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TYPES, DISTRIBUTION, AND SIGNIFICANCE OF AGRICULTURAL TERRACES IN ASSARAH, SOUTH-WESTERN SAUDI ARABIA

BY

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ABSTRACT

TYPES, DISTRIBUTION, AND SIGNIFICANCE OF AGRICULTURAL TERRACES IN ASSARAH, SOUTH-WESTERN SAUDI ARABIA

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Salih Ali Al-Shomrany

An attempt has been made to classify agricultural terraces of Bashut, Assarah, Southwestern Saudi Arabia, by the criteria of morphology and function. In the absence of a classification and distribution of these terraces, a large-scale survey of the terrace slopes and the mapping of land use on aerial photographs was subjected to statistical analyses for individual structural terrace components as rainfall, slope, soil characteristics, crop types, size, lip, width and wall.

Farmers of the study area were administered a questionnaire to determine patterns of land use and the crop emphasis. Some information was also derived from official records. Background information on the physical and socio-economic aspects of the Bashut area provided in the first part of the thesis clearly suggests that there is a distinct

relationship between the distribution and types of terraces and the natural landscape, between their quality and successful farming, and between the abandonment of terraces and the lack of manpower.

Unfortunately, since the only type of good farming technique in the area is based on slope terraces, the current lack of up-keep of the terraces will lead to growing deterioration of intensive agriculture in Bashut in particular and in Assarah in general.

To the memory of

my uncle

Ali Saad Al-Shamrany

ACKNOWLEDGMENTS

The completion of this study was only possible with the kind cooperation and assistance of many individuals. I am especially grateful to my advisor and committee chairman, Dr. Dieter Brunnschweiler, without whose help this manuscript would not have been possible--his direction, guidance, and valuable comments gave me the knowledge and the will to undertake a study in physical geography and agricultural landscape; committee members Dr. Ian Matley and Dr. Michael Chubb, for their helpful suggestions; to Dr. Stanley Brunn and Dr. Harold Winters who devoted several hours explaining to me how to conduct the field work; Dr. Ali Mughram, King Abdulaziz University, Jeddah, Saudi Arabia, for his help, explanations, and dissertation about the Assarah Region; my father Ali, brothers Hassan and Abdullah, uncle Abdulrahman and my nephews Ali, Mohammad and Sād who conducted me into the field, without them all the field work would have been impossible; king Abdulaziz University, for its financial support for this study; and finally, to Peter Krafft and Cymbria Thompson for their aid with the study's illustrations.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd.)

TABLE OF CONTENTS (cont'd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (cont'd.)

LIST OF PLATES

LIST OF PLATES (cont'd.)

CHAPTER I

INTRODUCTION

Human beings have tried since early times to modify or use the physical environment for their own benefit. One example is the utilization of steep land for cultivation by constructing terraces. Agricultural terraces are distributed throughout the world, especially in mountainous regions, and have attracted the attention of many researchers.

The Assarah highland in southwestern Saudi Arabia is an area of high concentration of man-made terraces. These phenomena provide the basis for agricultural development by reducing soil erosion, conserving water, and segmenting slopes into a series of flat surfaces suitable for crop cultivation.

Statement of the Problem

The spatial distribution of agricultural terraces in the Assarah highland and the factors affecting this distribution are a very interesting but complex problem from the geographical standpoint. There has been no comprehensive study concerning these terraces either in terms of their origin, their spatial distribution, or their economic significance to the area. The intent of this study, therefore, is to analyze the terrace complex of the Assarah region, with emphasis on:

(1) terrace types, especially their morphology and functions;

(2) the impact of physical factors upon the distribution and types of terraces;

(3) the land use characteristics which have evolved over time; and

(4) the significance of this specialized character of agriculture to the economy of the people of the Assarah region.

The Selection of the Study Area

The study area is located in the central portion of southwestern Saudi Arabia. Physiographically, Assarah forms a narrow highland, 10-40 Km wide, and 600 Km long, with a north-south orientation and elevations ranging from 1700 to 3000 m. It extends from the borders of Yemen in the south to Al-Hada and Taif City in the north. The Assarah highland is bounded by an escarpment in the west and a plateau region to the east. This narrow belt is the natural divide between the interior and the Red Sea drainage in the southwest region (Fig. 1).

The Assarah region can be divided into two distinct sections. The northern part, from Wadi Fieg between Baljorashy and Al-Bahah northward to Taif and Al-Hada, is characterized by sharp peaks and V-shaped valleys. The dominant rock in this area is schist. The southern section extends from Wadi Fieg southward to the Yemen border; it is characterized by flat summits of granite bedrock, overlaid with thick layers of weathered sandstone (Plate 1a and b).

The Assarah region is climatically influenced by different air masses that produce its seasonal weather patterns and these in turn are affected by variations in topography. During the winter season, the region comes under the influence of cold air masses flowing southeast from the Mediterranean Sea; cyclonic depressions are frequently associated with these air masses. These air masses, when

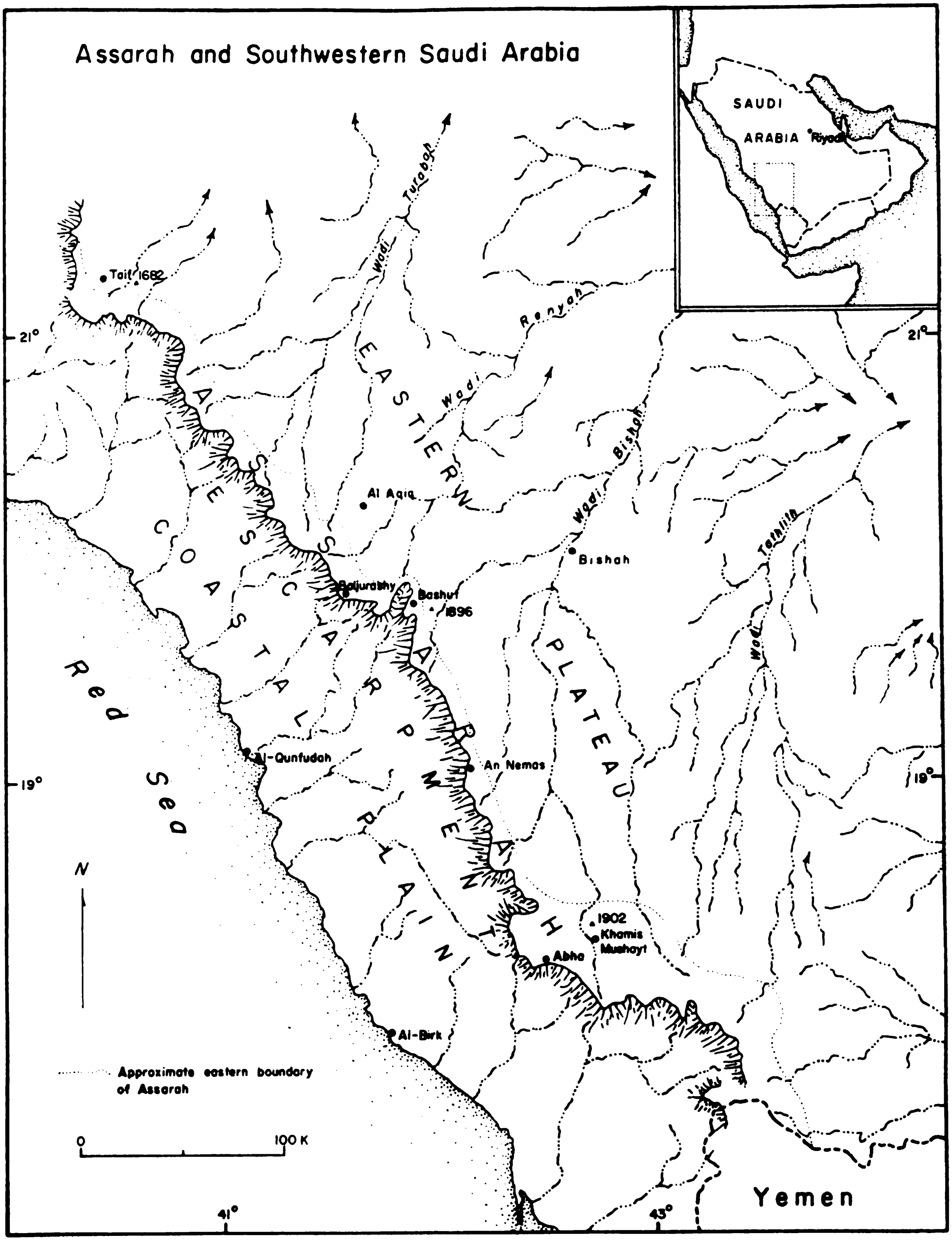
Assarah and Southwestern Saudi Arabia
SAUDI
ARABIA
Riyadh
Taif
1682
21°
Wadi
Turabah
Wadi
Renyah
Wadi
Bishah
EASTERN
ESCARPMENT
ESCARPMENT
COASTAL PLAIN
PLATEAU
Al Aqiq
Bishah
Baljurashy
Bashut
1896
Red Sea
Al-Qunfudah
An Nemas
19°
Wadi
Tathlith
N
1902
Khamis Mushayt
Abha
Al-Birk
Approximate eastern boundary of Assarah
0
100 K
41°
43°
Yemen

Fig. 1

Plate 1a General view of the Assarah Highland; northern part, Wadi and villages Beni Kabir in the area of Ghamd.

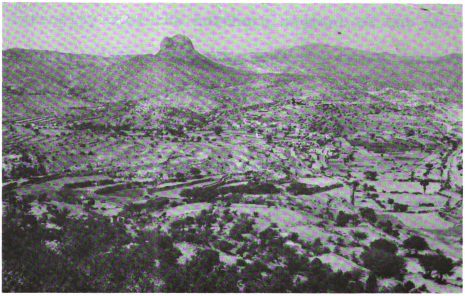

Plate 1b Southern part of Assarah, in the area of Beni Omro. Village in middle ground in Al-Matla.

combined with the localized effects of the Red Sea and the high escarpment, give rise to orographic rainfall along the western part of the study area. During the spring months (March through May), there is a strengthening of the monsoon-type flow, which gives rise to a widespread rainfall over the greater part of the Assarah region. During the summer season, June through August, the region is dominated by southerly monsoon winds which produced thunderstorms in the Assarah region as far north as Taif. During the late autumn months (October and November), the Inter-Tropical Front retreats and westerly air masses from the Mediterranean become more frequent, again coupled with widespread rain of medium to high intensity over the northern segment of the Assarah region (Kingdom of Saudi Arabia, Ministry of Agriculture and Water, Final Report (2), 1969, 29-41).

Bashut, an area comprising ten villages, was selected as a representative area of the Assarah region for this study for several reasons. The investigator's personal knowledge of and the familiarity with the representative area of study, its peasants and their customs was the most important reason for the selection of Bashut as a representative area to study the problems of agricultural terraces in the Assarah region. Bashut has extensive agricultural terraces. Some of them are under cultivation, while others are abandoned. For the majority of the local peasants, they represent an absolute necessity for the pursuit of successful farming activities.

The Bashut district is located almost in the central portion of the Assarah region, between three main urban centers, namely Taif in the north and Abha-Khamis in the south and Bishah in the east (Fig. 1). Bashut, our representative area of study, is still predominantly a rural agricultural land. Crossed by latitude $19^{o}35'N$ (Fig. 5), it represents climatically a transitional area between the northern part of Assarah and the southern half. Altitudinally, Bashut is between 2000 m and 2400 m above sea level; this is an intermediate elevation within Assarah itself, that is, between the lowest elevation of 1800 m in the region and its high elevation of 3000 m. Topographically, the Bashut district consists of basin-like flatland in the west and a rugged terrain in the east (Fig. 5); these two topographic features are the most conspicuous characteristics of the physiography of the Assarah highland. The ruggedness of Bashut has led to the shortage of cultivable flat land; and terracing has been resorted to as a solution to compensate for the lack of good arable land.

Method of Study

Field work for this study was conducted in the Assarah region during the summer and fall of 1978. Collecting basic reference materials from government agencies was the first step in this study. Small scale maps, aerial photographs, and some general reports were obtained from the Ministry of Petroleum and Mineral Resources and of Agriculture.[1]

In the absence of pertinent scientific documents in the initial stages, the researcher has depended heavily on his own observation and field measurements. A reconnaissance trip from north to south through the entire Assarah region was made. Interviews with the peasants through the region were conducted, and the types of terraces, the land use patterns and the methods of cultivation were investigated.

In Bashut, the representative area, there were 30 major sites of agricultural terraces. Those sites were

---

[1]Contour maps of any kind are non-existent, and the aerial photographs were not available during the field work, as it took the bureaucracy of the Ministry of Petroleum and Mineral Resources six months to release the photographs. Two trips to Jeddah and Riyadh were necessary. The aerial photographs were finally available as the completion of the field work was nearing the end, making the cross-checking of them in the field work possible within two weeks.

determined by the size of the villages and by the level of productivity of the terraces. All the terraces (a total of 578) in these sites were measured and studied intensively (Table 11). Soil profiles of the majority of terraces and natural arable lands were prepared. 110 soil samples, mainly from the 30 major sites of Bashut, were collected during field work. Soil color and structure were the criteria for the distinguishing features between soil horizons. The nature of the materials used in the construction of walls was investigated, and 40 rock samples were collected from the terrace walls.

Two hundred and seventy-eight interviews were conducted with the farmers in the villages in the Bashut district (Appendix b). It was felt that the clustering type of sampling was more practical to determine the location of the interviewees. This is due to the absence of numbered streets and houses and the difficulty of having a sampling frame which includes the total population of the Bashut area. The main mosques in each village were chosen to be the focal point for the cluster. Among the advantages of choosing the mosques as observation points are: (1) easier accessibility to and the availability of personnel, (2) obtaining the advantages of better supervision and control, and (3) at mosques the different socio-economic strata of the farming population of a village are best represented.

The base map of the Bashut district was developed from aerial photographs and field data. The data were analyzed with the assistance of Michigan State University's CDC 6500 computer, and the soil and rock samples were analyzed and examined at Michigan State University's Soil Science and Geology Laboratories.

Organization of the Study

This thesis is divided into seven chapters. After having briefly outlined the objectives and field mechanics in this chapter, chapter II discusses the importance of agricultural terracing per se, reviews the related literature, and introduces origin, and objectives. Significant features of the physical environment are described in chapter III. An attempt has been made to show the relationship of soil, topography and climate with the spatial distribution and existence of agricultural terraces in the Assarah region. The emphasis in chapter IV shifts to the human environment in the Bashut district, the representative area selected for this study. Emphasis is on the major linkages of interaction between physical and human factors. Population and settlement characteristics are also explained in this chapter. Chapter V is concerned with land use patterns, their spatial distribution, and contemporaneous problems of socio-economic nature. Chapter VI classifies terraces with regard to their morphology and functions, and human organizational aspects of agricultural terracing in Bashut. The last chapter is devoted to the conclusions reached in this study and to possible future avenues of geographic research in Assarah.

CHAPTER II

A REVIEW OF TERRACING AS AN AGRICULTURE ENTERPRISE

General Aspect

Geographers have investigated various aspects of artificial terraces. Some have viewed terraces as the influence of the natural landscape upon man, others as the imprint of humans on the surface of the earth.

Spencer and Hale (1961) viewed agricultural terracing as a cultural phenomenon, man's permanent imprint on the surface of the earth. They did not accept the influence of the natural landscape over man, when they said that "the spatial distribution of agricultural terracing does not agree at all with the distribution of agriculture in the rough lands of the earth, so that it is a matter of culture rather than one of environmental influence." Spencer and Hale defined the terrace as a break in slope, either natural or man-made. In other words, they stated that "the agricultural terrace may be conceived as any artificially flattened surface on which crops are grown subsequent to the flattening, no matter how small, how crude, or how purposeful." Spencer and Hale developed a new system of terrace classification based upon morphology and function, and further identified ten different specific kinds of terraces that are widely distributed on the surface of the earth, especially in the Middle East, India, China, the Pacific Islands, the Mediterranean countries and in the Andes.

Field (1966) and Hale (1966) described and classified man-made terraces in Western Darfur, the Sudan, and Southern Andes. They applied the Spencer and Hale classification, functionally satisfactory concluding that the classification was indeed appropriate. Hale concluded that "contemporary terrace practices and uses are no longer operative manifestations of viable terrace agriculture, but instead are cultural relics of earlier general conditions now undergoing atrophy." These two studies provide a precedent for the study of terraces in the Assarah region.

Andress (1970), Lewis (1953), Maher (1973) and Wright (1963) contain descriptions of agricultural terraces in the mountains of Lebanon, the Himalayas, Northern Chile and other places of the world. These works explain the nature, construction, maintenance, and economic characteristics of agricultural terraces. Andress classifies Himalayan terraces in India into (1) irrigable terraces and (2) rain-fed terraces. Lewis states that there were several types of terraces, with no fundamental differences between them. He suggested three types of terracing: (1) terracing of moderate slopes, (2) terracing of steep slopes, and (3) terracing with buried retaining walls. At the same time, he concluded that terracing is an absolute necessity on the seaward side of the mountains of Lebanon, where slopes are steep and rainfall heavy. Maher indicates that the maintenance of terraces in areas where there are no stones is a problem to which there appears to be no solution. He also mentioned that the continuance of stone walling, where it is carried out, still requires much cheap labor force (Ibid., p. 204-205). Wright studied agriculture in northern Chile and concluded that the majority of agricultural terraces in that region are abandoned. He writes that, "The art of terrace building seems to have died out completely in the region. No recently constructed terrace systems were seen and, at best, ancient terraces are kept in use by simply repairing the retaining walls (Ibid., p. 71)." Wright found that about 80 percent of the ancient terrace gardens are abandoned, and those that are still in production do little more than grow subsistence crops for their owners. He suggests that the reasons for the abandonment of terraces in some areas were: (1) the spring and streams formerly nourishing them have dried up commersurate with the general drying out of the landscape, and that (2) in recent years the drift of the younger generation to the urban centers has accelerated. If this exodus continues, Wright asserts, almost all the major terrace gardens in northern Chile are likely to be abandoned within the next two generations.

ASAE (1972), Beasley (1957), Broberg (1965), Jacobson (1951), Jacobson (1965), Livingston (1967), McAlister (1960), McKinzie (1966) and Philips (1965) present description of terrace construction from an engineering point of view [especially for controlling] erosion in the U.S.A. They have suggested the introduction of parallel and contour terraces in areas of undulating topography. At the same time they classify terraces according to their alignment, cross-section, grade and outlet. The feasibility of the use of agricultural machinery has come to determine the size of the terrace.

Literature Relating Specifically to Assarah

A review of literature related to terrace agriculture in the Assarah region immediately reveals the scarcity of such material. In fact, no work has been written on that specific topic in either Arabic or English. The closest thing to the study of agricultural terracing in the Assarah region is Mughram's 1973 study of change and development in a rural context.

Mughram (1973) believes that the most characteristic farming features in the Assarah region are the terraces, their building and maintenance. According to his own observations, the reclamation of the arable land had been already developed to the fullest possible extent by using the technique of terracing before he undertook the study. He stated that most terraces are built on high steep slopes and in the narrow high gorges. Sometimes the height of the terrace from the one below may equal or exceed their surface width.

Twitchell (1943) indicated that the Assarah region is, or has been extensively terraced and cultivated. To him most of the western slopes of Assarah are too steep for the agricultural practices, but the more subdued slopes in the east of the divide are extensively terraced.

Kingdom of Saudi Arabia, Ministry of Agriculture and Water, Agricultural census (1962-64) made a survey of the population and the arable lands and concluded that in the past the population and the total arable land were greater than at present. It shows that the percentage of the cultivated land in two localities of Assarah (Ghamd and Zahran's districts) is 95.4% and 98% of the arable land, and 50% of that at least is abandoned terraces. According to Mughram, all the conclusions reached by the agricultural census are valid. In this connection, the following observation summarizes fairly succinctly the state of the terraces in Saudi Arabia:

> I believe that the total terraced area has gone through an oscillation of expansion and retraction in direct relation to the number of population. What happened in the past . . . is probably that whenever the population increased in an isolated community, the first means of coping with the excess number was by terracing an additional couple of yards, which every individual family did on their own on the margins of their land, or by reclaiming old derelict terraces. When the population was reduced through epidemics, the remaining people were less than the number required to work and maintain all the terraces. Consequently, the marginality law acted against working the higher terraces which reverted to waste and disuse until the following increase in population brought them under cultivation again, terrace by terrace (Mughram, 1973, 162-163).

Origins and Diffusion of Agricultural Terracing

> The origins of the techniques of terracing remain unknown. Where terracing started and how it spread so widely is still a matter for speculation. Almost nothing is known about terraces, their techniques of construction, and their cultural associations, in time, even in areas long studied by archaeologists (Field, 1966, 7).

The contribution of some geographers to the problem of terracing indicates that there is little certainty about the place of origin of artificial terracing. It is postulated that agricultural terracing originated in the Middle East in the form of dry-field terracing for several different purposes (Spencer, 1964). It has been suggested also that the Phoenicians were the first to build terraces several centuries B.C. along the side slopes of the mountains of Lebanon, especially those mountains that are parallel to the shore of the Mediterranean Sea (Maher, 1973).

> The basic suggestion is that the initial developments in terracing took place in any of several roughly equivalent landscape situations in the classical Near East. Reference is not to the lowlands of the great valleys, but to the then semiarid to arid foothill margins possessing small intermittent streams debauching upon flat lowlands (Spencer and Hale, 1961, 32).

According to Spencer and Hale, not all terrace types originated in the Middle East. However, the terraces with stone retaining walls were and are still dominant all through the Mediterranean region. From the Middle East the routes of diffusion and the spread of agricultural terracing were westward, southward, and eastward with some modifications in technique and configuration (Wheatley, 1965). Wet field terracing is a type that originated in China. From there it spread westward to the Himalayan front, the margins of humid lowland India, and eastward to the Pacific Islands.

In southwestern Arabia, the Assarah highlands are to-day a region of intensive utilization of agricultural ter-racing. There are no historical documents regarding the origin and diffusion of artificial terracing in this area. The only enlightenment we have concerning these terraces is that Spencer and Hale--in their study about the nature and origin of the traditional practice of agricultural terracing--recognized southwestern Arabia (Yemen) as an area where agricultural terracing originated and diffused from toward southeast Africa.

Another postulation is that the origin and diffusion of terracing in southwestern Arabia was associated with ancient Yemeni civilization, as represented by the three kingdoms which flourished during the first millenium B.C. The diffusion of terracing from Yemen towards the northern part of Assarah might be associated with the exodus of many tribes, who migrated from Yemen to the northern parts of Assarah during the early Christian era[1] (Fig. 2). Mughram, in 1973 added:

> As for Assarah, no definitive answer is given as to whether there was any previous community or not. The newcomers, one assumes, having acquired their agricultural skills from their original home and having settled in an area geographically similar to their previous land, went about their activities more or less as they were used to (Mughram, 1973, 116).

The Objectives of Agricultural Terracing

The general advantages of agricultural terracing are obvious in differing environments and cultures alike. Since early time, people must have realized that excessive runoff could be reduced by the construction of terraces, which lessened the slope gradient and broke up the original slope into shorter units; that soil and soil moisture would thus be better conserved; that to improve farming by increasing

[1]The reasons that caused this exodus were (1) the collapse of the old Yemeni Kingdoms, and (2) the land could no longer support its people, especially after the destruction of the dam of Mareb.

