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INTEGRATED DEVELOPMENT OF MOUNTAIN FARMING AREAS OF THE ECWA REGION: A CASE-STUDY OF THE YEMEN ARAB REPUBLIC

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OVERVIEW OF THE FINDINGS

Based on the study carried out by the mission, the main conclusions and recommendations are listed in the following paragraphs:

1. Changed socio-economic environment

In the mountain areas of the Yemen Arab Republic, the traditional rain-fed farming system of growing sorghum on good land and millet on marginal land with labour-intensive techniques in an isolated, self-sufficient society, is breaking down. This is a result of the emigration of farm labour to neighbouring oil-rich countries, creating a labour shortage but an influx of money, increased employment and business opportunities in cities within the country and schooling facilities for children in both urban and rural areas. Thus the whole rural socio-economic system is undergoing a rapid change. At this stage there is a dire necessity of directing the change process in order to safeguard the national interest.

2. Constraints

The study area, Al-Haymat Al-Kharjiyah and Al-Haymat Al-Dakhliyah, constitutes the low rainfall zone, arid to semi-arid, of the central highlands of the Yemen Arab Republic. The major constraints for agricultural development are:

- low and uncertain rainfall;
- small and fragmented agricultural land holdings;
- shortage of labour;
- lack of knowledge among farmers about modern agricultural technology;
- lack of communications; no proper roads except some jeepable tracks.

3. Favourable features

There are some good points which must be mentioned and taken into account while planning agricultural development:

- The cultivated land is very well terraced and the bench terraces are reinforced with stone walls, a very good soil conservation practice that helps to maintain the productivity of land;
- the farmers have mastered the art of rain harvesting by diverting the run-off water from mountain slopes into their terraced fields, thus increasing the effective rainfall;
- the farmers grow sorghum as the main crop, which is highly suited to the climatic condition of low and uncertain rainfall.

4. Integrated development approach

The agricultural development should be planned as a part of an integrated comprehensive plan, including agricultural crops, livestock, soil and water conservation, health, education and roads.

5. Watersheds as development area units

Because of the mountainous terrain, soil and water conservation should have the central position in any agricultural development programme, and development projects should be prepared for areas covering complete watersheds or subwatersheds.

6. Components of the development programme

- Adjustment of land use according to suitability of land, based on soil and land classification.

- Improvement and maintenance of stone terraces, including minor field levelling, and provision of spillways for the safe disposal of excess rain-water.

- Planting of suitable trees on terraces, e.g. Cordia myxa, as seen in Beni Matar area.

- Crop diversification through introduction of new crops, such as sunflowers, ground nuts and brassica.

- Introduction of a minimum, workable package of modern crop production technology for the main crops, which would include new plant varieties; sowing, spacing and weeding techniques; and pesticides.

- Mechanization of agricultural operations by introducing small tractors such as two-wheeled 3-5 h.p.. machines to overcome the labour shortage.

- Introduction of suitable tillage implements, for example chisel ploughs to break the dense plough pan, duck-foot sweep cultivators to till expeditiously and efficiently, tine harrows for weeding, ridgers to earth up plant rows, and suitable planters. The local cultivator is both inadequate and inefficient.

- Construction of ponds and small dams where feasible to store excess rain-water for supplemental irrigation of crops.

- A proper management system of grazing land (rangeland) through grazing cooperatives, taking a village or community ownership as a management unit. Rotational and deferred grazing, along with experiments on re-seeding of some suitable grasses, legumes and shrubs under a modified traditional hema system, but based on a proper rangeland survey, is recommended.

- Inclusion of agriculture, soil conservation and range management subjects in high school curricula.

- Ongoing training of local staff.

7. A pilot project

A subwatershed should be selected for establishing a pilot project which would provide a training ground for local staff as well as the first-hand experience about the suitability of the programme for the local conditions, the practical problems in its execution and the desirable modifications.

8. First phase of the pilot project

It would have two components - surveys and detailed work plan.

a. Surveys. In order to provide the necessary detailed data for planning and executing the project, the following surveys are recommended:

- Detailed soil and land classification survey;
- Detailed vegetation and rangeland classification survey;
- Detailed hydrological survey to assess stream flows and the amount of run-off water available for irrigation;
- Ground water survey through geo-physical investigations and test borings to assess the quantity and quality of ground water;
- Socio-economic survey to collect information on the size and fragmentation of land holdings, the number and type of animals per household, education level of the farmer, available labour and input/output ratio of each crop.

b. Detailed work plan. Based on the surveys, a detailed work plan should be prepared, including all the development components mentioned under item 6 of this chapter.

9. Additional meteorological stations

Every report on the Yemen Arab Republic has pointed out the inadequacy of the currently available meteorological data. It is therefore highly desirable to establish a network of meteorological stations. The World Meteorological Organization (WMO) may be approached for technical assistance and instruments. Local schoolteachers can be trained to record the observations.

I. INTRODUCTION

The Economic Commission for West Asia (ECWA) attaches great importance to developing a methodology for the development of mountain farming areas of the member countries. These areas have special problems because of mountainous terrain, inaccessibility, poorly developed road systems, high soil erosion hazards, traditional farming systems that resist change, exploitative communal rangeland grazing, and small and fragmented farms.

Mountain farming areas with a growing season of more than 75 days constitute about 14 percent of the ECWA region's total land area. Nationally, their agricultural importance is well recognized. Their development would have both national and local benefits.

The Yemen Arab Republic was selected for a sample study of mountain farming areas, as the country is mainly mountainous, and a study mission was formed with the following members:

Mr. Mohammad Rafiq - Mission Leader
Soil Scientist/Land Use Specialist

Dr. A.K. Toma Hirmiz - Member
Ecologist/Forester/Range Specialist

Mr. George S. Panayiotou - Member
Farm Management Specialist

The terms of reference of the mission are to study in depth a specific mountain area/watershed in the Yemen Arab Republic in order to formulate a conceptual approach and strategy for the integrated development of mountain farming areas in the ECWA region in the context of resource conservation and management, and in this connection:

- describe the essential features (climate, topography, vegetation, etc.) of the selected area or watershed;

- review the current status of resource use and development in this selected area and isolate its main problems and the real causes of misuse of resources, if any;

- outline a comprehensive and integrated development approach for the rational development of this area, which will conserve the resources while providing maximum sustainable employment and income to its population; and

- based on the above case-study, conceptualize an integrated development approach for the mountain areas of the ECWA region, identifying relevant available methodologies and technologies.

The respective duties of the members of this mission in the above context are as follows:

Soils scientist/Land-use specialist

To study the soils, land use, water use and soil conservation aspects of the area, delineate issues involved and offer appropriate solutions.

Ecologist/Forester/Range specialist

To study climate, range-land, forestry, animal and wildlife, delineate issues involved and offer appropriate solutions.

Farm management specialist

To study prevailing farming systems, farm tenure and farm economics, and to survey a few selected farms to identify their problems and offer solutions, considering in this context FAO's Farm Management and Production Economics Service, a wide-ranging system for gathering demographic and agricultural information.

The mission will be supported by an ECWA economist

II. THE YEMEN ARAB REPUBLIC

1. Location, area and population

The Yemen Arab Republic has a land area of approximately 200 000 km^2 and lies in the southwestern part of the Arabian Peninsula, between latitudes $12^{o}40'$ and $17^{o}26'$ N and longitudes $42^{o}32'$ and $46^{o}31'$ E.

The human population is estimated to be 8.6 million (1981 census), of which approximately 1.4 million people live and work abroad. The rural population represents 89 percent of the total. The literacy rate is estimated to be 10-15 percent for males but only 2 percent for females.

The gross domestic product in 1982 was estimated at 16 387 million rials (US$ 3 642 million), for a per caput GDP of US$ 490.

2. Agro-ecological zones

The country is divided into four zones in terms of physiography, climate and soils (Rafiq, 1979 and FAO/WFP Mission, 1983).

a. Zabid zone. It covers the Tahama coastal plain, 30-70 km wide. The climate is hot arid tropical, with less than 200 mm rainfall. High winds are common. The area receives spate irrigation from the flood water of seven 'wadis', rocky watercourses whose streams fluctuate seasonally.

b. Taiizz zone. It includes the western and southern slopes of the central mountain range. The altitudes are 1 000-1 500 m and the climate is semi-arid tropical highland. The southern part has 500-1 000 mm rainfall but the northern part gets 250-600 mm. The rain occurs mainly during July and August but there is some during March, April and May.

c. Sania zone. Covering the central mountain region of the country, this zone is 1 500-2 500 m high. Most of the area is highly dissected but there are some mountain plains. The climate is of the tropical highland type, with a mild summer and cool winter. Annual rainfall is 300-600 mm, increasing from north to south and from east to west.

d. Mairib zone. It is the desert area, comprising dry plateau and sandy desert. The climate is of hot subtropical desert type, with less than 150 mm annual rainfall.

3. Agriculture in the national economy

The contribution of agriculture, forestry and fishing to the GDP of the country was 44.3 percent in 1975/76 but dropped to 36.9 percent in 1980/81. The number of workers employed in the sector remained unchanged at 830 400 between 1975/76 and 1980/81, but as a proportion of the active population they decreased from 75.4 percent in 1975/76 to 69.1 percent in 1980/81.

The agricultural sector stagnated during the period 1975/76 to 1980/81; it exhibited an average annual growth rate of only 1 percent, while GDP registered 6 percent yearly growth at 1975/76 constant prices (Central Planning Organization, undated). The main reasons for the unsatisfactory performance were: migration of farm workers to urban areas or abroad; unsatisfactory conditions for storage and marketing of agricultural products: inadequate support for the sector; and the failure to carry out planned agricultural projects.

TABLE 1. Production of important crops and livestock products in 1975-76 and 1982

	1975-76 (1 000 tonnes)	1982 (1 000 tonnes)
Cereals	940.0	760.0
Pulses	76.0	75.0
Vegetables	183.0	305.0
Fruit and grapes	107.0	152.0
Potatoes	76.0	150.0
Coffee	3.4	3.3
Cotton	13.5	6.5
Milk and dairy products	77.5	95.8
Meat	18.5	20.9
Hides and skins	3.8	4.2
Poultry	1.3	11.2
Eggs (million)	102.0	128.0

The production of staple foods (cereals and pulses) declined during the same period. In the early 1970s, the Yemen Arab Republic was producing about 90 percent of its cereals needs, but by 1978 the production had fallen to about 70 percent of requirements. The shortfall was met through food imports, which increased from 100 000 tonnes at the beginning of the 1970s to 300 000 tonnes in 1982 and will be even larger in 1983/84 owing to an extraordinary drought in 1983. Cotton production has registered a conspicuous decline. Livestock products, however, exhibited an increasing trend (FAO/WFP Mission, 1983).

4. Agricultural institutions

Over the last 15 years, the Government has strongly supported agricultural research and development, seeking to transform traditional farmers into modern entrepreneurs. Given the shortage of trained labour, these advances are especially important; moreover, they demonstrate the Government's commitment to prompt achievement despite numerous obstacles.

The Ministry of Agriculture is organized into nine sections, each under the charge of a Director-General who deals with a specific subject and works

directly under the Deputy Minister or the Minister. The Agriculture Research Authority has been recently reorganized and is now under the charge of a Director-General.

Three new semi-autonomous bodies, each headed by a Director-General and responsible directly to the Minister of Agriculture, were set up recently to deal with specific fields or enterprises. These are:

- the Fisheries Corporation, to deal with seafood resources;
- the Tibama Development Authority, to deal with the development of the coastal plain;
- the Agricultural Cooperative Credit Bank, to provide credit for agricultural development.

III. MOUNTAIN FARMING AREAS OF THE YEMEN ARAB REPUBLIC

1. Location and extent

Covering about 75 percent of the country, the mountain areas form the most important physiographic region of the Yemen Arab Republic. These mountains extend from the southern to the northern border and from the limit of the Rub'al Khali Desert in the east to the coastal plain of Tahama in the west. The latitude and longitude limits are:

latitude: $12^{\circ}50' - 17^{\circ}26'$N
longitude: $43^{\circ} - 46^{\circ}$ E (approximately).

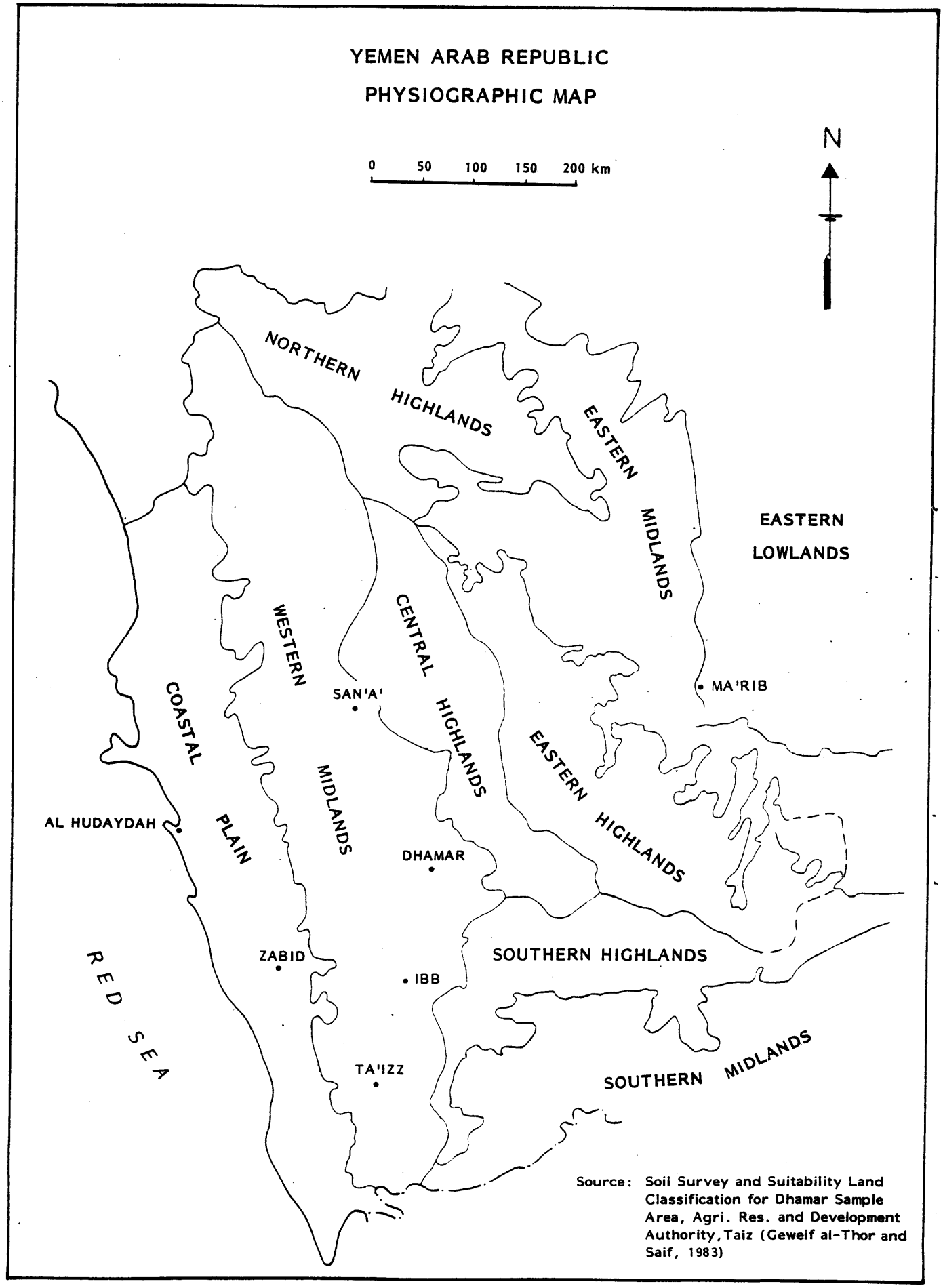
The total extent of the mountain areas is approximately 150 000 km^2. These are divided into: central highlands, eastern highlands, northern highlands, southern highlands and western midlands (see Fig. 1).

