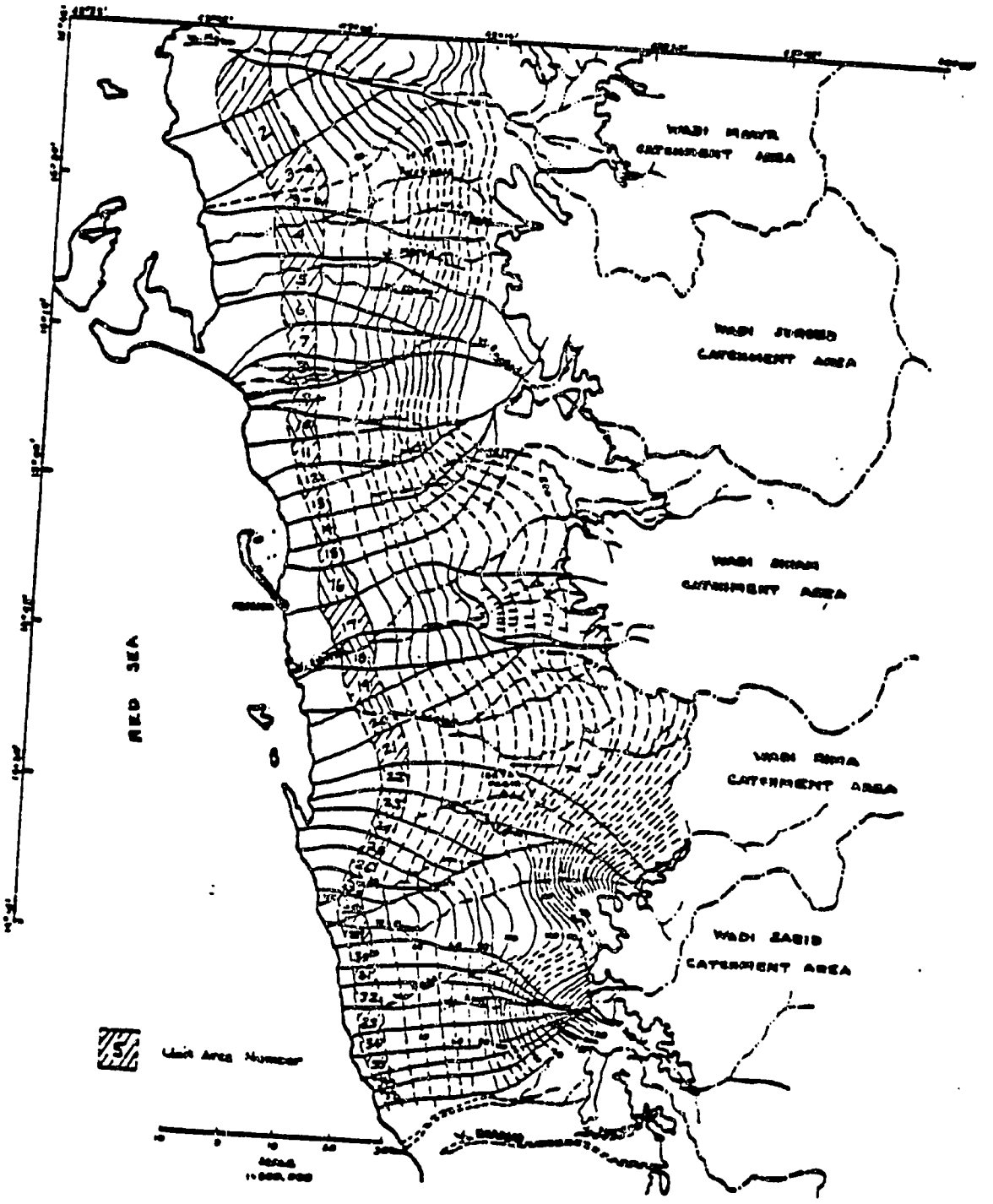

Figure 2. Regional Flow Pattern of the Tihama

Source: al-Eryani. 1979.

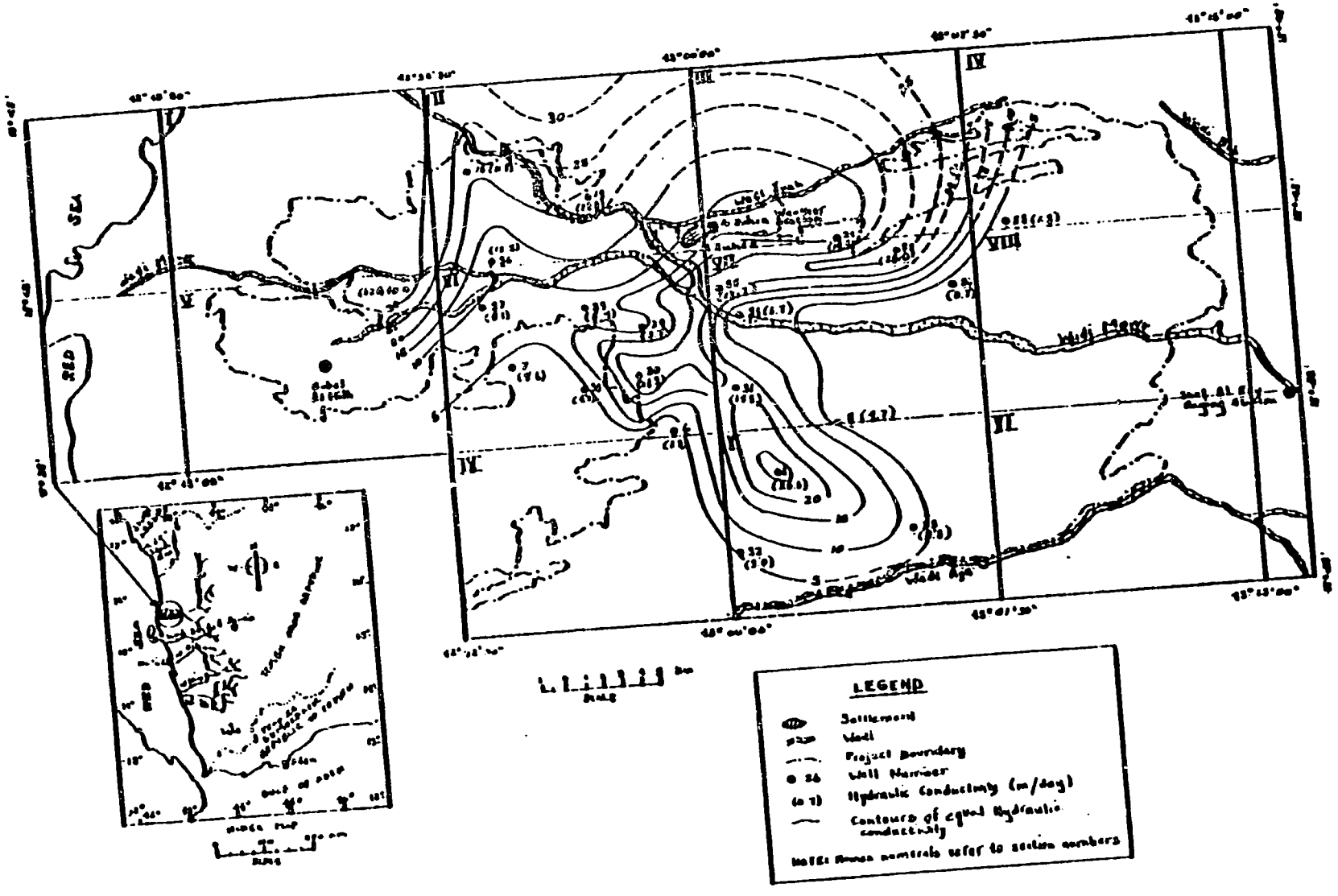

Figure 3. Contour Map of Hydraulic Conductivity, Wadi Mawr

Source: al-Eryani. 1978.

Source: al-Eryani. 1978.

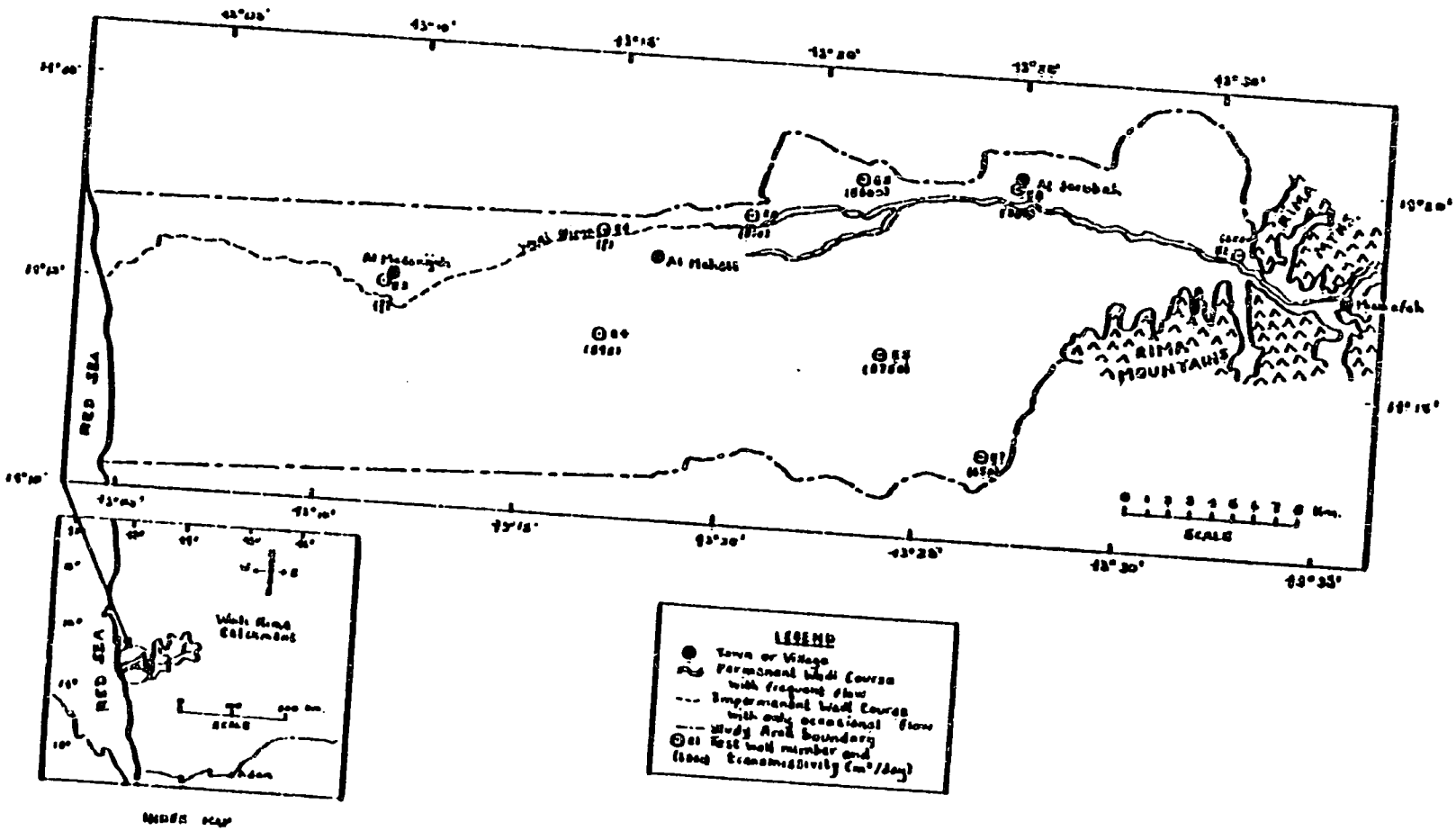

Figure 4. Exploratory Wells, Wadi Rima

Source: al-Eryani. 1979.