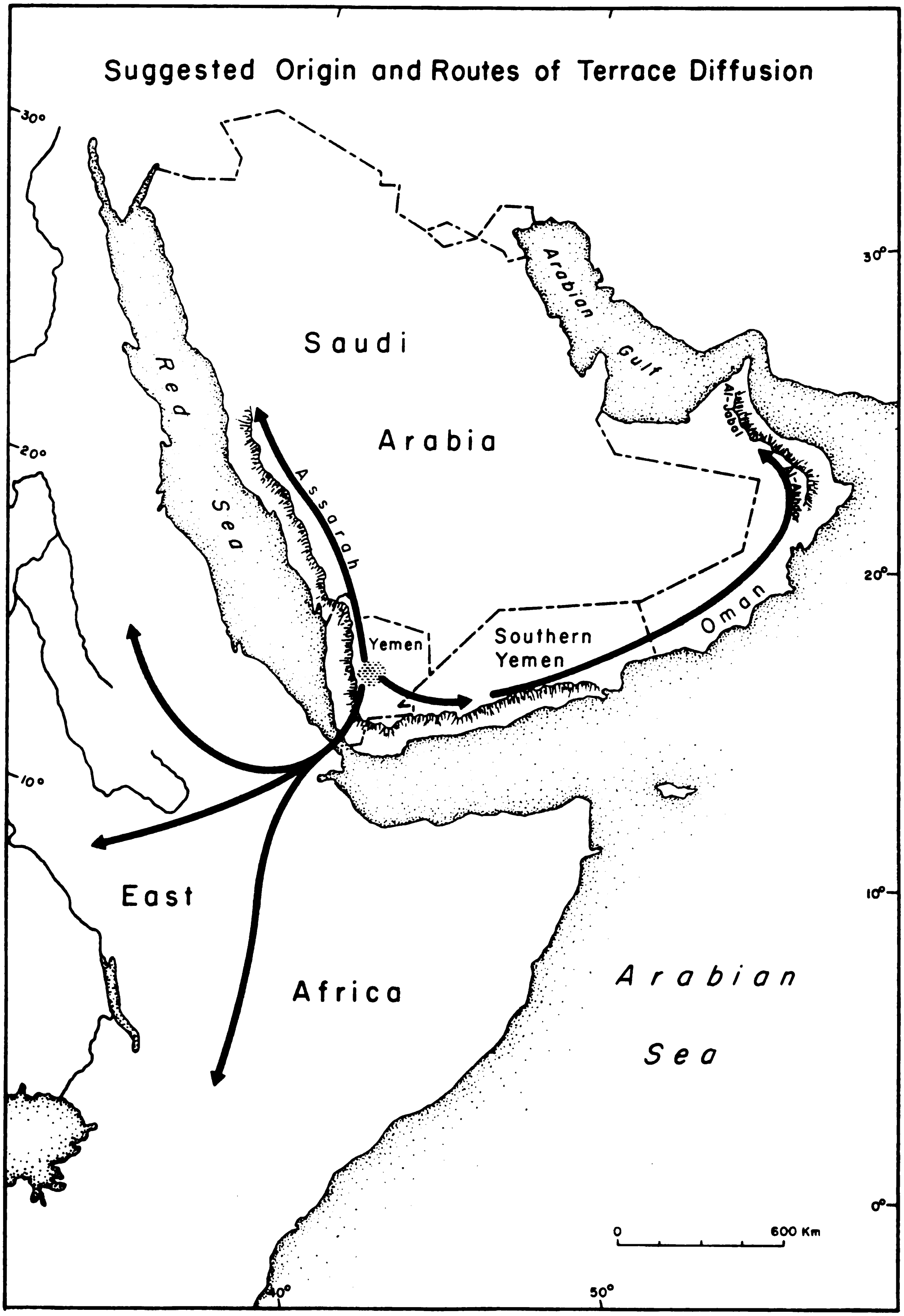
Suggested Origin and Routes of Terrace Diffusion
Saudi
Arabia
Arabian Gulf
Red
Sea
Assarah
Yemen
Southern
Yemen
Oman
Al-Jabal
Al-Akhdar
East
Africa
Arabian
Sea
0
600 Km
30°
20°
10°
0°
40°
50°

Fig. 2

farm size, by constructing terraces, building terrace walls, digging and filling would create more flat land for crops to grow; and that it would keep the water and soil trapped and prevent runnoff. Besides, rainfall would have been found to be more effective and to better infiltrate on the flatter slopes of terraces than on steeper ones. Early terrace builders must have deduced that on terraces it was possible to create gradients that would either retain water or drain it to wells, depending on the needs of the crops wherefore it was designated (Field, 1966, 9).

CHAPTER III

THE PHYSICAL ENVIRONMENT OF ASSARAH

Location

Assarah, in Arabic, means, among other things, "the top." It refers here to the area selected for this study. This region is an extended mountain belt, 10 to 40 kilometers wide and approximately 600 kilometers long, that runs along the top and to the east of the escarpment. The region extends from the Yemeni borders in the south to Al-Hada northwest of Taif. The geographic alignment of Assarah is northwest to southeast parallel to the escarpment and the Red Sea Coast. The Assarah region is bounded by the geographic coordinates of N $17^{\circ}30'/21^{\circ}30'$ and E $40^{\circ}/43^{\circ}30'$ (Fig. 1).

> The eastern limit of Assarah can be said to be the limit of rain-fed settled agriculture, which nearly coincides with the areas where the high mountains give way to more denuded and more dissected terrain. This change in physiography tends to take place along a zone lying somewhere between 1700 and 1900 meters a.s.t. (Mughram, 1973, 10).

The western and the northern limits of the Assarah constitute the geomorphological line between the interior of the Saudi Arabian shield and the Red Sea natural drainage basin (Plate 2a and b), while the southern limit of the Assarah region forms the political boundary between Saudi Arabia and Yemen.

Geological Background

Assarah lies within the Arabian Precambrian Complex and on the edge of its escarpment of the western Red Sea Graben Wall. The geology of this region is poorly known. The first geological maps of the region were published in 1963, based primarily on aerial photographs and reconnaissance investigation by helicopters. Detailed field work on smaller areas is presently being undertaken by many agencies and departments (Mughram, 1973, 21; and Al-Mishwt, 1977, 5).

The shield area in Western Saudi Arabia is the most easterly portion of the Afro-Arabian crystalline shield. This shield was split during the Upper Cretaceous by the Red Sea rift. It extends eastward for distances ranging from

Plate 2a The Western Escarpment of Assarah near Al-Hada, NW of Taif: note exposed bedrock and sparse vegetation.

Plate 2b The western limit of agricultural terraces at the edge of escarpment near Beni Omro.

50 to 700 km inland from the Red Sea to the points of contact with sedimentaries (Twitchell, 1953, 8-10). The shield consists of Precambrian to early Paleozoic rocks partly overlain by younger sedimentary rocks, Tertiary to Quaternary basalt and alluvium. The Precambrian rocks are either granitoid or schistose. The volcanic activity has been described as follows:

> The shield stratigraphy indicates that this massive block has been subjected to two major volcanic periods, with a very long interval between them. The first eruption took place during the Precambrian era covering most of the shield, but most extensively in the central and southern parts. The second eruption took place during the tertiary period covering an area about 75,000 square kilometers over central and northern most parts of the shield (Mughram, 1973, 22).

The second eruption is represented by the basalt and the ashes of the Harrats. Assarah, therefore, has metamorphic rock as a basement overlain by formations in which the volcanic rocks dominate.

Greenstones, schists and granite rock of various types are widespread, and dominate in some localities. Granites dominate the areas around Taif, Abha, and the area between Baljorashy and An-Nimas (Fig. 3). Schists are the major rock around Al-Baha and in the west of Asir, between the escarpment and the coastal plain. Greenstone forms the

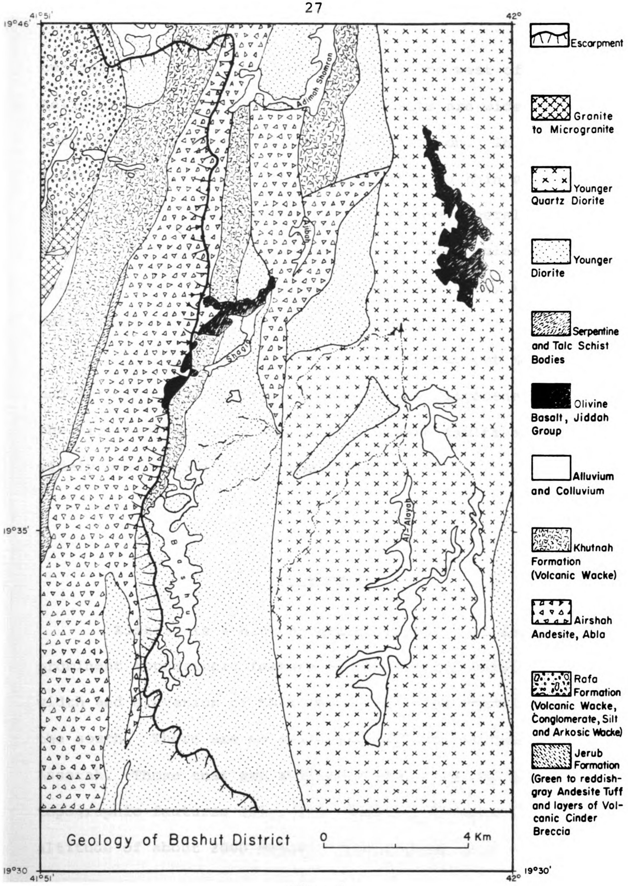
41°51'
42°
19°46'
Adimah Shomran
Ajibah
Shaqiq
Al-Alayah
19°35'
Geology of Bashut District
0
4 Km
19°30
41°51'
42°
19°30'
Escarpment
Granite to Microgranite
Younger Quartz Diorite
Younger Diorite
Serpentine and Talc Schist Bodies
Olivine Basalt, Jiddah Group
Alluvium and Colluvium
Khutnah Formation (Volcanic Wacke)
Airshah Andesite, Abla
Rafa Formation (Volcanic Wacke, Conglomerate, Silt and Arkosic Wacke)
Jerub Formation (Green to reddish-gray Andesite Tuff and layers of Volcanic Cinder Breccia

Fig. 3

central part of the southern shield, in the west of Abha and Baljorashy. Quaternary alluvial deposits are widespread throughout the whole of the southwest region. In the Highland of the study area, they are limited to thin strips along the valleys of the major wadis. These are generally coarse alluvia and consist of sand and gravel with boulders. The absolute age of the igneous rocks of Assarah--by isotopic determination--is around 1 billion years.

Faulting may have taken place throughout Mesozoic and Tertiary times, specially during the Oligocene Age when the Afro-Arabian Swell was broken. These faults are spread widely over Assarah (Whiteman, 1968, 224).

Topography

Assarah is a high mountainous belt. It forms a prominent topographic feature in the Arabian Shield. The width and elevation of this region increase steadily toward the south. There are no available accurate contour maps of Assarah. Those that are available show only the general topographic features (Fig. 4). Most of the area lies at an altitude of about 2000 meters. The highest peak is called

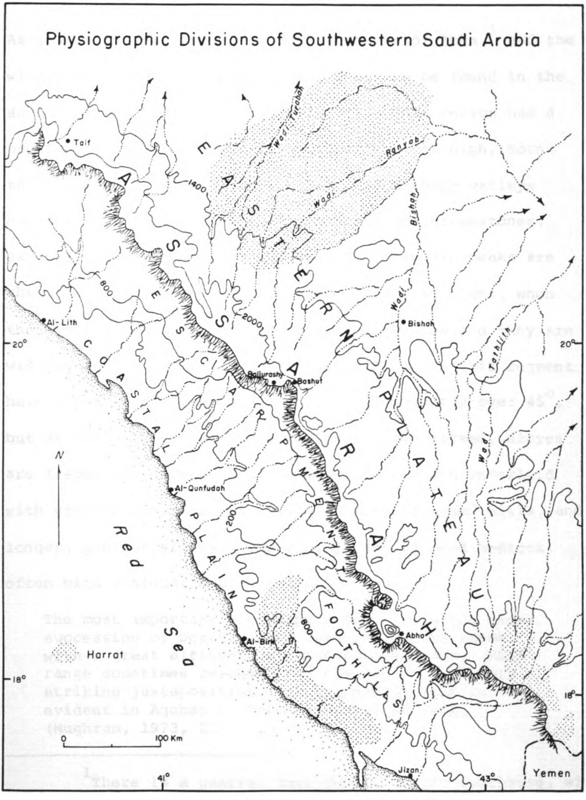
Physiographic Divisions of Southwestern Saudi Arabia
Taif
Wadi Turabah
Wadi Ranyah
Wadi Bishah
Wadi Tathlith
Bishah
EASTERN PLATEAU
ASSARAH
ESCARPMENT
COASTAL PLAIN
FOOTHILLS
Red Sea
Al-Lith
Al-Qunfudah
Al-Birk
Baljurashy
Bashut
Abha
Jizan
Yemen
Harrat
1400
800
2000
200
800
20°
20°
18°
18°
41°
43°
N
0
100 Km

Fig. 4

As-Sawdah and is located in the northwest of Abha,[1] and the widest extension of these mountains are to be found in the southeast of Abha (Mughram, 1973, 23). This region has a pronounced relief with deeply cut valleys. A high, mountainous country with narrow, entrenched V-shape valleys dominates the area underlain by schists and greenstones, expecially in the northern parts. The mountain peaks are sharp, and the valleys are continuous, and straight, when they follow the strike of the schistose bodies,and they are winding in a cross-strike direction. Hills in this segment have steep slopes ranging from 20° to frequently over 45°, but at valley bottoms, where pediments have formed, slopes are frequently more gentle. Areas in the south underlaid with granite materials have flat summits, rounded hills, and longer, gentler slopes. The slopes have exposed bedrock, often with residual boulders (ILACO, 1972, 11).

> The most important topographic feature is the close succession of positive and negative relief zones with a great altitudinal range between them. This range sometimes reaches over 600 meters in a very striking juxtaposition. An example of this is evident in Aqabat Al-Gamah south of An-Nemas (Mughram, 1973, 23).

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[1]There is a general increase in height southward, with numerous peaks between 1800 to 3200 meters, south of 20° north latitude. The elevation reaches its highest point, about 12,000 feet, in a summit west of Sana in the northern Yemen (ARAMCO Hand Book, 1968, 212).

In the west, sharp peaks and ridges separated by deep canyons and ravines dominate Al-Hafia Canyon, which separates Assarah into the two halves of Bashut and Shura. The canyon extends from the southwest towards the northeast with a width of about 8 kilometers. The canyon slopes are as steep as 45°, and the Basement Complex appears completely denuded of soil by erosion.

The eastern half of Assarah is characterized by low topographic features, with an elevation ranging from 1700-1900 m above sea level. Slopes at this altitude are gentle and merge into the plateau region. To the east the relief becomes more subdued and the wadis get wider. There is, however, a notable increase in the deposit of alluvium at the bottom of the valleys, which has considerably reduced the height of the mountains above the flat surface (Mughram, 1973, 24).

The central part of Assarah is characterized by conspicuous physiographic features. Flat-topped, elevated blocks of different size dominate these features. They are aligned in a north-south direction and are scattered throughout the region. At lower levels, there is a complex, rugged topography.[1]

Basin-like areas are another topographic feature of this region. These, too, are spread all through the study area. Their sizes are larger than the perched platforms mentioned above. The relief is moderate in contrast to the surrounding hills. The Bashut basin is a good example of it. It extends north-south about eight kilometers, and three kilometers from east to west. Other examples of this feature are the Baljorashy and Tanomah basins. Sharply pointed high peaks are prominent topographic features in Assarah. They are similar to monadnocks. Harfah Mountain in the region of Bani Amro is a representative example (Plate 3a). The mountain peaks are formations of bare resistant rocks, while the hills around them are of subdued relief and are extensively terraced. Hozna Mountain near Baljora is another example. It has very steep slopes, especially the western slope which forms the western limit of Assarah and drops sharply toward the escarpment region. In this area are found spheroid large granite boulders probably due to exfoliation.

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[1]Al-Balas in Khatham Country is exceptionally interesting. It is no more than a high mountain bluff, yet it supports seven small villages agriculturally (Mughram, 1973, 24).

Plate 3a Harvah Mountain near Al-Hasba in the country of Beni Omro, is an example of the monadnock-like mountain in the study area.

Plate 3b Slab and pillar-like formations in schists in the area between Al-Bahah and al-Mandag.

Other representative examples of these mountains are Baidhan Mountain in Balharith, Othrub Mountain in Ghamid, Ibrahim Mountain in Bani Malik and Batharah Mountain in Zahran (Mughram, 1973, 24-25).

The schistose body in the northern half of Assarah forms a conspicuous geomorphological feature. Groups of pillar-like formations or stocks constitute most of the natural landscape (Plate 3b). Their strike is from southwest to northeast. They stand vertically because of the almost vertical schistosity or foliation plane which contribute to the development of such features. These pillar-like formations seem to be the result of differential weathering and subsequent differential erosion of the nonresistant rock separates the resistant rocks from each other and forming deep recesses between these resistant stocks. Quartz is prevalent in the composition of these pillars and determines their linearity. This fascinating landscape has had both favorable and unfavorable effects on the people of the area. Obviously, agricultural use is impossible in the upper parts of the slopes but the formations provide building materials for various uses (Plate 4a).

Bashut, the core of the study area, is located in the central part of Assarah. As Fig. 5 shows, Bashut lies

Plate 4a Aspect of rock formation (schist) terrace type, and slope characteristics in the Zahran district, the northern section of Assarah.

Plate 4b Granite hilltop with quarried blocks for use terrace construction (northern Al-Shawhatah Mountain in Bashut).

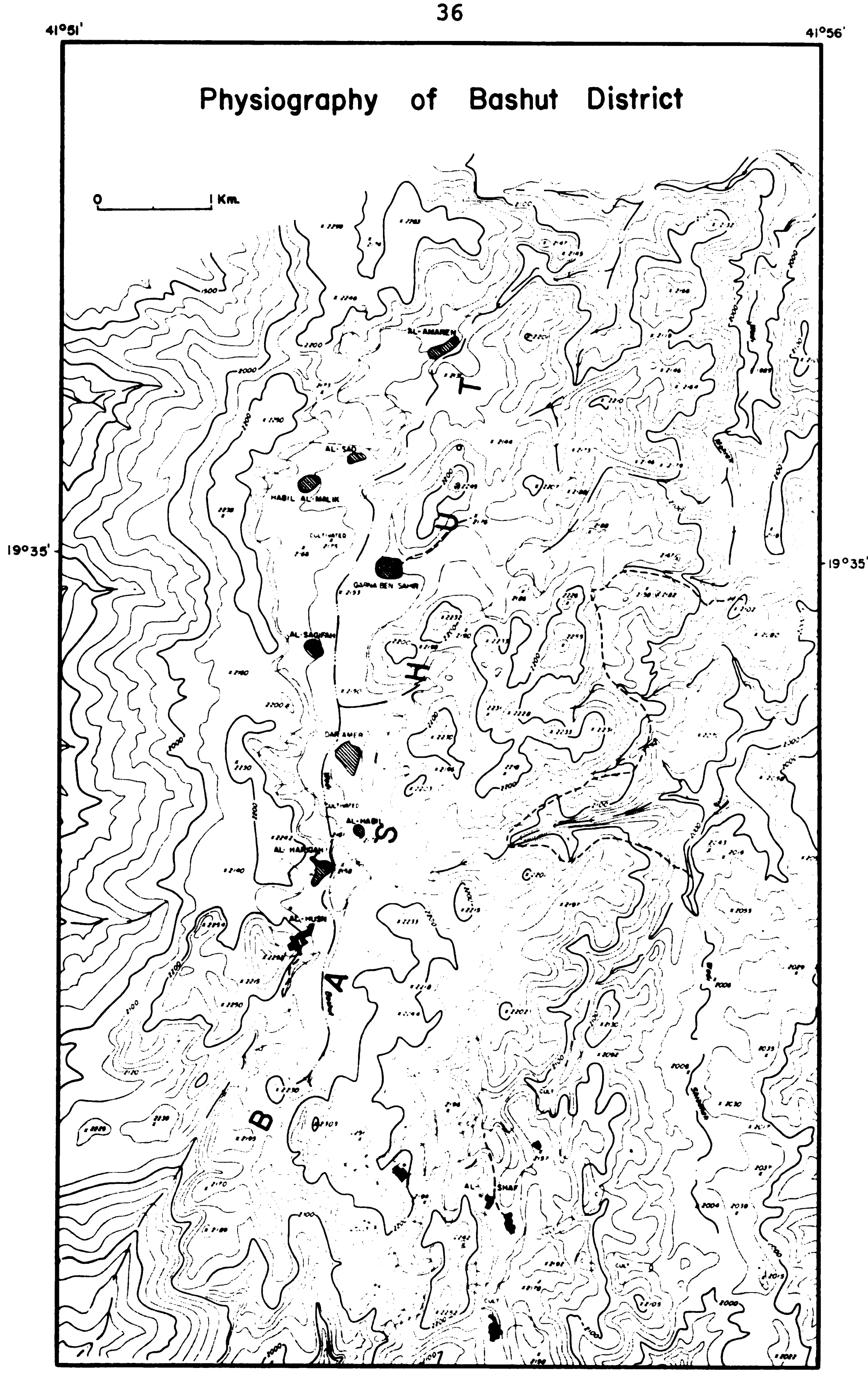
41°51'
41°56'
Physiography of Bashut District
0 1 Km.
19°35'
19°35'
AL-AMAREN
AL-SAD
HABIL AL-MALIK
GARNA BEN SAHIR
AL-SAQIFAH
DAR AMER
AL-HABIL
AL-HARIDAH
AL-HUSN
B A S H U T

Fig. 5

between the escarpments to the west and the Wadies of Shibanah and Mohrah to the east. It occupies an area of approximately 55 Km^2 of subdued relief in the west and rugged terrain in the east. The altitude ranges from 1900 m to 2303 m. It increases gradually and steadily southward and reaches the maximum height of 2303 at Al-Shohatah peak near Al-Shaf.[1]

The western escarpment drops very sharply to the Tihamah region. A line connecting the escarpment peaks is the natural divide between the western and the eastern drainage. This line coincides approximately with the western limit of Bashut. The land between this line and the new highway, which runs through Bashut from north to south, is extensively farmed. Th eastern rugged terrain is heavily punctuated with abandoned terraces and is characterized by heavy soil erosion. In some areas, slopes are totally denuded of soil. The Mohrah, Shibanah and Bashut valleys are the largest wadies in the Bashut area. They run northeast-southwest, winding through the rough mountainous country.

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[1]The contour map of Bashut district has been developed by Abrams Aerial Survey, Lansing, Michigan, from data collected during the field work and from the aerial photographs taken by the Government of Saudi Arabia. Contours are drawn at 20 m interval for Bashut district and 100 m interval for the escarpment.

Volcanic lava and ashes form a large part of the rock formation in the eastern part of the Bashut area. Al-Saoda Mountain to the west of Wadi Mohrah is a typical area formed of volcanic lava and ash.

Some high mountains in the area have attracted a great deal of geographical attention on account of their beauty and research possibilities. Al-Shohatah Mountain in the southern part is noted for its sharp peaks and steep slopes. Qirsh Mountain in the central part of Bashut is characterized by a flat summit, a large area, moderately steep slopes, and a basement which consists of heavily weathered sandstone. Al-Shohatah Mountain in the northern part is the largest in area. It has a flat summit in its southern part and a very sharp peak in the north (Plate 4b). Its slopes are gentle to moderately steep in the west and very steep in the east. Large granitic boulders are scattered along the sides of the slopes from the foot of the mountain to its peaks. The basement complex of this huge mountain is almost denuded; the soil is shallow and heavily eroded, except in areas where the abandoned terraces still manage to contain the soil.

Soil Characteristics

It is unfortunate that no soil survey or classification has ever been undertaken in the Assarah region. In recent years some attention has, however, been paid to the importance of soil surveys in the area, but they have been of a reconnaissance nature only.[1]

The development of a rich soil is controlled by many physical factors, the most important of which are the parent material, climate, vegetation and slope, considered over a long span of time. In Assarah the slope factor outweighs all others in importance, and any soil survey must acknowledge the critical significance of the slope factor (Mughram, 1973, 26).