2. Importance of mountain areas in national agricultural sector

According to a study (Blas, unpublished), 13.4 million ha, or 69 percent of the country, have a growing season of 75 days or more, when soil moisture and temperature conditions are favourable for plant growth. The whole of this area falls within the mountain region of the country. It has great agricultural significance, as it includes cultivated land, grazing land, woodland and watershed areas. About 18 percent of the area, or 2.42 million ha, has a nearly level to gently undulating surface, and comprises mainly mountain plains. About 33 percent of the mountain area with more than 75 days of growing season, covering 4.43 million ha, has a rolling to hilly surface with 8 to 30 percent slope. It contains some important areas of terraced fields under cultivation as well as grazing and forest lands.

According to another source (FAO/WFP Mission, 1983), mountain areas cover 90 percent of the country if the eastern desert plateau is included. The area under cultivation in mountain regions amounts to 1.35 million ha, more than 90 percent of which depend upon rains. The provinces of Sania, Ibb and Taiizz in the central highlands account for about 65 percent of total cereal production, and for nearly all the wheat.

Fig. 1


YEMEN ARAB REPUBLIC
PHYSIOGRAPHIC MAP
0 50 100 150 200 km
N
NORTHERN HIGHLANDS
EASTERN MIDLANDS
EASTERN LOWLANDS
WESTERN COASTAL PLAIN
CENTRAL HIGHLANDS
WESTERN MIDLANDS
EASTERN HIGHLANDS
SOUTHERN HIGHLANDS
SOUTHERN MIDLANDS
SAN'A'
MA'RIB
AL HUDAYDAH
DHAMAR
ZABID
IBB
TA'IZZ
RED SEA
Source: Soil Survey and Suitability Land Classification for Dhamar Sample Area, Agri. Res. and Development Authority, Taiz (Geweif al-Thor and Saif, 1983)

3. Classification of mountain areas

The factors that are considered important in classifying mountain areas of the Yemen Arab Republic are:

- physiography; altitude, slope and slope aspect;
- climate;
- soils;
- water supply for agriculture;
- natural vegetation;
- present land use.

a. Physiography, altitude, slope and slope aspect. Yemeni mountain areas can be divided into the following categories:

- highly dissected, high mountain areas, with altitudes of 1 500-3 000 m;
- moderately dissected medium mountain areas with altitudes of 500-1 500 m;
- mountain plains or high plateaux, with altitudes of 1 500-2 500 m (Rafiq, 1979; Geweif, al-Thor and Saif, 1983; Cornell Yemen Soil Survey Staff, 1981).

The highly dissected high mountain areas have very steep slopes, ranging from 60 to more than 150 percent, and deep gorges several hundred metres deep.

The moderately dissected medium mountain areas have steep slopes, of 30 to 100 percent, the elevation differences are 100-300 m and gorges are uncommon. The mountain plains or plateaux have undulating or gently sloping surfaces which may have some rock outcrops.

Within the dissected mountain areas, the slope aspect has a great effect on local micro-climate. The east- and north-facing slopes are more humid and carry better vegetative cover than the west- and south-facing slopes. These aspect differences are more important in highly dissected high mountain areas. Thanks to long slopes interspersed by wadis, frost is rare in dissected mountains because there is good air movement.

The high mountain plains or plateaux experience a high incidence of frost, as the cold air settles down in low parts of the plains. Frost sometimes damages temperature-sensitive crops, such as sorghum, at its grain-filling stage in October. This happened in Ma'har in 1975 (Williams, 1979). The higher, sloping margins of the plains with terraced fields, however, have a distinct advantage as these escape from frost.

b. Climate. The whole of the mountain area of the Yemen Arab Republic has tropical highland climate with an arid to semi-arid moisture pattern. Only a few small areas are subhumid, for example, that near Ibb. The mean annual rainfall ranges from about 200 to 1 000 mm, increasing from east to west and from north to south in the high mountain areas, but from west to east in the western slopes of the mountain range bordering the coastal plain, At-Tahama.

The rainfall has a bimodal pattern; the main rainy season in July-September and the minor one in March-April. The rain occurs as high-intensity

showers of short duration, resulting from convective air movements forming cumulus clouds, a typical tropical phenomenon.

The temperature pattern of the mountain area is isohyperthermic, isothermic or isomesic; in each case, the difference between the mean summer and the mean winter temperatures is less than 5°C (Cornell Yemen Soil Survey Staff, 1981). It is isohyperthermic where the mean annual temperature is more than 20°C, isothermic where it is 15-20°C, and isomesic where it is less than 15°C. The mean annual temperatures range from 14°C to about 27°C in mountain areas, depending upon the altitude and slope aspect; the lowest temperatures occur in mountain plains. The seasonal variation is small, less than 5°C difference in mean summer and mean winter temperatures, but the diurnal changes in temperature are quite extreme, often 15-20°C.

The evaporation from free water surface, as shown by measurements at Ma'har and Rabat (mountain planes), is about 2 400 mm (Williams, 1979).

The most important features of the climate with respect to agriculture are:

- low and highly variable rainfall;
- dry month of June, affecting crops sown in March-April;
- dry months of October and November, adversely affecting the sorghum crop during the grain-filling stage;
- frosts in mountain plains in October-November, damaging crops such as sorghum during the grain-filling stage.

c. Soils. Since the land use and the suitability of an area for various crops depend primarily on the climate and soil, soil properties have a paramount importance in the classification of mountain areas. The main soils of the mountain areas of the Yemen Arab Republic, according to available literature (Cornell Yemen Soil Survey Staff, 1981; Acres, 1982) are:

- very shallow soils and rock outcrops;
- shallow and deep stony and gravelly soils of mountain slopes;
- shallow and deep loamy soils of terraced fields on mountain slopes;
- very deep loamy and somewhat clayey soils of lower mountain slopes;
- very deep loamy and clayey soils of mountain planes;
- sandy and loamy soils of wadis.

Very shallow soils and rock outcrops. These occur on the upper parts of steep and very steep mountain slopes. Their shallowness limits moisture retention and plant rooting depth, affecting agricultural use. Only in relatively high rainfall areas do these soils carry a cover of some useful grasses and shrubs; in low rainfall areas these are mostly bare or have some hardy, useless shrubs.

Shallow and deep stony and gravelly soils of mountain slopes. These occupy the middle and lower parts of mountain slopes. They are formed of colluvial material, which results from weathering of rocks on higher parts of mountain slopes and is deposited by gravity aided by water action. The soil surface is covered by stones and gravel which also occur in the various layers of the soil profile. These soils are shallow on upper parts of slopes but quite deep in the lower parts. These usually contain from 30 to 80 percent stones or gravel, the remainder consisting of sand and silt. The lime content of these soils is usually high, and in old deposits a zone of lime accumulation may occur in the subsoil, especially in semi-arid areas. These soils also occur on old alluvial fans that have been dissected by geologic erosion and form low, gravelly foothills in some areas.

Their utility for agriculture is limited by their low water-holding capacity and their stony or gravelly nature. They offer limited possibilities for grazing and extraction of firewood.

At some places in high mountain areas, stone terraces have been built to form fields, but most of them are now abandoned.

Shallow and deep loamy soils of terraced fields on mountain slopes. These occur on the lower parts of mountain slopes, adjoining the wadis or mountain plains. The texture is usually silt loam, silty clay loam, clay loam or loam. The lime content is 8-15 percent. The pH is about 7.6-8.0. The organic matter content is about 0.6-1.2 percent in the surface and 0.3-0.6 percent in the subsoil. In many places a burried soil is found in the subsoil and it has 0.8-1.0 percent organic matter.

These soils are mostly terraced and have been formed by deposits of alluvial material (flood leavings) and loess (wind-laid silt) as well as the silt from rain water diverted into the fields. These soils are quite productive with two limitations. If terraces are not regularly maintained, soil may erode and some soil is shallow over gravel.

Very deep loamy and somewhat clayey soils of lower mountain slopes. These soils resemble those in the preceeding category but are very deep. Their textures are silt loam, silty clay loam and clay loam. They are formed in the deposits of loess, alluvium and the silty material carried by water of mountain streams. These soils are moderately to strongly calcareous, with a lime content of 8-15 percent. The pH is usually 7.6-8.0, except at a few places where it may be higher due to sodicity. The organic matter content is usually 0.7-0.8 percent in the surface soil and 0.4-0.6 percent in the subsoil, which has a weak to moderate subangular blocky structure.

These soils are highly productive and low rainfall is the main limitation. This is compensated to some extent by the run-off water coming down the mountain slopes and streams.

Very deep loamy and clayey soils of mountain plains. These are very deep soils which are formed in alluvium and loess inter-layered with lacustrine materials (lake deposits). Often the surface soil consists of a loess layer of silt loam overlying a burried silty clay loam or silty clay subsoil. The soil is moderately or strongly calcareous with lime content

of 10-20 percent. The organic matter content of surface soil is 0.6-1.2 percent, and that of subsoil (burried soils) 0.8-1.0 percent. These are very fertile soils and their productivity is limited by low rainfall and some frost hazard. The clayey soils are difficult to till. The clay fraction of these soils comprises an expanding type of clay, montmorillonite or smectite. The calcium to magnesium ratio may be narrow, which may adversely affect crop production. The lowest parts of the plains are often occupied by saline and waterlogged soils.

Sandy and loamy soils of wadis. These soils occur in wadis, which are narrow flood plains of mountain streams flanked by steep mountain slopes. The soils are usually sandy loams, loams and silt loams, varying in gravel content and depth over gravel. These are usually moderately to strongly calcareous, with 10-15 percent lime content, and have a pH of about 7.8-8.1. Their organic matter content is low, 0.3-0.5 percent. The soil is layered with materials of different textures and either a massive or platy structure. These soils benefit from flood water irrigation, without which agriculture would not be possible. However, sometimes the flood water erodes the soils after damaging the field banks or terraces. Some soils are limited by shallowness, sandiness or gravel.

d. Water supply for agriculture. In the mountain farming areas of the Yemen Arab Republic, there are various types of water supply.

- Rain-harvesting utilizes the run-off water from mountain slopes by diverting it into fields, thus supplementing the rain moisture.

- Spring water is used for domestic and irrigation purposes. The water supply is assured but it is shared by a number of farmers.

- Ground water is pumped from wells and used for irrigation, usually by individual owners. Often the quantity of water is limited and the cost is high. At some places it is excessively exploited, while at others it may be under-utilized since a proper ground-water survey has not yet been made.

- Perennial wadi flows usually provide abundant water for irrigation, the culturable land area in wadis being limited.

- Flood water of wadis is used to provide a deep soaking of soil in fields situated along wadis. This represents a semi-irrigation condition, as the quantity and the timing of available water are uncertain.

Water supply conditions are important for any development planning exercise.

e. Natural vegetation. To classify range and forest land, and plan their management, range and vegetation surveys are needed.

The following broad divisions can be made of the natural vegetation of the mountain areas of the Yemen Arab Republic.

High-altitude mountains. Extensive tracts in mountain areas have been deprived of much of their original vegetation owing to excessive grazing, repeated cutting, pollarding and browsing of forest-trees and ever-

expanding cultivation into marginal lands. The nutritious and palatable surface vegetation has been largely replaced by useless xerophytics, cacti and composite species of Opuntia, Aloe, Salvadora persica, Euphorbia and Desmostachya. There are a few remnants of the original vegetation dominated by Dodonea viscosa and Juniperus procera in fissures between boulders and in remote and inaccessible sites on high mountain peaks of the humid Ibb region. There are numerous natural springs in the area, which drain into narrow streams. Along their banks, several species of Ficus, i.e. F. vasta, F. populifolia and F. pseudosycomorus grow naturally, with surface vegetation dominated by Juncus spp. Desmostachya bipinnata and Phragmites communis. The main surface plant associations occur occasionally in association with the species of Euryopas, Coleus, Salvia, Lavandula, Boxus, Lantana and Andropogon. At elevations of 2 000 m and higher, species of Poa, Bromus and Danthonia are found (ACSAD, 1981).

Middle-altitude mountains. Rich forests exist on the slopes of lower mountains having moderate rainfall (400-500 mm), for example around Taiizz and Rahdah and in the plains and valleys nearby. The most conspicuous are: Acacia seyal, A. arabica, A. etbaica, A. tortilis, Prosopis africana, Jatropha spp. Albizzia lebbeck, Tamarindus indica, Ficus pseudosycomorus, F. salicifolia and Ziziphus spina-Christi.

Low mountains. Low-mountain valleys west of Ta'izz have a dense cover of Ficus spp. Ziziphus spina-Christi, Tamarindus indica Jatropha spp., Sterculia spp. Conocarpus lancifolius, Anogeissus sentis and several species of Acacia, such as A. albida, A. arabica, A. seyal and Adansonia digitata.