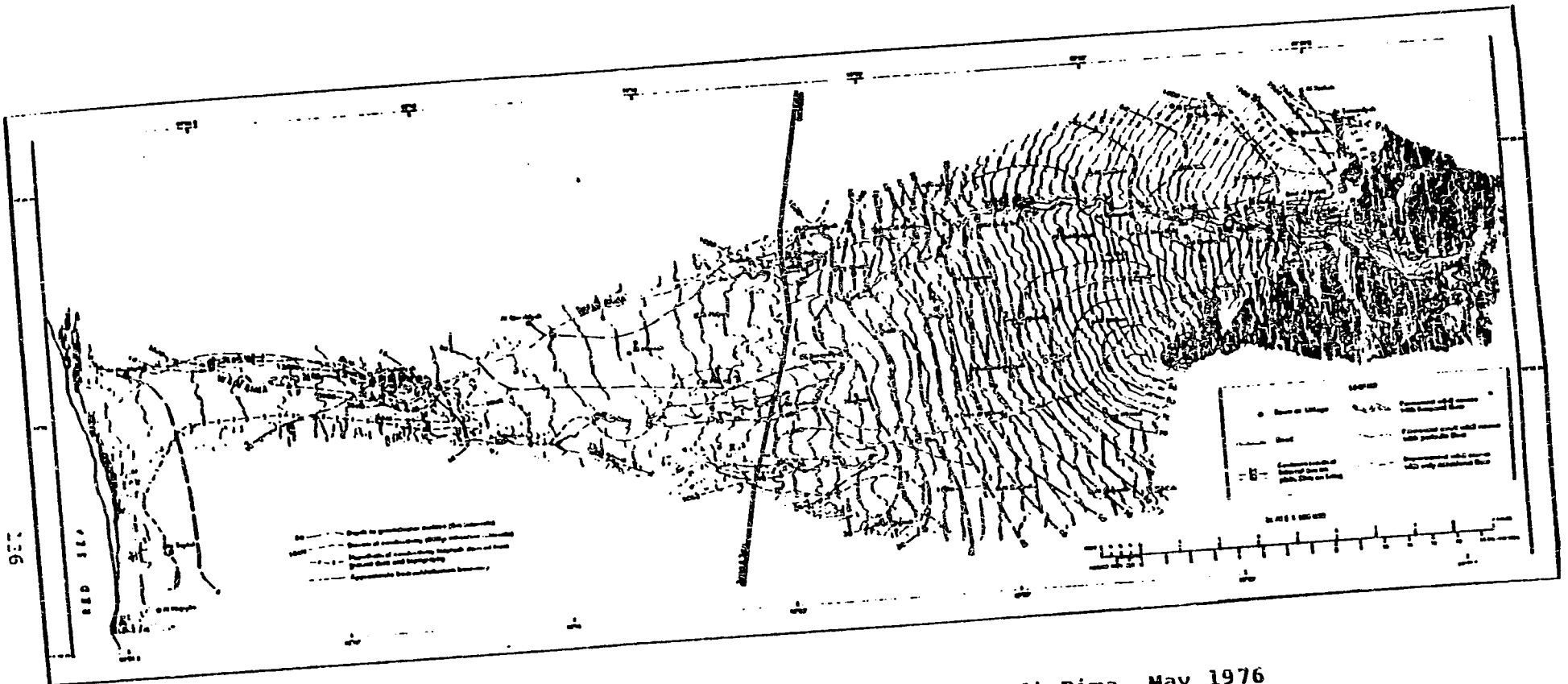

Figure 5. Salinity and Depth to Groundwater, Wadi Rima, May 1976

Source: Pratt. 1977

Table 1. Total Monthly Streamflow of Wadi Rima at Base of Mountains, Al Misgrafah Gaging Station

(million cubic meters)

Month	Year 1975	1976	1977
January	—	1.50	2.90
February	—	1.60	2.70
March	—	4.40	1.60
April	(5.20)[a]	22.90	—
May	5.50	19.50	—
June	8.40	13.70	—
July	22.10	11.10	—
August	23.90	10.50	—
September	12.10	6.40	—
October	6.40	3.90	—
November	2.40	3.20	—
December	4.50	1.20	—
Annual Totals	(90.50)[a]	99.90	(7.20)[a]

[a]Partial month or year totals.

Source: al-Eryani. 1979.

Table 2. Total Monthly Streamflow of Wadi Mawr at Base of Mountains, Shat Al Erg Gaging Station

(million cubic meters)

Month	Year			
	1975	1976	1977	1978
January	6.9[a]	4.4	11.6	20.7
February	5.4[a]	4.0	9.0	19.3
March	6.3[b]	6.4	11.0	17.4
April	19.6	22.8	38.8	20.1
May	8.2	18.0	33.8	40.1
June	24.1	13.3	13.0	20.3
July	24.9	23.8	12.0	36.1
August	27.4	33.3	9.6	50.6
September	17.4	24.0	14.3	42.9
October	9.9	11.8	27.7	27.5
November	5.6	11.0	18.3	28.3
December	6.4	10.4	16.6	21.1
Annual Totals	162.1	183.6	215.6	344.4

[a]Estimated.

[b]Estimated prior to March 22.

Source: al-Eryani. 1978.

Table 3. Flow Net Computations of Natural Groundwater Discharge

Unit and Unit Area Number[a]	Average Hydraulic Gradient (i) (m/m)	Average Transmissivity (T) (m²/day)	Width of Unit Area (m)	Average Annual Discharge (Q)=iLT (MCM)
Unit Three				
1	1.342	1250	9.60	[illegible]
2	1.300	1250	10.60	4.836
3-4	1.297	1250	6.00	[illegible]
Total				[illegible]
Central Irrigation Area				
3-4	1.087	1250	1.20	1.402
4	1.225	1300	9.10	[illegible]
Total				[illegible]
Unit Irrigation				
5	1.304	1750	6.66	6.287
6	1.786	1750	5.80	6.617
7	1.300	1750	5.72	7.307
8	1.100	1750	5.72	7.673
9	1.308	1750	5.28	[illegible]
Total				[illegible]
Central Irrigation Area				
10	1.283	1000	4.80	7.239
11	1.283	1000	4.80	7.239
12	1.273	1000	4.40	7.301
13	1.273	1000	4.40	7.301
14	1.236	1000	4.40	8.177
15	1.338	1000	4.90	[illegible]
Total			2.28	[illegible]
Unit Three				
16	1.724	1250	6.32	[illegible]
17	1.470	1250	7.25	8.493
18	1.667	1250	5.60	[illegible]
Total				[illegible]
Central Irrigation Area				
19	1.436	1375	5.72	[illegible]
20	1.436	1375	6.44	[illegible]
21	1.400	1375	5.36	[illegible]
22	1.300	1375	4.89	8.369
23	1.293	1375	4.70	[illegible]
24	1.250	1375	4.70	8.440
25	1.232	1375	3.89	7.585
26	1.913	1375	3.89	[illegible]
27	1.300	1375	3.00	[illegible]
Total			3.89	[illegible]
Unit Three				
28	1.439	1300	3.73	[illegible]
29	1.273	1300	4.40	[illegible]
Total				[illegible]
Unit Twelve				
30	1.606	1900	4.30	10.443
31	1.300	1900	3.72	9.505
32	1.273	1900	4.40	[illegible]
33	1.100	1900	4.30	[illegible]
34	1.300	1900	4.30	[illegible]
35	1.777	1900	3.63	[illegible]
36	1.372	1900	3.36	13.446
37	1.666	1900	2.40	13.803
Total				[illegible]
Grand Total				101.432
			(or approximately 100 MCM)	

[a]See Fig. 2 for Unit Area Number localities

Source: al-Eryani. 1979.

Table 4. Aquifer Parameters and Test Well Construction Data at Wadi Mawr

Test Well No.[d]	Total Depth (m)	Screen Length (m)	Pumping Rate (l/s)	Duration of Test (hours)	24-Hour Specific Capacity (l/s/m)	Average Storage Coefficient (unitless)	Average Transmissivity Coefficient (m^2/day)	Average Hydraulic Conductivity (m/day)
1	175	24.4	20.8	6.0	1.06	N.D.[c]	650	26.6
6	186	32.6	8.8	6.0	0.33	—	42	1.3
7	234	26.2	13.8	24.0	0.60	—	121	4.6
8	?	23.7	22.3	72.0	0.86	—	111	4.7
13	154	35.8	25.7[a]	72.0	0.93	—	200	5.6
14	180	32.8	42.4	24.0	2.53	—	790	23.8
15	111	32.9	44.2[a]	60.0	2.27	—	719	21.9
23	?	15.8	2.3	1.0[b]	0.14	—	20	1.3
24	?	29.8	10.1	6.0	0.34	—	430	14.4
25	111	21.4	17.2	36.0	0.65	—	600	28.0
26	?	27.4	6.3	6.0	0.27	—	20	0.7
29	134	40.7	26.1	6.0	0.73	—	150	3.7
30	206	33.3	57.6	6.0	0.99	—	350	26.3
31	205	66.7	64.5[a]	120.0	4.73	0.0010	1300	19.5
32	152	60.0	28.3	96.0	1.42	0.0008	300	5.0
33	165	60.1	12.3	6.0	0.48	N.D.	500	8.3
34	137	67.1	6.8	24.0	0.49	—	450	6.7
35	154	8.8	5.9	24.0	4.30	—	200	22.7
36	158	51.9	44.6	24.0	3.42	—	650	12.5
37	160	49.9	13.4	24.2	0.74	—	400	8.1
38	161	60.2	29.0	24.0	2.21	—	283	4.7
39	150	40.8	26.1	24.0	1.34	—	320	5.4
40	140	32.8	43.3	16.0	4.91	—	1050	32.0

[a]Averages form step-drawdown tests.

[b]Test by airlift

[c]N.D. = Not Determined

[d]See Figure3 for test well localities

Table 5. Estimated Annual Well Discharge, Wadi Mawr, 1975 - 1976

Location[a] (Sector)	Average Pumped Volume per Well per Year (MCM)	1975		1976	
		Number of Wells	Annual Total (MCM)	Number of Wells	Annual Total (MCM)
I	0.14	4	0.56	5	0.70
II	0.14	1	0.14	1	0.14
III	0.14	1	0.14	3	0.42
IV	0.056	6	0.34	9	0.50
V	0.14	2	0.28	3	0.42
VI	0.21	12	2.52	12	2.52
VII	0.14	1	0.14	3	0.42
VIII	0.14	1	0.14	2	0.28
IX	0.134	40	5.36	62	8.31
X	0.179	16	2.86	28	5.52
XI	0.14	1	0.14	2	0.28
		84	12.62	130	19.51

[a]See Fig. 3 for sector locations

Source: al-Eryani. 1979.