The soil of Assarah is of two types in terms of their morphology--that is, the soil formed under natural conditions;;and the soil formed under human utilization (Fig. 12). The soil formed under natural conditions has the beginning of profile development. This is a marked feature in places where vegetation carpet is extensive enough to

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[1]For this reason (110) soil samples, mainly from Bashut, were collected during field work and analyzed at Michigan State University Soil Testing Service to determine at least soil texture.

prevent heavy erosion. A natural profile of moderately deep alluvial materials of up to 60 cm is possible. Along the mid-slope the soil profile is composed of A and C horizons. An A-horizon is indicative of fertile contents. However, in some areas where a thick vegetational spread is mainly of Junipers, horizon-A does contain some organic matter. The C-horizon is generally composed of weathered and fractured rocks. Along the footslope, toward the bottom of the valley, the deposited materials get thicker and the existence of the B-horizon becomes evident (Plate 5a).

The soil formed under the human influence is very important for this study. The artificial terraces would indicate that the soils retained by the terraces are also anthropogenic. However, alluvial and colluvial material at the terrace toe are 1 to 3 meters deep and are more matured than they are in the rear of the terrace. The soil profile on the terrace faces typically consists of 3 to 5 nongenetic horizons (Plate 5b), and at the back of the terraces, it is no more than an A/C sequence. On the upper slope terraces the soil profile thins out and bedrock is commonly exposed. On the abandoned terraces, the soil has eroded heavily and the bedrock is exposed especially in the upper slopes (Plate 6a and b).

Plate 5A Coarse fan glomerate, overlying man-made Terrace alluvial soil (Al-Hawasha, Qrish Mountain, NW of the new highway).

Plate 5b Alluvial deposits with a two-layered sequence: Plow layer overlying prismatic structured subsoil (Al-Ganeh, NW of Garn Ben Sahir, Bashut).

Plate 6a Soil erosion in an abandoned man-made terrace; the gullies are deep and the bedrock is exposed (Al-Ganeh, NW of Garen Ben Sahir, Bashut).

Plate 6b Torrential flood waters, indicative of the erosive power of the streams (note exposed bedrock), Wadi Bashut, Al-Mehmel.

According to field measurements of soil depths, the deepest soil development is found in basin-like areas on the man-made terraces. The soil is thickest at footslope terraces and becomes increasingly shallow toward the upper slope terraces, and here stoniness and rockiness are more pronounced (Table 1).

Table 1

Soil Depth to Bedrock in Bashut District

Depth in Meters	Slope	Absolute Freq.	Relative Freq. %
1	Steep	110	19.0
2	Moderate -----	(115	19.9
3		(125	21.6
4		(78	13.5
5	Gentle---------	(64	11.1
6		(86	14.9
		578	100.0

The soil texture of Bashut, our representative area of study, is generally clayey and clayey loam in terraces that occupy near-flat surfaces. It becomes sandy loam and sandy clayey loam on the side slope terraces and silty clayey loam on the cross-channel and lateral terraces, especially in the upper layer (see Table 2).

Table 2

Soil Characteristics of the Bashut District

		Chemical Composition							Grain Size			
		LBS. Per Acre of				PCT. Exchangeable Bases						
No. of Samples	Soil pH	Phosphorus	Potassium	Calcium	Magnesium	Potassium	Calcium	Magnesium	% Sand	% Silt	% Clay	Soil Texture
20	8.45	21.19	230.26	9799.96	974.47	1.05	84.70	13.51	32.23	27.94	36.21	Clay loam
53	8.38	15.27	218.91	11470.00	1353.95	.87	83.44	15.72	25.78	28.61	46.34	Clay
14	8.39	15.64	139.71	8133.57	819.86	0.71	85.84	13.44	50.03	25.89	30.25	Sandy clay loam
15	7.92	34.40	244.13	5887.60	450.60	1.70	86.58	11.53	59.34	26.50	14.73	Sandy loam
3	7.97	14.00	42.00	3763.33	178.00	1.13	87.17	11.70	41.09	44.91	14	Loam
2	8.08	3.5	122	964.00	975.00	0.6	85.00	14.40	14.68	44.16	38.16	Silty clay loam
1	7.8	2	76	4907.00	846.00	0.6	77.2	22.2	7.88	39.96	52.16	Silty clay

In terms of the physical properties of Bashut soil the soil structure is subangular blocky with a friable and firm consistency when the soil is dry. The soil drainage is somewhat poor in the western half which is occupied by irrigable terraces. The areas of moderate and steep slopes at the margins of the irrigable terraces are moderately well-drained. The water which penetrates the soil is removed from the soil slowly enough to keep it moist and wet for significant periods, though not all the time and throughout the year. Assarah, as a region with an annual rainfall of about 400-500 mm, needs this moisture badly. The problem of the Bashut soil in particular and that of Assarah in general is that when it is dry, it is difficult to be plowed, and when it is irrigated, large cracks usually begin to appear after a short period of time as soon as the soil gets dry. This problem is attributed to a high content of expanding clay. Thin flaky pieces form on the surface of the upper layers and they are the result of the plate-shaped nature of the clay particles (as described by Foth and Turk, 1972, 168).

Profile: Typical Soil Profile in a Man-made Terrace, Central Part of Bashut Area.

Depth of Horizon in cm	Types of Horizon	Description
0-30	AP	Very dark grayish brown 10 YR 3/2, clay loam, (38%) clay, moderate medium angular blocky structure, friable, strong effervescence. pH 8.5
31-60	C_1	Brown 10 YR 4/3, clay loam, (40%) clay, moderate fine angular blocky structure, firm, strong effervescence. pH 8.7
61-80	C_2	Dark brown 10 YR 3/3, clay, (41.8%) clay, moderate fine angular blocky structure, firm, strong effervescence. pH 8.7
81-110	C_3	Very dark gray 10 YR 3/1, clay loam, (34.16%) clay moderate very fine subangular blocky structure, friable, moderate effervescence. pH 8.7
111-140	C_4	Dark grayish brown 10 YR 4/2, clay loam, (28.16%) clay, weak fine subangular blocky structure, friable, slightly effervescence. pH 8.5
140 +	C_5	Dark brown 10 YR 3/3, clay loam, (27.20%) clay, weak fine subangular block structure, friable, slight effervescence.

The soil of Assarah before being refreshed by new deposits, a high level of exchangeable base materials, particularly calcium, magnesium, and potassium, become readily available through the weatherable minerals. The level of nitrogen and phosphorus is low for such immature soils, but the soil reaction is high (pH 7.8-8.45) (Table 2). This does not result in excessive soil salinity, however, because of satisfactory surface circulation due to runoff. An additional beneficial factor for soil fertility is the manure of plants, crops, and animals. Residues as well as roots of leguminous crops, contribute to the deposition of considerable quantities of organic matter and organic nitrogen in the soil (Kingdom of Saudi Arabia, Ministry of Agriculture and Water, Final Report (4), 1969, 14-16).

Soil Formation

Assarah soils are derived from different parent materials, such as granites, schists, greenstones and basalt, the most important rocks of this region. Differences in mineralogy, weathering processes, and water retention lead to considerable local variations of Assarah soils.

Greenstone is the least resistant material in the study area followed by schists and granites. The rapid weathering of greenstone produces the thickest soil profile. The most important feature of these parent materials are their high water retention capacity. Greenstones crumble with a little pressure from one's fingers (Mughram, 1973, 28).

The best examples of this material are in the schistose areas on either side of the highway between Abha and Taif. The schists are prone to heavy weathering, and the parent materials derived from these rocks tend to accumulate as silt quickly. The soil profile developed from schists is thick enough to permit agriculture without terracing. The soil is, however, immature and consists mainly of semi-disintegrated rock particles. Most typical formations of this kind of soil are seen around Al-Bahah. Granites, with extensive outcrops, are dominant in the Assarah region, especially in the area between An-Nimas and Baljorashy. The weathering process is slow and soils formed out of particles of granite are characterized by a high quartz content and a considerable proportion of mica. The soil texture is coarse and sandy. Nutrient deficiences are more likely to occur in soils derived from granite than in those underlaid with schists and greenstones. The soil profile developed from these formations is very shallow in areas under natural conditions, but fairly thick in areas under human utilization (ILACO, 1972, 15).

In the Assarah region, the slope and the drainage of the land surface are two important environmental factors influencing the soil character. The variation in slope affects the chemical weathering of the materials and soil moisture. Under natural conditions, the soil, in areas of steep slopes of more than 25^{o}, erodes heavily due to excessive runoff. The gentle and moderate slopes on the other hand, retain a very thin soil, punctuated with very stoney structures and fragment bedrock outcrops. At the foot and mid-slopes, the soil shows a shallow profile of A and C horizons, with more water running through it. In some areas a very thin B-horizon is pronounced only at foot-slopes where the soil is deep. At the crest where a very thin soil is noticeable, less water moves down through it as a result of rapid runoff causing rapid surface erosion. The wadies and their tributaries have cut into the bedrock and contain no soil at all. Boulders and exposed bedrock are a common occurrence along the wadi courses. In areas of low relief the valleys are two or three times wider than they are in areas of high relief, and they usually contain thin strips of alluvial soil that are highly dissected and deeply gullied. Patchy pockets of soil are typical in the areas of granite bedrock. This soil is highly variable in depth, consistency and maturity, and maintains some natural vegetation.

A quite different soil arrangement is observed in areas where the catena is controlled by the terrace construction. At the bottom of the wadies, along the two sides, strong field walls avoid gullying. Terrace construction helps to retain a good and thick alluvium, varying in depth from 1 to 3 meters, thinning upslope, and often broken by outcrops of bedrock. The depth to the zone of accumulation increases as the slope gradient and the runoff decrease. Field measurements show that about 82% of the terraces have been constructed in areas of gentle slopes ranging from 0.5^{o} to 10^{o}. Here the accumulation of the transported soil material is thick enough for crops. On the upper slopes between 10^{o} and 15^{o} appears to be the critical angle range at which soil begins to form under natural conditions.

Climate is a dominate factor in soil formation. It influences the formation of soil mainly by precipitation. Precipitation in the form of rain produces the greatest amount of runoff and erosion. Raindrops detach particles of silt by their splashing movement. Runoff has a positive correlation with both rainfall intensity and the degree of slope and it is apparent in the transportation of loose materials by water flowing in sheet waste, rills and gullies (Cooke and Doornkamp, 1974, 27-38).

In the study area the part of the rainfall that seeps through to the soil profile affects its formation and development. Some materials are washed from an A-horizon and are carried down into the C-horizons. The accumulation of clay particles, organic materials, and minerals in the subsoil is one of the most important functions of soil water. Chemical weathering in the C-horizon produces a thick soil profile because iron and aluminum minerals usually get accumulated in that layer.

Rainfall helps keep particles of silt together. This compactness of soil makes the soil resistant to wind erosion. The obvious danger to the soil in Assarah comes from erosion by runoff, especially on the abandoned terraces, alongside the slopes. The soil erodes and the bedrock is exposed. In the footslope areas deep gullies are formed. This phenomenon is best illustrated in the area around Al-Bahah.

Plants and animals influence the process of soil formation and largely determine the character of the soil formed. Vegetative cover tends to reduce both runoff and erosion. It protects the soil against the impact of rain-drops and reduces the amount of water available for runoff. Plant roots help to keep the soil in place, especially in the areas of steep slopes (Cooke and Doornkamp, 1974, 39-40).

On the rainfed terraces and the surrounding land are scattered some Junperus procera and Acacia seyal, and the terrace margins are fringed with some shrubs all along. Some of these trees are evergreen and some shed a considerable amount of leaves all year round. The fallen leaves enrich the soil and add to its fertility and development (Mughram, 1973, 30-31).

Soil under trees shows evidence of distinct enrichment. It has a thicker profile than that formed in areas with no vegetational cover. A-horizon has more organic matter. In areas under natural conditions, the quality of soil profile depends ont he thickness of the vegetation cover and the amount of grazing carried on. In regions where the vegetational cover is absent due to heavy grazing and the cutting of woods, the surface denudation has led to a heavy soil erosion. There are only a few small, protected areas where the soil now is mature and rich in organic matter.

The effect of fauna on soil formation is both beneficial and detrimental. Animals, from camels to tiny rats, may expose the soil to erosion agents. The farmer himself often contributes to the denudation of terrace soil. The result of careless terrace maintenance can be seen along the two sides of the new highway. Here, instead of repairing damaged walls, the rocks have been used for building materials to maintain the road. The terrace soil is thus lost to runoff. On the other hand in areas of dung concentration natural fertilization is extensively practiced. This refuse helps add to soil fertility and its development (Mughram, 1973, 31-32).

Climatic Characteristics

Almost all of Saudi Arabia is an arid mass of land, except for the central part of the southwest region within which is located Assarah. Assarah enjoys a moist subhumid climate and has a much greater rainfall than any other part of the country. The mean temperature is much lower than in most parts of the country, and is marked with mountain, forests and woodland greenery (Al-Sayari, and Zotl, 1978, 31-44).

Topography and relief play an important role in climate of Assarah. Indeed, temperatures depend directly on the altitude above sea level. Assarah is located along the crest of the main escarpment at a height of over 1700 m above sea level stepping toward the east and merging with the interior plateau at about 1500 m.

As a background to this study, a description of the factors determining the climate, temperature, humidity, precipitation, evaporation and vegetation and their impact on agriculture and the necessity for terraces in the study area is in order.

The Influence of Elevation on the Temperature

Always, there is an inverse relationship between the atmospheric temperature and the altitude, and it is particularly true in Assarah. The altitudinal position of Assarah works in its favor in reducing summer temperatures. As shown on the physiographic map (Fig. 4), the high mountainous areas occur in the south of the region. The massive nature of southern Assarah creates convectional currents causing rain. The annual and diurnal temperature range, especially during the summer, is fairly wide. Isotherm maps show that within the region, the latitude plays no part in determining the range of temperatures recorded. However, these isotherm maps do point to the temperatures increasing eastward from the crest of the escarpment to the interior plateau as the altitude decreases. The annual temperatures range from 10^{o}C to an altitude of 2270 meters at Bashut to 18^{o}C at an elevation of about 800 meters in the Plateau region (Fig. 6a and b).

Climate Characteristics

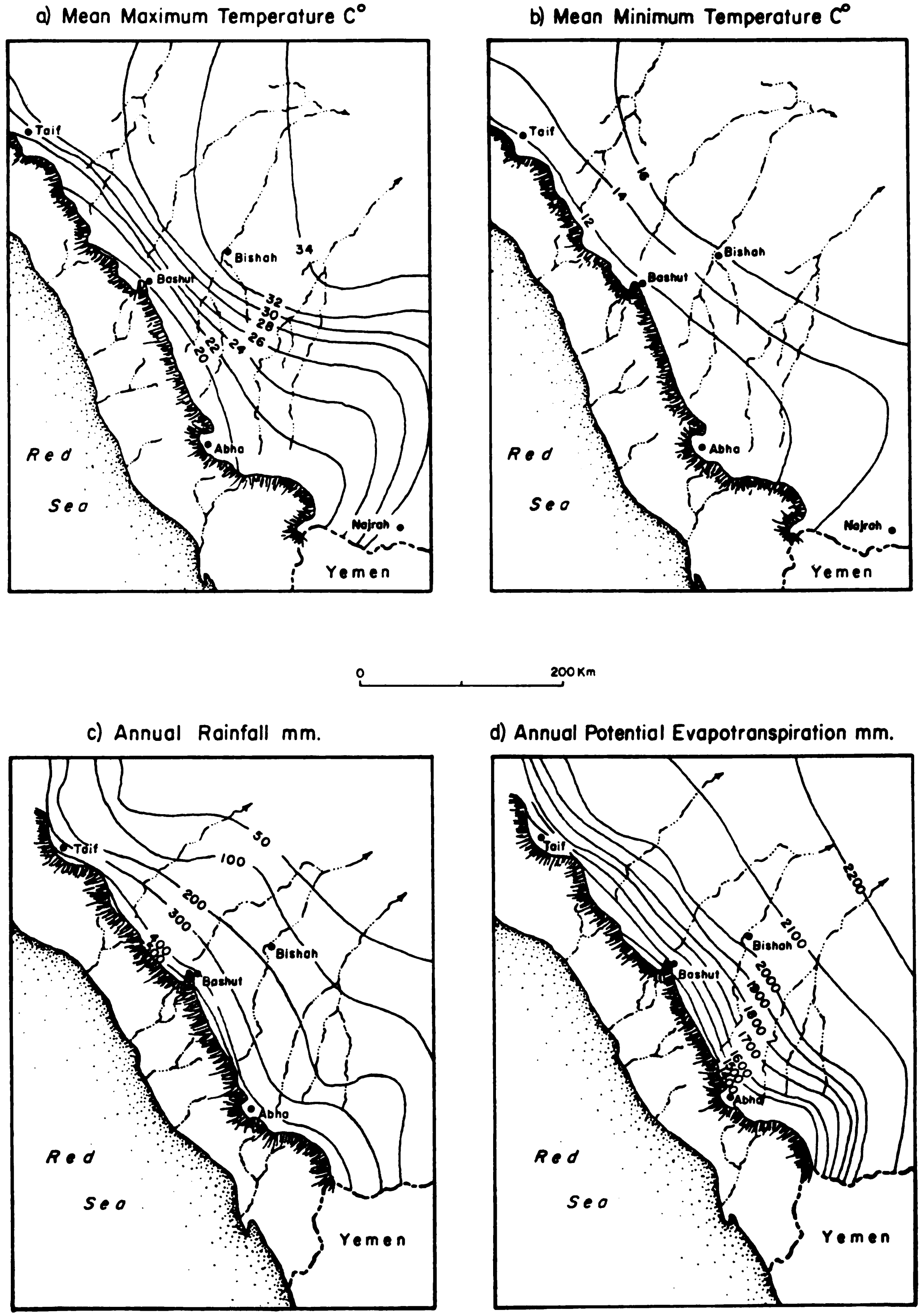

Fig. 6

During the months of January and February, temperatures are usually low for the latitude, reaching below 0°C in some areas, causing frost in the morning.

During the spring, the temperature begins to rise, touching the peak in July. The summer, however, records the highest atmospheric temperatures of the year. Monthly temperatures for June and July have the same means. For instance, Abha has 21.3°C, 21.5° and 20.7°C for the months of June, July, and August respectively. The maximum mean temperature in the summer rarely exceeds 26°C. This gives Assarah the ideal temperature condition within the country in the summer time for farming. The temperatures in fall are 2 to 3 degrees higher than in spring. With a sharp drop in temperature in late fall, trees begin to shed their leaves (Fig. 7, Tables 3 and 4).

Rainfall and Moisture Characteristics

Assarah is subject to the influence of two basic air masses during the year. During the cold season the Westerlies bring in the moist Mediterranean air masses, while during the warm season the monsoon flow drives in moist tropical air masses from both the southwest and the southeast. Owing

Mean Monthly Temperature for Selected Stations in Assarah 1966-1976

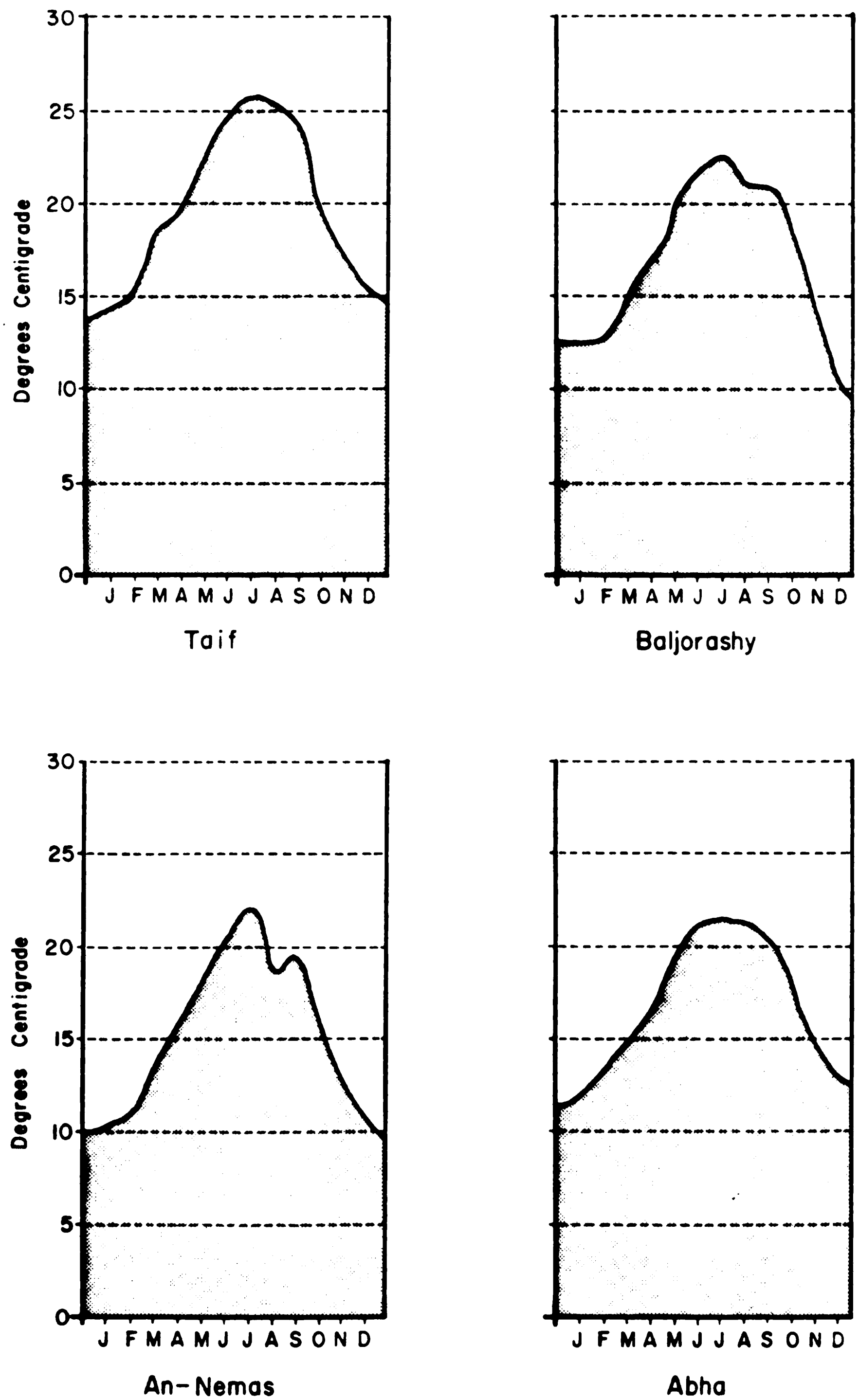

Fig. 7

Table 3

Monthly Mean Temperatures At Various Stations in Assarah
1966-1976

Station		J	F	M	A	M	J	J	A	S	O	N	D	Mean
Taif	1682	14.3	14.7	17.8	18.7	22.2	24.5	25.6	25.2	23.8	19.8	17.5	15.2	19.9
Baljorashy	2335	12.5	12.3	14.9	16.4	19.7	22.0	22.3	21.5	21.4	18.0	15.1	13.3	17.5
An Nemas	2600	10.4	10.6	13.6	15.0	17.7	20.0	21.4	18.6	19.2	15.7	12.1	10.0	15.4
Abha	2159	12.0	13.2	15.0	16.1	19.0	21.3	21.5	20.7	20.3	17.0	14.5	12.8	17.0

Table 4

Temperature Characteristics At Various Stations in Arrarah
1966-1976

Station	Abs. Max.	Mean Max.	Abs. Minimum	Mean Minimum	Mean
Taif	35.0	28.0	-1.5	12.2	20.1
Mindak	33.5	23.6	1.0	10.5	17.05
Baljorashy	32.9	23.5	2.4	12.8	18.15
An Nemas	32.5	20.4	-6.0	9.7	15.05
Abha	33.5	23.6	1.0	10.5	17.05

Source: Ministry of Agriculture and Water; Department of Water Resources Development, Hydrology Division, Riyadh, 1966-1976.

to the high altitude of Assarah, the temperatures drop by about 15°C on an average in comparison with the surrounding areas, resulting in its experiencing a relatively higher relative humidity all through the year. The annual average relative humidity for Assarah is about 60%, whereas it is only 30% for the adjacent regions.