Western and southern slopes of the central highland. At an elevation of 2 000-2 500 m with rainfall of 200-500 mm, extending from Torbah to the Saudi Arabian border, there are scattered trees of Acacia tortilis, A. nubica, A. humulosa, A. seyal and Ziziphus spina-Christi.

Mountain plains. Between high and medium-high central mountains, in plains and valleys having deeper soils, there are many more or less open stands of Tamarix orientalis, Ficus salicifolia, F. pseudosycomorus, Cordia myxa and Tamarindus indica (al-Junaid, 1980).

Although the palatable and nutritious surface vegetation has been greatly depleted by continuous excessive grazing on the sloping rangeland, some remote and inaccessible localities still have valuable natural vegetation such as Andropogon hordeum, Medicago, Brassica, Lolium, Poa and Bromus.

f. Present land use. It indicates to a large extent the suitability of an area for different land uses as well as the technical skill of the farmer. The following land uses are prevalent in the area:

- Rainfed cropping, mainly of cereals, but including some beans intercropped with sorghum;
- Irrigated field crops, mainly maize, wheat and sorghum;
- Irrigated orchards, mainly coffee, banana, grapes and kat;
- Spate-irrigated cropping, mainly of sorghum and millets, but some tomatoes and other vegetables;
- Grazing and fuelwood extraction, grouped together because grazing is the main land use, but some fuelwood is also extracted from the same land.

These land use conditions should be considered in any classification meant to provide a basis for planning the integrated development of an area.

IV. THE STUDY AREA

The districts of Al-Haymat Al-Kharjiya and Al-Haymat Al-Dakhliya have been selected as the study area, being representative of semi-arid and arid mountain areas having high and medium altitudes, and also in keeping with the wishes of the Ministry of Agriculture of the Yemen Arab Republic.

1. Location and extent

The study area is located between latitudes $14^{\circ}45'$ and $15^{\circ}20'$ N and longitudes $43^{\circ}45'$ and $44^{\circ}0'$ E, forming a part of the central high mountain region. About 75 km from north to south and 10 to 25 km from east to west, the total area is approximately 800 km^2 (see Fig. 2).

2. Basic data

The data are presented in Table 2 below.

TABLE 2. Cultivated area, population and livestock in the study area

	Al-Dakhliya	Al-Kharjiya
Cropped area (ha)	14 992	11 186
Abandoned area (ha)	2 043	1 856
Population (residents)	39 324	30 236
Population (emigrated)	9 495	5 806
Camels	-	424
Cattle (mainly cows)	11 816	8 665
Sheep	18 397	10 495
Goats	23 827	17 343
Donkeys	6 011	3 503

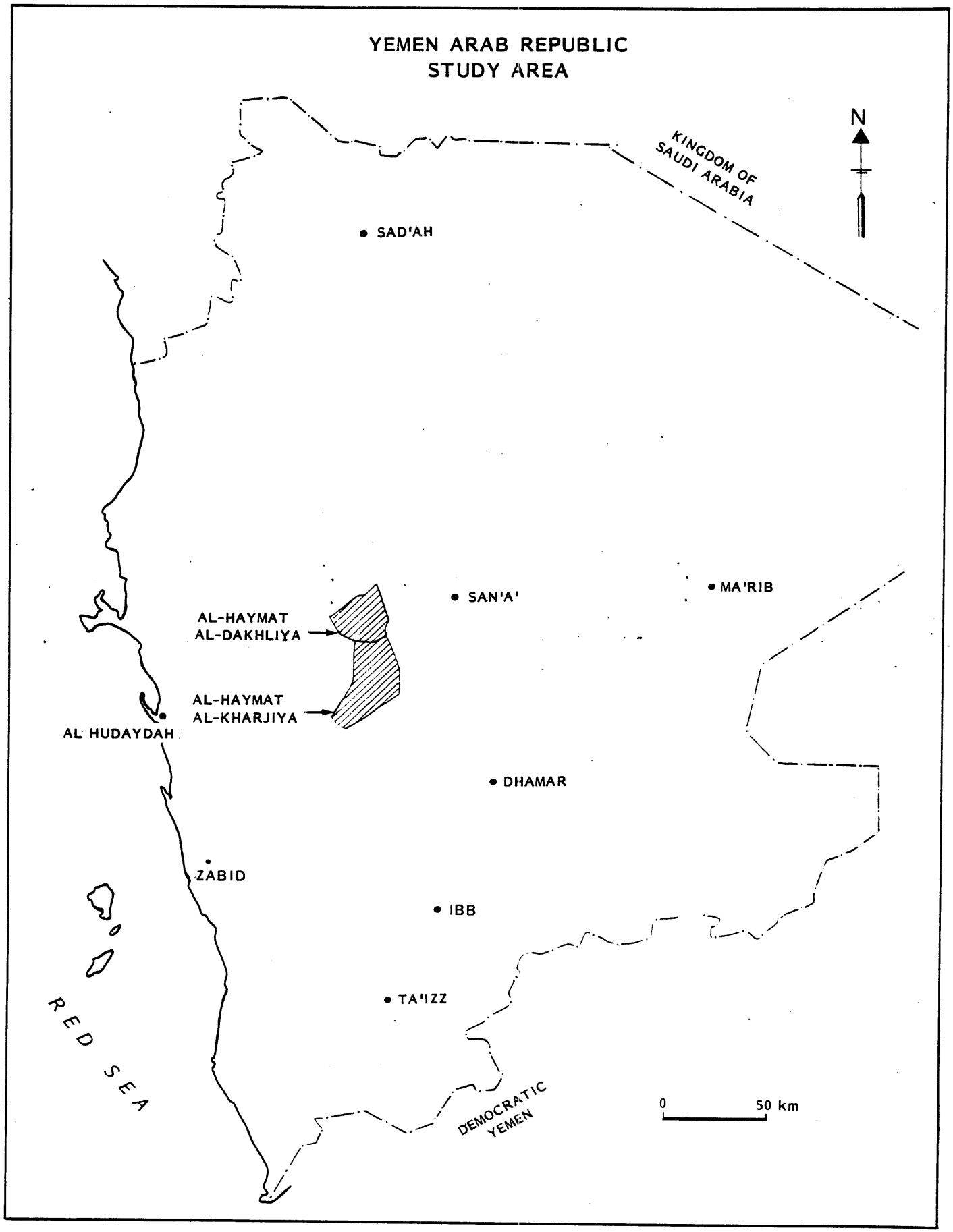
Sources: Agricultural Statistics Project, Ministry of Agriculture and Fisheries, Sania, Yemen Arab Republic.

3. Physiography

Although the whole study area, covering Al-Haymat Al-Kharjiya and Al-Haymat Al-Dakhliya, is a part of the central high mountain region, it can be subdivided into the following physiographic units:

- high altitude mountains;
- middle altitude mountains;
- mountain plains;
- wadis.

Fig. 2


YEMEN ARAB REPUBLIC
STUDY AREA
N
KINGDOM OF SAUDI ARABIA
SAD'AH
SAN'A'
MA'RIB
AL-HAYMAT AL-DAKHLIYA
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ZABID
IBB
TA'IZZ
RED SEA
DEMOCRATIC YEMEN
0
50 km

a. High-altitude mountains. With altitudes of 1 600 to 3 000 m, it is a highly dissected area with deep gorges and great relief differences of 500 to 1 000 m. The slopes are steep but often converted into terraced fields with meticulously built stone walls. However, there are some high plateaux, 2 000-2 800 m above sea-level, with gentle slopes.

b. Middle-altitude mountains. With altitudes of 1 000 to 1 600 m, this physiographic unit is less dissected than the high altitude mountains. The slopes are steep, but not excessively so. Unlike in the high mountains, mountain slopes are not cultivated: cultivation is limited to wadis along streams, and depends on spate irrigation or spring water. Exceptions are some plateau areas where fields are cultivated by diverting the run-off water from adjoining hills. The mountain slopes are generally rocky in the upper part but have deep stony soil and a fairly dense vegetation of thorny shrubs.

c. Mountain plains. These are nearly level to gently sloping areas that occur within the high- and middle-altitude mountains. They are characterized by cultivated fields which have replaced natural vegetation. Examples are: areas around Al-Urr and Al-Hjrah (altitude about 1 900 m), Bani Mansur, Hilaqah and Al-Nasiryah areas (altitude 1 300-1 400 m), the plain southwest of Wadi Dayan in Al-Haymat Al-Dakhliyah, the area east of Al-Mudayr and As-Sulamah and west of Al-Husayn, the land around Az-Zuhrah, Al-Lakmah, Qamran and As-Subar, and the areas around Al-Madani, Dar-Al-Mawrid, Bayt-ar-Rumaym, Bayt Ghawbar, Al-Khamis, Khamis Modhyul and Bayt-as-Sadi in Al-Haymat Al-Kharjiyah.

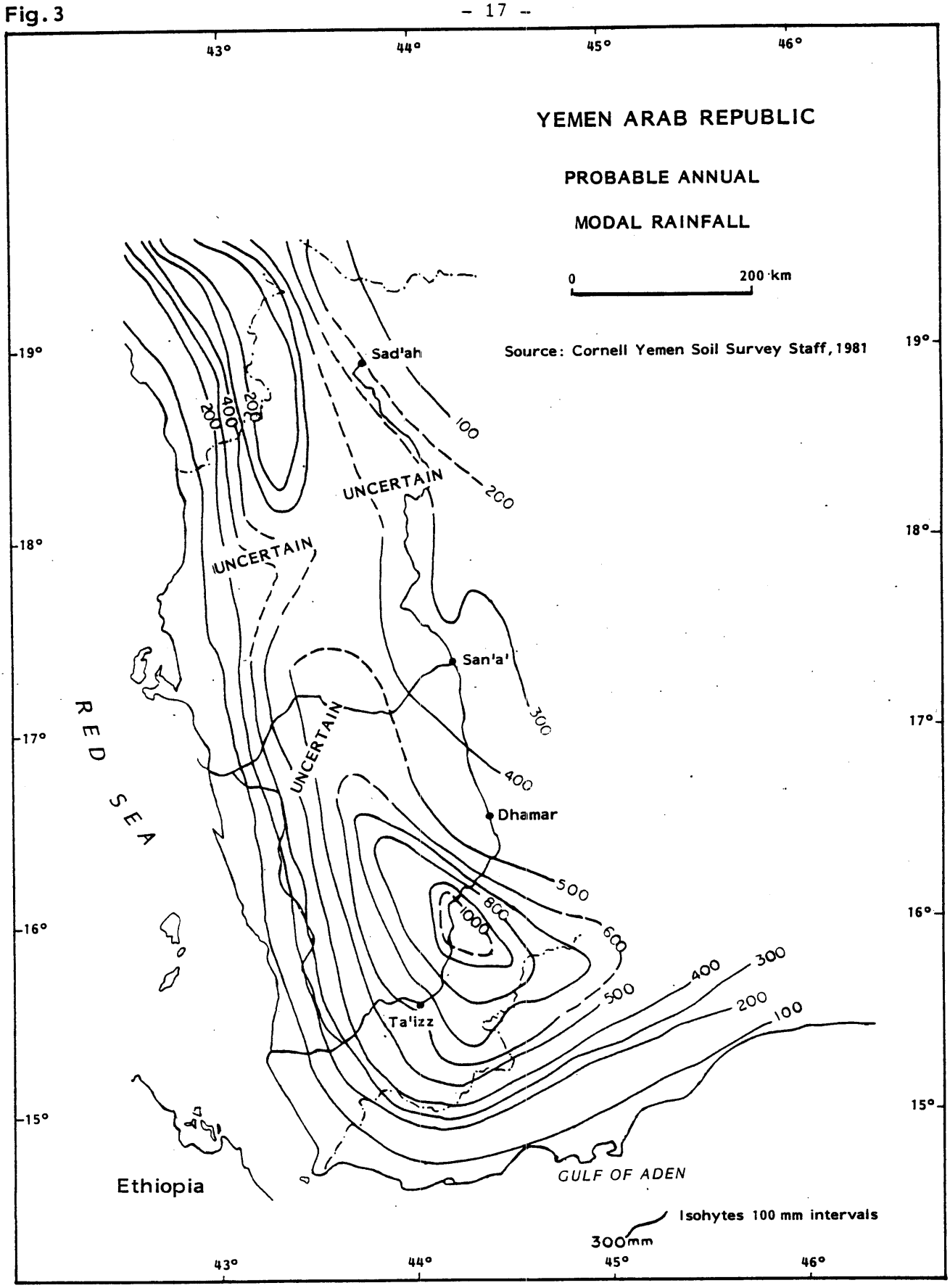
d. Wadis. Forming an integral part of the mountains, wadis exhibit their own distinct character in the middle-altitude mountains where they irrigate important crop areas with spate or perennial flows. Wadi areas are protected by the surrounding mountains from desiccating winds. There is not only surface water but also ground water for irrigating crops and for meeting needs of livestock and households.

4. Climate

Located within latitudes 14°45' and 15°20' N and having altitudes 1 000-3 000 m, the study area has a tropical highland climate characterized by mild summers and winters and low seasonal variations in temperature. The Yemen Arab Republic lies at the southern edge of polar westerlies (Williams, 1979).