Table 7 Chemical analysis of Irrigation Water from Ausselfra Farm, Ta'izz; Gomaisha Farm, Hodeida; and Zabid Farm, Zabid

Location and Source	pH	E.C. Milli-mhos/cm at 25°C	Milliequivalent/litre											
			Ca^+	Mg^+	K^+	Na^+	HCO_3^-	CO_3^-	Cl^-	SO_4^-	NO_3^-	Sum of Cations	Sum of Ca + Mg	Sum of Anions
Ausselfera Farm Ta'izz Nov. 1976	7.76	** 2.90	** 14.0	* 4.0	0.35	17.50	9.91	NIL	* 10.92	** 11.56	** 2.75	35.85	18.00	35.14
Oct. 1976	7.78	** 3.10	** 14.4	* 5.6	0.35	18.00	10.16	"	* 11.70	** 12.60	** 1.79	38.34	20.00	36.25
Sep. 1976	7.76	** 3.12	** 12.0	* 5.8	0.40	16.50	8.32	"	* 11.00	** 12.00	** 2.71	34.70	17.80	34.03
Aug. 1976	7.58	** 3.60	** 14.2	* 6.4	0.37	15.00	7.92	"	* 11.80	** 11.60	** 2.07	35.97	20.60	33.39
June 1976	7 60	** 3.60	** 15 0	* 6.0	0.40	14.0	11.28	"	* 12.56	** 9.60	** 3.00	35.40	21.00	36.38
May 1976	7.60	* 2.28	** 13.6	* 5.8	0.35	14.00	8.20	"	* 13.40	** 12.33	** 3.03	33.75	19.40	36.96
Gamaisha Farm North Well no. 3	8.07	** 3.70	* 8.2	* 5.0	0.14	29.5	5.46	"	21.0	** 12.6	** 3.71	** 42.84	13.2	42.77
Gomaisha Farm South Well no. 4	8.22	** 2.28	3.0	2.0	0.13	22.5	6.86	"	* 8.8	** 9.2	** 2.25	27.63	5.0	27.01
Gomaisha Farm South Well no. 5	6.14	* 2.05	2.2	2.8	0.07	18.5	8.06	"	* 7.4	5.8	** 2.36	23.57	5.0	23.62
Zabid Farm	7.53	* 0.95	5.6	1.6	0.12	8.0	7.2	"	4.0	1.95	* 0.40	15.32	7.2	13.55
Zabid Farm	7.39	0.76	2.2	1.2	0.16	11.5	7.6	"	4.4	1.95	* 0.32	15.06	3.4	14.27

*Above desirable limit **Above maximum permissible level

Source: Lateef. 1978

Table 8 Chemical Analysis of Drinking Water, Various Towns

Location and Source	pH	E.C. Milli-mhos/cm at 25°C	Millequivalent/litre											
			Ca^+	Mg^+	K^+	Na^+	HCO_3^-	CO_3^-	Cl^-	SO_4^-	NO_3^-	Sum of Cations	Sum of Ca + Mg	Sum of Anions
Spring Water Salah, Ta'izz	7.33	0.50	2.8	0.8	0.04	2.30	3.68	NIL	2.77	NIL	* 0.26	5.94	3.60	6.71
Jabel Sabor, Ta'izz	7.31	0.45	2.72	0.48	0.03	1 30	3 50	-	0.80	-	0.14	4 53	3.20	4.44
Ta'izz Water Supply Oct. 1975	7.55	** 3.10	* 7.98	* 7.03	0.25	23.0	12.0	-	* 11.76	** 12.25	** 1.14	38.29	15.01	37.151
March 1976	7.58	** 3.20	* 7.80	* 6.80	0.29	25.0	10.0	-	* 12.56	** 16.79	** 0.84	41.29	14.60	40.19
June 1976	7.30	** 3.30	** 10.40	* 6.60	0.30	22.50	12.48	-	* 14.80	** 9.40	** 3.15	39.80	17.00	39.83
Nov. 1976	8.12	** 3.34	* 8.80	* 6.40	0.28	26.00	11.43	-	* 13.09	** 12.56	** 3.03	41.48	15.2	40.11
Drinking water Mokha	7.50	** 2.90	* 6.2	* 7.8	0.14	33.50	9.60	-	** 23.75	** 14.50	** 0.75	47.64	14.00	48.60
Baida Well 1[a]	7.70	** 2.40	3.60	* 4.80	0.08	22.50	6.80	-	** 20.00	5.00	** 1.07	30.98	8.40	32.87
Baida Well 4[a]	7.60	** 2.30	* 4.20	4.20	0.08	21.00	6.40	-	** 19.30	4.00	** 0.75	29.48	8.40	30.45
San'a[a]	8.00	0.50	2.90	0.20	0.04	2.45	2.80	-	1.60	1.30	* 0.20	5.59	3.10	5.90
Supply Sana'a	8.10	0.62	* 4.20	0.20	0.06	2.30	3.76	-	1.80	1.10	* 0.25	6.76	4.40	6.91
Capital Water Supply Jibiah	7.64	* 0.86	* 4.4	1.6	0.11	2.50	5.80	-	3.47	0-.20	* 0.27	8.61	6.00	9.74
Drinking Water Jibiah	7.46	0.40	* 4.0	1.0	0.03	1.50	4.92	-	0.78	0.37	0.07	6.53	5.00	6.14

Location and Source	pH	E.C. Milli-mhos/cm at 25°C	Milliequivalent/litre											
			Ca^+	Mg^+	K^+	Na^+	HCO_3^-	CO_3^-	Cl^-	SO_4^-	NO_3^-	Sum of Cations	Sum of Ca + Mg	Sum of Anions
Drinking Water														
Rihab	7.59	0.73	* 4.6	1.3	0.18	3.50	5.20	-	3.60	0.45	* 0.21	9.58	5.90	9.46
Badaan	7.53	* 1.75	* 9.2	4.4	0.07	1.90	2.0	-	* 12.80	0.20	** 1.18	15.57	13.60	16.18
al-Radma	8.14	0.60	2.2	1.8	0.08	3.10	4.50	-	3.0	0.10	** 0.78	7.18	4.00	8.38

*Above desirable limit

**Above maximum permissible level

[a]Exact source illegible in source

Source: Lateef. 1978

Table 9.

Yemen Water Resources Information Summary

STUDY IDENTIFICATION	SUBJECTS DISCUSSED									EXPLANATION
REGION / AREA / Study	Agricultural Development	Domestic Use	Sewerage	Groundwater	Surface Water	Present Water Use	Water Rights	Watershed	None	Thorough coverage; Some attention; No coverage; No study
WEST / TIHAMA										NOTES
WADI MA'BAR									◉	
WADI KHULAB									◉	
WADI HARAD									◉	
WADI HAYRAN									◉	
WADI BAWHAL									◉	
WADI MAWR	■			■	■	▨	▨	▨		
(1) Tipton-Kalmbach (1979)	■			■	■	▨	▨	▨		
(2) Tesco-Vizitery (1971)	■			▨	▨			▨		Recon study
WADI SURDUD	■			▨	▨	▨	▨	▨		Needs more detailed study
(1) Wm. Halcrow (1978)	■			▨	▨	▨	▨	▨		Limited data
WADI SIHAM	■			■	■	■	▨			
(1) Sogreah (1979)	■			■	■	■	▨			
HUDAYDAH		■	■	■	■	▨				
(1) Italconsult (1973)		■		■	■					
(2) Italconsult (1976)			■			▨				
(3) Kocks (1978)		■		■						
WADI 'ASALAH									◉	
WADI RIMA'	■			▨	■	■				Needs detailed groundwater study
(1) GHV (1978)	■			▨	■	■				Groundwater data sparse
WADI ZABID	■			■	■	■	■	▨		
(1) Tesco-Vizitery (1971)	■			■	■	■	■	▨		
WADI NAKHLAH									◉	
WADI RAYSAN	■			▨	▨	▨	▨			Needs more detailed study
(1) Sir Alex. Gibb (1978)	■			▨	▨	▨	▨			Limited data provided
WADI AL-GHAYL (WADI AL-KABIR)									◉	

(continued)

Table 9. (continued)

Yemen Water Resources Information Summary

STUDY IDENTIFICATION	SUBJECTS DISCUSSED									EXPLANATION
REGION / AREA / Study	Agricultural Development	Domestic Use	Sewerage	Groundwater	Surface Water	Present Water Use	Water Rights	Watershed	None	Thorough coverage; Some attention; No coverage; No study
CENTRAL										
AL-HARF									◉	NOTES
HUTH									◉	
RAYDAH									◉	
AMRAN									◉	
(1) U.S.G.S. (1980)										Surface hydrology as a function of groundwater recharge
AL-MAHWIT										
(1) Sir Wm. Halcrow (1978)										Specific water resources data negligible
SANA'A										
(1) Italconsult (1973)										
(2) Italconsult (1975)										
(3) H. Humphreys (1977)										
(4) H. Humphreys (1979)										
(5) H. Humphreys (1980)										
(6) Mullick (1977)										
BANI HUSHAYSH										
(1) Awad and Dewan (1977)										

(continued)

Table 9. (continued)

Yemen Water Resources Information Summary

STUDY IDENTIFICATION (REGION / AREA / Study)	SUBJECTS DISCUSSED: Agricultural Development	Domestic Use	Sewerage	Groundwater	Surface Water	Present Water Use	Water Rights	Watershed	None	NOTES
SOUTH										
DHAMAR		■	■	■	■					
(1) Italconsult (1978)		■	■	■	■					
IBB		■	■	■	■					
(1) Italconsult (1978)		■	■	■	■					
TAIZ		■	■	■						
(1) Montgomery (1975)		■	■	■						
(2) Hazen & Sawyer (1977)		■		■						
(3) Leggette, Brashears & Graham (1980)		■		■						
WADI BANA	■			■	■	▨	▨			Phase II is recommended
(1) Sir Alex. Gibb (1977-78)	■			■	■	▨	▨			
WADI TUBAN									◉	
WADI WARAZAN									◉	

EXPLANATION:
- ■ Thorough coverage
- ▨ Some coverage
- □ No coverage
- ◉ No study

(continued)

Table 9. (continued)

Yemen Water Resources Information Summary

STUDY IDENTIFICATION	SUBJECTS DISCUSSED									EXPLANATION
REGION / AREA / Study	Agricultural Development	Domestic Use	Sewerage	Groundwater	Surface Water	Present Water Use	Water Rights	Watershed	None	■ Thorough coverage; ▨ Some attention; □ No coverage; ◉ No study
EAST										NOTES
WADI NAJRAN (Including SA'DAH)									◉	
WADI IMRA'A									◉	
WADI AMLAH									◉	
WADI SILBA									◉	
WADI KHABB									◉	
WADI JAWF BASIN	■			▨	■	▨	▨	▨		
(1) Sir Alex. Gibb (1978)	■			▨	▨					
(2) Agrar-Und Hydrotechnick (1980)	■			▨	■	▨	▨	▨		
WADI MADHAB (Lower Wadi)	■			▨	■	▨	▨	▨		
(1) Agrar-Und Hydrotechnick (1980)	■			▨	■	▨	▨	▨		
WADI KHARID	■			▨	■	▨	▨	▨		
(1) Sir Alex. Gibb (1978)	■				▨					
(2) Agrar-Und Hydrotechnick (1980)	■			▨	■	▨	▨	▨		
WADI FURDAH	■			▨	■	▨	▨	▨		
(1) Agrar-Und Hydrotechnick (1980)	■			▨	■	▨	▨	▨		
WADI MUKHAYMA									◉	
WADI SADD (MA'RIB)									?	
WADI HARIB BASIN									◉	
WADI BAYHAN									◉	
WADI MARAKA									◉	

Source: Bernhardt et al. 1980.