In the summer, there is a considerable rise in the relative humidity due to a high moisture content of the prevailing maritime air masses. But even at this time the relative humidity is not excessively high and tends to mitigate the summer heat.

Assarah experiences monsoon type of rain in August, rain accompanied by thunderstorms in the spring, and cyclonic squalls in the winter. The precipitation during any of these periods is light, erratic and local, or it may fail altogether for some years. The northern half of Assarah around latitude 19°N comes under the influence of the Mediterranean winter storms and the southern half experiences the influence of the summer monsoon. Failures of the monsoon or winter rains are serious for agriculture in the northern parts of Assarah.

The reliable available rainfall data for various stations in the study area indicate that Assarah has never experienced a total failure of both winter and summer rains the same year[1] (Tables 5 and 6, and Fig. 8).

Seasonality Aspects

During the winter months of December-February, Assarah comes under the influence of the Mediterranean cyclonic system, with its frontal precipitation, accentuated by orographic effects of the western escarpment. Winter rainfall provides most of the surplus needed for the growing season, particularly in the northern half of Assarah. In the southern half this dependency on the winter rain is not as distinct. However, a few weeks' delay or an early start of the winter rains can jeopardize the agricultural production (Mughram, 1973, 60).

In the spring months, March-May, the northern half of Assarah is still subject to the northwesterly Mediterranean moisture-saturated air masses producing considerable precipitation. The southern half to the south of latitude 18°N begins to come under the influence of the southeast

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[1]An interview with old farmers during the field work indicated that Assarah had experienced two severe droughts in the past. One of them was about eighty years ago and the other in 1940. Both droughts took a heavy toll of life by starvation and temporary migration to the region of Tahamah.

Table 5

Rainfall: Monthly Average (mm) at Selected Stations in Assarah
1966-1978

Station	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Taif	30	15.7	15	83	27.3	12	6.2	14.6	51	5	31	5	296
Baljorashy	62.6	29	26	62	28	9	22.2	40	6	22	61.2	41	409
Ademah	46	25	97	100	51.2	4	6	40	2	2	22.1	29.3	426
Al-Alayah	65	24.5	59	100	46	6	13	70	17.3	4	35	70	510
An-Nemas	98	33	100	98.4	63.5	9.5	19	35	7.6	3.5	39	62	569
Abha	24	30	24.5	64	40	16	44	46	5	17	11	27	349

Source of Data: Ministry of Agriculture and Water: Hydrology Division, Riyadh, Saudi Arabia

Table 6

Annual Rainfall in Assarah, in Millimeters: 1965-1978

Station	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Ave-rage
Taif	300	280	246	290	320	132	120	496	250	290	395	247	419	270	163	260	213	220	242	328	243	376	268	276.00
Al-Baha	525	480	495	850	521	880	551	438	368	557	281	360	420	550	650	590	475	529	625	887	626	559	575	556.17
Baljorshy	494	458	415	448	520	275	242	261	385	312	320	443	471	436	415	500	668	324	358	742	435	447	535	430.61
An-Nimas	393	403	326	436	386	462	437	439	295	306	259	524	515	225	542	428	367	632	400	563	703	575	576	443.13
Abha	253	396	148	155	181	560	834	738	385	312	236	443	472	436	415	302	668	325	358	742	435	447	503	423.65

Source of Data: Ministry of Agriculture and Water, Hydrology Division, Riyadh, Saudi Arabia

Mean Monthly Rainfall at Selected Stations in Assarah
1966 - 1978

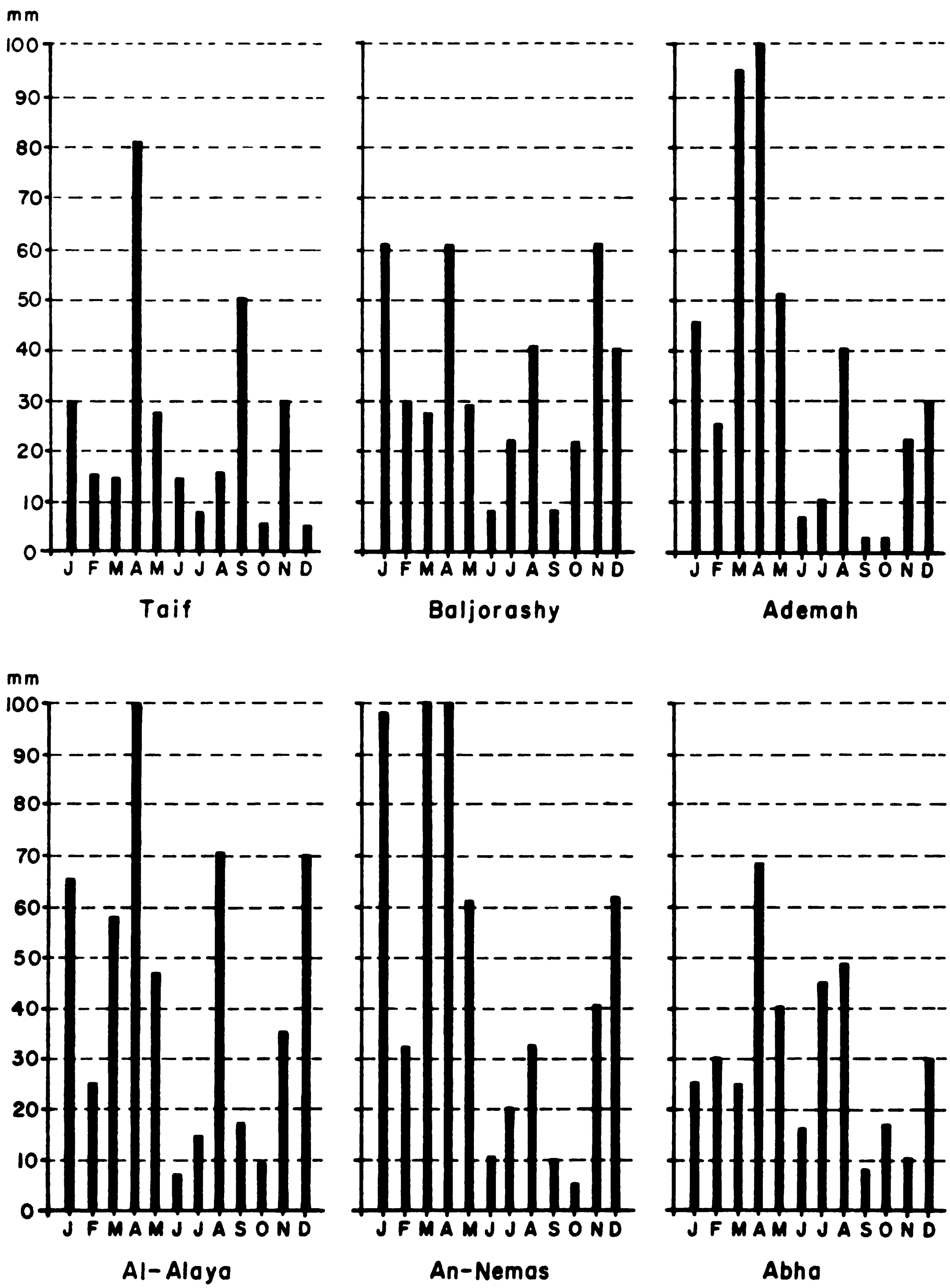


Fig. 8

monsoon air flow from the Indian Ocean. Instability rains develop and yield a widespread moisture over Assarah and over the interior plateau region. Spring rainfall is critical for the wheat and barley crops--especially in the upper-terrace zone where production relies almost completely on natural rainfall--besides being essential for summer sowing of sorghum and millet.

During the summer months of June through August, southern Assarah experiences southerly and southwesterly monsoon from the Indian Ocean. These air masses build up unstable conditions over the study area, giving rise to thunderstorms in the south and along the main escarpment. In the northern portion, anticyclonic subsidence in the Westerly flow has a dampening effect on the rainfall. Summer rainfall is confined mostly to the southwestern region to the south of latitude 20°N and west of the 44th meridian. This summer rain contributes much less to agriculture than the winter rainfall and farmers need must rely on ground water.

During the fall months, September through November, air masses of westerly origin reform over Assarah to the north of latitude 19°N. Widespread rainfall of medium to high intensity occurs to the north of An Nemas. To the south the amount of rain becomes scanty and unreliable. The monthly mean precipitation, however, for November at any station in Assarah exceeds that for September and October except at Abha in the southern part of Assarah. This clearly shows that the moisture source lies in the west during the fall.

The monthly rainfall average at various stations in the study area shows a distinct and recognizable pattern with four peaks. These peaks occur in January, April and November followed by a decline in the amount of rainfall. April has the highest amount of rainfall at all stations in Assarah (Fig. 8 and Table 5). There are two dry periods, one of them occurs in the summer season in June and the second in the fall months of September and October (Mughram, 1973, 53-54).

The Amount and Variability of Rainfall

The mean annual rainfall over the study area varies from about 1000 mm in the western side of Assarah to about 200 mm in the interior plateau. The amount of rainfall decreases eastward from the escarpment because of subsidence, the influence of altitude and temperature being minor (Fig. 6c).

In the Assarah region, the distribution of the terraces is directly related to the amount of rain in the area. The most intensive agricultural areas are those found in the western half of Assarah, between the crest of the escarpment and the new highway, where the annual rainfall exceeds 400 mm, but the intensity of agriculture decreases eastward gradually in the low rain areas. The eastern limits of agricultural terraces lie between the 300 and 200 mm isohyets.

There is a considerable variation of regional and seasonal intensity of rainfall in Assarah. Also, Assarah experiences an interesting variety of precipitation, like rain, hail, dew and fog-drip, and in a wide range of intensity. The western part of Assarah has the highest amount of rainfall and the rains last longer in this region than at any other part in the eastern half of Assarah. The spring season, which has the highest amount of rainfall in the study area, contributes about half or more of the annual rainfall. For instance, in April 1975 precipitation at various localities in Assarah exceeded 340 mm and Ademah in the northeast of Bashut once had as much as 409.2 mm in that month. The highest daily rainfall yet recorded in Assarah has been 222 mm at Azazah on February 11, 1968 (Ministry of Agriculture and Water, No. 3, 1969, 39). Other daily maximum recorded were 185 mm at Abha, 130 mm at Baljorashy, and 117 mm at Taif in 1968. In January 1969, an intensity of 11.5 mm/5 minutes was recorded at An Nemas in the central part of the study area. In such extreme cases, terrace-walls are washed away in Assarah, and catastrophic soil erosion in the natural watersheds and abandoned terraces are common.

Hail, usually unwelcome, is an indication of spring and summer instability, leading to convectional thunderstorms. High intensity thunderstorms at times precipitate a foot of hail accumulation with hailstones varying in size from a few millimeters to an inch in diameter. Despite its hazard to crops, hail contributes to the moisture being retained in the well-built terraces. However, dew and fog-drip are highly welcome to the farmers, especially during the excessively dry summer and autumn seasons. Dew provides as much as 25% of effective usuable moisture needed by plants, especially by natural vegetation (Fisher, 1973, 56). Fog-drip is particularly beneficial when it is accompanied with a light drizzle, and the moisture persists for a few days. However, lingering moisture is known to restrict activities on the terraces and causes some damage to crops, especially at the harvest time (Mughram, 1973, 56).

Precipitation Efficiency

Assarah has relatively low temperature, high cloudiness and humidity. These factors combine to lower evapotranspiration fromthe bare soil, vegetation and open wells. The amount of rain is sufficient to support non-irrigated fields, but because of the ruggedness of the terrain the water is drained away very fast. On the other hand, rain is irregular, variable and intense--factors that decrease moisture efficiency.

A clear picture of the relationship between the precipitation and evapotranspiration can be obtained by Thornthwaite's water balance equation. By Thornwaite's calculations, An Nemas shows both a surplus and a deficit of moisture. Its PE is 74.5 cm and its moisture index is 25.6. Thus, it has a mesothermal efficiency and humid climate. From the agricultural point of view, moisture deficit occurs during the summer and early autumn months of June through October, the computed value of which is 21.5 cm. High rates of evapotranspiration resulted from high temperatures at this time reducing the amount of moisture available to plants. Although sometimes intense precipitation of short duration occurs, but due to the shortness of the time most of it runs off and soil cannot absorb it to compensate the high PE. To compensate for the amount of moisture loss by evapotranspiration and run-off, artificial irrigation is resorted to by the majority of farmers.

Moisture surplus occurs during the winter and spring months, November through May, the computed value of which is 19.2 cm January contributes 7 cm of the moisture surplus which is the highest of all months. The mean temperature at this time is as low as 10^{o}C, precipitation as high as 10 cm, and relative humidity 77%. All these factors combine to bring about a low evapotranspiration rate of 3 cm and is of longer duration than during the short intense summer rains.

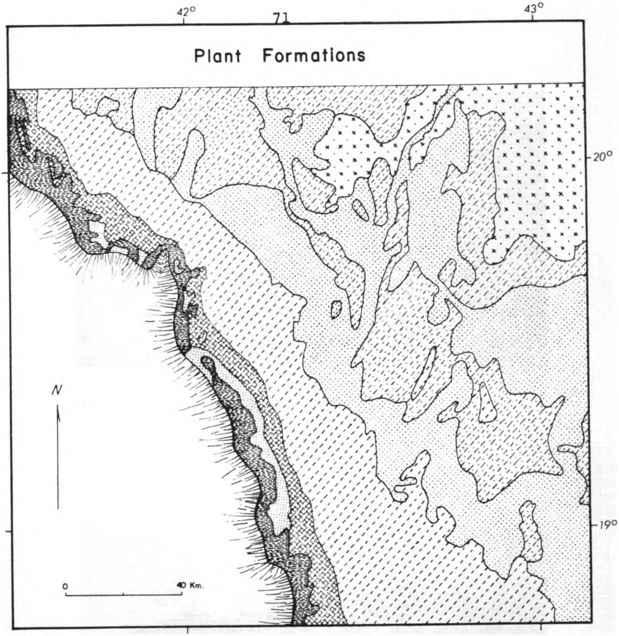
Even if the terrace soil can retain about 20 cm of water, it can never be said to be fully saturated at the highest storage value in Thornwaite's water balance is only 18 cm. This fact clearly indicates a need for artificial irrigation (Fig. 6d).

Vegetation

The impact of altitude and climate upon vegetation is very pronounced in Assarah. An annual rainfall of some 400 mm and a moderate temperature regime combine as the most important factors in the type and physiology of the plants in the study area. Assarah's vegetation has unique characteristics in that unlike another district in Saudi Arabia, there is an aspect of lushness and continuity in the plant cover.

The amount of rainfall and elevation decrease from west to east. This leads to successive vegetational belts being different in types eastward (Fig. 9). Bashut, representative of the area of study, is characterized by Juniperus procera at an elevation of more than 2000 meters. The area to the east is dominated by wild olive and Acacia seyal at an elevation of about 1800 m (Plate 7). At an altitude of about 1700 m where annual rainfall is less than 250 mm lies the lower limit of forest growth. The growth below that elevation is restricted to short and bush plants. This semiarid belt can be regarded as a transitional zone between the arid plateau and the subhumid Assarah regions.

Judging by the patches of forest scattered through the region, Assarah must originally have had a continuous woodland cover. Excessive deforestation in the study area is clearly evident and can be attributed to various causes. Overgrazing, not only by animals raised by villagers, but also by those belonging to nomads who used to migrate to



Steppe and Shrub Steppe of Acacia Tortilis and Raddiana

Acacia Tortilis, Flava, Odora and Seyal

Open Woodland of Acacia Tortilis, Flava, Aska, Lycium Arabicum, and Panicum Turgidum

Acacia Seyal and Kleinia Odora

Acacia Seyal and Euryops Arabicum

Montane Evergreen Dry-forest (Juniperus Procera, Lavandula Dentata, and Olea Crysophylla)

Permanent Cultivation

Fig. 9

Plate 7a Natural mountain vegetation on steep slopes (Juniperus procera), SE of Habil Al-Ameren, near the highway.

Plate 7b Natural vegetation composed of Acaic and wild olive (olea). Wadi Gabgab in the country of Adimah Shomran.

Assarah during the drought seasons, had the greatest impact over time. Severe droughts of the past have taken their toll of arboreal vegetation, especially the mesophytic type which is sensitive to ground water penetration. A not lesser effect is evident from an extensive use of wood for various human needs, such as large beams for roofing, small branches and bushwood for roof thatching. Dry wood is used as fuel and charcoal in normal circumstances; but when there is a shortage of dry wood, people resort to the prohibited use of living trees. The wild olive suffers most on account of its hard wood providing raw material for agricultural implements. During the drought season peasants and nomands alike use its evergreen leaves and small branches for fodder for their animals. Use of these trees as firewood and tar has greatly decimated throughout the area.

The plant cover is influenced greatly by the type of land use, protective methods, and the ownership system. Juniper and acacia, for instance, grow on terraces. Though they could grow plentifully over the terrace flats, often enough only the margins of the terraces were left for Juniper and acacia plantation. Some terraces have been diverted to wood crops. The quality of their wood is good. The trees grow to a large size and where privately owned woodland is carefully terraced in plots of deep soil and adequate moisture supply, a good wood crop can be obtained. In contrast, the picture under natural conditions is bleak. Here, the vegetation consists of small trees and shrubs, because the soil profile is shallow, and the moisture is inadequate. In many localities the growth of vegetation is impeded by erosion or it grows only sparsely on the steep, bouldery slopes. This kind of woodland is communally owned by a tribe or a village. There are protective methods applied here, too; the most important is the El-Hema system, which prohibits woodcutting and grazing of an area exceeding 6-8 Km^2 for one village at any time of the year. The only time all farmers have the right to graze their animals without restrictions is during a severe drought.

It is difficult to predict the future fate of the vegetation cover. For the purpose of reforestation, reconstruction of abandoned terraces is required; this would fulfill a double purpose of erosion control and creating the necessary prerequisites for successful tree plantation.

The contribution of vegetation to agriculture has been amply demonstrated: it protects the soil from strong water erosion; it adds to its fertility and development; it keeps more moisture in the soil and at the same time adds to the rate of transpiration, especially during the summer months. Vegetation accounts for the implements of agriculture, grazing, tanning, house roofing, and some medicinal uses.

CHAPTER IV

THE HUMAN ENVIRONMENT

Bashut, the representative area selected for this study, is located in the central part of the Assarah region, to the south of Baljorashy. The area is characterized by a rugged terrain and a shortage of cultivable land; yet the land is rich in cultural heritage.

The technique of terrace construction used by the people is a monument to the farmers' ingenuity and technical skill. The farmers in this area have so transformed the natural landscape that the land has been made available to agriculture to the maximum of possibilities.

Terracing in this area has been practiced for generations to compensate for the shortage of cultivable flat land, to increase absorption of precipitation, and to prevent soil erosion. Bashut is noted for a highly efficient terracing technique and cultivation of the land. However, the absence of soil around the bouldery steep slopes and the system of land tenure have inhibited the full exploitation of the area for terracing.

Through centuries of land use, the local population has developed an ecologically viable environment. The farmers attach great value to their environment as a guarantee to successful subsistence. They manure terraces and irrigate their holdings in order to preserve a high level of productivity without waste and deterioration of the soil quality.

The local population has developed a conservation technique called Al-Hema (Arabic for "protection"). Al-Hema is applied to agricultural as well as non-agricultural activities. The community abides by an agreement handed down by tradition which requires certain areas to be designated as communal reservations for pastures and forests. Al-Hema, among other things provides for the preservation of the pastureland by prohibiting its use for a year or more and imposing a ban on cutting trees in the pastureland.

Al-Hema, as a conservational technique, has ensured an ecologically sound environment to the community. The area enjoys luxuriant vegetational growth, trees, and the natural habitat for wild life. Soils are in good conditions, considering the long time span they have been under cultivation.

Local farmers understand very well that water conservation is dependent upon soil conservation. Prevention of soil erosion has ensured water conservation. The main source of water supply for human, animal, and irrigational use is precipitation, and the way this limited supply of water has been used by the farmer suggests that he has well understood the main factors that determine the hydraulic regime.

All through the valley where the aquifer is more likely to be found, farmers have dug wells to compensate for the scarcity of water in the area. They have been supported by nature in their efforts by the rock formation. The study area rests on an impermeable igneous rock complex, covered with a porous sandstone formation varying in thickness from a few meters to fifteen and overburden with a thick layer of alluvial materials. This formation has guaranteed a reasonable supply of water to the area, for the rain water is absorbed and trapped in the soil, which ultimately seeps down to the igneous rock base through the subsoil forming a reservoir which is tapped by the farmers through the dug wells. Besides, wells dug in ravines, fissures and faults are known to have plenty of water. Centuries of experience has given these farmers a gift of divining water underground reservoirs. Besides, the farmers have taken every precaution to trap every drop of the runoff water, by digging channels and flanks that lead the water to a place where it can be easily dammed up by means of mud-barrages, sand, stones and branches of trees assembled into a makeshift arrangement.

Despite all these efforts, farmers work long hours all year round to eke out a living. They are confronted with some formidable environmental hazards like drought, hailstorms and disease. A serious drought during the sowing season may ruin the crop. This has made the farmers fatalistic and they tend to attribute such natural calamities as drought and disease to the will of God. However, this pessimism is counterbalanced by an unshakeable faith. Despite temporary setbacks, the farmers always look forward to a high-yield harvest. The farmer's attitude is summed up in the local saying "Law hassab Azzaraa ma Zara" (Mughram, 1973, 91-92), that is, if they brooded over such natural calamities, they would have no time for farming their land. This explains why the Bashut farmer has survived a relatively harsh environment and has continued to retain his love for the land.

The farmers have a great love for their land and have an insatiable desire to extend their holdings by acquiring new farms. The larger the holding, the greater is their prestige. A farmer selling his farm is held in contempt. Even those farmers who have migrated to the cities and have lived there for as long as thirty years are unwilling to part with their farmlands. They keep sending money to their friends and relatives for the maintenance of their farms and wells. They even pay some local farmers to keep their farms going, for abandonment of their farms amounts to the eventual loss of their terraces and wells.

Population

The people inhabiting Wadi Bashut belong to a tribe called Shomran. This tribe occupies a strip of land that extends from the Red Sea coast south of Al-Qunfudah in the west to Wadi Bishah in the east. Bashut, the core of the study, occupies Sarat Shomran, the transitional zone between the people of Tehamah Province in the west and the people of the plateau province (nomadic people) to the east.

No accurate demographic information about Bashut is available at the present time. However, workable data with regard to the population of Bashut were obtained from an

Table 7

Villages, Holdings and Population of the Sub-Areas of Bashut According to the Agricultural Census, 1969

Area	Number of Villages	Holding Household	Population	Male	Female	Family Average
Bashut	10	1143	7397	3504	3893	6.5

Table 8

Estimated Population of the Sub-Areas of Bashut (Author's Interviews and Field Survey, 1975 and 1978)

Village	Households	Population	Male	Female	Family Average
Garn Ben Sahir	200	1700	800	900	8.5
Dar Amer	155	1200	660	540	7.7
Al-Sagifah	140	1000	520	480	7.2
Al-Habil	48	300	140	160	6.2
Al-Harigah	56	350	170	180	6.2
Tha'Alaysen	13	80	40	40	6.1
Al-Husn	24	200	87	113	8.3
Habil Al-Malik	52	400	189	211	7.7
Al Sad	22	170	83	87	7.7
Al Amaren	100	700	342	358	7.0
Total	810	6100	3031	3069	7.3

agricultural census of 1969, the Ministry of Finance of 1975, and from the author's house-to-house field survey in the summer of 1975, his interviews with the farmers and government agencies during the field work of 1978. In addition, the author's intimate knowledge of the territory and the population as a Bashut inhabitant for twenty years, was helpful in analyzing the population characteristics. The discrepancy in the figures for population of Bashut is due to the fact that, at best, these figures are reasonable estimates. For the purpose of this study, the estimates in Tables 7 and 8 form the basis for the demographic and socio-economic conclusions.