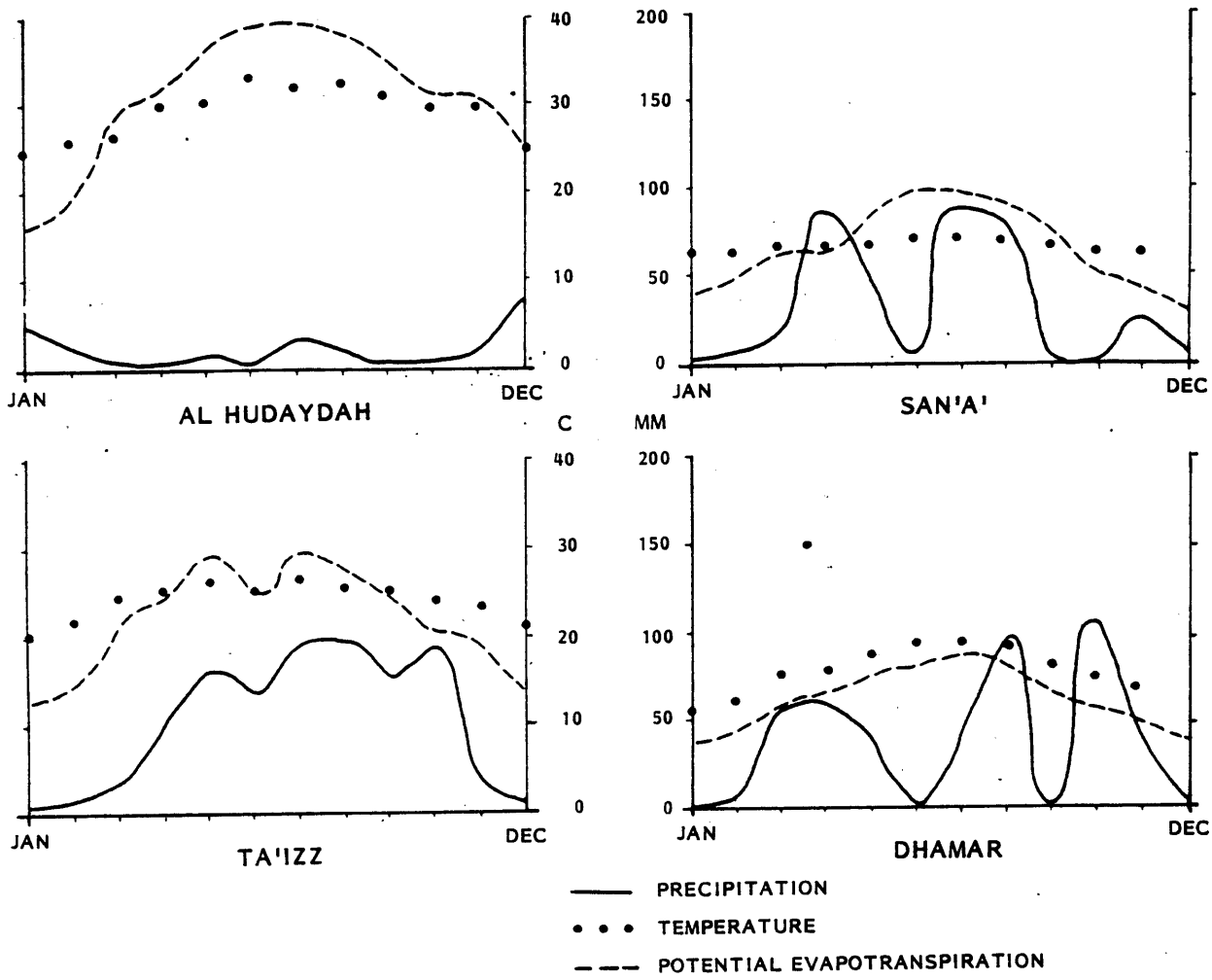
There is no meteorological station in the study area but the data available for Sania and Ta'izz can be used with some modifications. The mean daily temperature ranges between 11°C in December and 15°C in June. There is a high diurnal variation in temperature, ranging from 15 to 20°C. During the summer, the maximum temperature in the high altitudes (1 600-3 000 m) is 23-26°C, sometimes reaching 30°C. The minimum is 4-10°C. During winter, the minimum temperature is 2-4°C but sometimes dips as low as -8°C in high plateau areas, and the maximum is 18-22°C. At middle-altitudes (1 000-1 600 m), the mean daily temperature ranges between 20°C in December and 27°C in July (Taiizz data). The maximum temperature in summer is 25-35°C and the minimum in winter is 8-12°C.

Fig. 3


YEMEN ARAB REPUBLIC
PROBABLE ANNUAL
MODAL RAINFALL
0
200 km
Source: Cornell Yemen Soil Survey Staff, 1981
43°
44°
45°
46°
19°
18°
17°
16°
15°
Sad'ah
San'a'
Dhamar
Ta'izz
UNCERTAIN
UNCERTAIN
UNCERTAIN
100
200
300
400
500
600
800
1000
RED SEA
Ethiopia
GULF OF ADEN
Isohytes 100 mm intervals
300mm

YEMEN ARAB REPUBLIC

RAINFALL AND TEMPERATURE



Source: Cornell Yemen Soil Survey Staff, 1981

The mean annual rainfall (extrapolated data from San'a) ranges between 300 mm at middle-altitudes (1 000-1 600 m) and 500 mm in some parts of the high mountain areas (altitude 2 000-3 000 m).

There are two rainy seasons, a minor one during April/May and the main one during July/August. The dry season extends from September to March, and June is also dry. Lack of rain in June adversely affects the growth of rain-fed crops during the early development stage, and dry weather in September and October affects sorghum during the grain-filling stage. Potential evapotranspiration is 1 200-1 500 mm per year.

The mean relative humidity remains low (20-35 percent), except during the main rainy season in July/August when it may be 70-80 percent.

High solar radiation is a favourable factor in crop production. Rainfall varies considerably from year to year, as shown by the monthly rainfall data for the years 1980-83 for San'a and Ta'izz, presented in Table 3 (FAO/WFP Mission, 1983).

To show the general pattern of rainfall distribution in the area, a rainfall isohyte map is given (see Fig 3), along with graphs showing monthly rainfall and mean temperature (see Fig. 4).

TABLE 3. Monthly rainfall (mm) in San'a and Ta'izz during 1980-83

	San'a				Ta'izz			
Month	1980	1981	1982	1983	1980	1981	1982	1983
January	0	0.3	5.6	30.9	6.4	0	8.7	35.0
February	14.1	0	18.9	11.2	0	0	0.9	15.8
March	36.3	65.9	48.7	0	0	97.2	37.1	0
April	42.4	0	34.9	7.8	-	39.4	10.3	20.3
May	0	0	86.7	0	97.5	1.5	13.4	12.5
June	0	0	0	0	-	30.1	19.8	0
July	0	20.8	0	8.0	0	18.8	12.0	6.0
August	0	79.8	17.7	-	103.0	30.7	114.2	-
September	0	0	0	-	86.1	52.1	89.7	-
October	5.8	0	51.1	-	7.0	0	0	0
November	0	0	0	-	0	0	0	-
December	0	0	0	-	0	0	0	-
Total	98.6	166.8	263.6		300.0	269.8	306.1	-

N.B. Data for 1983 available until July only.

5. Water supply

Since rainfall is low and erratic in the study area, crop production is highly influenced by the type of irrigation supply. According to an FAO study (FAO, 1983), the area falls in a zone having 0-90 days of plant growing period, considering stored soil moisture and rainfall exceeding 0.5 potential evapotranspiration when temperature is favourable. There are four main situations: rain harvesting to utilize the run-off from hill slopes; spring water; well-water; and wadi flows.

a. Rain harvesting. This is an old and highly developed technique in the Yemen Arab Republic. The run-off water from hill slopes is diverted into terraced fields for irrigation, so that the inadequate direct rainfall is supplemented to store enough water in the soil to grow a crop. Most of the sorghum and other crops are sown in April and May after a soaking irrigation is given through rain harvesting. The crop receives several irrigations of this type during the growing period. The value of cultivated land depends to a large extent upon the degree of certainty of such water supply.

b. Spring water. At some places there are perennial springs, which provide water for domestic purposes as well as for irrigation. The flow of water is affected by the amount of rainfall. The land served by spring water is highly prized and is used generally for high value crops such as kat (a mild narcotic), vegetables, fruits, coffee and alfalfa.

c. Well-water. With the introduction of pumps during the last 15 years, irrigation is increasing rapidly in those plain areas where ground water has been found. There are some mountain plains in the study area where ground water may exist, and it would be useful to survey the area's ground water resources systematically through geophysical investigations and some trial borings. The supplies of well-water provide supplementary irrigation during the critical stages of crop growth, especially in September when sorghum is in its grain-filling stage and the soil is dry because of the weather.

d. Wadi flow water. Some wadis such as Wadi Sukhna have a perennial flow, while others have flood water only for a few hours after each rain. The perennial flows are extremely important in providing irrigation water on a regular basis for the cultivated lands in the wadis. Even the flood water is very useful to soak-irrigate the fields located in wadis.

The land served with perennial water supplies is used for growing coffee, bananas, kat, maize and vegetables. The areas with facilities for soaking irrigations with flood water are mainly used for sorghum and in some cases for tomatoes and cucumbers.

6. Soils

For describing soils, the study area can be divided into the following land forms: mountain slopes; montane plains and wadis.

a. Soils of mountain slopes. Near the mountain peaks, the upper parts of slopes are very steep and comprise mainly bare rock and very shallow soils (lithosols). These have only watershed value and some very limited grazing utility.

The middle parts of mountain slopes, with angular stones on the surface, are usually steep (30-45° slope) and have stony and very stony soils. Generally these are calcareous, with pH 7.8-8.1 and low organic matter content (0.7-1.0 percent). At some places fields have been made by picking out the stones to build stone wall terraces and enriching the soil with the silt deposited by the run-off water which comes from the hillsides and is diverted into fields through rain harvesting.

The lower parts of mountain slopes generally have deep silty soils (silt loams and silty clay loams). These are free of stones and are moderately or strongly calcareous with a pH of 7.8-8.1 and organic matter content of 0.6-1.0 percent. At some places a burried soil profile is found, with a dark layer relatively high in organic matter, about 1.2-1.5 percent. At favourable sites these soils have been terraced with stone walls to make cultivated fields. These soils are mostly yermosols, with some xerosols.

b. Soils of mountain plains. There are some plains or plateaux within mountain areas. The soils of these plains are formed either in loess, alluvium or lacustrine materials. Characteristically, the soils are very deep, mostly silt loams and silty clay loams, occasionally silty clay in texture, and moderately or strongly calcareous, with a pH of 7.8-8.1 and an organic matter content of 0.6-0.8 percent. In some places the surface soil layer of silt loam or silty clay loam is underlain by a dark-coloured silty clay loam or silty clay of a burried profile. They clay in the subsoil is of montmorillonite type (2:1 lattice) with a high cation exchange capacity and expands greatly when wet. Near the margins of the plains, the gentle slopes have been terraced with stone walls but in other parts the surface is nearly level and fields are made by building soil terraces. In the lowest parts, the land surface is concave and soils are saline due to intermittently prevailing poor-drainage conditions during the rainy season.

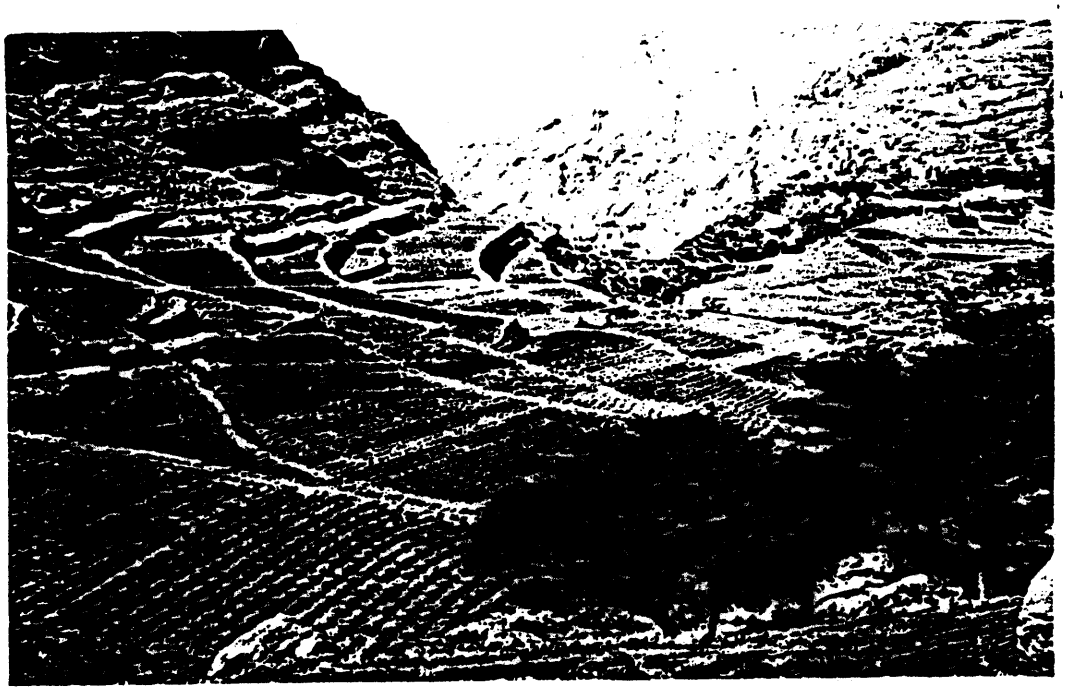
These soils are very fertile and productive, with the exception of saline areas, but often lack water because of rainfall and lack of rain-harvesting facilities, which are available only in areas adjacent to mountain slopes. In some places tube-wells are being installed to exploit ground water, but a systematic geohydrological survey is needed to assess the ground-water potential to avoid over-exploitation.

High contents of lime and silt and low content of organic matter in these soils can cause surface crusting, a low infiltration rate, phosphate fixation and a scarcity of certain micronutrients like zinc, iron and manganese. Zinc and iron deficiencies in coffee and citrus have been reported (Rezania, 1973).

These soils are classified as mostly yermosols, some xerosols and some solonchaks.

In some places, a zone of lime accumulation is found in the subsoil at a shallow depth, thus limiting the root zone for crops.