APPENDIX V

Miscellaneous Agricultural Data

Table 1a. Total Consumption by Crops, Wadi Rima (June 1975-May 1976)

Table 1b. Computed Seasonal Effective Precipitation and the Net Consumptive Uses by Crops in Wadi Rima (June 1975-May 1976)

Table 2a. Total Consumption by Crops, Wadi Mawr (May 1975-April 1976)

Table 2b. Total Consumptive Use by Crops on Ground Water Irrigated Lands, Wadi Mawr (May 1975-April 1976)

Table 3a. Irrigation Practices and Patterns of Land Use in Wadi Mawr: Ground Water Irrigated Land, 1974-77

Table 3b. Irrigation Practices and Patterns of Land Use in Wadi Mawr: Wadi Irrigated Land, 1974-77

Table 3c. Irrigation Practices and Patterns of Land Use in Wadi Mawr: Rainfed Land, 1974-77

Table 4. Agricultural Technology to Yemen 1970-1976

Table 5. Common Weeds in Yemen

Table 6. Common Plant Pathogens of Grain Crops of Yemen

Table 7. Insect Crop Pests

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Table 1a. Total Consumption by Crops, Wadi Rima (June 1975 - May 1976)

Crop	Land Category							
	Ground Water Irrigated Lands		Wadi Irrigated Lands					
			Perennial		Regular Spate		Irregular Spate	
	Area Planted (ha)	Total Consumption (MCM)	Area Planted (ha)	Total Consumption (MCM)	Area Planted (ha)	Total Consumption (MCM)	Area Planted (ha)	Total Consumption (MCM)
Cotton	1,008	9.070	75	0.483	345	1.856	90	0.495
Sorghum (1)	3,500	18.839	260	1.262	1,765	8.530	1,230	5.945
Sorghum (2)	1,908	14.231	375	1.398	2,430	8.882	3,850	14.621
Sesame (1)	300	1.690	N.P.[a]	N.P.	180	0.350	155	0.322
Sesame (2)	300	1.319	N.P.	N.P.	15	0.063	N.P.	N.P.
Maize (1)	360	1.667	360	1.842	330	1.114	900	N.P.
Maize (2)	365	2.938	1,000	7.297	630	4.600	N.P.	N.P.
Vegetables (1)	175	1.115	N.P.	N.P.	N.P.	N.P.	N.P.	N.P.
Vegetables (2)	175	1.155	N.P.	N.P.	N.P.	N.P.	N.P.	N.P.
Watermelon	175	1.023	N.P.	N.P.	N.P.	N.P.	N.P.	N.P.
Totals	8,259	54.115	2,250	12.190	3,695	25.468	6,325	24.728

[a]N.P. = Not Planted.

Source: al-Eryani. 1979.

Table 1b. Computed Seasonal Effective Precipitation and the Net Consumptive Uses by Crops in Wadi Rima (June 1975 - May 1976)

Crop	Growing Season	Seasonal Consumptive Use (mm)	Land Category							
			Ground Water Irrigated Lands		Wadi Irrigated Lands					
					Perennial		Regular Spate		Irregular Spate	
			P_e[a] (mm)	NCU[b] (mm)	P_e (mm)	NCU (mm)	P_e (mm)	NCU (mm)	P_e (mm)	NCU (mm)
Cotton	Aug-Feb	907.0	0.0	907.0	309.1	537.9	369.1	537.9	356.5	550.5
Sorghum (1)	Jan-Apr	547.5	7.8	539.7	62.0	485.5	64.2	483.3	64.2	483.3
Sorghum (2)	May-Sep	749.0	0.0	749.0	376.3	372.7	383.5	365.5	360.2	389.8
Sesame (1)	Aug-Nov	566.0	0.0	566.0	N.P.[c]	N.P.	368.4	197.6	364.1	204.6
Sesame (2)	Dec-Mar	439.7	0.0	439.7	N.P.	N.P.	21.9	417.8	N.P.	N.P.
Maize (1)	Aug-Nov	743.6	0.0	743.6	402.6	341.0	406.1	337.9	398.3	345.1
Maize (2)	Mar-Jun	805.0	0.0	805.0	75.9	729.1	74.8	730.2	N.P.	N.P.
Vegetables (1)	Feb-May	644.8	7.7	637.1	N.P.	N.P.	N.P.	N.P.	N.P.	N.P.
Vegetables (2)	Aug-Nov	660.0	0.0	660.0	N.P.	N.P.	N.P.	N.P.	N.P.	N.P.
Watermelon	Oct-Jan	584.3	0.0	584.3	N.P.	N.P.	N.P.	N.P.	N.P.	N.P.

[a]P_e = seasonal effective precipitation.

[b]NCU = Net Consumptive Use.

[c]N.P. = Not Planted.

Source: al-Eryani. 1979.

Table 2a. Total Consumption by Crops in Wadi Mawr (June 1975 - May 1976)

Crop and Year	Total Area Planted and Harvested (ha)	Crop's Percentage of and Area (ha)		Percentage[a] and Area Receiving Winter Canals Irrigation (ha)		Percentage[a] and Area Receiving Flood Canals Irrigation (ha)		Percentage of Water Requirement	Net Consumptive Use (mm)	Total Crop Consumption (MCM)
		%	Area	%	Area	%	Area			
Cotton										
1975	12,130	23.8	2,886.9	N.A.[b]		N.A.[b]		80	772.1	17.83
Sorghum										
1975	12,130	70.5	8,551.7	0	0.0	75	6,413.7	80	794.4	40.76
1976	12,375	70.5	8,726.4	25	2,181.1	0	0.0	60	583.5	18.22
Sesame										
1975	12,130	1.6	194.1	25	48.5	0	0.0	80	502.7	0.20
1976	12,375	1.6	198.0	0	0.0	75	142.5	80	474.2	0.36
Maize										
1975	12,130	2.0	242.6	N.A.[b]		N.A.[b]		80	574.7	1.12
Vegetables										
1975	12,130	2.1	254.7	25	63.7	0	0.0	80	663.0	0.34
1976	12,375	2.1	259.9	0	0.0	75	194.9	80	520.0	0.83

[a]Used in inferring seasonal cropping intensities.

[b]N.A. = Not applicable for single growing season crops.

Source: al-Eryani. 1979.

Table 2b. Total Consumptive Use by Crops on Groundwater-Irrigated Lands, Wadi Mawr (May 1975 - April 1976)

Crop	Year	Total Area Planted and Harvested (ha)	Crop's Percentage of Total Area and Area (ha)		Seasonal Cropping Intensity	Percentage of Water Requirement	Net Consumptive Use (mm)	Total Crop Consumption (MCM)
			%	Area				
Cotton	1975	1,050	88	924.0	N.A.[a]	85	772.1	6.06
Sorghum	1975	1,050	10.9	114.5	0.5	85	794.4	0.39
	1976	1,775	10.9	193.5	0.5	85	583.5	0.48
Sesame	1975	1,050	1.1	11.5	0.5	85	474.2	0.02
	1976	1,775	1.1	19.5	0.5	85	502.7	0.04

[a]N.A. = Not applicable for single growing season crops.

Source: al-Eryani. 1979.

Table 3a. Irrigation Practices and Patterns of Land Use in Wadi Mawr, Groundwater Irrigated Land, 1974 - 1977

Type and Year of Survey	Total Area Commanded (ha)	Pumpage (MCM/yr)	Cropping Intensity (%)	Total Area Planted (ha)	Total Area Harvested (ha)	Percentage of Water Requirement
Land use, 1974	740[a]	8.13	100	740	740	85
Irrigation system, 1975	1,050[a]	12.62	100	1,050	1,050	85
Irrigation area, 1977	2,500	27.50	100	2,500	2,500	85
Projections, 1976	1,775[b]	19.51	100	1,775[b]	1,775[b]	85

[a]Inferred from pumpage.

[b]Inferred by comparison with 1975 and 1977 data.

Source: al-Eryani. 1979.

Table 3b. Irrigation Practices and Patterns of Land Use in Wadi Mawr, Wadi Irrigated Land, 1974 - 1977

Type and Year of Survey	Total Area Commanded (ha)	Pumpage (MCM/yr)	Cropping Intensity (%)	Total Area Planted (ha)	Total Area Harvested (ha)	Percentage of Water Requirement
Land use, 1974	740[a]	8.13	100	740	740	85
Irrigation system, 1975	1,050[a]	12.62	100	1,050	1,050	85
Irrigation area, 1977	2,500	27.50	100	2,500	2,500	85
Projections, 1976	1,775[b]	19.51	100	1,775[b]	1,775[b]	85

[a]Inferred from pumpage.

[b]Inferred by comparison with 1975 and 1977 data.

Source: al-Eryani. 1979.

Table 3c. Irrigation Practices and Patterns of Land Use in Wadi Mawr: Rainfed Land, 1974 - 1977

Type and Year of Survey	Total Area Commanded (ha)	Rainfall (mm)	Cropping[a] Intensity (%)	Total Area Planted (ha)	Total Area Harvested (ha)	Percentage of Water Requirement
Land use, 1974	12,493	—	35	4,373	3,088	50
Irrigation system, 1975	14,000	493	40	5,600	3,955[b]	50
Irrigation area, 1977	17,000	—	35	5,950	4,200[b]	50
Projections, 1976	15,500	438	35	5,425	3,830[b]	50

[a]Inferred from wadi Rima data (Rhein, 1977).

[b]Inferred from 1974 data.

Source: al-Eryani. 1979.

Table 4. Agricultural Technology to Yemen 1970 - 1976

Year	Number of tractors		Number of agricult. water-pumps		Fertilizer (tons)		Pesticides (tons)	
1970	20	1%	1.382	6%	3.153	13%	135	3%
1971	80	4%	1.205	5%	4.046	16%	218	5%
1972	31	2%	3.928	17%	1.699	7%	345	7%
1973	53	3%	3.479	15%	4.256	17%	457	10%
1974	53	3%	3.285	14%	3.869	16%	717	15%
1975	238	12%	4.333	18%	3.363	13%	1.834	39%
1976	1.420	74%	5.916	25%	4.471	18%	1.004	21%
1970-76	1.915	100%	23.528	100%	24.857	100%	4.710	100%

Source: Bernhardt et al. 1980.

Table 5. Common Weeds in Yemen

Common Name	Plant Family	Scientific Name	Demonstration Location
"Zoheyra" or "Makhraba"	Compositae	Flaveria repanda Lag.	148 Km/NW - Sana'a
"Wobel" or "Zeel" (Bermuda Grass)	Gramineae	Cynodon dactylon (L.) Pers.	Near Huth - 126 Km/N - Sana'a
"Helgub" or "Shager"	Cruciferae	Diplotaxia erucoides L.	Maf-Dan, 43 Km/N - Sana'a
"Se'ed"	Cyperaceae	Cyperus rotundus L.	—
"Edar"	Scrophulariaceae	Striga Hermonthica Benth.	—

Source: University of Arizona. 1981.

Table 6. Common Plant Pathogens of Grain Crops in Yemen

Host	Common Name	Scientific Name
Sorghum (*Sorghum vulgare*)		
	Leaf Blight	*Helminthosporium turcicum*
	Leaf Blight	*Ramulispora sorghi*
	Leaf Blight	*Ramulistora sorghicola*
	Downy Mildew	*Sclerospora sorghi*
	Covered Kernal Smut	*Sphacelotheca sorghi* Link (Clint)
	Head Smut	*Sphacelotheca cruenta* Kuhn, Potter
	Long Smut	*Tolyposcorium ehrenbergii*
	Bacterial Leaf Spot	*Pseudomonas syringae* (?)
	Bacterial Stripe	*Pseudomonas andropogonis* (?)
	Yellow Stripe	Virus
Millet (*Pennisetum glaucum*)		
	"Green Ear"	*Sclerospora graminicola*, Sacc. Schrot
Wheat (*Triticum aestivum*)		
	Leaf Rust	*Puccinia recondita*, Rob. ex Desm.
	Stem Rust	*Puccinia graminis*, Pers.
Barley (*Hordeum vulgare*)		
	Leaf Rust	*Puccinia recondita*, Rob. ex Desm.
	Stem Rust	*Puccinia graminis* Pers.
	Stripe Rust	*Puccinia striiformis* West.
	Loose Smut	*Ustilago nuda* Janson Rostr.
Maize (*Zea mays*)		
	Rust	*Puccinia sorghi*
	Leaf Blight	*Helminthosporium turcicam* Pass.
	Yellow Stripe	Virus
Common Weeds		
Euphorbia hypericifolia L.		
	Rust	*Melampsora euphorbiae* -
Carthamus tinctorius L.		
	Rust	*Puccinia calcitrapae* DC V. *centaureae* (DC) Cumm. (*P. carthami* Cda.)