The population under review consists of those persons residing in Bashut during 1975-1978 and those who had temporarily left the village. The population of individual villages ranges from 80 to about 1,700 people. There is a slightly larger number of females in the population.

A striking feature of the populace is that most of the inhabitants are under 18 and over 40 years of age. Females constitute a distinct majority of the population of these villages. The reason for this disparity is the emigration of the male population between the ages of 20 and

40 to places of "better opportunities" around oil fields in the east or to the capital in the central part of the country or to the western region.

In the past these migrant young men visited their villages perhaps once in two years and during the holidays and vacations. With the completion of the highway passing through the Assarah region transportation has been greatly facilitated. Home visits of the migrant male population have become almost a monthly event. Despite the comforts of city life, most migrants retain their deep roots in their villages and families. Indeed, during the recent years, many of the villagers have begun to return to their villages.[1]

Another significant demographic fact to be noticed is the steady increase of population during the last twenty years due to the rise of the birthrate over a low, stable deathrate. The estimated population of Bashut of 6,100 people is twice that of twenty years ago, with a density

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[1]The migrant population to the cities from Bashut shows an interesting professional pattern: the people from Garn-Ben-Sahir village join the army or proceed to educate themselves; those from the village of Al-Sagifah become truck drivers; villagers from Al-Ameren go to the cities to join the army; and most migrants from Al-Malik find themselves easily placed in the agricultural offices through the good offices of their relatives already working in government offices.

between 110 and 120 per square kilometer. People are marrying at as young an age as eighteen and younger, compared to twenty and thirty in the past. Besides, improved medical care has reduced the deathrate and child-mortality. The area is practically free of the ravages of infectious diseases that took their heavy toll in the past twenty-five years. Water supply has been freed from contamination and overall improvements in sanitary conditions have almost eliminated disease. Starvation, a scourge of the past, has been unheard of even in severe drought conditions. Food, mostly imported, has become cheap and wholesome. Improvement in the economic condition of the people has made nutritous food within easy access of the population.

Modern methods of agriculture have made farming less strenuous for the farmer. Though his life can hardly be described as easy, he works less hard than his ancestors. All these factors have added to an extraordinary rise in Population in Bashut.

Settlement

Bashut is one of the first areas which was settled in the Assarah region. The settlement can be described as of the sedentary-subsistence tillage type, based on a mixed-farming peasantry and a tribal system of social organization. Historically, there is some question as to how this type of settlement came to take its traditional form (Mughram, 1973, 136).

The spatial distribution of villages and their locations are very interesting from a geographical point of view (Fig. 10). There is a remarkable succession of villages in the north-southward direction, flanking the two sides of Wadi Bashut. The distance between these villages is usually less than two kilometers. Some of these villages are built on the top of hills, while others are located at the foot of these hills. The reasons behind these locations are obvious: avoidance of occupying the arable land, i.e., the deeper soils on the gentle slopes, availability of building material, and, in a historical sense, the defense motif.

Settlements in Bashut are characterized as dispersed, nucleated villages. This distribution is clearly related to the pattern of cultivable land. Villages within the area

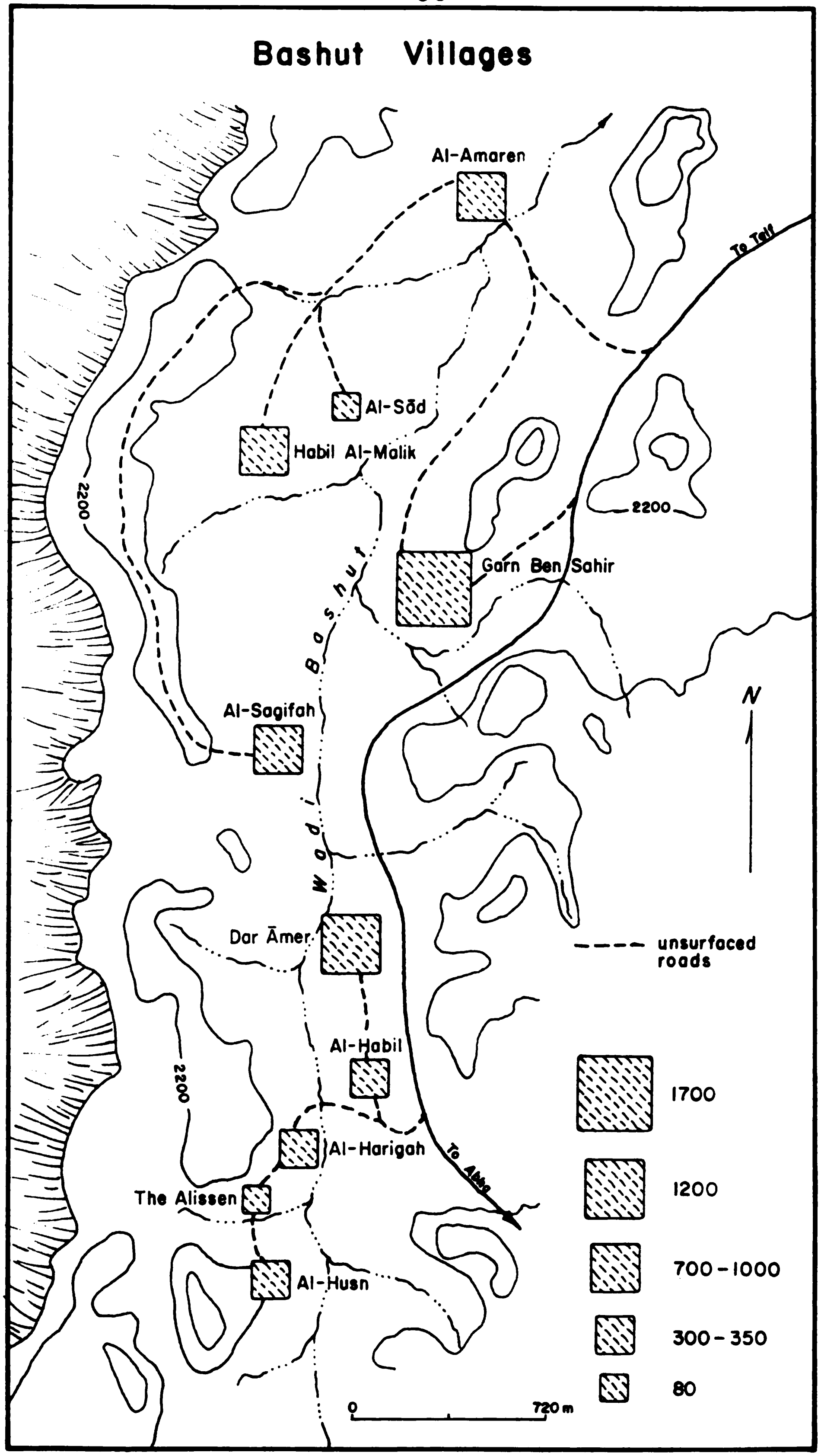
Bashut Villages
Al-Amaren
To Taif
Al-Sōd
Habil Al-Malik
2200
2200
Garn Ben Sahir
Wadi Bashut
Al-Sagifah
N
unsurfaced roads
Dar Āmer
Al-Habil
2200
1700
Al-Harigah
To Abha
1200
The Alissen
700-1000
Al-Husn
300-350
80
0
720 m

Fig. 10

of study are of different sizes (see Table 8 and Fig. 10) which is directly attributable to either the importance of the village through history or the physical character of the terrain they occupy, or both. The village of Garn-Ben-Sahir is one of the oldest in history and the largest in size. Village buildings are tightly packed together and cluster around the main mosque. This village structure of clustered houses is attributed to the functional needs for safety and greater social cohesiveness (Mughram, 1973, 136) (Plate 8).

Villages are divided into "blocks", separated from each other by unpaved streets three or four meters wide. Each block consists of at least ten adjoining houses. Houses are built mainly of granite and basalt. Roofs are made of strong and long juniper beams, thatched and plastered over with mud. Doors and windows are made of such hard wood as acacia. Houses normally have two stories, with three large rooms on each. The first floor is usually used as a storage for fodder and firewood and as a shelter for farm animals. The second floor provides space for dwelling and storage of food grains. The walls are thick, with few openings. This architecture keeps the inside warm and dry. The houses face east and northeast with no openings in the

Plate 8a View of Garn Ben Sahir. Village showing clustered housing pattern, Bashut.

Plate 8b View of Al-Foga village in the country of Khatham, with a more diffuse settlement pattern.

west or the southwest, thereby protecting the interior from being flooded by westerly showers. Besides, the alignment of the houses toward the east and northeast ensures maximum insolation. Winter winds are very cold and dry, and doors and windows are always kept shut. The farmer, in- and off-season, spends his daytime outdoors. He cares less for interior decoration than for the sturdiness of the house. Houses are built to provide shelter for the younger generation.

Traditional methods of building houses have undergone marked changes in the recent past. Nowadays, houses are carefully planned, and the materials used for contruction are imported cement, iron rods, timber and paints. The only local materaials used for building are stones, gravel and sand. Unlike in the past, toilet and bath facilities are treated as essential parts of a house. Houses contain several medium-sized rooms, with at least one window and one door facing the directions suiting individual needs.

The expansion of the villages has varied from place to place, depending on history, functional needs, population size, and location. The village of Garn-Ben-Sahir, in the central part of Bashut, is the largest in this representative area selected for this study (see Fig. 10 and 11). It functions asthe capital not only for Wadi Bashut, but also for the whole area occupied by the tribe of Shomran. The expansion of this village at present is taking place toward the land unsuitable for farming and terracing. However, encroachment on arable land frequently occurs along the two sides of the new highway. The expansion of other villages, like Al-Sagifah, Habil-al-Malik and Al-Harigah on the western side of Wadi Bashut, has been towards the crest of the escarpment. Here, there are wide and flat summits suitable for houses; and encroachment of arable lands of the irrigable terraces adjacent to these villages in the east is not allowed by the village customs and laws. The village traditions maintain that arable lands are a natural resource and a means of subsistence for their lives.[1]

Villages in Bashut are essentially agricultural in nature, but some of them have taken on other functions in recent years. Al-Garn, for example, is the center for government services. It includes four schools, a court, a

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[1]The expansion of Al-Husn village in the southern part of Bashut is a special case. Here, the village was built alongside the slope, even when a large piece of flat land was available at the foot of the mountain. The tribe could not extend its housing program towards this flat land because of a terrible war in the past. After settling the dispute with its neighbors about ten years ago, the village has since begun to expand towards the gentle slopes of the land.

clinical center, a post office and other official buildings. The village also holds markets on Sundays and in the evening of the other days of the week. Peasants sell their crops and buy goods like sugar, tea, rice and clothes. Other villages have at least an elementary school and a post office.

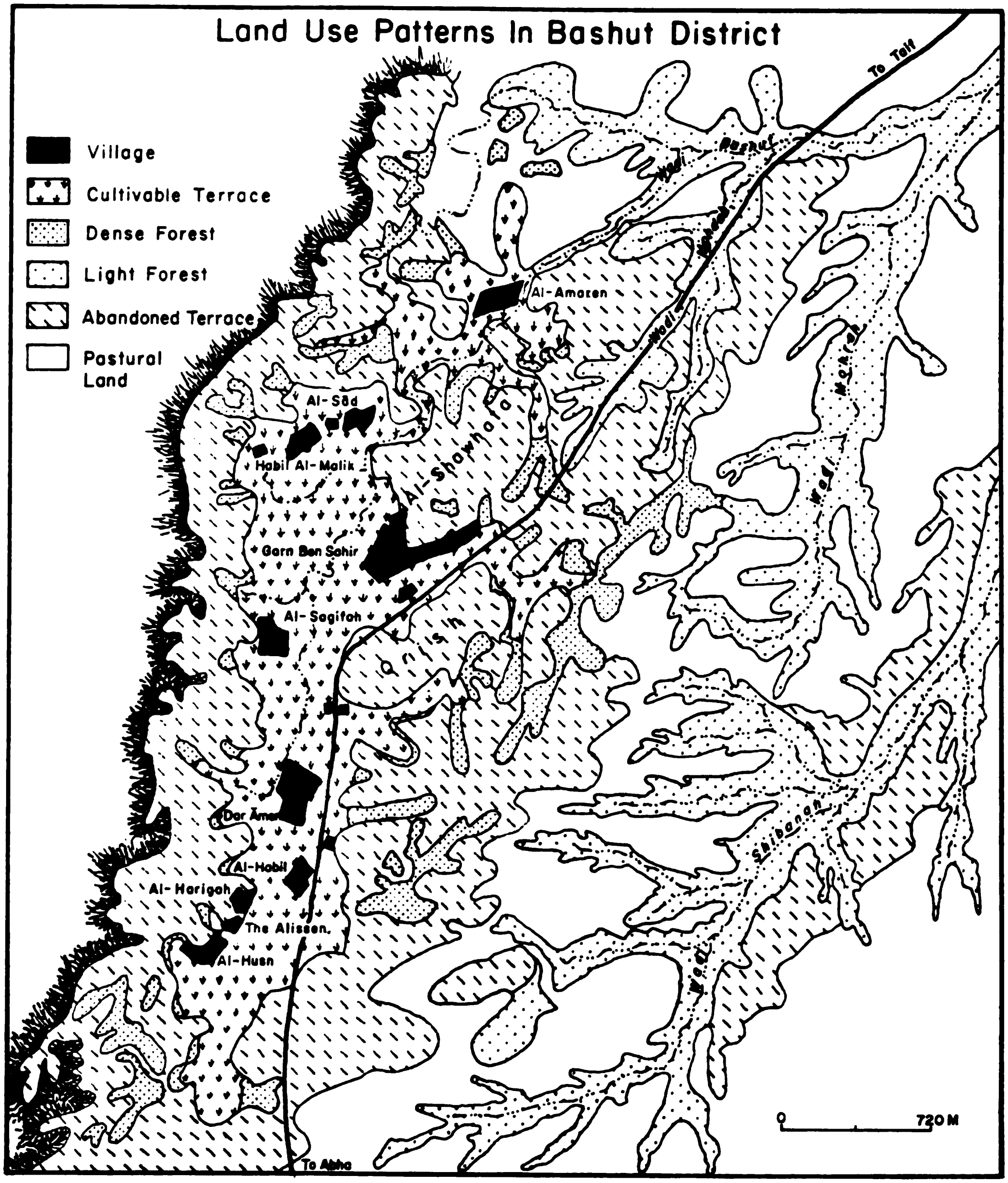
The location of government agencies and other services, such as the market and the mosque, is geographically interesting. The mosque, the place of worship, forms the center of the village so that it is easily accessible to all residents. Al-Husn, whose designs were dictated by defense needs against the tribal warfare, is located on one or two sides of the village. Government offices and the market are located on the other side of the village towards the open pastural lands where the possibilities of constructing large offices exist. Other facilities, like the village cafe, bakery, butchery, businesses, and workshops are located in the market area. In some villages where roads are wide enough for heavy vehicles, the markets are in the midst of the villages.

CHAPTER V

LAND USE PATTERN

Despite the most diligent search during field work, the author could not find any maps or data that indicated previous geographic or any other kind of research in the Bashut area. No description or classification of land use patterns exists, either in official or non-official documents. In the total absence of any usable information, therefore, research efforts were concentrated on establishing the basic nature of land use in the Bashut region, particularly as far as the importance of terracing for land use is concerned.

The main source of information was a set of the 1:60,000 scale aerial photographs (Kingdom of Saudi Arabia, Ministry of Petroleum and Mineral Resources, 1953) from which a map of land use patterns was prepared. On a careful comparison of the aerial photographs taken in 1953 and 1969, it was found that the land use in Bashut had hardly changed except for the emergence of a few new cluster of houses and the new highway (Fig. 11).



Land Use Patterns In Bashut District
Village
Cultivable Terrace
Dense Forest
Light Forest
Abandoned Terrace
Pastural Land
To Taif
Bashut
Al-Amaren
Al-Säd
Habil Al-Malik
Al-Shawhata
Garn Ben Sahir
Al-Sagifah
Anish
Dar Amer
Al-Habil
Al-Harigah
The Alissen.
Al-Husn
Wadi Wahdah
Wadi Maarah
Wadi Shibanah
To Abha
0
720 M

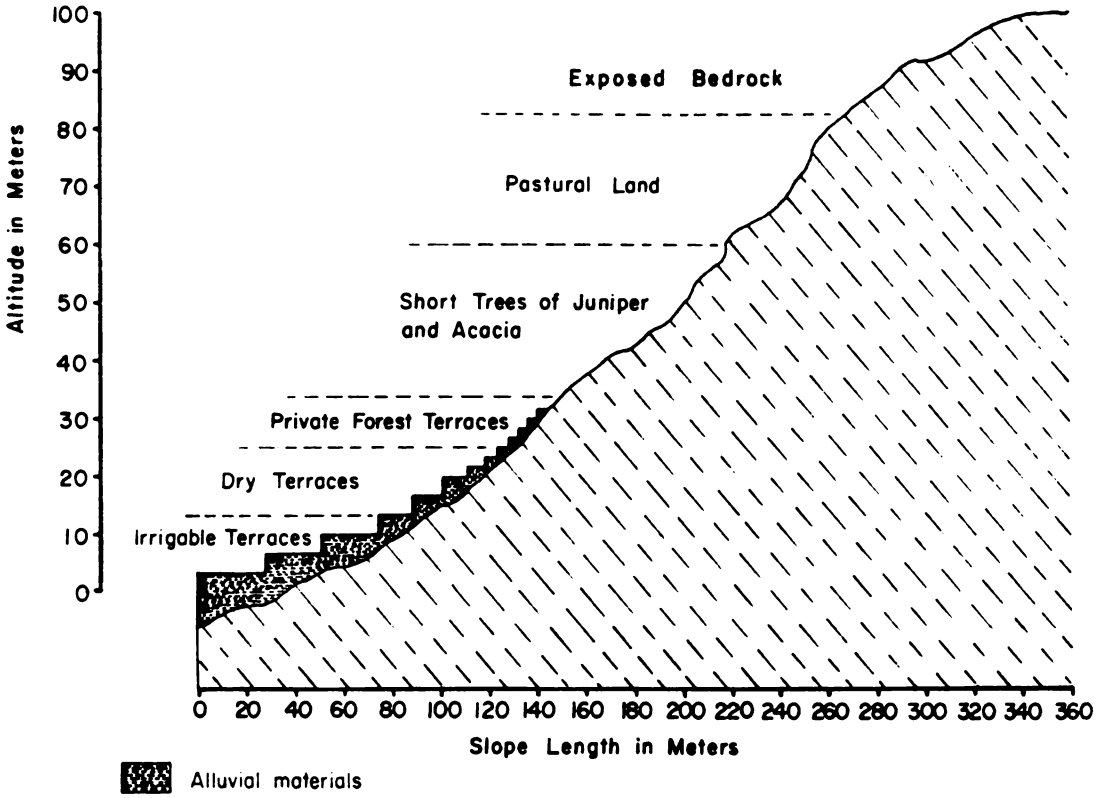
Fig. 11

At the outset, it was recognized that the "geographic factors" of climate, topography, and soil condition determine the spatial distribution of the land use patterns of a region. Topography forms the basis for the classification and evaluation of land, and the slope angle generally determines the nature of use to which land is put (Fig. 12). The climate of a region--in the absence of a technology to compensate for its limitations--directly affects the capability of land for agriculture. Soil depth, fertility and texture determine the productive possibilities of both dry and irrigable land. Shallow soil is generally incompatible with successful agriculture unless the condition is suitably modified by technology and other means. Population pressures, too, over long periods of time are known to have had their effects on land use patterns. The dominate feature in the human adjustment to land types in Bashut has been the construction of terraces and the reclamation of areas that had long been given up for wasteland.

The Land Use Types

The major land use types that are discernible in Bashut are crops, pastures and forests. As shown in Table

Land-use Patterns On a Slope Under Human Utilization



Land-use Patterns On a Slope Under Natural Conditions

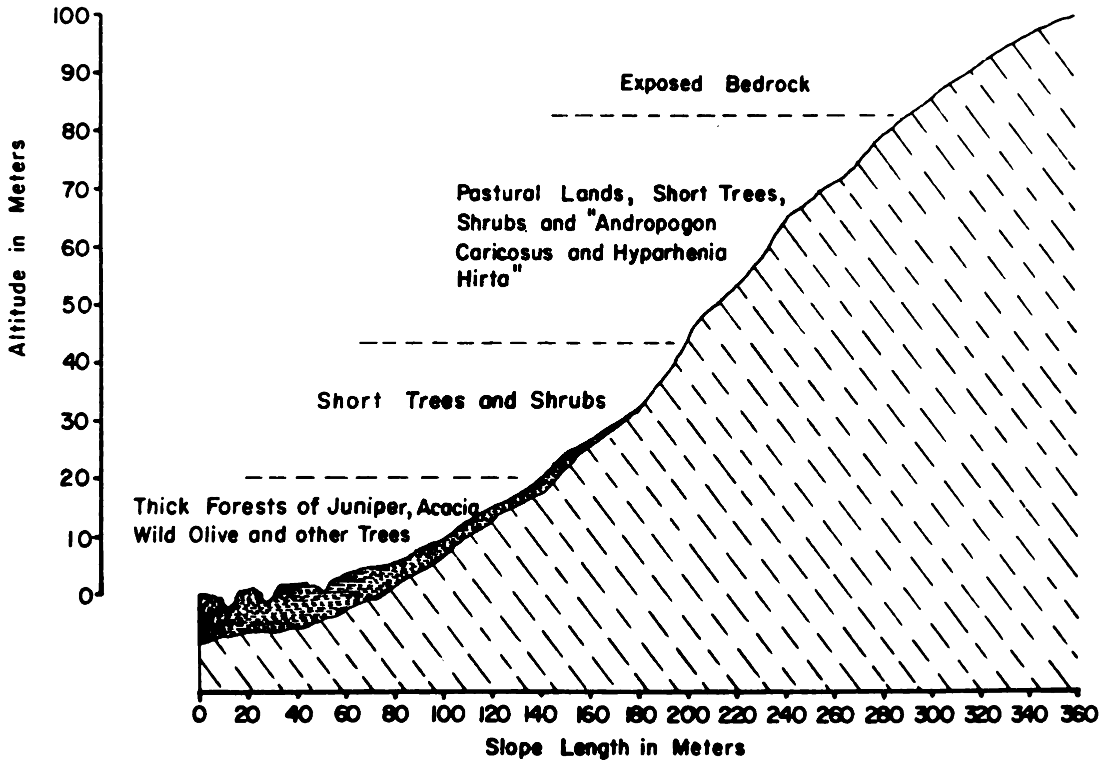


Fig. 12

9 and Figure 1, these, together with the villages and roads, make up the cultural landscape.

Table 9

Land Use Patterns of Bashut[1]

Type of Land Use	Approximate Total Area (Km^2)	Percent of Total Area
Cultivable Land		
Irrigable and Dry Terraces	10	18.2
Abandoned Terraces	10.5	19.1
Forests	8.0	14.5
Pastural Lands	20.0	36.4
Villages	4.0	7.3
Highway	2.5	4.5
Total	55	100%

Farming is still basic to the socioeconomic life of the people of Bashut, despite the recent economic boom in Saudi Arabia. The cultivable land in Bashut comprises about 37% of the total surface of the area. This estimate takes into account all agricultural land, including active and

[1] The interpretation of aerial photographs and field investigation were the bases for this classification of land use patterns.

abandoned terraces, both irrigable or dry (Table 9). Terraces flanking Wadi Bashut itself can be distinguished from those on the slopes by their soil and slope characteristics. The former are noted for their deep, fertile soil and gentle slopes. These terraces are cultivated twice a year, during the winter and summer seasons. They are irrigated by rain water and groundwater wells. The main crops that are cultivated here are wheat and sorghum, though some vegetables, fruits, and alfalfa are also grown.

On the slopes, terraces usually have a shallow soil profile and moderate to steep slopes. These terraces become smaller and smaller in size with increasing slopes. At places, the terrace area hardly exceeds 10 m^2. These terraces depend totally on rainfall for their yearly cultivation activities. The major crops cultivated on these terraces are barley and wheat; some sorghum is also grown.