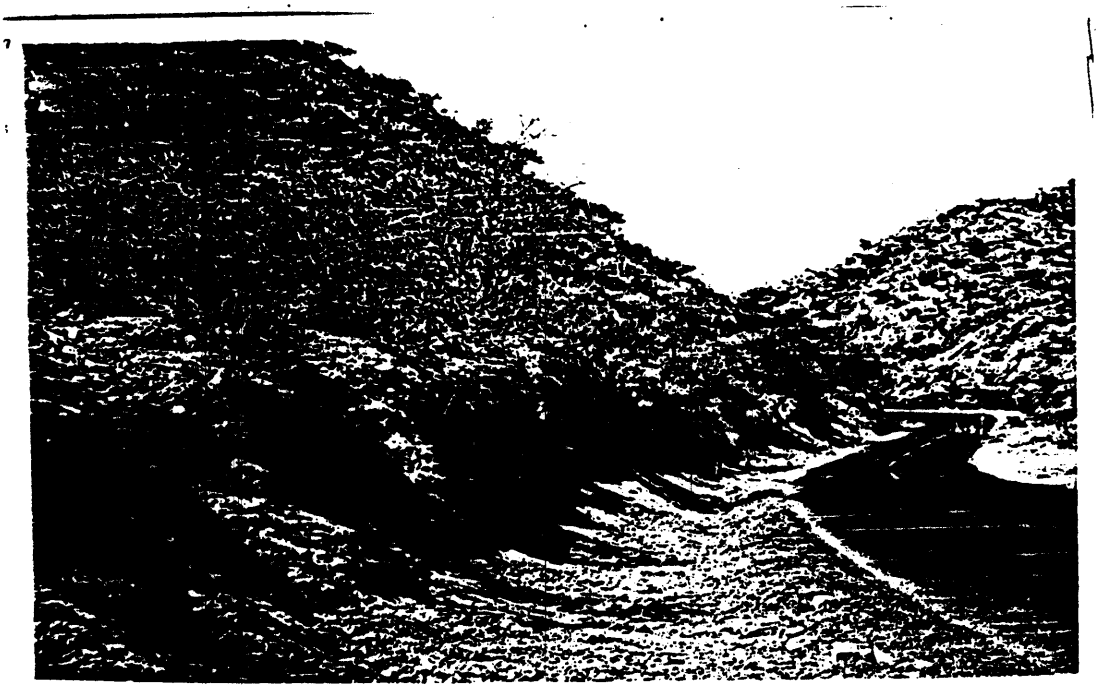
c. Soils of wadis. In protected places or in relatively wide parts, wadis have formed flood plains of their own, with gravelly loamy or loamy soils (mostly silt loams and loams). These soils are characteristically layered and laminated (platy structure) and are highly calcareous. The pH is 7.8-8.1 and organic matter content is low, 0.4-0.6 percent. Generally, large soil patches also occur in areas where side streams join the valley.



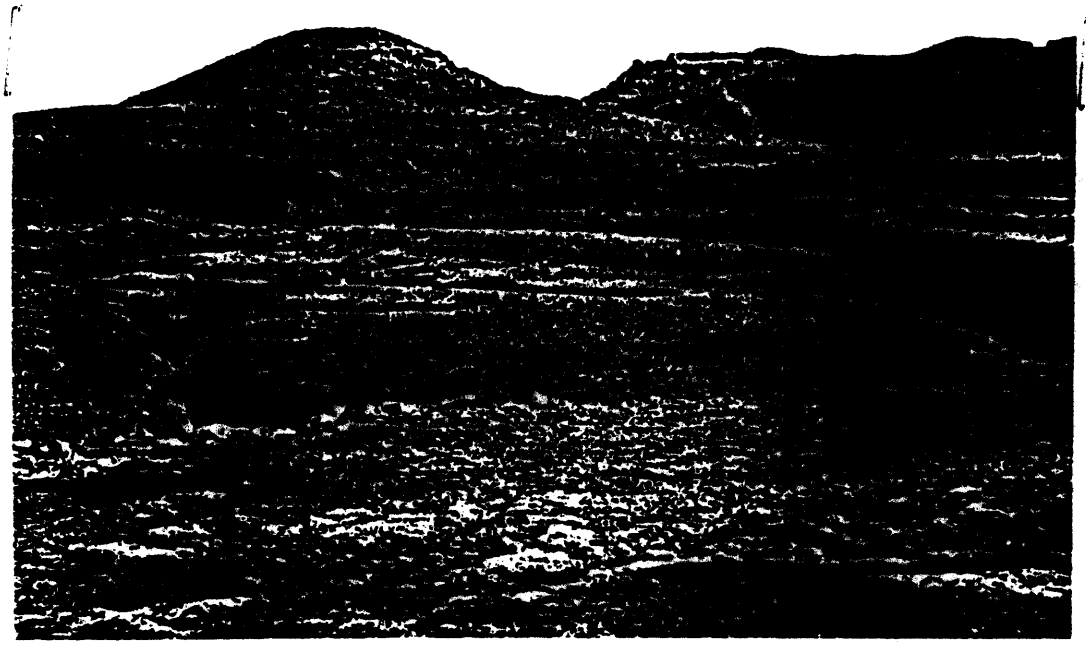
Bench-terraced fields in high mountains in Al-Haymat Al-Kharjiyah

Forest tress planted on well-maintained terraces

A close view of trees on well-maintained terraces



Gravelly soil formed in colluvial material and natural vegetation in middle-altitude



Gully erosion resulting from lack of terrace maintenance

The agricultural value of these soils depends primarily on their depth over gravel and the availability of water for irrigation. In some wadis, perennial flow is available for permanent irrigation. In others, cultivation of crops depends on the flood water which is diverted into fields for deep-soaking irrigation.

7. Natural vegetation

a. Upper slopes of high mountains Vegetative cover is largely non-existent on the precipice slopes, from 2 000 to over 3 000 m in elevation, except a few short-lived annuals and bulbs which complete their life cycle during the rainy season and disappear soon afterwards. Where there is some perennial vegetation, it consists mainly of Peganum harmala, Cleome arabica and Daemia spp. (Draz, 1983).

b. Middle slopes of high mountains. This zone is characterized by stony soils. Vegetation is sparse, and grazing by livestock, especially goats, is obvious. Forest cover has been greatly thinned due to repeated cutting for fuel. Notwithstanding continuous grazing in this zone, there are localized sites in remote areas where valuable Andropogon, Hordeum, Medicago, Poa, Bromus and Lolium grow. Because most of the original ephemeral and perennial species have disappeared, xerophytic and thorny shrubbery such as Aloe, Opuntia, Salvadora Persica and Euphorbia has taken over. What is left

of forest cover consists of scattered Acacia mellifera, A. negri, A. Seyal, A. arabica, A. erbaica and Ziziphus spina-Christi.

c. Low mountains. This zone is heavily grazed as it is easily accessible to local sheep and goats. There is seldom a trace left of the palatable original surface vegetation and the area is invaded by Euphorbio, Aloe, Opuntia, Peganum and several unpalatable species of the Compositae family. Tree cover is dominated by Acacia spp. and Ziziphus spina-Christi, which are heavily utilized for fuel, fodder and timber.

d. Plains. They are mainly utilized for crop production, rain-fed and irrigated. The natural surface vegetation is virtually absent and the tree species found occasionally along terraced fields are mainly of Acacia, Ziziphus and Tamarix.

e. Wadis. Wadis, the water courses of perennial and intermittent streams, are of sandy, gravelly and stony nature. On the banks and on sandy islands there is usually a dense canopy of forest trees dominated by Ficus vasta, F. pseudosycomorus, F. populifolia, F. salicifolia, Cordia myxa, Ziziphus spina-Christi, Balanites aegyptiaca, and on drier sites there are several Acacia species, Tamarix articulata and T. orientalis. In cultivated fields valuable forage grasses of Panicum spp. and Cynodon dactylon may be found. The unpalatable Desmostaychya bipinnata grass is found in moister sites in valleys and along field streams. Numerous other forage plants grow in the valleys during the wet season but they are grazed to the ground, and therefore, many invaders of Compositae, Opuntia, Aloe and Euphorbia are established:

Forest trees, heavily exploited by the local population as a source of fuel and fodder, are mainly of the Ziziphus family.

8. Present land use

The main land uses in the study area are:

- rainfed cropping;
- irrigated cropping;
- irrigated orchards;
- spate irrigated cropping;
- grazing;
- forest utilization.

a. Rain-fed cropping. The predominant land use in the study area is rain-fed cropping, mainly of sorghum, but also of millet, wheat and barley. Rainfall is often supplemented by run-off water from the hills. This water is led from one field to the other through a series of fields. Thus the rainfall deficiency is made up to some extent. The efficiency of this practice depends upon the depth and texture of the soil; deep loamy soils produce good results but gravelly soils perform poorly. Crop yields depend upon the amount and distribution of rainfall, the facility of rain harvesting and the depth and texture of the soil. On the average the yield of sorghum is about 1 tonne per ha, but varies from 0.5 to 3.0 tonnes. Sorghum and millet are sown in May and harvested in October in high mountain areas (2 000-2 600 m altitude). Wheat and barley are sown in June and harvested in August or September.

On marginal land, the common crop is millet, but it produces little grain or none at all. It would be better to cut the crop at the flowering stage and dry it to produce hay, which would be much more nutritious than the plant material produced by maturing the crop as at present.

No crop rotation is followed. Sorghum or millet is grown in the same fields year after year. Some fields remain fallow, more in low-rainfall years. The land is well prepared by ploughing with the local chisel-type cultivator worked with bullocks. Many farmers own only one bullock and share it with others for cultivating the land. Medium and large tractors have been introduced but their use is limited to the mountain plains. In terraced fields on mountain slopes, land is still tilled with bullocks or by hand. Only small tractors (3-5 h.p.) could be used in the terraced fields.

Dung manure is applied to the cropland once every two or three years. The chemical fertilizers have just been introduced during the last one to two years, and farmers have yet to learn about their use.

Sorghum is sown in furrows. One person works the chisel plough and another, walking behind the plough, places the seed in the furrow by throwing a pinch of seeds at a time just behind the plough. The plants are earthed up when the crop is 30-45 cm high during the rainy season and thinned, leaving two to three plants per hill. Thus the crop stands on ridges during its growth. This practice helps the crop to escape water-logging during heavy rains in July and August. When the crop reaches the grain-forming stage (about 70 days after sowing), all the leaves except the top two or three are removed and fed to cattle or dried and used for wrapping kat. After the crop matures, the upper part of the stem is used for feeding animals and the lower part, along with the stubble, is used as fuel.

b. Irrigated cropping. Wherever water is available from springs, wells or perennial stream flows, it is used for irrigation, mainly to grow alfalfa, wheat, maize and some vegetables (potatoes, tomatoes, onions, cabbage and cucumbers). Fields are subdivided into small plots to use the water more efficiently, since the flows are usually small. Vegetables are grown on ridges, with furrow irrigation. Dung manure is applied to vegetables before sowing and to cereals once every two years, but some of these are grown after vegetables to use the residual effect of the manure.

Chemical fertilizers have just been introduced. It will take a few years for farmers to learn their proper use. Some farmers complained of insect attacks when a chemical fertilizer (probably urea) was used.

The proportion of cultivated land under irrigation is very small. Alfalfa is traditionally the main crop because fodder is in short supply in mountain areas, especially during the dry season.

c. Irrigated orchards. Coffee and kat are by far the most extensive orchard crops. Kat is surpassing coffee in importance because the income from it is five to ten times more than that from coffee. Maize is sometimes inter-planted among young coffee plants. Plant populations per unit area are generally much higher than desirable.

d. Spate-irrigated cropping. In wadi areas, cereals, mainly sorghum and millet, are sown after applying a heavy soaking irrigation by diverting flood water of streams into fields with high dikes. Bullocks are used to make earthen diversions to guide the flood water into fields. During the course of its growth a crop may get one or more such irrigations, depending upon the rains and the stream flood. As the cultivated land is limited in the wadis in the study area, water is usually available in abundance. The crop yields depend mainly upon the depth and texture of the soil; they are fairly high on deep loamy soils but low on gravelly and shallow soils. Manure is seldom used. Building and maintaining dikes around the fields makes it a labour-intensive process.

e. Grazing. By far the highest proportion of total land area is used for extensive grazing of livestock, mainly goats and sheep. With the exception of high mountain peaks, very steep slopes, terraced cropland, coffee, banana and kat plantations and other areas occupied by irrigated crops, all the land is open for grazing. Thus, more than 90 percent of the land in the study area is grazed and even the cultivated fields are grazed when fallow.

Generally, the grazing rights are held by tribes on a collective basis and every member of the tribe is free at any time to graze his animals in the area of his tribe, and sometimes even in the area of other tribes as well. However, some tribes practice a system of rotational or deferred grazing locally known as the hema system, under which the grazing area (or rangeland) of a tribe is divided into sections, and each section is opened for grazing for a certain period. A total of 424 camels (all in Al-Haymat Al-Kharijiya), 20 481 cattle, 28 892 sheep, 41 170 goats and 9 514 donkeys graze the area.

The production, measured as wool, lambing percentage or meat per animal is very low because there is a dearth of forage, especially during the dry period, and no supplemental feeds are given to livestock.

Because of uncontrolled and excessive grazing, forage resources in rangeland are continuously dwindling and the useful vegetative cover has been largely replaced by useless thorny, xerophytic succulents and occasionally poisonous plants such as Citrullus colococynthis.

Depletion of rangeland has become so severe that the energy spent by livestock in searching for food is often greater than the energy derived from it. If it were not for the limited supplementation with sorghum and alfalfa and grazing in fallow fields and crop stubbles, the livestock would lose rather than gain weight.

f. Forest utilization. The present-day forest-tree cover of the area consists of scattered trees or at best very open capony dominated by Acacia, Euphorbia and Ziziphus species with occasional occurrence of Cordia, Tamarindus, Ficus, Salvadora and Brugieriae. Forests growing in areas away from cultivated land, as solitary trees or as stands, are presumably public property. However, someone often claims to own them.

The major uses of forest-trees are fuel, forage and timber. It is estimated that per caput consumption of fuelwood in similar communities amounts to about 1 m^3 or 750 kg per year (US AID, 1982) and about a third of this

consists of live branches. With about 85 000 residents extracting fuelwood at this rate, the survival of the existing forest trees in the study area is highly questionable. Pollarding branches for feeding livestock and cutting trees and large branches for roofing, etc., further threaten the trees.

9. Farming systems

Both rainfed and irrigated farms in the mountain areas consist of fields well protected by stone terraces that are generally maintained in good condition, except for those covering marginal land. The discussion on farming systems relates to the whole mountain area, because of the lack of specific data for the study area.

a. Cropping patterns. These are discussed according to the water supply situation.

Rain-fed farms. Most of the area under rain-fed cultivation is occupied by sorghum (over 50 percent) which is sown in April/May and harvested in September/October. In areas having rainfall of more than 800 mm (outside the study area), maize is an important crop (22.9 percent) which is sown in May and harvested in September. A smaller percentage of the rain-fed farms grow wheat (11.2 percent) and barley, which are sown in June and harvested in August. Some legumes such as cowpeas (Vigna sinensis) and lentils are also produced. Cowpeas are generally intercropped with sorghum.

Due to the bimodal rainfall pattern (April-May and July-September) in the area, some fields with sufficient moisture can give two crops in one year. The cropping intensity ranges from 108 to 120 percent in high-rainfall areas, but may be as low as 50-60 percent in areas with low rainfall.

Sorghum and maize are grown for grain, which is used as a staple food by the farmers and their families. The stalks are collected and fed to livestock. During dry years when the rain is inadequate for the plants to produce grain, the stalks are cut and made into hay for the livestock.