Source: University of Arizona. 1981.

Table 7. Insect Crop Pests

A. Major Insect Pests of Sorghum and Millet

Rhopalsiphum maidis Fitch	(corn leaf aphid)
Sesamia cretica Led.	(stalk borer)
Microcerotermes diversus	(termites)
Podagrica spp.	(flea beetles)
Atherigona varia soccata R.	(sorghum shoot fly)
Spodoptera exempta (Walker)	(African or nutgrass armyworm)
Schistocerca gregaria	(desert grasshopper)
Oligonychus (Reckiella) simus P. & B.	
Sitroga cerealella (Oliver)	(angoumois grain moth)
Liposcelis diviniatorius (Mueller)	(cereal psocid)
Tribolium confusum (Duv.)	(confused flour beetle)
Sitophilus granarius (L.)	(granary weevil)
Sitophilus oryza (L.)	(rice weevil)

B. Miscellaneous Crop Pests of Yemen

Alfalfa	
Acyrthosiphon pisum (Harris)	(pea aphid)
Aphis crassivora Koch	(cowpea aphid)
Bruchophagus roddi (Gussakovsky)	(alfalfa seed chalcid)
Chrysanthemum	
Myzus persicae (Sulzer)	(green peach aphid)
Cucurbits (muskmelons, watermelon, and cucumber)	
Aphis gossypii Glover	(melon or cotton aphid)
Asbecesta traversa	(spotted melon beetle)
Dacus ciliatus or longistylus Wied.	(melon fruitfly)
Epilachna chrysomelina	(12-spotted lady beetle)
Dates	
Arenipses sabella	(date moth)
Batrachedra amydraula Meyr.	(date moth)

Parlatoria blancharidii Targioni-Tozzetti)	(parlatoria date scale)
Maize	
Chaetocnema sp.	(flea beetle)
Heliothis armigera Hubner	(corn earworm)
Rhopalosiphum maidis Fitch	(corn leaf aphid)
Sesamia cretica Led.	(stalk borer)
Spodoptera exempta (Walker)	(nutgrass armyworm)
Potato	
Chaetocnema sp.	(flea beetle)
Gryllotalpa spp.	(mole cricket)
Leptinotarsus decemineata	(Colorado potato beetle)
Myzus persicae (Sulzer)	(green peach aphid)
wireworms sp.	
Sesame	
Antigastra catalounalis	(sesame seed pod borer)
Spinach	
Aphids sp.	
Flea beetles sp.	
Tobacco	
Myzus persicae (Sulzer)	(green peach aphid)
Tomato	
Blister beetles sp.	
Flea beetles sp.	
Heliothis armigera Huber	(tomato fruitworm)
Microcerotermes diversus	(subterranean termite)
Mycus persicae (Sulzer)	(green peach aphid)
Plusia sp.	(looper)
Watermelon	
Myzus persicae (Sulzer)	(green peach aphid)
Wheat	
Diuraphis noxia Mordvilko	(aphid)

C. Miscellaneous Insects Collected (not associated with a plant at time of collection)

Adesmia interrupta	(tenebrionid beetle)
Chlorochroa sayi	(Say stink bug)

Coccinella undecimpunctata	(lady beetle)
Gryllus bimaculatus DeGreer	(black cricket)
Heliocopris gigas	(large scarab beetle)
Pachnoda histrio F.	(scarab beetle)
Pockilocerus vittatus	(lubber grasshopper)
Pontia glauconome	(pierid butterfly)
Spilostethus pandurus militaris	(lygaeid bug)
Vanessa carduii (L.)	(painted lady)
Xylocopa Aestuans	(carpenter bee)

D. Beneficial Insects and Mites (from miscellaneous plants)

Anthocoridae	
Orius spp.	(minute pirate bugs)
Cheyletidae	
Cheletogenes ornatus (C. & F.)	(cheyletid mite)
Cheyletia spp.	(cheyletid mites)
Chrysopidae	
Chrysopa vulgaris Schn.	(lacewing)
Coccinellidae	
Coccinella spp.	(lady beetles)
Scymnus spp.	(coccinellids)
Phytoseiidae	
Amblyseius gossypi	(amblyseid mite)
Amblyseius spp.	(amblyseid mites)
Typhlodromus spp.	(typhlodromid mites)
Stigmaeidae	
Agistemus exertus (Gonzales)	(stogmaeid mite)
Tydeidae	
Tydeus californicus Banks	(tydeid mite)

Source: University of Arizona. 1981.

APPENDIX VI

Flora

Figure 1. Synthetic Land Classification Compiled From Landsat-imagery

Figure 2. Dynamics of Vegetation Growth as Interpreted From Imagery of Dry Season (Jan. 1973) and Wet Season (Sept. 1972)

Table 1. The Socio-ecological Plant Species Groups in Rada'

Table 2. Vegetation Types in Rada' District

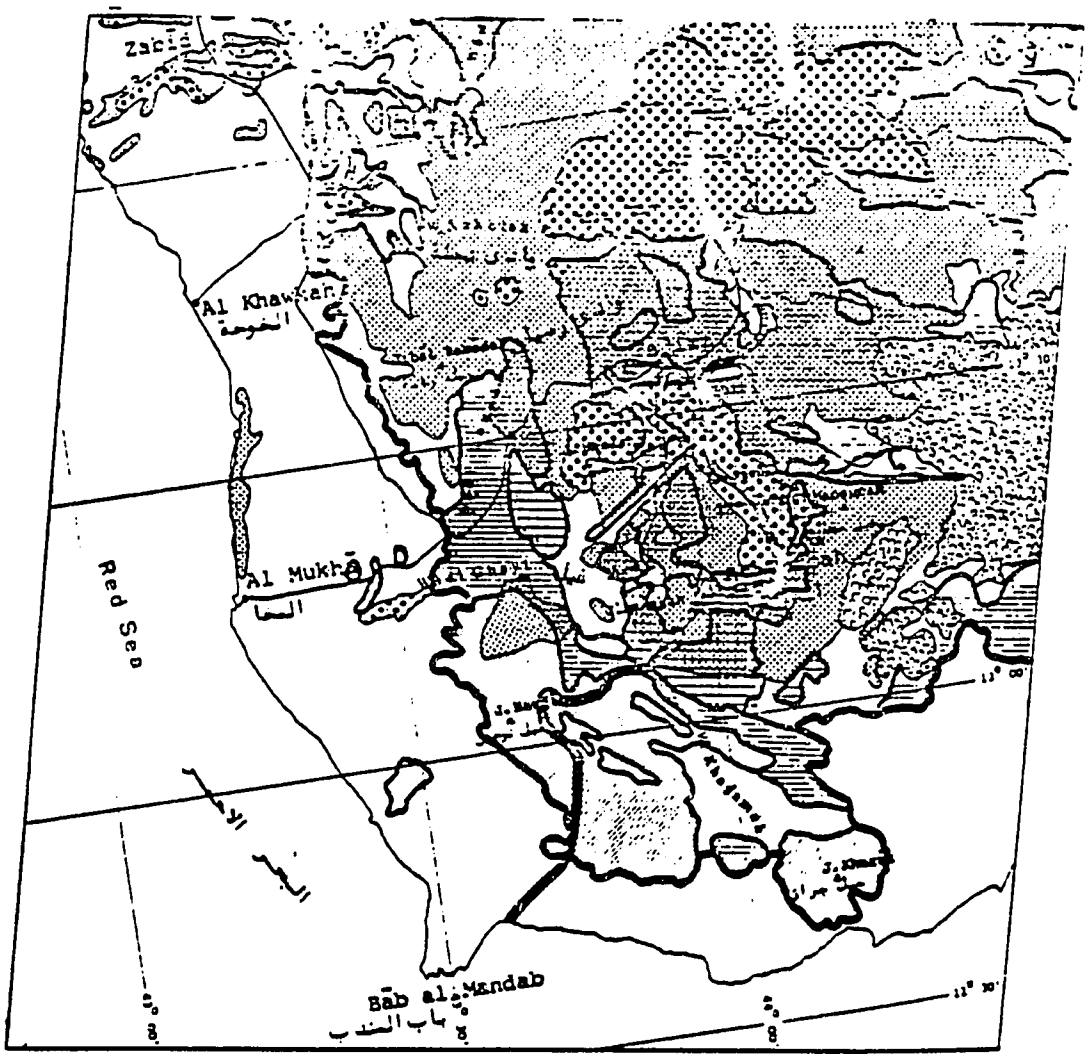

Figure 1: Synthetic Land Classification Compiled From Landsat-Imagery

Delineation of land facet units

- land region
- land system
- land facet
- vegetation delineation

Units of land facets

- sand plain
- large valley bottom
- intramountainous plain
- plateau
- hilly area
- mountainous area
- low density vegetation
- high density vegetation

Source: Haefner, H. et al. 1978.

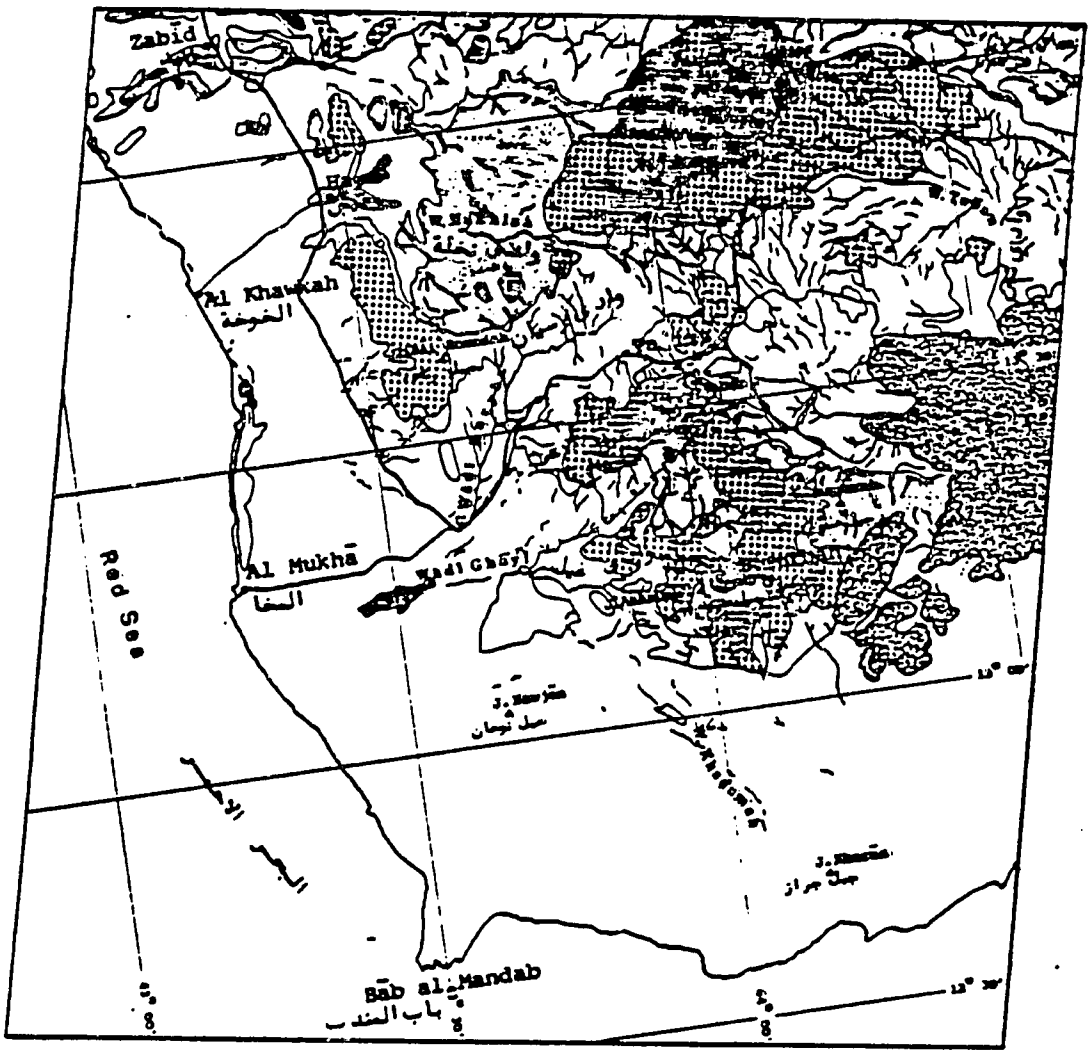

Figure 2: Dynamics of Vegetation Growth as Interpreted From Imagery of Dry Season (Jan. 1973) and Wet Season (Sept. 1972)

Extent of rainfed areas in the wet period:

- low density vegetation
- medium density vegetation
- high density vegetation

Extent of rainfed areas in the dry period:

- low density vegetation
- medium density vegetation

Pump-, spring- and flood-irrigated fields:

- low to medium density vegetation
- high density vegetation
- intensive vegetation in the wadi channels
- clouds

Source: Haefner, H. et al. 1978.