Abandoned terraces occupy about 19% of the total surface area of Bashut. In other words, these abandoned terraces constitute about half the cultivable land. They form patches of rough land adjacent to the margins of the actively cultivated terraces on the western and eastern sides of Wadi Bashut. Some of these terraces actively engaged in cultivation occupy areas around the gentle slopes that have a deep soil, but they are in need of reconstruction and are located far away from the villages.

Despite the fact that Saudi Arabia is in dire need of cultivable land, half of the agricultural land in Bashut is abandoned. The reasons for this considerable degree of abandonment of terraces are not far to seek. First, these terraces had been scenes of tribal hostilities for long periods of time. War would erupt if one tribe encroached on the arable or pastural land of another, resulting in the death of many farmers. Those who escaped death would emigrate to safer areas. Second, severe droughts and epedemics took a heavy toil, with the result that many terraces were abandoned as their owners were claimed by these calamities. Third, the discovery of oil in Saudi Arabia and the economic boom have brought about a heavy migration of the male population from the farms to the cities, resulting in the abandoment of farming and disintegration of many terraces. Since grass grows plentifully on the abandoned terraces, animal grazing is widely practiced on them. Besides the grass, Juniper, Acacia and shrubby vegetation grows freely on these terraces.

Pastoral land is the second major land use type in the Bashut area. Pastures occupy the rough terrain located on the west and east sides of the study area. They cover an area of approximately 36% of the total land surfaces. A distinction between the pasture land in the west and in the east must be made. The pastoral land located in the west is very rugged and steep. It has a very shallow soil that is affected by heavy erosion. The annual rainfall exceeds 800 mm which is adequate for herbaceous vegetation. Goats are the only animals that can survive in this rugged grassland. The pastoral land located in the east is rough and comprises moderate and steep slopes. This segment is interspersed with numerous valleys. Some of them occupy areas of gentle slope. The soil flanking the Wadi-sides is deep and a reasonable supply of water is in evidence. Villagers who graze their animals in this terrain usually pitch their tents around the grassland at the bottom of the Wadi. The olive, acacia and junipers, together with a variety of bushes and shrubs, dominate this area. Slopes facing the west and the northwest have a thicker vegetable growth than those exposed to the east and the southeast. The reason for this difference seems to be that the heat of the sun during the summer season on the western and northwestern slopes is less intense because of the daily cloud formation during the summer afternoons--a fairly common phenomenon in this area (see under slope aspect in chapter VI). Andropogon caricosus and

Hyparrhenia hirta are the most important grasses. Grazing animals to be found here are largely sheep and cows, though some goats too, are seen. These days, farmers are getting rid of their flocks and herds, as modern agricultural technology has reduced their dependence on their herds. The pastoral lands are non-arable, and the only activities are extensive grazing and cutting grass for hay. However, the vegetation growth is becoming increasingly dense and the soil erosion that was caused by heavy grazing has begun to shown signs of diminishing.

Forests claim an area that roughly approximates 14% of the total land. They are scattered throughout the study area. Some of these forests are located at the bottom of the valleys in the eastern half. Here the soil is deep, moisture relatively high, and the slopes gentle. The trees in the forests are large and dense, though bushes and shrubs form a sizable underbrush. *Juniper procera*, *Acacia seyal* and *Olea chrysophylla* are the dominant tree varieties. Some forests flourish even around the margins of the terraces under active cultivation. Here, too, juniper is the dominant species. These trees make excellent timber, and cutting trees for timber and firewood is the main activity in the forests. Nowadays, the demand for the trees for lumber has fallen, as most of the construction materials are imported. There is every indication that these forests will regrow which will result in a better prevention of soil erosion from runoff and in the increase of moisture retention in the soil.

The villages, roads, and trails comprise about 12% of the land area of Bashut. The villages were built in areas unsuitable for agriculture, immediately adjacent to the farm land. In the recent past, the encroachment of arable land has become pronounced. Houses are constructed along the terrace margins and the new highway was laid out along the eastern side of the active terraces. The loss of cultivable land must be evaluated in terms of the gains that have accrued from t he new highway.

General Aspects of Terrace Agriculture

The investigation carried out regarding impcrtance of the terrace in the present land use pattern leads to the conclusion that agriculture is the mainstay of the majority of the farmers in Bashut. For the annual rainfall is relatively abundant for the cultivation of different types of food crops. Also, the terrace soil in some of the areas is very fertile because of the organic manuring which the farmer regularly undertakes. Sorghum, locally called Durrah, continues to be the most common summer crop. It is grown both for its grain as well as green forage value. Wheat and barley are extensively cultivated as winter crops, but these days they are also grown as summer crops with good results. Alfalfa is grown all year round on irrigable terraces. It is used as fodder for domestic animals, such as cows and sheep. Fruits, especially grapes, peaches, apples and figs, and vegetables of all kind are grown during the summer. They provide the farmer with an income per land unit much higher than he could derive from the sale of food grains. An exceptional family had, in fact, devoted one of its irrigable terraces to the cultivation of tomatoes which fetched them a total income of 30,000 Riyals or about $8,100--a terrace of this kind has never yielded more than $450 per year. 44% of Bashut's arable land is devoted to annual crops such as barley and green fodder. Trees fringe the margins of the terraces and are grown all through the terraces. The majority of these terraces were suddenly put under the plow following a heavy monsoon in August 1978. This rainfall came much later than the usual sorghum plantation time, and the farmers instead of planting sorghum, sowed barley and green forage. The terraces that had been lying fallow were plowed, manured, and were prepared for winter cultivation (Table 10).

Table 10

Crop Types on Terraces in Bashut
Summer Season, 1978

Terraces in	Absolute Frequency	Relative Frequency
Sorghum	161	27.9
Wheat and Barley	63	10.9
Alfalfa (Barseem)	17	2.9
Fruit & Vegetables	11	1.9
Forest & Mixed Crops	253	43.8
Fallow	73	12.6
	578	100.0

Land Use Problems

The agricultural development of Bashut in particular, and of Assarah in general, has many problems; some of them have been mentioned directly or indirectly in the course of this thesis. The foremost problem that one encounters is the fragmentation of agriculture holdings. The factors that exert an influence on the final spatial shape of any agricultural holding are physical, socio-cultural, and operational. The rugged topography of Bashut and the steepness of its slopes are responsible for the uneconomic small-sized terraces. Soil fertility, water availability, and thickness of vegetation have all contributed to fragmentation because each family has tried to acquire fertile land to add to the value of the holdings. The laws of inheritance in the country and the farmers' capacity to farm only limited portions of their holdings, too, have added to the reduction in size of the farms which families and individuals hold. Terraces, scattered far and wide, tend to be neglected by farmers as too time-consuming to farm.

Climatically, the study area is subject to erratic and unpredictable rainfall. The rains are highly variable and may come too early or too late for the agricultural process. Scarcity of rain has usually led to the abandonment of farming and consequently of terraces.

Soil erosion, as it is, is a serious problem in all farming operations and it is excessively so on terraces. Soil erosion on terraces has brought about a total disintegration of the terrace system. Abandoned terraces look no better than deep gullies and washed-out pieces of granite, particularly during the rainy seasons. The terrace soil is fertile, because organic fertilizer is used to manure the soil. The income from farming is very low as compared with salaries in the cities. Most farmers naturally prefer city jobs to farming.

Farming on the active terraces is in the hands of old farmers and women who have moved little from the ancient traditional methods. The same crops are cultivated year after year. Though fruits and vegetables are considered more profitable and rewarding, the farmers have done precious little to grow them. The younger generation, best suited to work these terraces, has largely emigrated to the cities, leaving a big shortage of farm labor. This emigration had additionally caused a rise in the wages of the outside help. A combination of these factors has increased the number of abandoned terraces--a most dangerous problem in the study area.

Farmers, by tradition and custom, do not like to sell their agricultural land. They would rather die than give up their land, because of the shame attached to the seller and the prestige the buyer enjoys. Only a very high price can induce a farmer to part with his farm. This fact itself discourages an outsider or an enterprising farmer to bring his expertise to the area.

The transportation facilities are quite poor. The new road which runs through the study area is the only paved road. The unpaved feeder and farm roads are not suitable for heavy farm machinery. Even high-yielding farms lack facilities to transport their produce to the nearest market area.

There are no dams of any kind in the area except small barrages that the farmers have built for their own use. Surplus water, in the absence of a dam, is lost to farming. Agricultural developmental planning is unheard of in Bashut in particular and in the Assarah region in general.

CHAPTER VI

CLASSIFICATION AND FUNCTIONS OF TERRACE AGRICULTURE IN THE BASHUT DISTRICT

Terraces are the most conspicuous element in the agricultural landscape of Bashut. Wherever an observer's glance may reside, the stepped slopes are in evidence. The original settlers and present-day inhabitants alike discovered that the best means to lower the slope angle, control soil erosion, conserve, distribute, and control water was to construct terraces. There were few or no alternatives for a successful and permanent cultivation of crops in this topographically and climatically "marginal" landscape.

Agricultural terrace systems are determined by the morphology of the landscape on the one hand, their function and structural characteristics on the other. In this chapter an attempt will be made to analyze the terraces of Bashut according to morphologic and functional criteria. These criteria account for most of the significant variation of the terracing technique in the investigated area.

In this study, a terrace is defined as an artificial horizontal surface, constructed on a natural slope, exhibiting three main components: the retaining wall, which traps the soil which accumulates behind it; the lip, an extension of the terrace wall which conserves water in the terrace; and the terrace flat unit, the agriculturally productive area.

Morphology

Terrace morphology is the product of constructional and repair procedures. In the study area there are three ways in which the filling is carried out and the terrace is formed (Fig. 13). The first of these may be described as backslope digging and foreslope filling up to a considerably high degree. This type of filling is used for the constrution of terraces located on slopes of moderate to steep angles. The most widely occurring terrace types originates from natural, or hydraulic filling, since particles of erosion are transported to and deposited at the walls by water, thus plugging gaps in the walls. This method of filling is practiced on the cross-channel terraces. The third method of filling is a combination of the above two,

Structural Terrace Types

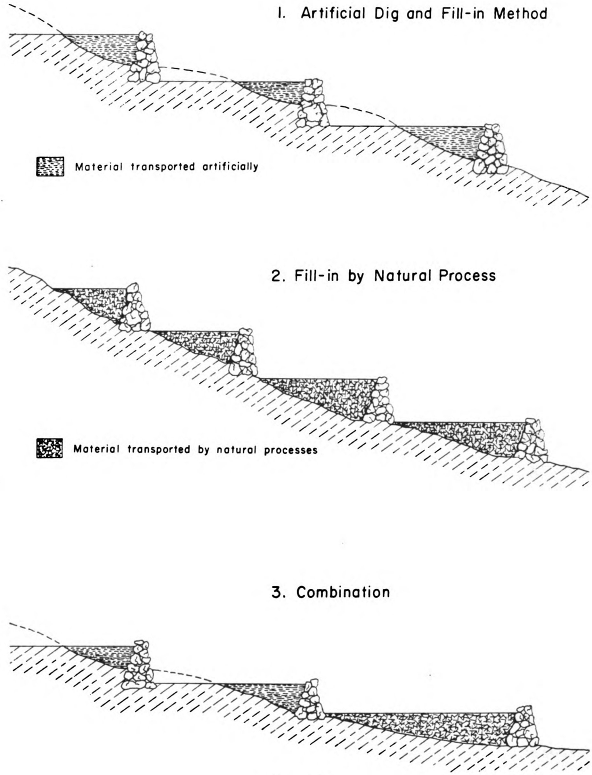


Fig. 13

and is commonly found on terraces located at the foot of the slopes or near flat surfaces that are easily irrigable. Once the walls are filled, levelling and smoothening is undertaken. In the past these activities were either carried out by hand or by animals, but these days bulldozers and graders are commonly used. The construction of the lip follows the compilation of the terrace wall and the levelling of the terrace berm.

In order to reconstruct abandoned terraces the top soil is removed to one side before infiltrating the subsoil with the fines. The surface is then covered over evenly with the organically rich soil that was first removed. In some cases, this scraped-off soil has been used in the next terrace below, because these reconstructions begin with the lowermost terrace and rise successively to the top. A terrace is generally given a backward tilt against the slope dip for irrigation and maintenance purposes.

Terrace Relationship to Terrain Configuration

The agricultural terraces of Bashut can be classified into four basic types with respect to their relationship to the nature of the terrain (Fig. 14).

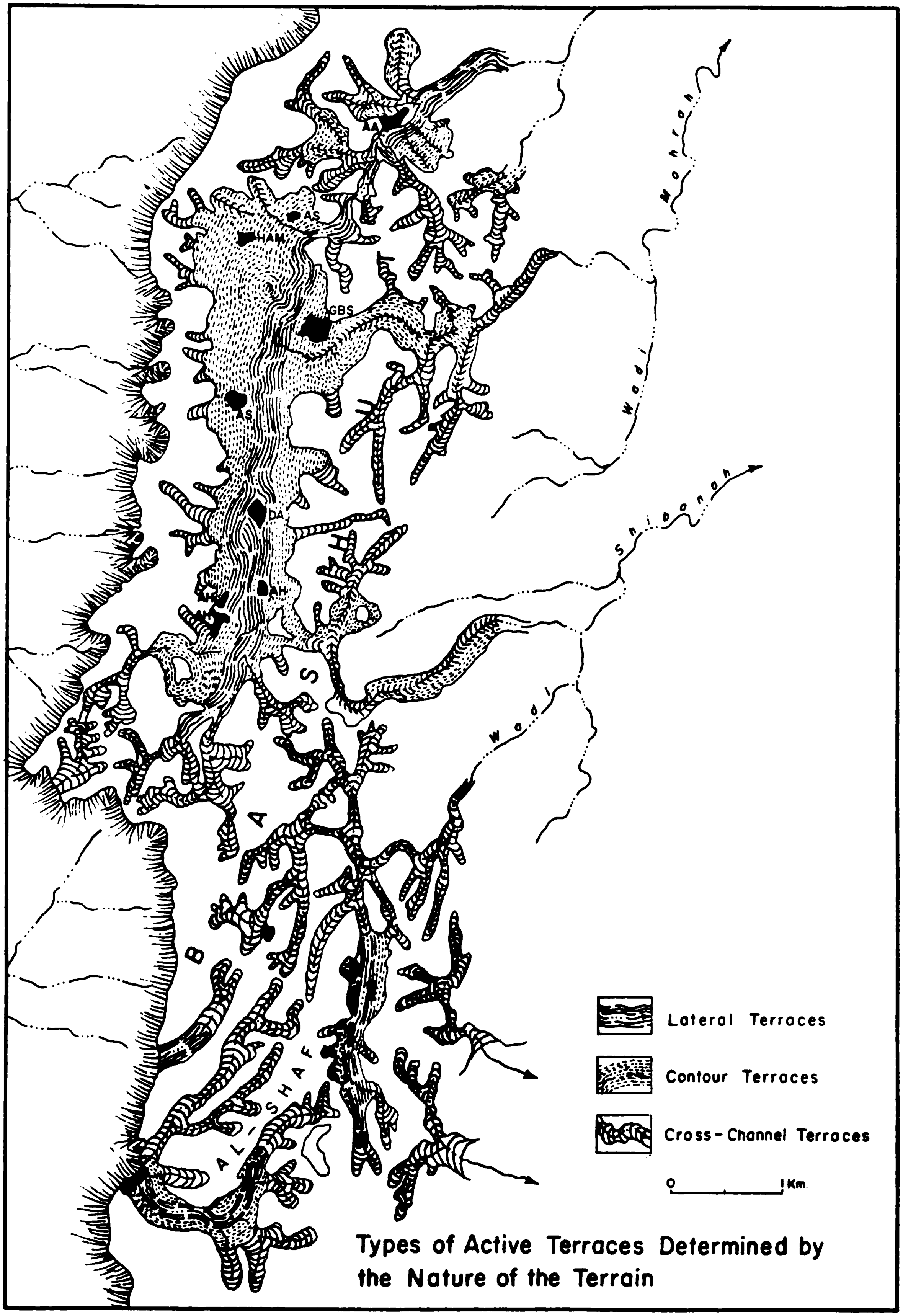

Wadi Mahrah
Wadi Shibanah
Wadi
Lateral Terraces
Contour Terraces
Cross-Channel Terraces
0
1 Km.
AL-SHAF
Types of Active Terraces Determined by the Nature of the Terrain

Fig. 14

Lateral Terraces

Terraces which occupy the two sides of Wadi Bashut may be called lateral terraces. These terraces are undoubtedly the oldest in the Bashut district: they were built where the most productive soils of the valley occur, where the slopes are gentle, and where water can be most easily obtained (Plate 9).

The lateral terraces are protected by retaining walls that run along the sides of the Wadi and are built from large, non-dimensioned granite boulders. The boulders used at the base of these walls are as large as 1 m in diameter, strong enough to withstand the force of surface run-off. Smaller boulders are usually piled on top of the base boulders. The height of these walls varies from place to place along the valley. Lateral terraces flanking the entrenched portion of Wadi Bashut in the northern part tend to have walls of about 2 to 3 m; the terrain here is rugged and the side slopes of the valley are steep. The walls in the southern segment of Wadi Bashut, on the other hand, are low, reaching about 1 m in height. The valley here is broad and the slopes are gentle.

The cultivable area for crops from each of these terraces is as large as 150 m in length and 60 m in width.

Plate 9a Lateral terraces of Wadi Bashut, sub-rectangular in shape and of level surface. They are divided into strips by small embankments of dry stones and mud.

Plate 9b Lateral terraces near the new highway in the Al-Shaf, south of Bashut. These terraces represent the original shape of lateral terraces with some modification.

Most lateral terraces are sub-rectangular in shape and of level surface. They are irrigated by water from wells, which is carried to all parts of the terrace through small channels cut in the surface. Wherever the water cannot reach because of the uneven ground, the surface is manually levelled to facilitate the flow.

The terraces of today are markedly different in shape from what they used to be in the past. Some of the terraces are decimated by parallel mud boundaries dividing a single unit into fragments. This fragmentation is largely due to the complex laws of inheritance. Each proprietor prefers to have a piece of the property divided along the face of the hills with the belief that this will ensure the maximum of water supply from down the slopes, and soil fertility. While fighting for his portion, each farmer would make sure that his portion suffered the least loss due to damage to the terrace walls. Besides, such a division makes it easier to add to one's holding by purchasing the adjoining smaller and consequently cheaper piece of the property along the length of the terrace.

The material of these lateral terraces is fertile and runs to the depth of about 3 m because of its alluvial nature. Profiles of alluvia prepared in the area indicate that the AP horizon is made up of silty clayey loam texture, while the sub-soil is composed of a clayey loam over a formation largely sandy loam overlying mixed coarse fragments and sand. Agriculture on these lateral terraces depends largely on the amount of water available from wells, as well as from rainfall. Floods usually leave behind a new and thin layer of silt, locally called "rabdd", of a few millimeters which adds to the fertility and thickness of the soil. Some ignorant farmers scrape off this silt and dispose of it, while others who understand the value of these deposits distribute it well over the whole terrace.

Contour Terraces

There are two types of contours or along-the-slope terraces found in the area: the irrigable contour terraces and the dry contour terraces. The former are located between the lateral terraces and the dry contour terraces and occupy the foothill areas at the margins of the lateral terraces on both sides of Wadi Bashut. Terrace walls of the irrigable terraces consist of a double row of stones with mixed filling of rock debris, gravel and mud. The height of the terrace walls generally does not exceed 1.5 m, since these contour terraces are built on the gentle and moderate slopes of the hillsides.

Cultivable areas reclaimed by each terrace unit are flat and level and are easily irrigable through man-made means. Generally, a terrace of this type is of about 70 m long and about 40 m wide. Wherever the slopes are gentle, terraces tend to be square in shape, but, in the areas of steep slopes, the majority are rectangular. The soil on these terraces is fertile and about 2 to 3 m deep. These irrigable terraces were originally built at the foot of the hills where silt was accumulating in alluvial fans. The soil is evenly distributed all through the cultivable areas on these terraces. Besides the soil being rich and thick, it is azonal, dominated by clayey loam texture in the AP and clay in C horizons. The irrigable contour terraces are fed with water from rain a nd wells. Water is plentiful and the whole area is served with wells (Plate 10a).

The second type of contour terraces, the dry variety, usually dominates the higher slopes on either side of the valley, both in the west and the east of the study area. Terrace walls are made of dry masonary rocks along the contour lines. The wall material was brought in from an adjacent outcrop of granite rock. The walls usually consist

Plate 10a Irrigable terraces on moderate and steep slopes in the Jedaen Mountain, NW of Garen Ben Sahir. The walls are semi-vertical and they usually consist of two rows of boulders with filling of gravels and earth in between. The wall face is smooth and consists of semi-symmetrical materials.

Plate 10b Dry field terraces on moderate and steep slopes, near Shomran Elementary School, Garen Ben Sahir. Terrace length sometimes exceeds 150 m; the walls are high and sometimes closely spaced, with a pathway between. Dry field terraces need less maintenance than irrigable terraces.

of a single row of stones, of sizes varying from 40-100 cm across. Terrace walls are parallel to each other as well as the river course. They become higher as one goes up-slope, as the gradient of the slopes usually increases up-hills (Plate 10b).

The area reclaimed for cultivation on the majority of terraces is flat and level, in order that irrigation may be carried out efficiently. These terraces vary in size, the larger ones being found on lower slopes. Their lengths vary from 10 to 60 m and their widths vary from 4 m in the upper region of the slopes to 30 m in the lower regions.

The soil on these terraces is usually thicker at the terrace toes, as the silt tends to get accumulated along the retaining walls. Away from the retaining walls the soil is getting shallower, from about 30 to 50 cm in thickness, until at the upper ends of the terrace the bedrock is reached, often level and filled-in with silt. In these portions of the contour terraces the surface is marked by rock outcrops and stony soil. Because of the change of the physical conditions of the lower and upper terraces of the contour types, the land use patterns and irrigation methods are also different. As Fig. 14 shows, the spatial distribution of these terraces is interesting. They occupy moderate to steep slopes, especially on the Al-Shafa Mountains in the west and the Al-Shoahatah and the Qrish Mountains in the east of Wadi Bashut.

Cross-Channel Terraces

The Bashut district is marked by headwater channels of the first and second orders. These channels are almost exclusively transformed by cross-channel terraces which were formed by building massive stone walls across the channels. Terrace walls are strong, double rows of masonry granite, with basaltic stones laid across the channel floor. Massive boulders, some as large as 100 cm across, are used at the base of the walls. The walls either run straight across the bed of the dry channel or curve convexly upstreams. Curved walls are the most popular method of cross-channel terracing, as they are the most efficient buffers to withhold the force of flood waters. Their height ranges from .5 to 2 m (Plate 11).

The original development of the cross-channel terraces may well have been the result of natural forces. Obstruction by massive boulders resulted in interstitial accumulation of sediments after the rainy seasons. The

Plate 11a Irrigable cross-channel terraces; the walls are curved convexly upstreams (near the village of Al-Amaren).

Plate 11b Dry cross-channel terraces with straight walls (near the village of Shagig, just east of the new highway).

layer of silty soil mixed with sand, gravel, and organic materials behind the dam in time becomes thick enough to make agriculture possible. These small dams and the areas behind them formed the threshold from which the expansion of cross-channel terraces towards the lower areas and upper reaches of the channels progressed. The building of stone walls across the alluvial channels was an obvious method for incipient agriculture in the area. Possibly, the construction of the cross-channel terraces followed successive stages of downstream terrace development.

The cultivable areas salvaged in each unit runs to a length of approximately 50 m and a width of 30 m. Some of these terraces are as large as 80 m in length and 40 m wide. Terraces of this kind dominate the broader portions of the valley which are wide and have a deep soil. Terraces become smaller in size towards the upper reaches of the valley. Here, they hardly exceed 50 m^2, and alluvial fill is shallow. Cross-channel terraces depend for irrigation directly on the amount of rainfall runoff in the watershed during the rainy seasons. The deposition of a thin layer of fresh sediments, mainly silt, carried by the run-off water, is pronounced during each rainy season.