Spring-irrigated farms. In the irrigated farms near springs and along the wadis, maize is the dominant crop, covering 39.2 percent of the crop area. It is grown also during the winter under irrigation, sown in October and harvested at the end of December. Other important crops in the spring-irrigated farms are potatoes, covering 16.3 percent of the crop area, and to a lesser extent tomatoes and onions. In these farms there are also some perennial crops such as bananas, papayas, coffee, grapes and kat. The permanent crops are found mainly is those wadis with a perennial supply of water. The cropping intensities of the spring-irrigated farms range from 167 to 171 percent.

Tube-well farms. On the farms irrigated by tube-wells, the cropping pattern consists of about 50 percent cereals (sorghum and maize on equal areas), 31 percent grapes, 15 percent vegetables, dominated by potatoes (some tomatoes and onions), and about 5 percent other crops such as kat, citrus and watermelon. The smaller farms concentrate on potatoes because this crop pays better and is easier to store and market. Contrarily, grapes are grown on medium and large farms because they require a lot of capital for supporting materials, packing and marketing, which are beyond the means of small farmers. Moreover, grapes yield only once a year and this limits small farmers, especially tenants with little money.

The cropping intensity of farms with tube-well irrigation ranges from 118 to 143 percent, although certain crops such as cereals and vegetables can be grown three times a year. The cropping intensity may be low because the perennial crops such as grapes, kat and citrus (covering about one-third of the farm area) are counted as 100. However, the main reason for the low cropping intensity is the inadequate supply of irrigation water. Most of the tube-wells are open wells, dug by hand; they are shallow and the water level drops during pumping.

b. Farm animals. The domestic farm animals raised by mountain farmers are bullocks, which supply the draught power for ploughing and other farm operations, and camels and donkeys, which provide transportation. One cow is generally kept by each household for milk, used fresh, or processed as ghee and cheese. Sheep and goats supply the meat and poultry supply eggs or meat. Generally, the livestock depends more on grazing than processed feed. A few recently-established commercial livestock and poultry farms are well organized and operated according to modern methods. These farms account for 50 percent of the chicken production in the country.

Most of the crop and livestock products are utilized for family subsistence, and only small quantities of butter or cheese, bananas, papayas and kat are sold in the local markets. Local markets operate once a week in certain centrally located villages. The farmers who attend these markets sell their products and bring home the needed supplies, usually on horseback, or on foot. Very few farmers own four-wheel drive vehicles to take their products to the town market, where they usually get higher prices. Some of them deal also in agricultural products. Whenever farmers urgently need cash, they sell a sheep, a goat, even a calf or the cow but they never sell cereal grains. This seems to be an old custom from the days of complete isolation and self-sufficiency when they used to store all grains for long periods as a guarantee for survival during the dry years when no grain was produced.

c. Farm tenure. In the mountain areas of the Yemen Arab Republic, 65 percent of the agricultural holdings are totally owned by their operators and 10.5 percent are totally sharecropped. In 14 percent of the holdings the operators own more than half of the land they cultivate and rent or share-crop the rest, and in the remaining 10.5 percent of the holdings the operators own less than half of their operated land, the larger part being share-cropped.

The type of share-cropping arrangement varies, depending on the irrigation system, but falls into a few definable categories.(ECWA, 1980).

Rain-fed irrigation. In 40 percent of the cases the farmer (tenant) gets three-quarters of the produce, in 38 percent of the cases he gets two-thirds, and in the remaining 22 percent he gets one-half.

Spring-fed irrigation. In 66 percent of the cases the farmer (tenant) gets one-half share, in 33 percent of the cases he gets two-thirds share, in 14 percent of the cases he gets three-quarters share, and in the other 14 percent, four-fifths share.

The agricultural holdings are highly fragmented. The area of a holding hardly exceeds 1 ha, except in case of a few big landlords or sheikhs who may own 10 ha or more.

Usually the big landlords operate the best parcels of their land themselves, mainly the ones with permanent or reliable water supply, and lease the less productive land under one of the above-mentioned share-cropping arrangements. Almost always the owner-tenant agreement is based on share-cropping and rarely on fixed rent or payment in kind. The system predominates because of custom, religion and inheritance, as well as the landlord's desire to supervise his land and his expectations for higher income, and the tenant's reduced risk of indebtedness in dry years.

In all the share-cropping arrangements, the cost of production (bullocks, tractor, labour, seed, fertilizer, pecticides and harvesting costs) are generally borne by the tenant farmer. The landowner pays only his share of zakat (religious tax on 10 percent on produce of rain-fed land and 2.5 percent on that of tube-well farms. In the case of tube-well irrigation, the landlord shares pumping costs with the tenant, but the tenant's share of the crop is reduced to 50 percent.

d. Farm crop economics

Sorghum. The main food crop was grown in 1980 by 88 percent of the farmers in mountain areas and occupied 63, 26 and 43 percent of the total crop area on rain-fed, spring-fed and tube-well-irrigated farms respectively. The yields ranged between 2 700 and 4 000 kg/ha and the value of the produce, including stalks and hay, ranged from 11 000 to 17 500 YRls/ha. The cost of production ranged from 7 000 to 9 500 YRls/ha and the major cost items were labour, about 35 percent of total cost; harvesting and bullocks 32 and 14 percent of total cost respectively. The input/output ratio was 63.1, 53.6 and 53.0 percent in the rain-fed, spring-fed and tube-well irrigated farms respectively (see Table 4).

Maize. The second major food crop in the mountain areas, it was grown by 67 percent of the farmers and occupied 23, 33 and 24 percent of the total crop area in rain-fed, spring-fed and tube-well irrigated farms respectively. The yields ranged between 3 000 and 4 000 kg/ha, and the value of the produce between 11 000 and 16 500 YRls/ha. The cost structure was similar to that of sorghum, with labour taking up 30-40 percent, harvesting cost 26-30 percent and bullock cost 14 percent of the total. The input/output ratio in the rain-fed, spring-fed and tube-well irrigated farms was 58.8, 63.0 and 51.9 percent respectively.

Wheat and barley. On rain-fed land with some supplemental irrigation, wheat was grown by 18 percent of the farmers on 9 percent of the land. Under the same conditions, 10 percent of the farmers grew barley on 5 percent of the crop area. Wheat yielded 2 088 kg/ha, and barley 2 413 kg/ha. Including straw, wheat produced 15 000 YRls/ha and barley 6 700 YRls/ha. The input/output ratio was 30.3 percent for wheat and 56.7 percent for barley. (See Table 5). (Chaudhry and Bashan, 1980.)

Vegetables. The most important vegetable crop in the mountain areas was potatoes, which was grown by 20 percent of the farmers and covered 4, 6 and 4.5 percent of the cropland under rain-fed, spring-fed and tube-well irrigated farms respectively. The average yield ranged from 10 000 to 20 000 kg/ha and the value of production ranged from 28 000 to 47 000 YRls/ha. The major cost items were seed, 22-45 percent; labour, 20-33 percent; and harvesting, 15-22 percent of total cost. The input/output ratio was 30.7, 38.1 and 38.1 percent in the rain-fed, spring-fed and tube-well irrigated farms respectively.

Tomatoes were grown by 7 percent of the farmers in the mountain areas and covered 6 percent of the cultivated area on tube-well irrigated farms. The value of the produce amounted to 26 500 YRls/ha, while the cost of production was 6 660 YRls/ha. Major cost items were labour, 32 percent; harvesting, 28 percent; bullocks, 18 percent; and tractor use, 12 percent. The input/output ratio was 27.2 percent.

Onions were grown by 5 percent of the farmers in the mountain region and occupied 4 percent of total cropland on tube-well irrigated farms. The value of production amounted to 47 750 YRls/ha and the cost of production to 9 500 YRls/ha. Labour and harvesting were the major cost items incurring 51 and 26 percent of the total cost respectively. The input/output ratio for onions was 19.9 percent.

Permanent crops. The main permanent crop on the mountain region farms was grapes, grown by 7 percent of the farmers and covering 33 percent of the crop area on tube-well-irrigated farms. The average yield was 7 125 kg/ha, valued at 78 500 YRls/ha. Total production cost was 46 500 YRls/ha, with wood and stone support taking up 42.7 percent, labour 34 percent and harvesting 20.1 percent. The input/output ratio was 59.2 percent.

Kat was grown by 9 percent of the farmers and covered 2.5-3.0 percent of the area on rain-fed and tube-well irrigated farms respectively. The average value of production amounted to 121 500 YRls/ha, while the cost of production was only 20 500 YRls/ha. The main cost items were: labour for harvesting (51 percent) and labour for other operations (35 percent). The input/output ratio was as low as 16.7 percent (Chaudhry, 1981).

Assuming equal land value for rain-fed, spring-fed and tube-well-irrigated farms, and based on the input/output ratio, the relative profitability of crops grown on rain-fed farms in descending order is: kat, potatoes, wheat, barley, maize and sorghum. The relative profitability of crops on irrigated land is: kat, onions, tomatoes, potatoes, maize, sorghum and grapes.

TABLE 4. Average yields and costs of sorghum production and maize

Crop		Sorghum			Maize		
Irrigation method		Rain	Spring	Tube-well	Rain	Spring	Tube-well
A.	Yield (kg/ha)	2 725	3 608	3 947	2 970	3 050	3 993
	Value (YRls)	10 984	14 732	17 524	10 670	12 339	16 594
B.	Costs (YRls/ha)	6 936	7 896	9 283	6 271	7 769	8 613
	1. Bullocks	1 025	1 050	1 300	789	1 190	1 150
	2. Tractor	748	738	850	895	688	800
	3. Labour	2 425	2 900	3 275	1 783	3 350	3 470
	4. Seed	125	138	175	146	128	163
	5. Fertilizer	438	445	495	483	513	555
	6. Harvesting	2 175	2 625	3 188	2 175	1 900	2 475
C.	Input/output ratio (%)	63.1	53.6	53.0	58.8	63.0	51.9

TABLE 5. Average yields and production costs of wheat, barley, tomatoes, onions and potatoes

Crop		Wheat	Barley	Tomatoes	Onions	Potatoes		
Irrigation method						Rain	Spring	Tube-well
A.	Yield (kg/ha)	2 088	2 413	-	-	-	-	-
	Value (YRls)	15 089	6 635	24 485	47 750	27 933	44 750	47 443
B.	Costs (YRls/ha)	4 574	3 762	6 657	9 489	8 582	17 071	18 091
	1. Bullocks	-	-	1 200	1 012	1 300	1 325	1 200
	2. Tractor	980	920	762	460	875	1 000	1 038
	3. Labour	1 942	1 718	2 150	4 875	2 043	3 280	3 925
	4. Seed	343	278	285	242	1 909	6 483	8 113
	5. Fertilizer	429	128	435	425	580	795	1 190
	6. Harvesting	880	718	1 825	2 475	1 875	4 188	2 625
C.	Input/output ratio (%)	30.3	56.7	27.2	19.9	30.7	38.1	38.1

Source: ECWA: Crop-sharing and land tenancy practices in the Yemen Arab Republic, E/ECWA/AGRI/80/2, 1980.

V. PROBLEMS AND CONSTRAINTS IN AGRICULTURAL PRODUCTION IN THE STUDY AREA AND PROBABLE SOLUTIONS

1. Soil and land-use problems

The main problems of soil and land use are discussed in the following section but their arrangement is not necessarily in the order of importance.

a. Shallow and stony soils. Although a high proportion of cultivated land in the study area has good, deep soils, there are considerable areas of shallow and gravelly/stony soils occupying terraced fields. These are areas of marginal land and are mostly abandoned, probably because of the labour shortage. However, in some places where abundant irrigation water is available, as for example in the Sukhna valley, a part of the land used for irrigated cropping has shallow or gravelly soils which have low production potential because of low water-holding capacity and low fertility. Also, there are shallow and gravelly/stony soils in some rain-fed cultivated areas and these produce low crop yields. Traditionally, these were used for growing barley and millet, but now wheat and sorghum are planted, resulting in lower production.

Such soils in terraced fields, whether under cultivation or abandoned, should be permanently planted with forest-trees or forage shrubs. Alternatively, millet-grass-legume mixture forage may be grown in these soils instead of cereal grains. The forage may be cut at the proper stage and made into hay

to provide supplemental feed for livestock. In irrigated areas, shallow but frequent irrigations should prevent overwatering. Suitable tree species should be planted.

b. Soil erosion. Almost all the cultivated land is bench-terraced and the terraces are reinforced by stone walls. This is one of the best soil conservation practices. But terracing often extends into marginal land with shallow and stony soils, and most of these fields have been abandoned, probably due to the shortage and high cost of labour. These abandoned terraces are generally broken and the soil is rapidly eroding.

Some terraces on good land are also broken, possibly because of lack of maintenance, and the fields behind these have been devastated by gully erosion. In fact, the terraces need yearly maintenance. This is becoming exceedingly difficult because of the emigration-induced labour shortage. The maintenance could, however, be minimized by improving the design of the terraces so that each field has a very gentle slope to a corner which is provided with a spillway to discharge the excess rain-water into the next lower field. Some farmers have already built this type of terraces, but most of the terraces need improvement.

Using the abandoned terraces for suitable forest-trees or forage shrubs would both protect the soil and extract some production from the land.

Soil erosion is also a problem on grazing land, which mostly comprises steep mountain slopes, due to excessive grazing and cutting of vegetation. This could be checked by improving the vegetative cover through deferred, controlled and rotational grazing. Reseeding of suitable grasses may prove successful in areas having more than 400 mm rainfall. As the grazing rights are held collectively by a whole community, it is more of a social problem and may be tackled accordingly. However, a communal system of range management (hema) does exist in some parts of the Yemen Arab Republic, under which different sections of land are closed to grazing to let the vegetation regenerate itself. It may be usefully revived, suitably modified and extended to other areas.

c. Depletion of soil fertility. The Yemen Arab Republic has been farmed for more than 2 000 years. Some dung manure and wood ashes are applied to the soil, but these are inadequate to maintain fertility. The silt carried by hillside water diverted into fields through rain harvesting techniques does contain some nutrients, and helps to rejuvenate the soil, but not to the desired level. Soil tests (Cornell Yemen Soil Survey Staff, 1981) show that cultivated soils are invariably low in phosphorous and nitrogen. Fertilizer experiments conducted on cereals (Choudhry, 1983; Kambal et al., 1983) also show positive responses of these crops to nitrogen and phosphorus in combination. This points clearly to the need for extending the use of chemical fertilizers. Intercropping of cowpeas or beans with sorghum is practised in relatively high rainfall areas (rainfall of more than 600 mm). It is a good practice for maintaining soil fertility and should be extended to other areas. In wheat fields, annual alfalfa was found to grow successfully (Choudhry, 1983), but the wheat-alfalfa system could not be established because of customary grazing after the wheat was harvested.

d. Improper land use. With the increasing pressure of population, cultivation has been extended to many marginal areas with shallow and stony soils and low rainfall. Such land barely produces a poor crop of millet, barley or

wheat in favourable years. Often it lies fallow, producing little and falling an easy prey to soil erosion. It would be much better to return this land to some kind of permanent vegetation, trees or forage shrubs, in order to ensure production on a sustained basis.