Table 1: The Socio-ecological Plant Species Groups in Rada'

I

Apium nodiflorum
Apium graveolens
Pulicaria arabica
Sonchus asper
Phragmites ? karka
Agrostis semiverticellata

II

Cirsium vulgare
Typha domingensis
Centella asiatica
Eleocharis palustris
Cyperus laevigatus
Lotus corniculatus

III

Paspalum vaginatum
Juncus oxycarpus

IV

Malva verticillata/parviflora
Erucastrum arabicum
Convolvulus arvensis
Chenopodium murale
Datura stramonium

V

Aeluropus lagopoides
Atriplex leucoclada

VI

Juncus heldreichianus
Dicanthium annulatum
Phoenix dactylifera

VII

Peganum harmala
Schangina hortensis

VIII

Sporobolus iocladus
Centaurea pallescens

IX

Euphorbia schimperianum
Xanthium spinosum
Citrillus colocynthis
Euphorbia inaequilatera
Heliotropium bacciferum
Pulicaria orientalis
Launea nudicaulis
Laggaria gariepina

X

Sporobolus spicatus
Pulicaria crispa
Cynodon dactylon

XI

Tamarix nilotica
Sporobolus consimilis

XII

Saccharum spontaneum
Pluchea dioscoriodes

XIII

Calotropis procera
Acacia pachycarpa
Solanum incanum

XIV

Neriandra benghalensis
Lavendula pubescens
Solanum schimperianum
Withania somnifera

XV

Solanum sepicola group
Echinops spinossisimus
Cassia italica
Ocimum serpyllifolium
Andrachne aspera
Themeda triandra
Euriops pinifolius
Centaurea schimperi

XVI

Achyranthes aspera
Loranthus curviflorus
Ephedra aphylla

XVII

Salvia aegyptiaca
Lavendula coronopifolia

XVIII

Ziziphus spina-christi
Coccinea grandis
Dichanthium insculptum
Pennisetum divisum
Salvadora persica
Jatropha spinosa

XIX

Acacia caupopilla
Commiphora myrrha
Sarcostemma viminale
Veronia cinarascens
Acacia ? nubica

XX

Euphorbia schimperi
Andrachne telephioides
Sagaretia spicifolia
Acacia laeta

XXI

Solanum albicaule group
Salsola spinescens
Euphorbia cuneata

continued

XXII

Aloe inermis
Acacia mellifera

XXIII

Berberis proxima
Berberis sp. nov.
Hibiscus somaliensis
Seddera secundiflora
Seddera latifolia

XXIV

Acacia nilotica ssp. kraussiana
Berberis perviflora

XXV

Pupalia lappacea
Commicarpus boissieri
Hyparrhenia hirta
Seddera arabica
Adenium obesum
Lantana pacitiana
Hibiscus micranthus
Psiadia punctulata
Enneapogon desvauxii

XXVI

Euphorbia inarticulata
Caralluma spec. 5

XXVII

Gaidia somaliensis

XXVIII

Portulaca quadrifida
Satureja biflora
Cyperus obtusifolius

XXIX

Acacia negrii
Dianthus uniflorus
Felicia abyssinica
Hypoestes paniculata

XXX

Enneapogon schisperianum
Andropogon sp. nov.

XXXI

Verononia spatulata
Kleinia odora
Grewia tembensis

XXXII

Aerva javanica
Chrysopogon plumulosus
Tetrapogon villosus

XXXIII

Aristida adscensionis
Farsetia longisiliqua
Stipagrostis obtusa
Heliotropium steudneri
Justicia odora
Indigofera spinosa
Commicarpus sinuatis
Blepharis ciliaris
Pagonia indica
Helichrysum somaliense
Cenchrus ciliaris
Otoscegia fruticosa
Eragrostis papposa
Lycium shawii

XXXIV

Leptochrium senegalense
Stipagrostis bifida
Polygala subaphylla
Tribulus longipetalus
Stipagrostis ciliata
Grass x
Retaropogon contortus
Aloe vaccilans
Kalanchoe crenata

XXXV

Heliotropium rariflorum
Salsola bottae
Polygala eriopteara
Ophiglossum polyphyllum

XXXVI

Fingerhuthia africana?
Teucrium yemense
Caralluma ? quadrangula
Ochradenus baccatus

XXXVII

Stolon grass
Tragus racemosus
Felicia dancata
Plantago spec.?
Bulbus monocotyl
Indigofera ? arabica
Asparagus africanus

Source: Westinga and Thalen. 1980?

Table 2. Vegetation Types in Rada' District
(cf. Figure 3.19)

AS1.

The Acacia caupoptila - Acacia nubica is characterized by having many types of trees Acacia caupoptila, Delonix elata and Commiphora myrrha are specific for this slope vegetation type. Acacia nubica and Acacia mellifera is not only found here, but also is another slope type AS2, which is also the case for the shrub Sarcostemma viminale and the dwarfshrub Vernonia cinerascens, who both may occur also in S1. The plants of group XXI and Seddera secundiflora are found also in AS1 and AS2, but may occur in some other types (see Appendix D). Anastatica hierechuntica is only found here. Salvadora persica and Jatropha spinosa are only found in this slope type and in the waditype W1, which occurs in the same area as AS1. These types occur only at low altitude North of the district.

AS2.

The Acacia mellifera - Aloe inermis type is characterized by these two species. Acacia mellifera occurs only in this slope type and the wadi type of lower altitudes. Acacia laeta, which very much resembles Acacia mellifera occurs mainly in this type. Aloe inermis is found sometimes on other slope types. Acacia nubica and Acacia nilotica spp. kraussiana are found in this type only in the transitional zones to AS1 and AS3 respectively. Group XXI is mainly occuring in this type and in AS1. Group XXIII mainly belongs to AS2 (two Barleria species, two Seddera species and one Hibiscus species).

AS3.

The Acacia nilotica spp. kraussiana Barleria parviflora type is actually a dwarfshrub type with shrubs and without trees. The Acacia nilotica ssp. kraussiana is the main shrub, next to Euphorbia cuneata. Typical for this type is that three Barleria species occur here, Barleria parviflora in particular.

AS4.

The Hypoestes paniculata - Acacia negrii type occurs only at high altitude above 2300 m. The slopes have a soft greenish appearance of the dominantly Hypoestes paniculata and Gnidia somaliensis. Acacia negrii is found here bordering agricultural fields and not scattered on the slopes as the Acacia trees in AS1 and AS2 and Acacia shrubs in AS3; therefore it was counted with the groups without scattered trees. Some specific plants for this slope type are Dianthus uniflorus, Pulicaria cf. petiolaris, Minnarthia fulifolia, Alkanna orientalis, Salvia merjamie, Antithrixia abyssinica. Loranthus regularis is found here in Acacia pachyceras trees. Many wadi elements of lower altitudinal wadis from group XIII, XIV and XV are found here on the slopes.

S1.

The Lantana petitiana - Hyparrhenia hirta is a dwarf shrubland type with scattered shrubs like Adenium obesum, Ochradenus baccatus, Euriops pinifolius, Lycium shawei, some Acacia pachyceras and Aloe inermis. The characteristic group for this type is group XV, with Commicarpus boissieri, Hibiscus micranthus, Lantana petitiana and Hyparrhenia hirta.

S2.

The Euphorbia inarticulata - Caralluna spec. b type is a dwarf-shrub vegetation with the mentioned characteristic shrubs. This type occurs only at lower parts of the southwest plateau slope.

S3.

The Chrysopogon plumulosus - Blepharis ciliaris 'rich' type.

S4.

The Chrysopogon plumulosus - Blepharis ciliaris 'poor' type.

S3 and S4 types are very poor and almost bare dwarf shrub lands. Both types are mainly build up by the general groups XXXII and XXXIII, while in S3 wadi elements from group XV occur. The S4 type is predominantly on the lava plateaus, virtually bare vulcanic hammada hills and the sandstone plateau. On the more favourable places along gullies, in lava flows and at higher altitudinal parts on the basalt plateau the S3 type is predominant.

W1.

The Acacia pachyceras - Solanum incanum + Salvadora persica type is characterized by group XVIII; Salvadora persica and Jatropha spinosa occur also in the slope type AS1; Ziziphus spina-christi, Coccinea grandis and Dichantium insculptum occur also in W3; Pennisetum divisum is only found here. Acacia mellifera, typical for AS2, is sometimes found here. This wadi type occurs only in the northern lower part of the district, together with the slope type AS1.

W2.

The Acacia pachyceras - Solanum incanum + Ephedra aphylla type is characterized by the sociological groups XVI and XVII. Group XVI is the more specific one of these two for this vegetation type; with Achyranthes apsera and the two epiphytic plants Loranthus curviflorus and Ephedra aphylla. Salvia aegyptiaca and Lavendula coronopifolia from group XVII are more common wadi species and occur also in high altitudinal slope types: S3, S2 and AS4. This vegetation type is common in the eastern gneiss and granite hills and mountains.

W3.

The Acacia pachyceras - Solanum incanum + Solanum sepicola type is common in the whole area except for the northern part. Characteristic for this type is group XV, which occur also in high altitudinal slope types like S2, S3 and AS4 and some species occasionally in the saline flat type SP3. Ziziphus spina-christi is found in this type and in W1.

W4.

The Acacia pachyceras - Solanum incanum + Withania sommifera type occurs only in the hammada basalt hills and mountains. It is characterized by Withania sommifera, Solanum schimperianum, Lavendula pubescens and Meriandra benghalensis (group XIV), which group also occur in the highest attitudinal slope type AS4.

TAM1.

The Tamarix nilotica - Schanginia hortensis type is a bush forest type, with Tamarix nilotica trees and shrubs and Schanginia hortensis shrubs on hummocky plains of Cynodon dactylon. This type is only found in the eastern hills and mountains, especially on the extensive saline plains in between the eastern steep mountain ridges.

TAM2.

The Tamarix nilotica - Pluchea dioscoriodes type is found in eastern hills and mountains and in the sandstone valleys. It is characterized by Tamarix nilotica, Sporobolus consimilis, Saccarum spontaneum, Pluchea dioscoriodes (group XI and XIX). Calotropis procera and Solanum incanum the typical wadi elements are found here also. The more halophytic grass Sporobolus spicatus is found here, as well as the common grass for wadis and plains, Cynodon dactylon.