Cross-channel terraces dominate the area occupied by the villages of Al-Shaf in the southern part of Bashut. They are also widely distributed through the Bashut district, especially in the upper valley reaches to the east and west of Bashut Valley. The land use of these terraces is fairly diverse: terraces that are located in the Wadi beds near villages are devoted to mixed farming, while those that are located far away from settlements have mostly seasonal farming or are forested.

Abandoned Terraces

Throughout Bashut Valley, a large number of terraces, of lateral, contour and cross-channel type, have been abandoned. Main areas of deserted terrace land are to be found in the more rugged portions of the area, though some abandoned terraces would be perfectly cultivable. The abandonment of these fertile terraces is attributed to their being located very far from the villages or their being owned by entire tribes or villages. If they are very distant from the villages, they entail a great deal of hardship for the farmers to maintain them; and if jointly owned by tribes or villages, no single individual feels personally responsible for its maintenance (Plate 12).

Plate 12a Abandoned dry-field terrace in the southern part of Bashut, near Al-Habil village east of the new road. Note the collapse of any part of the wall will lead to the collapse of the whole wall and the wash of terrace soil.

Plate 12b Abandoned dry-field terraces near Al-Matla, in the country of Beni Omro. Usually the collapse of any terrace wall leads to the destruction of both the terrace flats above and below the wall.

In addition, rainfall variability, ground water shortages, decreasing soil fertility, and changing land use patterns are among the most important factors that have contributed to the abandonment of these terraces. Although Bashut experiences an average rainfall of about 500 mm, two-thirds of this annual rainfall may be recorded in one downpour before or after the sowing seasons. Often, seasonal rainfall is inadequate to make farming worthwhile, the groundwater level depression may force farmers to abandon their wells--followed by their abandonment of their farming and, eventually, of the terraces. The system of inheritance has been another cause for the disintegration of fields originally owned by one farmer. Fragmentation, besides natural changes and human neglect, is clearly a contributory cause for the abandonment of terraces.

Classification of the Terraces According to

(a) Angle of Terraced Slope:

The terraces in Bashut can be classified into three types in terms of the steepness of the slopes on which they are located (Fig. 15). The majority of the agriculturally viable terraces in Bashut are on the near-flat surfaces of 0^{o}-10^{o} slope angle (Table 11a). Field measurements indicate that the average slope does not exceed 3^{o} for the majority of the irrigable terraces that occupy the central part of the area dominated by active terraces. The areas of concave slopes around the foot-hills are largely occupied by dry terraces. This type of terrace land has been observed to have an average slope of about 6^{o}, though some terraced areas of 10^{o} angle are well pronounced in the region. The cultivable area reclaimed by terracing is generally flat and smooth. Measurement show that these smooth surfaces are partically level (average slope less than $1/2^{o}$).

Field measurements have further indicated that there is a positive correlation between the height of the walls and the angle of inclination of the slopes. The height of the walls increases with the angle of inclination of the slopes. In other words, terraces that have low walls are located in the areas of gentle slopes. On near-flat land, the walls of the terraces do not exceed 1 m in height; on steeper slopes, the walls do not rise higher than 2 m. 84.1% of the terraces have walls that measure less than 2 m, and 82% of these terraces are located on gentle slopes.

Table 11

Terrace Classification According to Selected Criteria
(Sample Size 578 Terraces)

Terrace Characteristics	Absolute Frequency	Relative Frequency %
a) Angle of slope		
Gentle	475	81.8
Moderate	67	11.6
Steep	38	6.6
b) Slope Aspect		
East (exposer)	170	29.4
West terrace	186	32.2
North terrace	147	25.4
South terrace	75	13.0
c) Wall Characteristics		
Wall Height		
Less than two meters	493	84.3
Two to three meters	69	11.9
More than three meters	26	3.8
Wall Position		
Vertical wall terraces	246	42.6
Oblique wall terraces	332	57.4
d) Terrace Size		
Small terrace	152	26.3
Medium terrace	123	21.3
Large terrace	303	52.4
e) Terrace Width		
Narrow terrace	328	56.7
Wide terrace	250	43.3
f) Lip Size		
Small	296	51.2
Medium	137	23.7
High	145	26.1
g) Water Supply of Terraces		
Irrigable terraces	232	40.1
Dry-field terraces	342	59.1
h) Land Use		
Mixed farming terraces	240	41.5
Term farming terraces	233	40.3
Tree-crop terraces	105	18.2

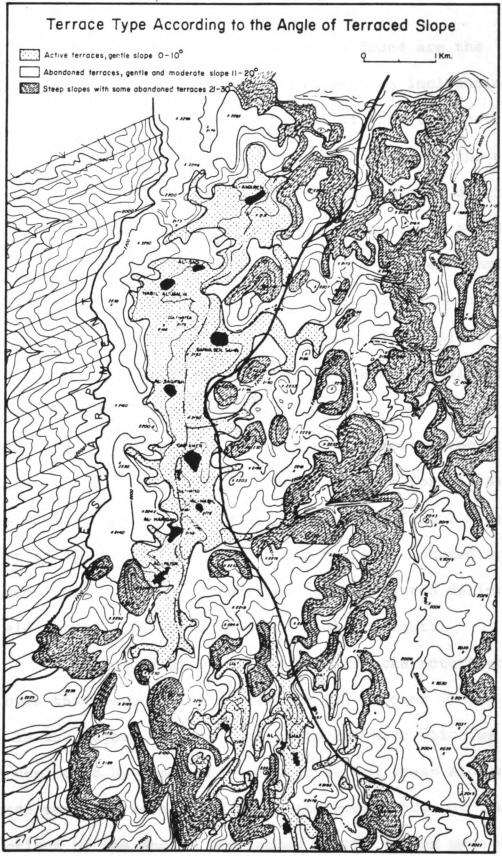

Terrace Type According to the Angle of Terraced Slope
Active terraces, gentle slope 0-10°
Abandoned terraces, gentle and moderate slope 11-20°
Steep slopes with some abandoned terraces 21-30°
0
1 Km.
ESCARPMENT

Fig. 15

The second variety of terraces found are the moderate-slope terraces that are located on inclinations that vary from 11° to 20°. Terraces of this type cover about 30% of the total land area. They are located at the margins of the land currently under cultivation and east of the new highway which runs through thousands of acres of abandoned terraces. The typical inclination of the slopes commonly found in this region varies from 15° to 20°. The occurrence of moderately steep slopes in this part of the study area is due to the ruggedness of the terrain. Heavy erosion has further steepened slope gradients.

Terraces located adjacent to the active terraces lie on an average slope of 13°. These terraces form 11.6% of the whole terrace area. Wall heights vary from 2 m at the foot of the hills to about 3 m for terraces located on the side-slopes. Of the terraces actually measured during the field survey 11.9% have walls of medium height.

The second group of terraces are characterized by slopes that have an inclination of 21° or over (Table 11a). It is the rugged terrain located to the east which is largely dominated by abandoned terraces cut on steep slopes. These terraces were built along the steep sides of incised sections of the Wadi. The angles of the slopes upon which these terraces were constructed here range between 21° and 25°, sometimes even reaching 30°. The majority of the terraced walls are damaged by flood waters in above-normal rainfall years. In most instances, the base walls are still there but the terrace soil has been completely eroded away from the terraces.

Within and around the agriculturally viable terraces rise some ten mountains that extend over quite a large area of land (Al-Shaohatah, Kerish, and Al-Gaza'āh). These mountains are extremely steep, especially in their upper reaches. In the past, their slopes were fully terraced, but at present the majority of these steep slope terraces have been abandoned, mostly due to heavy erosion. The soil thus washed away by the run-off water is not completely lost to agriculture as it is deposited by the surface water on the lower slope terraces.

Measurements made during the field work indicate that 7.1% of the terraces are located in the areas of steep slopes. Though most of them have been abandoned, some of them are still actively cultivated. The average slope of these terraces does not generally exceed 22° in the lower parts of the mountains and 26° in the upper region terraces.

It is found that 3.8% of the terraces have a wall height of 3 m or more, as indicated in Table 11a.

(b) Slope Aspect of Terrace:

Old-fashioned peasants in the study area have paid little attention to the slope aspect of their terrace, not because they have not understood the relationship between agriculture and the direction in which their terraces face, but because they have always been in such a dire need of every arable piece of land they could get. From the standpoint of aspect, three terrace types can be distinguished. Terraces with north and northwest exposure usually receive a high amount of winter rain which usually arrives with westerly winds. The terraces located on these slopes also retain a good amount of moisture during the summer season because of higher cloudiness. This phenomenon contributes to the cultivation of crops on the terraces by a ready supply of water from rainfall and wells.

Southwest-exposed terraces receive the highest amount of water during the spring and summer, during which seasons southwesterly flow predominates. The rate of evaporation on these slopes is lower because of the afternoon clouds that usually reduces the insolation.

East and southeast terraces always receive the lowest amount of rainfall because they occupy the slopes that are located in the shadow of the rain in most weather situations. Besides, these terraces lose a high amount of moisture to heat and exposure. The area receives intense morning heat (Table 11b).

<u>(c) Terrace Wall Characteristics</u>:

Essentially, the terrace wall consists of three well-defined segments: the base, the main wall, and the lip. The base wall usually rises on the contour from an excavated ditch or trench 30 cm deep and 1 m wide. Large boulders are then laid out in two rows in the ditch with a mixture of filling to cement them together. On top of this base are piled smaller pieces of stone which are shored up with large pieces of stone placed in strategic places for support. The majority of these walls have a well-defined face and a back. The face is generally smooth and is constructed out of symetrically shaped rock blocks, but the back may show cleavaged and rounded stones. After the stones have been piled on the base, the filling of the gaps begins. Sometimes this filling is undertaken after the whole wall has been erected (Plate 13).

Plate 13a Particularly high terrace wall in Bashut. This wall collapsed and was reconstructed at least twice. Due to levelling of the flat below the wall further destruction may occur.

Plate 13b Original stream line on valley bottom, artifically contained between walls of first lateral terraces. During the dry season, channel as a pathway (in the central part of Wadi Bashut).

In terms of wall height and position, vertical and oblique types can be differentiated (Table 11c). Terraces with oblique walls are usually high, reaching an average height of three meters and maxima of 3.5 meters. Terraces of this type dominate the areas that have moderately steep to steep slopes. These regions always suffer from heavy erosion by water, and the best way to control this erosion is to construct terraces that have oblique walls towards the rear of them. This type of walling is strong enough to hold down the thick soil that gets accumulated along the walls, especially in the steeply sloping parts. Walls of this type have always required massive boulders at the base.

The second wall type is characterized by vertical, short walls. Terraces of this type extend over areas that have gentle slopes, supporting the irrigable contour terraces. The wall heights rarely exceed 1 m, but constructions as high as 1.5 meter are noticeable. The wall on these slopes need not be oblique at the rear end of the terraces, as the run-off water does not pose a threat to the walls and the surface soil by way of erosion. The care and attention that seems to have been given to the vertical walls is due to the fact that the irrigable terraces generally receive greater maintenance. This type of terrace maintenance is directly related to successful farming.

(d) Terrace Size:

The agricultural terraces in Bashut can be grouped into three types according to their size, a classification taking into account the farmers' conventional breakdown into small, medium and large terraces (Table 11d and Fig. 16b). A terrace that has an area of 30 asas[1] is considered large, while the medium size terrace usually has an area ranging from 10 to 30 asas, and the terrace characterized as small is usually less than 10 asas in area.

Large terraces occupy the near-flat areas of land which have very gentle slopes. Most lateral and irrigable terraces fall under this type. The average size of the terraces of this type is about 1 ha, though in some parts they exceed 20 ha which is generally considered very large. However, these terraces have undergone a complete pattern change from what they used to be in the past. Under the complex Qur'anic system of inheritance, almost all of the surviving relatives of the original owner, have a right to a portion

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[1]1 asa = 60 m^2, is the basic unit of measurement used by the farmers of the area.

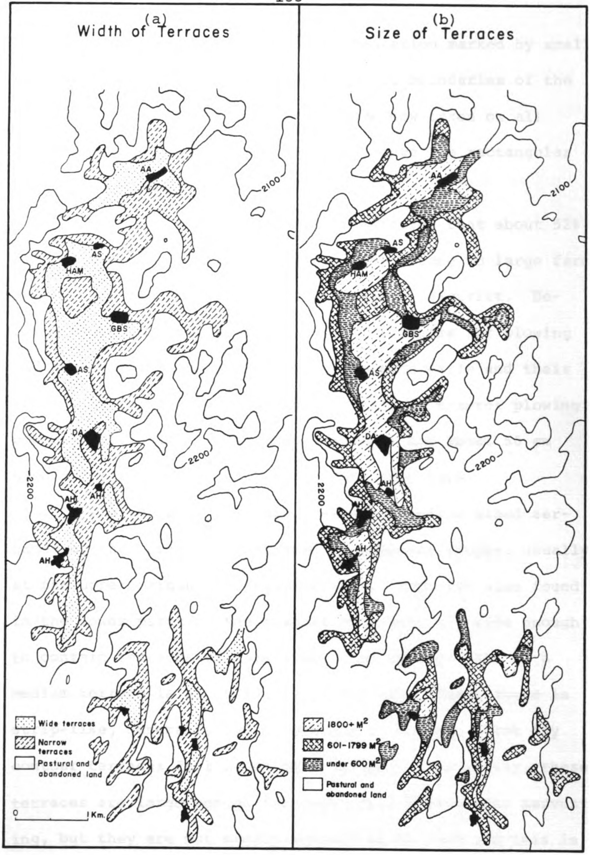
(a)
Width of Terraces
(b)
Size of Terraces
AA
AS
HAM
GBS
DA
AH
2100
2200
Wide terraces
Narrow terraces
Pastural and abandoned land
0
1 Km.
1800+ M^2
601-1799 M^2
under 600 M^2
Pastural and abandoned land

Fig. 16

of it, resulting in a thorough fragmentation marked by small embankments of mud and grass showing the boundaries of the division. These divided terraces have now taken on all kinds of shapes and sizes. Some fragments are rectangular and some are square.

The field measurements have indicated that about 52% are still in large compact units. They belong to large farms and are located in the heart of the Bashut district. Because of their large size, the use of tractors for plowing and other operations is possible. Terrace walls and their short lips do not pose a serious problem to tractor plowing because most walls around these terraces are about 50 cm high and the tractors can easily pass over them.

The terraces that are treated as medium sized terraces by the farmer concentrated on moderate slopes, usually at the upper margin of large terraces. Some are also found in the lower parts of the channel beds that are wide enough to contain terraces of this size. The average size of a medium terrace is about (.3 ha). The most common shape is strip-like, generally 150 m long and 20 m wide. Most dry contour terraces fall under this category. Generally, these terraces are large enough for mechanical plowing and harvesting, but they are not easily accessible by road and this is why mechanical farming has been very sparingly used in this area. Another factor inhibiting mechanical farming is the walls that are usually 2 m high. Medium-sized terraces constitute 21% of the total terraced area of Bashut.

The type of terraces described by the local farmers as small dominate the upper slopes and reaches of the Bashut district. These small terraces are characterized by steep slopes and high walls that rise as high as 3 m. Average size is about 40 m^2, though some can be as small as 50 m^2. Mechanical farming is impossible here. Besides the nature of the terrain, the tradition has tended to discourage advanced methods of farming.

(e) Terrace Width:

The width of a terrace is in an inverse relationship to the degree of inclination of the slope on which the terrace is located. As the degree of inclination increases, the terrace width proportionately tends to decrease.

Wide terraces usually have a width of about 45 m, though in some regions they are found to exceed 85 m. They are mostly found on slopes whose average inclination is 4°, though such wide features have been found to exist on slopes with an inclination of 8 degrees. They are located on the near flat land in the central part of Bashut and on the adjacent lower slope lands with concave slope profiles. The wide terraces constitute 43.1% of the total terraces of the area as has been indicated in Table 11e, and Fig. 16a.

The second variety of terraces described as narrow terraces are essentially a feature of moderately steep to steep slopes, exhibiting angle variations from 15° to 30°. The width of the narrow terraces generally does not exceed 14 m, though in places the terraces have been found to be as narrow as three meters wide. However, there were some isolated areas where width reached to almost 25 meters. During the field survey it was found that a good many terraces were in the range of 170 meters long and 24 meters wide, and at the same time some terraces admeasuring 220 by 9 m were also found. These terraces were developed on steep slopes in the east and west of Bashut. The narrow terraces amount to 56.7% of the terraced area of the study area. This percentage shows that the area is fairly equally divided between wide and narrow terraces, as it is evident from Table 11e, and Fig. 16a.

(f) Lip Size:

The term "lip" may be applied to the superstructure of mud, grass, gravel and stone piled on top of a wall to retain water and soil on the terrace itself. The terrace lip performs useful agricultural functions on terrace land, such as water conservation within the boundaries of a terrace, prevention of silt and sediments from being washed away, together with animal and vegetable manures as fertilizers. An additional function of the lip is that it provides a protection to the terrace walls. Any damage to the lip is an indicator that a threat to the wall itself is imminent.

Finally, the lip channels the water from the wells to the surface area of the terraces. By cutting a small channel 15-30 cm deep and wide in the lip, the water is led from one terrace to another.

Among the minor functions are that they serve as pathways between terraces, areas of luxuriant growth of grass for the farmers' sheep and cattle, and platforms for sheaves of fodder.

Small-sized lips point to dry field terraces at the margin of agriculturally viable terraces surrounded by forests.

On the other hand, medium-sized lips adorn most irrigable terraces, while most lateral-valley, cross-channel and lower slope terraces are dominated by big lips (Table 11f).

(g) The Water Supply of Terraces:

In broad terms, the terraces in Bashut can be divided into: the irrigable and dry field types (Fig. 17b). The irrigable terraces lie near the man-made wells. They can be further divided into those that directly depend on the underground water wells and incident rainfall and those that depend on the underground water and stream run-off, or indirect rainfall. The common feature these two types of irrigable terraces share is a flat cultivable surface, easily amenable to irrigation by simple gravity flow. Both types depend for irrigation on the water pumped from the well, either by the traditional methods or by modern electric devices. In order to make water available to the entire cultivable surface of the terraces, a continuous maintenance of small canals and channels is required for good quality irrigation. Before irrigation begins, the soil has to be plowed, the seeds have to be sowed, surfaces to be levelled and divided into small basins, each of about 4 m^2. The water is carried from one bed of these basins to the other by a system of interconnecting tiny channels, generally branching from the main atery of water that generally runs through the middle of a terrace. It has been estimated that the water absorbed by each basin does not exceed 15 cm at a time. These irrigable terraces require irrigation two to three times during the winter and four to six times during the summer. In above-average years artificial irrigation may not even be necessary (Plates 14-17).

Field measurements carried out during the survey have indicated that 40.1% of the terraces depend directly on the underground water and precipitation (Table 11g).

The field survey revealed that the terraces that depend on direct rainfall as well as on underground water usually have medium to small lips. The reason for this size of the lips is that the amount of moisture made available to these terraces by precipitation does not exceed 30 cm. However, in the event of a heavy shower or storm, each terrace looks like a pond full of water. This water is at least three times that is required through artificial irrigation.

The terraces that depend on stream run-off diverted from adjacent slopes usually have lips measuring at least 1 m wide and 1 m high. The run-off water is usually carried

Plate 14a Irrigable terraces on gentle slopes. These terraces are devoted to summer sorghum and winter wheat. Note the diseal pump in center (Amahian wells terraces, SW of Garn Ben Sahir).

Plate 14b Al-Farghain well terraces, SW of Garn Ben Sahir, Bashut. There are different types of landuse: to the middle-left is irrigable corn and wheat in the foreground. Note forest groves and dry field terraces at base of mountain. On the mountain side there are some acacias and short steppe used for pasture.

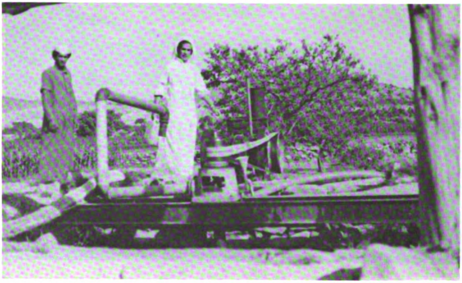

Plate 15a Artificial irrigation by modern pump (Al-Ghaliah well in the central part of Bashut).

Plate 15b Irrigation by runoff, which diverted to the terraces from the upper reaches (Al-Ganeh, N of Garn Ben Sahir, Bashut).

Plate 16a After the soil has been plowed and seeded, the terraces are prepared for artificial irrigation by dividing them into small basin and small canals (Al-Ganeh, north of Garn Ben Sahir, Bashut).

Plate 16b View over terraces along straight contours with lips standing perhaps 1 m above field level. Note settlement tank in right foreground for catchment of sediment. Grazing after harvesting is common.

Plate 17a This view shows the traditional method of plowing the soil. Furrows are not more than 30 cm deep.

Plate 17b Modern agricultural technology has been adopted in Bashut. The tractor plows soil to a depth of 50 cm.

by a stream of well-connected canals or channels. First, the water is led into the main channel of the uppermost terrace from which outlets are cut that connect the lower terraces. If there is a heavy shower the water accumulated on the surface of the terraces may exceed 100 cm because of the height of the lips. This quantity of water amounts to six times as much water as is needed by artificial irrigation.

The second type of terraces that we have identified are dry field terraces (59.9%) (Table 11g). These terraces are found largely at the margins of irrigable terraces. They are supported by massive stone walls that are built along the contours. Irrigation here depends solely on the moisture received from precipitation and natural drainage. There are two distinct types of dry terraces: those that depend on the direct rainfall, and others that rely on the water run-off from slopes located above these terraces.

Observations have shown that the terraces that depend essentially on direct precipitation generally have medium to small size lips. The amount of moisture absorbed by the soil of these terraces is adequate for winter crops. The fog and the cloudy skies contribute to the steady maintenance of moisture that the soil needs for cultivation. The nature of these terraces is such that advanced methods of irrigation are difficult to be applied. Continuous maintenance of the terrace lips is necessary to retain a normal functioning.

The terraces of the type that receive their moisture from the run-off usually have large lips, measuring 1 m wide and 1 m high, since advanced methods of irrigation are practiced on them. The most popular method for irrigation used is the building of dams and barrages across the courses of the channels. From these dams and barrages, the water is diverted to different terraces through two or three lateral outlets.

The field survey has been able to identify three methods of water distribution to these terraces. Most frequently the terraces are irrigated one by one by a construction of a system of channels. Once enough water has been diverted to one particular terrace for its needs, depending on the size of the terrace, the water is diverted to the next terrace. In the second method of irrigation used, the terraces are interconnected in such a manner that once a particular terrace has received its supply of water, the water overflows into the next terrace in succession until all the terraces connected to the system get irrigated. This overflow is made possible by cutting an opening or outlet in the middle of the terrace wall. The third type of irrigation is carried out by the construction of a canal running along the side of the terraces down to the valley. As the water runs down the canals, by damming it at the bottom of the lowermost terrace, the water rises in the channel and moves out to the lowermost terrace. And when this terrace is properly irrigated by damming the canal at an appropriate level, other terraces higher in level are irrigated in succession.

Among the most important advantages of irrigation by stream run-off are that, in the first place, the run-off water carries fine particles of silt which is deposited over the entire surface of the terraces, and these deposits add to the thickness of the soil of the terraces. Silt aslo carries with it a mixture of organic materials such as animal dung and humus that add to the fertility of the cultivable areas of the terrace. The third clearly discernible benefit of run-off water irrigation is that the water absorbed by the soil when the water is running off to the subsoils is that plenty of water gets absorbed in the soil and is filtered down to the underground reservoir.

However, the disadvantages of this type of irrigation cannot altoghether be discounted. Among the most important disadvantages are that the run-off irrigation may cause serious damage to the walls, and is very often responsible for the erosion both on weathered bedrock and the terrace flats; it tends to transport and deposit large quantities of sand over the fields. These deposits add to the cost of farming, as the farmer is obliged to clear these deposits before any cultivation can be undertaken.