As a high-level policy matter, extension of cultivated areas in mountain regions should be banned. Otherwise, with the introduction of tractors, new areas would be cleared of natural vegetation. This would prove uneconomical in the long run.

Soil surveys and crop performance studies are needed to evaluate the suitability of different crops for various agro-ecological zones and sub-zones. The information and data thus generated would form a basis for rationalizing land use. Likewise, rangeland surveys are required to assess the productivity of different types of rangeland for their proper classification and management.

e. Improper crop rotations. There is hardly any crop rotation. Generally, sorghum or millet is grown on most of the cultivated land year after year. This practice tends to deplete soil fertility. Some farmers intercrop cowpeas or beans in sorghum but this practice is limited to high rainfall areas. As the beans are deep-rooted and fix some atmospheric nitrogen, the practise of sorghum-bean intercropping needs to be encouraged. At the same time, research is needed to improve this cropping system further as well as to find new ones which are both economically sound and helpful in improving the soil. Chick-peas, groundnuts and sunflowers offer some new possibilities (Kambal et al., 1983).

f. Improper tillage operations. To a casual observer, the land tillage operations seem to be flawless, as the land is prepared well before sowing and is kept clean of weeds. But the drawback is that the land is tilled with the same local chisel-type cultivator, and to the same depth, season after season and year after year. This results in the formation of a plough pan, a compact layer about 5-7 cm thick occurring immediately below the plough layer, normally 8-10 cm thick. The dense pan prevents the water from infiltrating deeper soil layers and the roots from developing properly in the subsoil. The farmers are probably aware of this problem and try to solve it by practising unnecessarily deep ploughing with tractors in mountain plain areas. The deep ploughing to a 25-30 cm depth is only an expensive and inefficient way of solving the problem. The proper method would be to use chisel ploughs when the soil is nearly dry, working these to a 15-20 cm depth in order to shatter the plough pan. This could be done once every two or three years.

In order to increase the labour efficiency of tillage operations, it is necessary to introduce modern tillage implements such as duck-foot and tine sweeps for working with oxen and tractors. The experience gained in Australia, India and Pakistan would be useful in this regard.

g. Low yield-potential crop varieties. With the exception of sorghum, the existing crop varieties, such as those of wheat, millet and barley, have low yield potential. These are probably suited to conditions of low soil fertility, but have to be replaced with new higher-yield crops as farmers learn to use fertilizers, pesticides and disease control measures. The introduction of new crop varieties should be coupled with modern farming technology. Otherwise the benefit would be small and the farmer may lose interest.

h. Irrigation water shortage and lack of information on ground water resources . The shortage of irrigation water in the Yemen Arab Republic is recognized equally well by the high-level planner and the lay person, and extension of irrigated areas is considered a major step to increase agricultural production. There are some plains in mountain areas where ground water can be found, and at some places farmers are themselves trying to install wells. Such efforts need to be supported by systematic geo-hydrological surveys to assess the ground-water resources of the mountain plains and promising wadi areas. They surveys may be followed by test borings for quantitative estimation of the available water.

i. Low irrigation-water use efficiency. Credit must be given to the Yemeni farmers for using rain harvesting techniques to make the best of scanty and uncertain rainfall. But in areas where permanent sources of irrigation are available, such as springs, wells and perennial stream flows, age-old methods of irrigation result in inefficient water use. Such scarce and precious water must be used more judiciously by adopting modern methods, such as drip irrigation and sprinklers. In the case of orchard crops such as coffee and bananas, as well as vegetables, drip irrigation would be very useful. For close-growing crops such as wheat, maize and alfalfa, sprinkler systems may be suitable. These ideas need to be researched, so that the new technology is offered to the farmer only after it has been tested and perfected.

2. Forest and rangeland problems

Excessive exploitation and misuse of natural vegetative cover has been going on in Al-Haymat Al-Kharjiyah and Al-Haymat Al-Dakhiliya at such a rate that, unless practical and appropriate measures are immediately taken, it will inevitably lead to serious consequences. Forest cover has been drastically reduced by the extraction of wood for timber, fuel and fodder at a much faster rate than it can be replaced by natural regeneration. Valuable shrubs and other perennials have largely disappeared owing to alarmingly excessive and totally uncontrolled grazing, with the result that rengeland cover is now mainly made up of short-lived annuals and useless thorny shrubs, xerophytes and poisonous plants. The damage done by such misuse not only lowers animal production but also leads to deterioration of soil and water resources.

The following proposals are set forth with the aim of re-establishing vegetative cover, forests and range plants, to meet the needs of the nation, and the local communities in particular. They are an integral component of a watershed resources management system aimed at maximum production on a sustained basis.

a. Development of Forest cover

- Early enactment of a forest law is an absolute necessity. It should provide for delineation of forest boundaries, public, private and communal; protection of denuded forest land; infringement penalties; local rights; forest policy and utilization and management.

- Farmers must be encouraged to adopt agroforestry concepts whereby tree species that provide fuel, timber and fodder are planted on boundaries of cultivated fields.

- Planting of abandoned terraced fields, covering about 4 000 ha in the entire study area, with local tree species and suitable exotics of good timber quality and rapid growth would produce timber and fodder, prevent soil erosion and replenish ground water aquifers.

- Butane gas, sawmill waste, wood chips and charcoal from wood-surplus areas must be promoted as fuels.

- Fuel gathering and extraction from nearby forests and rangeland not only leads to depletion of natural vegetation but is time-consuming, taking an average of five hours a day of female labour to yield 10-25 kg of firewood. Furthermore, in terms of energy yield, fuelwood is about the most expensive type of fuel in use and its overall combustion efficiency is low - 15-20 percent (USAID, 1982).

- Alternative roofing materials, such as iron beams, must be introduced. Much of the wood, mainly that of the main trunk and primary branches, is utilized in roof construction as beams or poles. Once trees are cut, they are never replaced.

b. Improvement of rangeland and forage resources

- A grazing law should soon be passed if further deterioration of natural range resources is to be halted. Such a law should limit the grazing areas, restrict grazing in badly depleted sites, define the season and duration of grazing and limit the number and type of livestock in each grazing area on the basis of floristic composition and carrying capacity of each parcel of rangeland. Such limitation should be based on thorough investigations and research trials.

- Since all rangelands in the area are owned by the local communities and are utilized by their own livestock, it is, therefore, the prime responsibility of local communities to maintain this resource. In view of this, the hema system should be established in order to protect this natural resource through controlled and rotational grazing in accordance with optimum rangeland capacity.

- Reliance for feeding livestock should not rest solely on rangeland resources. Supplementary feeds in the form of concentrates or hay of legumes and sorghum should be provided in times when rangeland fodder is no longer available.

- Intercropping certain varieties of pigeon pea with sorghum is another possibility to produce supplementary feed for livestock. This crop, also known as red gram, which has been successfully intercropped with sorghum under similar ecological conditions (USAID, 1982), provides a high-quality pulse seed, leaves for use as fodder, and up to 4 tonnes per year per hectare of branches suitable for use as poles and fuelwood. The plant coppices well, so its branches can be cut twice a year for several years. Being a legume, it also fixes nitrogen in the soil, boosting yields of intercropped sorghum by 25-60 percent.

- In order to revive rangelands, it is necessary that badly deteriorated sites be fenced and closed to grazing, planted with suitable species of Atriplex and other appropriate forage perennials and seeded with suitable

grasses and legumes. Plant of Atriplex and other shrubs should be in contour trenches on the slopes, so that maximum moisture can be provided from run-off water without erosion.

c. Livestock production improvement

- Adequate veterinary services for livestock and other domestic animals in the area are badly needed. Periodic outbreaks of dangerous diseases, such as foot-and-mouth disease, cause great loss in livestock population. Attacks by parasites substantially lower their productivity.

- Exotic livestock breeds of high quality should be introduced and crossed with local breeds to raise the production capability of livestock in the area.

- Animal feed from rangeland resources fluctuates because of erratic and uncertain rainfall. This requires a policy to integrate animal production with the cropping system and build up feed reserves to assure production stability and minimize the pressure on the over-exploited rangelands.

- Sheep and goat fattening cooperatives should be established in order to minimize losses in dry years and limit increase in sheep and goat population through off-takes from the range, hence reducing grazing pressure and stimulating fodder crop production. Livestock is considerably more valuable when fattened.

3. Socio-economic Constraints

a. Breakdown of the traditional farming system. Under the traditional tribal system of community organization dominated by the ruling families, subsistence agriculture successfully served the population of the rural areas of the Yemen Arab Republic for centuries. The isolated communities of the mountain areas, having to produce all their staple foods locally, fully utilized the available land. The system enabled the big landowners to use the labour of the landless and poor farmers to build terraces that maintained soil fertility and produced staple food, mainly sorghum and maize.

With the developments of the last two decades, however, the country entered a transitional stage moving from the traditional barter economy based on subsistence agriculture to a modern market economy. The shock waves of the change process are felt in all sectors of social and economic life, especially in the agricultural sector. They are manifested in such forms as scarce farm labour, low crop yields, deteriorating terraces and fields, abandoned marginal land, rangeland deterioration and changed cropping patterns with increasing kat cultivation.

The most important socio-economic problems facing agriculture in the study area, and most probably in all the mountainous areas of the country, are listed below, together with some probable solutions.

b. Labour shortage With the opening of employment opportunities in the neighbouring oil-rich countries, the labour force became more mobile. The developmental efforts of the Government of the Yemen Arab Republic also created new jobs. The employment opportunities created in the trade, industry and service sectors during the last two decades caused a surge of young

people from the countryside to the towns and especially the capital, San'a. The young tenants and the landless farmers were the first to move away from the farms and villages (Cohen and Lewis, 1979).

Thousands of Yemeni farmers left their farms to seek their fortunes abroad. After a few years of hard work they returned home loaded with money and most of them started new businesses in towns instead of returning to their villages.

As a result of this development, the available agricultural labour has become scarce and costly. It is no longer profitable to farm marginal land, so that an increasing area of farmland is being abandoned every year. The terraces on this abandoned land break and the soil is washed away. Even some farmers with good land, but not enough hands to cultivate it, desert their villages to seek more profitable employment in towns or abroad.

A solution to the problem of labour scarcity is mechanization. A two-wheel tractor with low traction power (3-5 hp) can perform the ploughing and sowing operations in the terraced land much more efficiently and expeditiously than bullocks and human labour, and at a lower cost. Mechanization of cultivation will enable the remaining farmers to cultivate the whole area. The same tractors, connected with trailers, will also provide transportation.

In order to facilitate mechanization, the size of the average holding has to be enlarged to make it viable. This could be achieved by changing certain laws restricting the sale and purchase of land, so that absentee landowners can sell their land to farmers who are interested in enlarging their holdings.

c. Low farm income. Farm income is the sole determinant of whether a farmer will continue to operate or quit farming to seek a living in another sector. It depends on the quantity of crop and livestock production and the prices for these products. Crop production depends on the area and the productivity of the land as well as the potential yield of the crop itself. Similarly, livestock production depends upon the number of animals and their productivity.

The low income of the mountain farmer is due to the lack of one or more of the above components. Possible solutions to the problem of low income include the following:

- Bigger holdings and herds;
- Mechanization of farming operations through introduction of small 3-5 h.p. tractors;
- Better utilization of irrigation water through introduction of pipe, drip or sprinkler irrigation;
- Use of improved crop varieties;
- Introduction of improved livestock breeds;
- Introduction of chemical fertilizers and pesticides to increase yield and quality of crops;
- Shifting to high-value crops on irrigated land (e.g. fruits and vegetables);
- Price support for locally produced agricultural products and ban on imports of similar products.

In order to encourage farmers to adopt new technology by farmers, the Ministry of Agriculture should establish demonstration plots in the main farming area,

where the new technology could be applied under expert supervision. The demonstration plots may be located on government land or on farmers' fields leased by the Ministry. The farmers of the area could be invited periodically to study the results.

d. Inadequate transportation facilities. The study area, like most of the mountainous areas of the Yemen Arab Republic, consists of an endless number of mountain peaks interspersed with small mountain plains, deep gorges and narrow wadis. The villages are small and the houses are built on hilltops overlooking mountain plains. The tracks connecting villages with each other and with towns consist of narrow winding pathways full of big stones and deep pits, at times gaping over enormous precipices. They are extremely dangerous and barely passable by four-wheel drive vehicles, and are completely blocked during the rainy season.

Under these conditions of complete isolation, there is little chance for any kind of development. Roads must be built to bring modern inputs to rural areas and agricultural products to the town markets. Since the inadequacy of transportation facilities seems to be a general problem in all the mountain areas of the country, the Government must plan to deal with the problem of a long-term basis. Any project in the study area should include the construction of roads as a priority item.

e. Inadequate marketing facilities. The farmers in the study area, being isolated from major towns, have hardly any opportunity to market their surplus agricultural products. There are two or three local markets that operate once a week in certain centrally located villages, and farmers sell their products such as butter, cheese, hides, skins, fruits and kat at whatever price they can get. Naturally, the prices fluctuate widely due to the limited capacity of the market and the farmers' lack of storage capacity. When the market is oversupplied with the seasonal crop produce, the prices fall very low. The prices of the inputs, however, remain quite stable or even keep increasing because the sellers from the nearby towns usually are few and can afford to withold the commodities if the need arises.