V1.

The Salsola spinescens - Euphorbia cuneata type is a dwarf shrubland of dominant Salsola spinescens with small scattered shrubs of Euphorbia cuneata or Lycium shawei. This type occurs in the eastern and northern valleyflats.

V2.

Acacia pachyceras - Acacia nilotica ssp. kraussiana type is occuring only on the eastern valleyflats. This type is a dwarfshrubland of Aerva javanica and Heliotropium steudneri dwarfshrubs

with Acacia pachyceras and Acacia nilotica ssp. kraussiana trees and shrubs and with the common shrub Lycium shawei and grass Cynodon dactylon.

SP1.

The Aeluropus lagopoides - Atriplex leucoclada type occurs on the very salt, silty clay loam places. It is a very poor dwarfshrubland of Atriplex leucoclada and Schanginia hortensis with Aeluropus lagopoides. Schanginia hortensis can form at certain places some dominant hummocks.

SP2.

The Juncus heldreichianus - Dichanthium annulatum type has much in common with SP1 and SP3 but differs from both by the dominancy of the rush Juncus heldreichianus. Many species, especially all the salt species (group V, VI, VII, VIII, X, XI) are found here in between the rushes. Acacia pachyceras shrubs are found frequently. This type occurs on the medium salt, silty loam places.

SP3.

The Sporobolus ioclados - Centaurea pallescens typo is the most common of the three saltflat types. It has group VIII and X in common with SP2. The fallowland species occur also in these two types of group IX and Acacia pachyceras shrubs. Sporobolus ioclados and Sporobolus spicatus form the characteristic hummocks of these salt plains.

Peganum harmale and Schanginia hortensis, more typical for SP1 and SP2 have an erratic occurrence in this type. Dichanthium annulatum and Phoenix dactylifera more specific for SP2, occassionally occur in SP3. The main difference with SP3 is the lacking of the highly dominant rush in SP3 Juncus heldreichianus.

SP3 occur on the slightly salt places of the saltplains and valleyflats.

FAL

The Xanthium spinosum - Laggeria garieppina type occurs on the fallow agricultural fields. The characteristic species are from group IX, which occur also in the saltflat type SP2 and SP3 and occasionally in between the sorghum on the agricultural fields.

Peganum harmale and Centaurea pallescens, which are typical for the saltflat occur here as well, which is also the case for Pulicaria crispa and Cynodon dactylon, which occur also in the waditypes. Also here rare Acacia pachyceras shrub can be found.

AGR

The Convolvulus arvensis - Erucastrum arabicum type is found on the agricultural fields as weeds in between the Sorgum vulgare and Catha eduiis Qat. Most dominant is the Convolvulus arvensis with sometimes Cynodon dactylon and Malva verticillata/parviflora on the irrigated fields. Group IV belongs specific to this vegetation type. Some other weeds, which were only found one time, are: Calendula aegyptiaca, Solanum nigrum var. minutum, Euphorbia peplus, Lycopsis orientalis, Reichardia tingitana.

DW

The Apium nodiflorum - Agrostis semiverticellata type is growing along the irrigation channels. Group I is characteristic for this type.

Group II grows on the drainage ways and in the wetter marshy parts (MP) of the plains close to these drainage ways.

The next plants occur only in this type (and are not mentioned in group I because they were found only once): Juncus rigidus, Chara spec, Imperata cylindrica, Sonchus oleraceus, Plantago major, Verbena officinalis, Equisetum ramossisimum.

MP

The Paspalum vaginatum - Juncus oxycarpus type grows on the marshy places, close to drainage ways and wells. The grass Paspalum vaginatum is the dominant species, with on very wet parts: Typha domingensis, Eleocharis palustris and Cyperus laevigatus. Group II occurs here as in DW. The next species were found only once and only in this type: Plantago lanceolata, Fimbristylis feruginea, Taraxacum spec., Cichorium bottae and Juncus oxcycarpus.

Source: Westinga and Thalen, 1980?

APPENDIX VII

Development Projects

Table 1. Partial List of U.S. AID Projects in the Yemen Arab Republic

Table 2. Water Resources Projects

Table 3. Organizations involved in Aspects of Hydrology in the YAR

Table 1. Partial List of AID Projects in the Yemen Arab Republic

Title	Project No.	Begun	Final
Ta'izz Water Rehabilitation	2790017	73	75
Yemen Sorghum Production	2790018	73	78
Poultry Development	2790019	75	80
Training for YAR Development	2790020	73	78
Sana'a Emergency Water Supply	2790021	73	78
Rural Water Supply	2790022	73	77
Tropical Fruit Improvement	2790024	76	81
Water and Mineral Survey of North Yemen	2790025	74	79
Yemen-Taiz Water and Sewerage Design	2790027	75	79
Sorghum and Millet Crop Improvement	2790030	76	80
Al-Olofy Hospital-Yemen	2790034	76	79
Applied Health Nutrition-CRS	2790035	76	79
Ta'izz Water/Sewerage Construction	2790039	77	82
Development Training II	2790040	78	86
Water Resource Planning Management	2790043	79	84
Agricultural Development Support	2790052	79	80

Source: U.S. AID. 1980a.

Table 2. Water Resources Projects

A. (Experimental wells for measuring the amount and depth of groundwater level in the following regions)

Midlands	10 wells
Al Baida	10 wells
Rida	5 wells
Khawlan	10 wells
Al Ganad	5 wells
Marib	10 wells
Al-Turba	5 wells
Mawza'a	5 wells
Surdud	10 wells
Al-Jawf	10 wells
Saada	10 wells
Rest of Tihama	10 wells

Estimated Cost (one YR equals about $0.22 in the U.S.) YR (Yemen Riyals) 6,000,000,000.00.

B. Dams

a. Small Dams-construction of 300 dams for the exploitation of wasted rain water. 100 dams in the first 5-year plan. Estimated Cost YR 150,000,000.00.

b. Large Dams-three sites have been chosen for the construction of large dams. One of these sites is Marib, where there is a probability of re-constructing the ancient Marib Dam. Estimated Cost YR 105,000,000.00.

C. Irrigation

a. Water Storage Projects
   (1) Wadi Mawr
   (2) Wadi Rima'a

b. The Development of the Eastern Wadis
   (1) Wadi Al Kharid (est YR 101,000,000.00)
   (2) Wadi Jawf (est YR 1,500,000.00)
   (3) Wadi Abied (est YR 50,000,000.00)
   (4) Wadi Harib (est YR 30,000,000.00)
   (5) Wadi Bana (est YR 100,000,000.00)
   (6) Wadi La'ab (est YR 30,000,000.00)

c. Development of the Tihama
   (1) Wadi Zabid (est YR 149,500,000.00)
   (2) Wadi Mawr (est YR 250,000,000.00)
   (3) Wadi Rima (est YR 175,000,000.00)
   (4) Wadi Siham (est YR 200,000,000.00)
   (5) Wadi Surdud (est YR 190,000,000.00)
   (6) Wadi Rasyan (est YR 350,000,000.00)

Source: U.S. AID. 1977.

Table 3. Organizations Involved in Aspects of Hydrology in the YAR

Berger/Kampsax, U.S. and Danish Consultants
Urban planning for Sana'a, Hodeida, Ta'izz, Dhamar and Ibb

British Ministry of Overseas Development
Montaine Plain and Wadi Rima

Electrowatt-Swiss Consultants
Marib Water Projects

Food and Agricultural Organization (UN)
Uplands, Midlands and Lowlands Agricultural Projects

Gibb (Sir Alexander Gibb and Partners) British Consultants
Wadis Bana, Rasyan, Kharid and Jawf

Halcrow (Sir William Halcrow & Partners) British Consultants
Wadi Surdud

Hazed-Sawyer, U.S. Consultants
Ta'izz Water and Sewer Systems

Ilaco-Netherlands Consultants
Wadis Rima, Banya

Italconsult-Italy Consultants
Sana'a and Hodeida Water and Sewerage Systems

Kochs (F.H. Kochs KG) West German Consultants
Hodeida Water and Sewerage Systems

Montgomery (James M. Montgomery, Inc.) U.S. Consultants
Ta'izz Water and Sewerage Systems

Peoples Republic of China
Some wells along road North and West of Sana'a

Saudi Arabia
Rural Well-Drilling Projects-36 Wells

Tesec-Viziterv-Vituki, Hungarian Consultants
Wadis Mawr and Zabid

Tihama Development Authority
Wadis Mawr and Zabid

Tipton & Kalmbach, U.S. Consultants
Wadis Mawr and Zabid

U.S. AID
Sana'a, Ta'izz and Yemen Rural Areas

U.S.S.R.
Wadi Surdud, Al Kadan State Farm

West Germany
German Farm, Sana'a

World Health Organization (UN)
Scattered climatic data

World Meteorlogical Organization (UN)
Meteorological Data-Sana'a, Ta'izz, Hodeida, Mocha, Al Baida

APPENDIX VIII

Organizations

A. Governmental and Planning Structure

Table 1. Governmental Structure

Table 2. Planning Machinery

Table 3. Functions of the Central Planning Organization

Table 4. Current Ministers (Dec. 1979)