(h) The Terraces in the Bashut Land Use System

Agriculture in this area is practiced largely to meet the subsistence needs of the local population. This is why most crops cultivated on these terraces are food crops.

Agricultural Seasons

As far as the types of farming are concerned, the terraces under multiple cropping represent the most efficent land use. These terraces are located in the central part of the Bashut district in which most of the large irrigable farms are located. Agriculture on these farms is perennial. The majority of these multi-crop terraces are cultivated twice a year, and sometimes even three crops are grown. However, the basic cultivation pattern involves one crop for each winter and summer every year.[1] It is this sequence that gives the real character to the Bashut landscape (Fig. 17a).

The most important crop grown during the winter season is hard wheat. This wheat is drought resistant. There are three other types of wheat on terraces, known as the *kobary*, *shogaby*, and *mabeya*. They are identified by the pecularities of their stock and the size and color of their grain. In the absence of rainfall, these varieties of wheat need artificial irrigation for their growth. *Mabeya* is more resistant to drought than either the *kobary* and *shogaby* varieties, and is widely grown in the margins of irrigable terraces.

The main summer crop is sorghum, locally called *dhurah*. The varieties are distinguished by the nature and condition of their growth. "*Al-dafien*", one of the important varieties grown on the irrigable terraces, is characterized

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[1]The farmers of Bashut select the times of sowing and harvesting by the stars. Seeds are usually planted in the beginning of winter--which falls during a four month period from December to March and is locally called *shita*--as well as in the beginning of summer, a period that spreads over from June to August, and is locally called *seif*. The winter crops are harvested during the spring season, locally referred to as *rabi'a* and extending anywhere from April to June. The summer harvest, on the other hand, called *kharif* is harvested in the autumn--that is to say, between September and November.

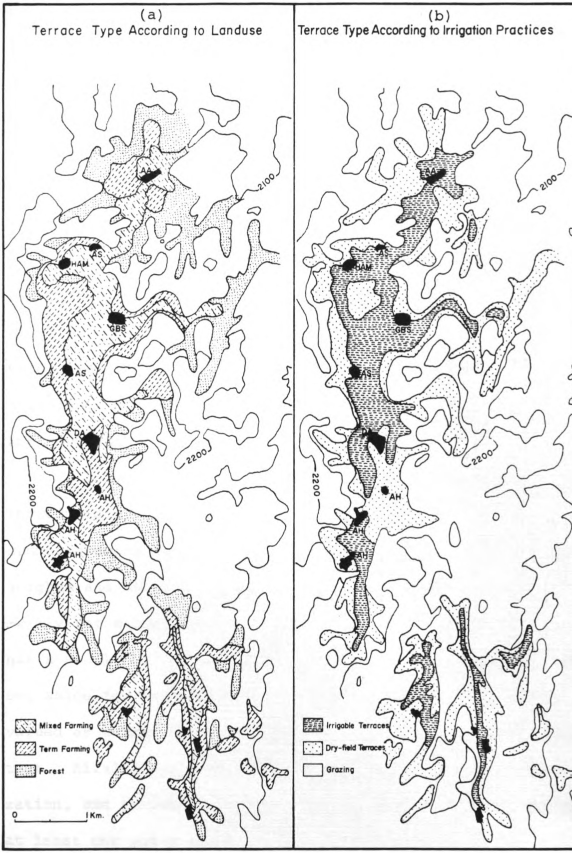
(a)
Terrace Type According to Landuse
(b)
Terrace Type According to Irrigation Practices
AA
AS
HAM
GBS
AS
DA
AH
AH
AH
2100
2200
2200
Mixed Farming
Term Farming
Forest
0
1 Km.
Irrigable Terraces
Dry-field Terraces
Grazing

Fig. 17

by a long, thick stalk rising up to 3 m, matures late, and requires four to six times the normal irrigation from sowing to harvesting. The second variety, locally known as "motwal" grows mostly in irrigable terraces at the margins of dafien. Unlike the first variety, it has a short stalk, makes for easy harvesting, and its demand for water is about three to four times the amount needed for small grains. "Gashashy" a third sparsely distributed kind, like the first variety, has a long stalk of three meters, and needs even more of water than al-dafien, takes a long time maturing, has limited distribution, and has its seed cub or head always compact and covered.

A new variety of white wheat called "khawlaneya" was introduced to the area fifteen years ago. It requires a summer growing season of only 90 days. Besides, wheat and sorghum and alfalfa (gadhb" or "barseem") is cultivated mainly for animal fodder. Generally, every farmer family has a small plot of irrigable terrace land, and about 300 m^2 set aside for green-feeding alfalfa to cattle. Alfalfa is valued as animal fodder because of its high nutritional content. Alfalfa needs considerable amount of care, fertilization, and irrigation about twelve times a year. It yields at least one cut a month.

The most important vegetables grown on terraces are tomatoes, okra, beans, carrots, onions, lettuce, and cucumbers. These vegetables require large quantities of water and good care, as well as experience which the farmer in Bashut at present lacks.

Multiple-crop terraces occupy 42.1% of the total terraced area of the study area. They require constant maintenance, care, fertilization, and artificial irrigation, as they are under heavy cultivation all through the year, and year after year (Table 11h).

The second type of terraces, here designated term-farming, or seasonal terraces, are farmed in winter only. They occupy the contoured dry-field areas located on the slopes. They are entirely dependent on rainfall. The most important crops of these terraces are wheat, barley, and "adass" or "belseen." The crops are generally drought resistant. Their stalks are short because the soil they grow in is shallow and has a low moisture absorption. Crops on these terraces will not yield well, especially when compared with the irrigable terraces. Besides, poor fertilization accounts for the low productivity. Term-farming terraces occupy about 40.3% of the total terraced agricultural area (Table 11h).

The third variety of the terraces may be described as the orchard flats, or viticultural terraces. A variety of fruits are cultivated on these terraces, generally located around the villages.[1] Grape vineyards are a special feature of these terraces. They are known for "Rasiqi" and "farsi" varieties of white grapes. "Ramadi," the black grape variety too, is widely distributed. Other fruits commonly grown on these terraces are apricots, small green apples, big red apples, pomegranates, quince, peaches, figs, etc.

Private forests of juniperus and acacia trees are frequent in areas occupied by cross-channel terraces. Terraces of this type are endowed with a high amount of moisture and deep fertile alluvial soil. The juniper evergreens form dense stands of up to 10 m height. Acacias grown as large, but they form open groves. Some of these trees, and others, flourish on the abandoned terraces on steeper valley sides. These terraces constitute about 18% of the total area (Table 11h, Plate 18).

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[1]This type of terraces known locally as rehy or hayat which are occupied by fruit tree culture. The soil of these terraces are fertile because of relatively high humus content; also, they are always irrigated with water diverted from the villages which contain high amounts of animal dung.

Plate 18a Irrigable terraces sometimes are dominated by fruit trees, mostly grape; fig and peach are grown at their margins (Al-Farghain well, Bashut).

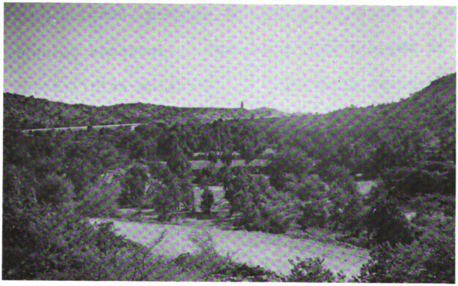

Plate 18b Cultivated forest terraces often used for winter crops (Nabtah, just West of the new highway, Garn Ben Sahir, Bashut).

Functions of Terraces in the Bashut District

The agricultural terraces in Bashut were developed to serve multiple functions. The most important among the functions were to conserve water and soil through slope reduction, to create more space for crops, and, finally, to intensity production through better management.

Ofter overlooked, but playing a major role in conservation of water, is the lip device. Its main function, together with the barrages, is to exploit the available water to the maximum and prevent overflow. Field analysis has shown that these terraces, by directly trapping rainfall and run-off from streams, provide an effective means to replenish the groundwater reservoir. The water thus trapped in the form of interstitial moisture, is a reliable resource for the cultivation on these terraces.

It must be recognized that most terraces, in fact, act as dams. They effectively interrupt the flow of water, which otherwise would be lost in natural run-off. Since the water stays on the surface for a reasonably long period of time, it percolates down to the subsoil to be readily available later on for the growth of the crop plants, either directly or by capillary ascendance. Since most terraces

Plate 19a Aluvial terraces, some of them are irrigated, others are dry. Natural vegetation is mixed between Junipers and Acacias (Wadi Ajibah).

Plate 19b Alluvial fan terraces in this view are dry and are planted to term crops (winter wheat and barley) and private forest (near Ajibah, west of the new road).

are practically flat, flow velocity approaches zero, and only downward movement takes place. The terrace walls themselves serve to block up the flow of the water and dam off the occasional flood waters.

Generally, the farmers control the flow of water from upper slopes into the terraces by a system of artificial canals, locally known as sagiah or swagy, and their method of irrigation of the terraces is thus achieved by an integrated artificial drainage network and represents an economic as well as conventionally sound agricultural engineering device.

Since the annual rainfall in the area of the study is only around 500 mm, any negative departure creates a potential drought situation; the system of canals allows the diversion of excess water from a surplus to a deficit area. Thus, by a careful planning, the farmers have learned to substantially increase the effective water availability.

It must further be pointed out that the soil of Bashut is essentially clay or loamy clay. This type of soil provides the best entrapment of moisture and the conservation of it for a long time because of its low permeability. However, observation during the field survey has shown that the moisture absorption in the terraces is not even, but shows a considerable variation due to the soil texture, structure and depth. It has been further found that the terraces that are irrigated by the run-off and underground water, have a tendency of absorbing greater amount of moisture than those that are irrigated by the direct rainfall or underground water only. Furthermore, flat areas tend to have a greater capacity for moisture absorption, retention of soil, and deposition of silt at the walls.

It has been observed that the terraces that are irrigated by run-off water are deeper in soil profile than the ones irrigated by wells and precipitation. This is a consequence of retention of the annual solid load. Not only are the terraces erosion checks, but also traps for new soil. Over a longer time period, the retained solid particle load amounts to thousands of tons which otherwise would have been lost in a natural erosion process.

The most obvious function of the terraces, of course, is the creation of productive crop land. The natural terrain was essentially rocky and mountainous. It goes to the credit of the Shomran tribe who have converted the steep and rocky slopes into a terraced landscape by using the rocks for building the terrace walls and vegetation as fillers. After the work of generations to retain a viable local subsistence base through terracing, it is sad to see the high degree of abandonment and ill state of repair throughout the study area.

Slopes with an average gradient of as much as 30° have been terraced and traditional agriculture has been carried on for a long time. But it seems that only the terraces that are located on the valley floors and on gentle slopes, those that are easily amenable to mechanization and modern agriculture technology, are kept up in the manner all terraces were originally taken care of.

Terraces in Bashut protect the seeds and plants from being washed away by stream run-off. They are so designed as to provide the maximum of the natural needs of the grain stalks to grow. Terraces safeguard the newly planted seeds and young, weakly rooted grains; terraces, indeed, are a guarantee against the loss of crops once they have taken root. On the terraces that are in active use, the broadcasting method is used for sowing seeds. This technique is the most harmful to seeds and plants because the scattered seeds always are covered only haphazardly. Sorghum is hand cast and seeds are dropped grain by grain into the furrow by a man following the plough. This technique is the best because seeds always are buried in the soil to a depth of

15 cm or more. When the seeds germinate into plant, their stalks always appear to be rooted deeply in the soil to resist wind erosion. Vegetables usually are planted by hand in shallow holes, normally not deeper than 3 cm, while fruit trees are always planted in deep holes up to 60 cm or more. Forest trees abound around terraces.

In abandoned terraces planted seeds and young weak trees are liable to be washed away by the erosive action of sheet washing and gullying during the rainy season. Also, the capacity of the soil to protect and nourish the crops has been greatly reduced in the abandoned terraces because of the collapse of their walls. Here, seeds are easily washed away and the top soil is unable to support plant life as it has been severely depleted.

Terrace Upkeep and Manpower Requirement

The construction of a terrace in Bashut is a family enterprise. All members of the family, young and old, join in the building of a family agricultural unit. Usually, the farmer and his older children are taking care of the construction and maintenance of the family terraces; in the initial stages, the neighboring farmers may give a helping hand. At times a whole village may be engaged in the construction and repair of a wall. This kind of mutual assistance in the building up of the property of a neighbor has been handed down to the population by tradition--an unwritten rule of conduct practiced by their ancestors. Sometimes, the services of a professional labor force are requested. These are men mostly provided by the tribe of Bni Amro or North Yemenites. These professional laborers show a remarkable engineering skill. It must be mentioned that this professional help is expensive, and few local farmers can afford it.

The tools used by the farmers to build terraces are often primitive, the same which are used for clearing the fields of brush and stones; digging and plowing tools, such as the plow-share, hoes, harrow, spade, sickle, baskets, oxen, and sometimes, tractors, trucks and bulldozers also may be involved. In recent times, some of these mechanized methods are being used for the reclamation of the abandoned terraces and for filling, digging and levelling work; the walls, however, have still to be constructed by a laborious, manual method.

The most commonly used material for the repair and construction of walls is natural stone. Local bedrock is available in abundance, mainly grandiorite, quartzite, diorite and basalt. They come in varying sizes both small and large. The boulders are used almost exclusively in their natural form. Gravel, small stones and mud are used as manual rams to ensure stability. Mud, bushes, shrubs and a mixture of varied materials are used to fill holes in the retaining walls. Very often, large beams or tree trunks are used to shore up the wall. It must be recognized that the farmers who have built these terraces have done so painstakingly. Some of the huge boulders that are used for the terraced walls had to be transported over large distances. Lithologic study of the walls of abandoned terraces shows that the material must have been hauled from the bottom of the valley to the topmost terraces.

It is probable that the first terraces were built along the contours of the lower slopes; subsequently walls were built progressively higher on the slope, with increasing degrees of construction-difficulty with increased slope angle.

The Bashut farmer, who still maintains his terraces, is well aware of the value of good workmanship. The majority of the farmers continue to work on their farms year after year to keep them in good shape. They regularly plow the field, manure the soil, and always see to it that their terraces are clear of useless or harmful growths. They undertake regular maintenance measures for the walls and wherever repairs are needed they are undertaken promptly. They take effective steps against rodents and other burrowing animals. Wherever holes or burrows are detected, they are immediately filled.[1]

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[1]The heavy new silt brought off the slopes is scraped from the terrace surfaces by the farmers and is spread to the terrace lips where grass is encouraged to grow to support the lips and to hold the soil together. The most commonly used material for the reconstruction of the abandoned terrace is the dry stone. Though there is a shortage of this stone in the terraced lands, it is transported from other areas in the neighborhood for reasons of good maintenance of terraces.

CHAPTER VII

CONCLUSIONS

There are some facts with regard to terracing in Bashut that stand out conspicuously. The distribution and the types of terraces are laregly determined by such natural environmental factors as the topography, soil characteristics, the availability of water either through natural or artificial means, and human and cultural needs. The history of the terraces of Bashut shows that they have tended to develop in areas which have enjoyed the greatest freedom from aggression, have either the possibility for the entrapment of silt from runoff or have already had a rich residual soil on gentle slopes. One factor that has played an important role in the diffusion of terraces in Bashut is the prestige the farmer attaches to the ownership of his terraces. This is why terraces in Bashut have hardly changed hands. All these factors that determine the distribution and quality of the terraces ought to be researched further to enable the farmers to exercise a better control over the use and productivity. There is scope for research to determine areas of possible high productivity that can be economically utilized for developing viable terraces on them.

The old axiom that what is productive is feasible is as true in Bashut as in any area in the world. One inconvertible conclusion the study points to is that farms that are highly successful are maintained best. The factors that constitute the success of a farm ought to engage the attention of those who regard terraces as an important cultural phenomenon. The study of these factors by such organized institutions as the government or the university can contribute to better farming and maintenance. Since maintenance is one of the most important factors contributing to successful farming, geographers will contribute a great deal to the cultural landscape of Bashut if they focused on such maintenance factors as the reduction of soil erosion by runoff, increase of soil retention, entrapment of rain water underground or in a dam, reduction of soil creep, the techniques of building flat surfaced terraces for agriculture, and the application of modern agricultural technology.

With regard to terrace building and agricultural technology it must be added that no technique can ever be efficient if it does not take into account the existing conditions and the expert knowledge of the soil, climatic conditions, and what constitutes, for instance, a good terrace wall and lip. In other words, the use of tractors for levelling, and building walls if used under the expert supervision of one thoroughly conversant with the entire terracing operation will eliminate all wasteful and very often even destructive efforts. Commonly observed pheonmena of wasteful use of tractors are often noticed when tractor operation scrape the rich fertile soil at the edge and expose the bedrock, without realizing that it had taken nature centuries to accumulate that soil.

Another compelling conclusion that suggests itself is that the change in the overall economic conditions has steadily led to the abandonment of terraces. Younger generations have moved to cities in search of non-farming occupations, leaving behind women and old people to work the terraces. Terraces fell into disuse by neglect and often enough because of the simple lack of manpower to farm them.

Most terraces face the threat of being abandoned. Farmers cultivating them are either too old or are getting to be too old. One wonders about the fate of their farms after this generation of old farmers has passed away. It does point to their abandonment.

Over the years, the acreage committed to wheat, barley, sorghum has been progressively reduced on all the terraces. It is a sign of future trends. These terraces have lost their value and importance for the local population because they have become unprofitable, yet the holders do not sell their farms because of the social stigma attached to selling. With the lack of interest in farming, the skill in agriculture has declined. Dependence on imported goods has taken a heavy toll of people's self-reliance and initiative.

However, the people have begun to realize that the oil income cannot go on forever, and they will have to return to the farms. In the meantime, some farmers have begun diverting the cultivation of food crops to the more economically profitable crops, especially fruits and vegetables. This will keep the terraces active even though they will continue to depend on imported food grains. Indeed, a considerable number of farmers have already started growing these cash crops, specially on farms located near the main towns and cities like Taif, Bahah, Baljorashy, Alayah, Nemas, Abha and Khamis Mushaif.

Some geographers believe that with the introduction of modern agricultural technology and mechanization, the production on these farms can be increased manifolds. If such a realization comes to pass among the farmers, the reactivation of the abandoned terraces may become economically viable. If the farmer is fully educated in the use of chemical fertilizers and their value to the productivity of his farm, the chances are that he might find farming competitive with the jobs in the cities. The establishment of government services in the agricultural centers is a first step in the right direction for a trend towards more mechanized and technology-supported farming.

In the opinion of this researcher the government will do well to remind the area residents of the great value of good terrace agriculture by making research-based information available to the residents and by encouraging programs that are intended to increase production, to make farming economically competitive through subsidies, and to rehabilitate the abandoned farms.

All available geographic data indicate that terraing is the only form of farming possible in the study area. Terracing in the area needs to be researched from all possible aspects to retain this unique cultural landscape. An inescapable conclusion that has been forced on this researcher is that the task of restoring the area is enormous, and it can be achieved only by the active participation and encouragement of the government. Private agencies lack the resources and wherewithals to undertake the development of the terraces in their various aspects. In order that the terraces may become economically viable and competitive with other competing centers of Saudi Arabia they must rely on the technology that is most suitable to the area. This is possible only through an enormous effort of public agencies. Farmers in the area have to be demonstrated the advantages of diversified farming. Fruits and vegetables are very profitable crops, but farmers are too ignorant to take advantage of that fact. One look by a geographer is enough to convince him that terraces must remain an integral part of the Bashut district. They must, therefore, receive the greatest amount of attention and energy of the research agencies and the government.

APPENDIX

APPENDIX A

SOURCE OF FIGURES

Fig. 1 and 9: Kingdom of Saudi Arabia, Ministry of Agriculture and Water, Water and Agricultural Development Surveys for Areas II and III, Final Report, Grazing Resource Inventory, Italconsult, Rome, February 1969. Also Mughram, A. "Assarah, Saudi Arabia: Change and Development in a Rural Context," Ph.D. Dissertation, Department of Geography, Durham, University of England (1973).

Fig. 3: Kingdom of Saudi Arabia, Ministry of Petroleum and Mineral Resources, Directorate General of Mineral Resources, Geology of the Biljorashi Quadrangle, Sheet 19/41B (1975).

Fig. 4: Kingdom of Saudi Arabia, Ministry of Petroleum and Mineral Resources, Directorate General of Mineral Resources, Topographic Map for the Arabian Peninsula, AB/3 (1974.

Fig. 6, 7, 8: Compiled from: Kingdom of Saudi Arabia, Ministry of Agriculture and Water, Water and Agricultural Development Surveys, for Areas II and III, Final Report, "Climate and Surface Hydrology," Rome, Italconsult, 1969: Ministry of Agriculture and Water: Hydrology Division, Riyadh, Saudi Arabia, 1966-1978, and Mugram (1973).

Fig. 5: Developed by Abrams Aerial Survey, Lansing, Michigan from Aerial Photograph (SAG 1-3-106), Taken by the Government of Saudi Arabia, Ministry of Petroleum and Mineral Resources, 2-18-1953, and from data collected by the author during field work (1978).

APPENDIX B

QUESTIONNAIRE ON SOCIO-ECONOMIC CHARACTERISTICS OF FARMING POPULATION

To collect socio-economic data about terrace farming and farmers in Bashut, the attached questionnaire was administered to 278 Bashut farmers. All of the 278 questionnaires duly filled out were returned.

The questionnaire was designed for data regarding Bashut terraces in the area of manpower, crops cultivated, cultural and development history, the feasibility of the use of modern technology and farming techniques, and the causes leading to the abandonment of some of the terraces.

It would be my recommendation that any future geographer base his research on one-to-one interviews and personal observations rather than on written questionnaires distributed to the populace who do not always understand the written word.

Name of the Village

A. Social Characteristics of Owner

1. How old are you?

   a. Less than 20 years

   b. 20-35 years

   c. 36-50 years

   d. Over 50 years

2. How long have you been living in this village?

   a. Less than 5 years

   b. 5-10 years

   c. 11-20 years

   d. Over 20 years

3. How many members are in your family?

   Male   Female

4. Are you a farmer?

   Yes.......   No.......

5. Are you employed in work other than farming?

   Yes.......   No.......

   If so, what is that?.............

6. How many workers do you have on your farm?

   ....

7. Are they all from your household?

   a. All.............

   b. Some. How many?.............

   c. None...................

B. Characteristics of the Farm

8. How many terraces do you have?.....................

9. What is the size of your terrace (s)?

   a. Less than 100 square meter

   b. 101-200 " "

   c. 201-300 " "

   d. 301-400 " "

   e. Over 400 " "

10. How do you irrigate your terrace (s)?

    a. By rainfall

    b. By underground water-wells

    c. By both rainfall and wells

11. How many times do you cultivate your terraces each year?

    a. One time

    b. Two times

    c. Three times

12. When do you cultivate your farm or terrace?

    a. Winter season

    b. Summer season

    c. Other

13. What kind of crops do you grow during the winter season?

	10%	30%	50%	70%	90%	100%
Wheat						
Barley						
Other						

14. What kind of crops do you grow during the summer season?

	10%	30%	50%	70%	90%	100%
Corn						
Wheat						
Vegetables						
Fruits						
Other						

15. How much of your farm is in cultivation now?

    a. All...............

    b. 3/4...............

    c. 1/2...............

    d. 1/4...............

    e. None..............

16. Do you use modern agricultural technology to plow and harvest your terraces?

    a. Yes....................

    b. No.....................

    If not, why?

    a. The terrace size is small

    b. My terraces are not close to each other

    c. The roads to my terraces are not available

    d. Other

17. Do you sell any products from your farm?

    a. Yes..............

    b. No...............

    If yes, what is your income?

    a. Less than 100 dollars........

    b. 101-200 dollars..............

    c. 201-300 dollars..............

    d. Over 300 dollars.............

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