B. Other Organizations

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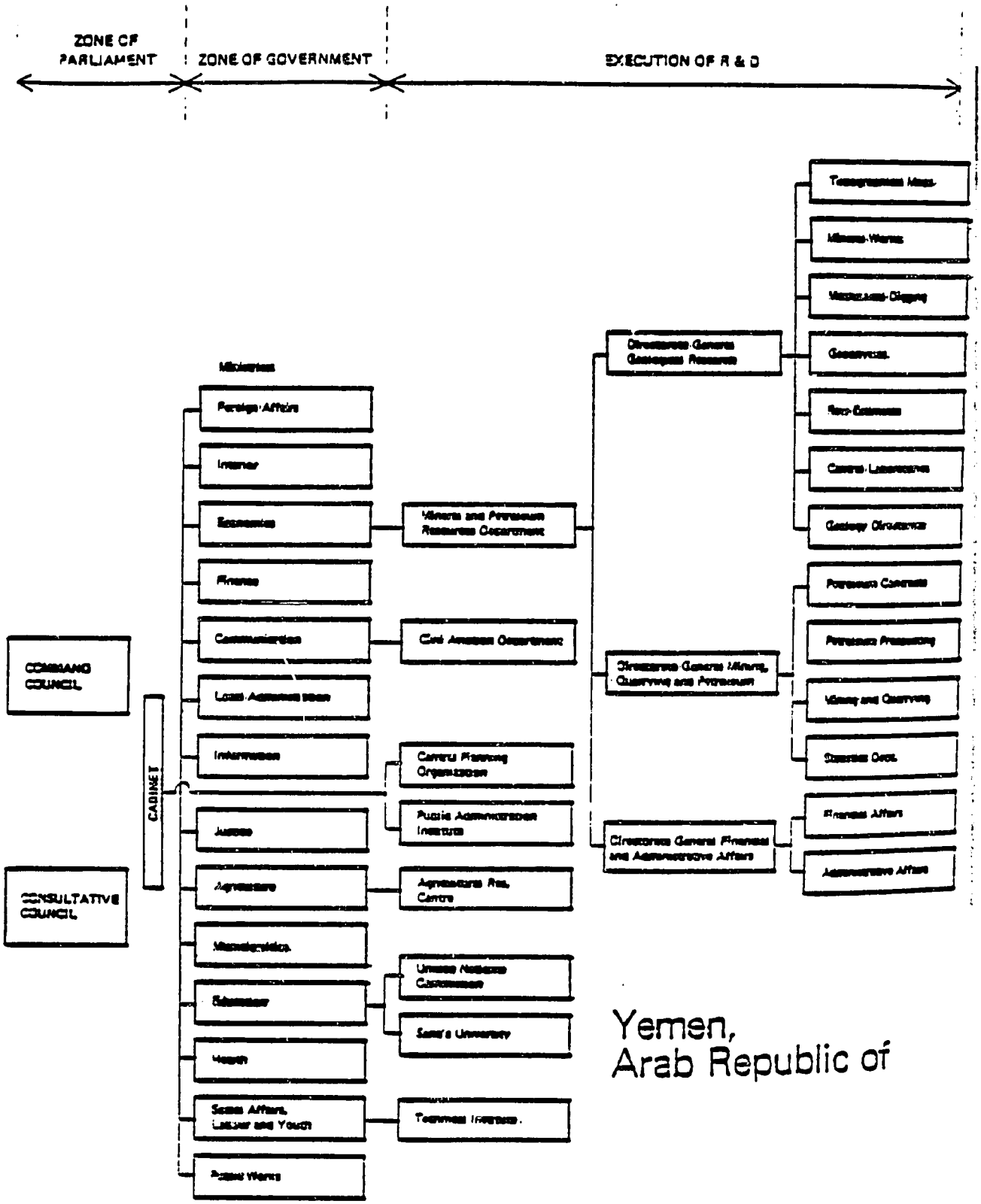
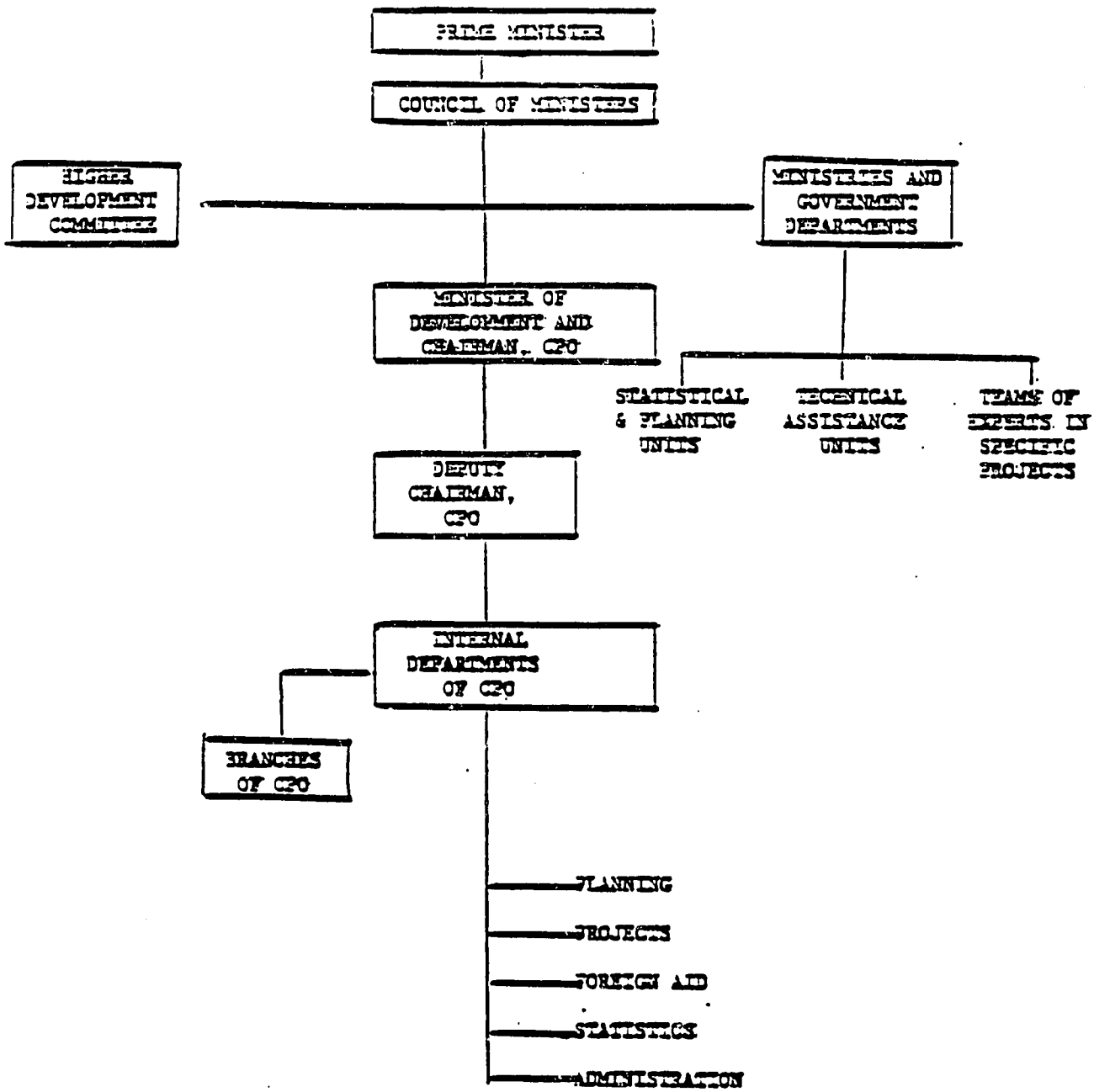
Table 1. Governmental Structure



Source: UNESCO. 1976.

Table 2. Planning Machinery in the YAR



* The CPO has two regional branches in the governorates.

Source: World Bank. 1979.

Table 3: Functions Prescribed by the CPO for Its 5 Departments

Planning Department

Conduct economic studies for the preparation of the development plans.

Prepare plans to achieve the general goals of economic and social development, having regard to the available resources and potentialities of the country.

Prepare economic and social policies and procedures which will help to develop the country and contribute to the achievement of the plans.

Projects Department

Study projects submitted by ministries, departments and public corporations, and determine project priorities in terms of the general plan.

Follow up on project implementation, according to agreed timetables. Prepare reports on projects and their stage of implementation.

Determine the reasons for good project execution, or for shortfalls, and propose procedures for improved implementation.

Foreign Aid Department

Supervise the contracting of foreign loans and technical aid, and direct the utilization of loans according to the development plan. Formulate the necesssary procedures for the proper utilization of loans, and provide for their repayment.

Coordinate, according to the provisions of the development plan, the applications for technical assistance submitted by the ministries, departments and public corporations.

Statistics Department

Conduct the census, partial and comprehensive surveys. Collect statistical data, analyze and publish them. This department is the formal source of all statistical data in the country.

Assist the ministries and government bodies in establishing their own statistical and planning units.

Coordinate the work of these statistical and planning units, so as to facilitate the supply of data for planning by the CPO.

Administration & Public Finance Department

Organize the internal regulations, finance and accounting procedures of the CPO. Prepare the CPO's yearly budget.

Preserve the CPO records and documentation.

Undertake the personnel functions for CPO staff.

Source: The World Bank. 1979.

Table 4. Current Ministers of the Yemen Arab Republic (October 1980)

Head of state President Ali Abdullah Saleh
First Vice-President Abdel-Karim al-Arashi
Second Vice-President Abdel-Aziz Abdel-Ghani

Cabinet Formed on 15 October 1980

Prime Minister Abdel-Karim al-Iriani
Deputy Premier for Economic Affairs Hasan Makki
Deputy Premier for Internal Affairs Mujahid Abu-Shawarib
Foreign Affairs Ali Lutf al-Thour
Finance Mohammad al-Aadhi
Awqaf (Religious Endowments) Ali Bin-Ali al-Saman
Health Mohammed Ahmad al-Kabab
Education Ahmad Abdel-Malik al-Asbahi
Agriculture Ahmad al-Hamdani
Transport & Communications Ahmad Mohammad al-Aanasi
Information & Culture Hasan al-Lawzi
Public Works Abdullah al-Kurushmi
Justice Mohsin al-Ulifi
Interior Ali Othrob
Development Fuad Raid al-Aghbari
Economy Mohammad Hizam al-Shohati
Social Affairs, Labour & Youth Ahmad Saleh al-Ruani
Civil Service & Administrative Reform Ismail al-Wazir
Local Government Lutf al-Kalabi
Supply & Trade Abdel-Khaleq al-Jalal
Power, Water & Sewerage Mohammad al-Junaid
Energy & Mineral Resources Ahmad Ali al-Bahr

Minister of State Hussain Ali al-Hubaishi
People's Assembly Ahmad al-Shigni

Source: Meed. 1981.

B. Other Organizations

British Council: P.O.B. 2257, Siman Abu Luhum Building, Sana'a; f. 1974; library of 5,247 vols., 40 periodicals; Rep. R. W. H. CHARLTON; Regional Librarian (vacant) (based in Sudan).

Library of the Great Mosque of Sana'a: Sana'a; f. 1925; the collection of 10,000 MSS. and printed vols. is not at present accessible to the public; Librarian ZAID BIN ALI ENAN.

SANA'A UNIVERSITY

P.O.B. 1247, SANA'A

Telephone: 3443.

Founded 1970.

State control; financial support from Kuwait; Languages of instruction: Arabic and English; Academic year: October to June.

President: Dr. ABDUL KARIM EL-ERYANI.

Vice-President: Dr. MOHAMED MOTAHER.

Secretary-General: SALEM M. AL-SAQQAF.

Librarian: FATHI AL-SHAFEI.

Number of teachers: 59.

Number of students: 3,139.

Publications: *University News* (monthly, Arabic), *Research Journal of the Department of English.*

DEANS:

Faculty of Arts: Dr. M. MANDOUR.

Faculty of Law and Sharia: Dr. H. AL-MARSAFAWI.

Faculty of Commerce and Economics: Dr. SAMIA AN BUTROSS.

Faculty of Science: Dr. A. MUHSIN AL-ABBADY.

Faculty of Education: Dr. M. ABDO GHANEM.

Kulliat Asshari'a Wa Algaanun (*Faculty of Islamic Law*): Sana'a; f. 1970.

There are also six vocational schools, a Military Academy, a College of Aviation, a College for Radio Telecommunications and an Agricultural School.

Source: Europa Publications Ltd. 1979.

APPENDIX IX

Selected Bibliography

1. General (including bibliographies, maps)
2. Climate
3. Geology, Minerals, Soils
4. Flora and Fauna
5. Water Resources and Management
6. Land Use and Agriculture
7. Public Health and Nutrition
8. Social Aspects
9. Development

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Report No. 1, Project Paper
Amendment One, Agricultural Development Support: Ibb/ATC
Individual Team Member Reports:

Section B, R. Saad, Soil Scientist
Section C, J. Thomas, Report of the Agronomist/Seed Specialist
Section E, D.G. Heckerman, Report on the Design Team Leader; Report on Design Team Procedures; Assumptions Underlying the On-farm Management Activity and Suggestions for Monitoring the Activity
Section F, W.F. Farnsworth, Extension Project Ideas
Section G, K.C. Nobe, Observation, Recommendation, and Outputs and Conclusions of Design Team Agricultural Economist
Section H, N.Kholdi, Report on Status of Ibb Agricultural Training Center
Section I, H.R. Matteson, Review of Activities and Recommendations IBB/ATC
Section J, J.R. Kerns, Design Team Social Scientist
Section K, E.P. Foerester, Trip Report to Tihama and Taiz by Design Team Water Management Specialist
Section M, K.D. Duft, Yemeni LDA's and Agricultural Cooperatives, Their Composition and Characteristics
Section N, C.Adams, Editor's Note

Appendices:

Appendix A, J.R. Kearns, Social Soundness Analysis for the CID Title XII Program, YAR
Appendix C, CID Design Team, Basline Field Study Report
Appendix E, J.R. Kearns, Proposed Satellite Activity, Women in Development--Home Economics Learning Program

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