The problems of marketing could be alleviated by the following measures (Morton, 1979):

- Improved road network;
- Farmers' cooperatives to market agricultural products and supply the agricultural inputs to the farmers;
- Packaging facilities to ensure that agricultural products will reach the market in good condition;
- Information and guidance to farmers for processing agricultural products (raisins, fried dates, smoked cheese, smoked meat, pickled onions and peppers, etc.).

f. Lack of standard weights and measures. The concepts of area, weight and volume are very vaguely understood by the farmers of the study area. They are unable to assess crop yields. The unit of area commonly used in the study area is the libna and the unit of length is the dhira'a, but both are variable from one area to the other. The dhira'a is equal to an arm's length, and the libna according to the farmers of different villages in the study area is the area equal to 10 x 10 dhira'a, 12 x 12 dhira'a, 16 x 16 dhira'a and 20 x 20 dhira'a. But in one village the unit area was

the neina, which was equal to 20 x 10 dhira'a. The unit of volume used is the katah, which is equal to 12 coconut-shells-full of grain. In short, the situation with respect to weights and measures is chaotic, pointing to an urgent need to adopting a standard system of measures and weights, preferably the metric system.

A standard system of weights and measures may be introduced gradually. It will take time, but its adoption by the farmers will help to modernize the whole farming system (Dept. of Planning and Statistics, 1983).

g. Inadequate health and education facilities. The literacy level of the farmers in the study area is very low, much lower than the national average of 10-15 percent for males and two percent for females. Some new schools have been established recently to serve the needs of school-going boys. It seems that very few girls attend school. The drop-out rate is very high, because the children are needed by the family for grazing livestock and other farming and household activities.

Health facilities are even more primitive. A very few villages have a clinic that is operated by a medical technician and a midwife. Very few villages have a potable water supply (from springs) and the women have to fetch water from long distances. The diet of farmers is generally inadequate and lacking in important elements such as proteins and vitamins.

In the field of health and education, the present situation may, however, be considered good compared with the situation that existed 20 years ago. This is not enough. The development of the two sectors should be given priority and planned on a long-term basis (Cohen and Lewis, 1979).

h. Inadequate agricultural research and extension. There is a good agricultural potential in the study area, especially in the mountain plains, in terraced fields with deep soil and in the wadis with perennial flow. The agricultural development of the area, however, would require certain basic data which are lacking at the moment.

It is suggested that the Agricultural Research Authority conducts some field experiments in the area to find out:

- Suitability of different soils and ecological conditions for different crops;
- A set of crop production practices for each of the important crops;
- Suitable cropping patterns for different ecological situations.

The findings of the research in the form of suitable cropping patterns, varieties of seeds and seedlings, farming operations and rates of fertilizer and pesticide application should be communicated to the farmers by an agricultural extension service. There is a need, therefore, to provide for a well-equipped extension service that will promote and disseminate to farmers the findings of agricultural research. The extension service will also supervise the proper application of the recommendations and report any drawbacks that arise during the implementation phase, as well as new problems to be researched. Finally, it will assess the results and evaluate them in light of the research.

i. Lack of statistics, especially at the farm level. Compilation of statistical data is a recent development in the Yemen Arab Republic. There are some fairly reliable statistics about agriculture, such as cultivated area, crop area, yields and prices of crops, livestock numbers and livestock products and imports and exports of agricultural commodities, but these are available only at the national, provincial or district level. Such data for the study area, especially at the farm level, are lacking.

In order to find out the existing situation in the area, a detailed survey is needed to determine such data as land tenure and use, cropping pattern and livestock numbers, area, production and yields of individual crops, input/output ratio and production costs. Data about the age and education of the farmer, number and age of children, number of wives and off-farm employment, if any, will facilitate the estimation of labour availability at the farm level and the farmers' potential response to innovation.

Farm-level data are particularly essential if a project of any kind is going to be implemented in the area. The present situation will represent the base against which the project's success will be evaluated (FAO, 1977; FAO, 1974).

This type of farm survey will require the following elements:

- Carefully chosen survey components, such as type of stratification, randomness and size of sample, geographic distribution, etc.;
- Specially designed questionnaires to accommodate all the required parameters;
- Specially trained enumerators to carry out the field work;
- An expert to analyse the data and present the results.

j. Kat. The increasing cultivation of kat (catha edulis) constitutes a very serious constraint to agricultural development in the Yemen Arab Republic. Due to the ever-increasing demand for this mild drug, its price has gone up tremendously. Since farmers can get more money from kat than from any other crop, they are increasing its production. Kat occupies the areas that are most suitable for coffee and fruits such as citrus and grapes.

If the present situation continues unchecked, after a few years all the irrigated fields will be planted to kat. There is, therefore, an urgent need to reverse the dangerous trend by discouraging kat cultivation through the following measures:

- A heavy tax on kat fields;
- Free or subsidized distribution of seedlings of coffee and fruit trees, such as citrus, in order to rejuvenate the old plantations and encourage planting of new ones;
- Ensuring a high price for fruits by imposing a tax on imports or banning them;
- Improving the marketing of coffee, so that the farmer gets a larger share of the final price; or

- Limiting the consumption of kat by restricting its use to certain days of the week.

k. Inadequate agricultural credit. Farmers emerging from traditional agriculture need to invest in modern technology in order to transform their holdings from subsistence-oriented units into modern farms, but they lack the necessary funds. As there are no retained earnings from agriculture to be reinvested in the sector, there is an urgent need for credit: long-term credit for establishment of orchards or drilling bore holes and short-term credit for fertilizers and pesticides. With the exception of a few returnees from abroad who invest their accumulated funds in agriculture, mainly in modern chicken farms and tube-well irrigated fruit-tree plantations, very few farmers have enough capital.

The cardinal role of credit in developing agriculture seems to be well understood by the Government, as indicated by the recently established Agricultural Cooperative Credit Bank under the Ministry of Agriculture. The next step should be a campaign to explain its role and encourage farmers to establish cooperative societies in every village. These cooperatives, by becoming members of the Agricultural Cooperative Credit Bank, will have access to loan funds.

With credit money at their disposal, the farmers' cooperatives could organize the marketing of agricultural products, dissemination of technology, provision of inputs and extension of short-term credit to member farmers. They could also act as intermediaries between the Agriculture Cooperative Credit Bank and the farmers. The cooperatives could also function as saving banks at the village level in order to mobilize the farmers' savings.

VI. METHODOLOGY FOR THE DEVELOPMENT OF MOUNTAIN AREAS OF ECWA REGION COUNTRIES

1. Review of available methodologies

The three available approaches are briefly discussed in the following section.

a. FAO guidelines for the development of less favourable environment areas. The theme is comprehensive integrated watershed development, taking a watershed or a subwatershed as a development project area (FAO, 1977).

The development plan is to be based on a complete inventory of all physical and human resources, both existing and to be developed. Basic data on climatic factors, soil and water resources, present land use, vegetation of forest and rangeland, human population and livestock number and kind, have to be collected to assess the present productivity per unit area of land and the productivity after development.

The first development project should be limited to a small subwatershed, so that it serves as a training ground for technicians and establishes the criteria to group work components and subjects under a watershed development plan. It will also help to evolve an organizational and administrative plan for implementing the programme.

b. FAO/ECE agricultural development of less-favoured areas FAO and the Economic Commission for Europe have come up with the following strategy (FAO/ECE, 1978), after reviewing the experiences of different countries.

The role of agriculture is de-emphasized. It is considered far more in terms of its relationship with other activities. In less-favoured areas agriculture is often the dominant sector, but is held back by the lack of vitality of other sectors, which restrains regional development.

The central concept is physical planning and balanced regional development. Although the detailed plan will differ from region to region and country to country, the main requirement is the precise knowledge of local conditions and, above all, of the reasons for migration from rural areas. For this purpose, studies are required at two levels: the small region and the farm.

The development programme is aimed at establishment, improvement and maintenance of community facilities, particularly to enable such areas to break out of their isolation. Different countries have tried different approaches, such as provision and improvement of public services, direct aid, capital investment, subsidies or increased credit.

The main objectives of the development programme are conservation and improvement of the land and water resources in each area which should raise incomes, production and standards of living in each area, with a view to reducing migration from rural areas.

c. Rural development programme. In various countries a rural development programme of one kind or another is being implemented. The main components, varying from country to country, are:

- Increasing agricultural production through introduction of modern technology, including high-yield crop varieties, chemical fertilizers, pesticides, tractors, and irrigation where feasible;
- Providing health and education facilities;
- Providing a hygienic water supply for drinking;
- Building roads;
- Providing electricity;
- Providing drainage systems for villages;
- Paving of village streets.

The programme plan is generally based on the proposals made by the local community, so it varies from area to area.

2. A suggested methodology for mountain areas of the ECWA region countries

Mountain areas of individual countries would be classified into agro-ecological zones and subzones based on physiography, climate, soils, water availability, present land use and natural vegetation. Because these are the natural subdivisions of land in mountain areas, watersheds or subwatersheds would form

the project areas for integrated development. The main components of the integrated development programme should be:

- Soil and water conservation, through adjusted land use;
- Diversification of cropping pattern by introducing new crops;
- Introduction of modern crop production technology, as a minimum package, through demonstration plots;
- Range land improvement and development;
- Improvement of forest resources through proper management for multiple use and agroforestry;
- Service cooperatives to procure agricultural inputs and market agricultural produce;
- Road construction and improvement;
- Schools;
- Human health dispensaries or hospitals;
- Veterinary dispensaries;
- Small dams and water storage ponds.

As a first phase, a pilot project in a small catchment or subcatchment may be started in each country. For detailed planning of the work programme of the pilot project, the following surveys should be carried out:

- Soil survey and land suitability classification for various land uses and crops;

- Present land use survey;

- Vegetation and rangeland survey to classify rangeland into different range types and to assess their grazing potentials and livestock carrying capacities;

- Geo-hydrological surveys to assess available water resources, both on the surface and in the ground;

- Socio-economic surveys to assess labour and capital availability, farm size and profitability, input/output ratios of different crops, farmers' education levels and attitudes toward modern agricultural technology, marketing systems, transportation facilities, and availability and requirement of agricultural credit.

A local staff must be trained to make up any deficiency of appropriate personnel.

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List of people met in the Yemen Arab Republic

1. H.E. The Minister of Agriculture, Dr Ahmed al-Hamdani
2. The Deputy Minister of Agriculture, Mr Mukbal Ahmed Mukbal
3. The FAO Country Representative, Dr Omar Salah Ahmed
4. UNDP Assistant Resident Representative, Mr Nabil Kahala
5. Dr Amir Agha Badiei, Agriculture Adviser, Consortium for International Development, Agricultural Development Support Programme, USAID, San'a
6. Mr Ali Noman Abdallah, Director-General, Agricultural Services, Ministry of Agriculture, San'a
7. Dr Abdel Rehman Sallam, Director-General, Agriculture Research Development Authority, Ta'izz
8. Mr Lutf al-Ansi, Director-General, Planning and Statistics, Ministry of Agriculture, San'a
9. Mr Ahmed Ali Lukman, Director, Foreign Relations, Ministry of Agriculture, San'a
10. Mr Ahmed Mohammad Johaishi, Agro-Economist, Ministry of Agriculture, Rada'a Integrated Rural Development Project
11. Mr Abdallah Ahmed al-Mehdi, Deputy Chairman, Survey Authority, Ministry of Public Works
12. Dr Ali al-Thor, Head Department of Soil Science, Agricultural Research Station, Ta'izz
13. Dr N.M. Choudhry, FAO Wheat Specialist, Agricultural Research Station, Ta'izz
14. Mr Shakir Amer, Soil Scientist, Agricultural Research Station, Ta'izz
15. Dr Ismail al Geweif, Soil Surveyor, Agricultural Research Station, Ta'izz
16. Dr Hassan al-Fosail, Director, Livestock Project, Ministry of Agriculture, San'a
17. Mr Mohammad Abdul Wahhab, Director of Hydrology and Water Utilization, Ministry of Agriculture, San'a
18. Mr Hameed Naji al-Beshari, Agricultural Officer, Ministry of Agriculture, San'a
19. Mr Mohammad al-Navaira, Director, Agricultural Statistics Project, Ministry of Agriculture, San'a

20. Mr. Reinhard Kastl, Project Manager, al-Harraz Erosion Control and Afforestation Project, German Agency for Technical Cooperation, Manakha

21. Mr. Aberhard Lutz, Sociologist, al-Harraz Erosion Control and Afforestation Project, Manakha

22. Mr. Ibrahim Abu-Dahab, Programme Officer, FAO Office, San'a

MISSION ITINERARY

11.12.83	Mr G. Panayiotou arrived in Rome
13.12.83	Dr A.K. Toma Hirmiz and Mr M. Rafiq arrived in Rome
13.12.83) to 16.12.83)	Briefing in RNEA, FAO, Rome Met Dr S. Juma, Chief, RNEA, Mr M. Khozemy, AGF, Dr R. Dudal, Director, AGL Division, Mr G.M. Higgins, Soils Services, Dr H. Kunert, AGSP, Mr Ibrahim Ben Salem, Dr A. al-Jaff, AGO
17.12.83	Left Rome and arrived in Cairo
18.12.83	Left Cairo and arrived in San'a, Yemen Arab Republic
19.12.83) to 22.12.83)	San'a
23.12.83	San'a. Studied various publications to extract information
24.12.83	San'a. Field trip to Beni Mataar and Wadi Al-Fajara, Al-Haymat Al-Dakhlijah and back
25.12.83	San'a. Field trip to Al-Haymat Al-Kharjiya, accompanied by Mr Hameed Naji al-Beshari, Agricultural Officer, Ministry of Agriculture and back. Also visited German Project: Al-Harraz Erosion and Afforestation - A Pilot Project
26.12.83	San'a. Field trip to Al-Haymat Al-Dakhliya, through Sooq at Salf, Al-Halila, Beit al Qatab, Dara al Manama, Jeram, Majahzi, Wadi Quba, Jadar Ba'aer, and back through Wadi Al-Haroor, Beit al Khattabi, Wadi Guba, Wadi Sukhna and Wadi Al Mawjer and back
27.12.83	San'a. Visited Ministry of Agriculture to prepare for a trip to Ta'izz. Visited UNDP and FAO Offices
28.12.33	Field trip from San'a to Ta'izz by road; studied soils, land use and vegetation along the road. Night in Ta'izz.
29.12.83	Visited Agricultural Research Station, Ta'izz, and held discussions with research staff. Field trip along Ta'izz-Aden road in the afternoon. Night in Ta'izz
30.12.83	Field trip from Ta'izz to Al Hudaydah to San'a. Studied soils, land use and vegetation along the road
31.12.83) to 2.1.84)	San'a. Collected and studied reports and publications relevant to mountain areas of the Yemen Arab Republic
3.1.84	Meeting with Deputy Minister of Agriculture, Mr Mukbal Ahmed Mukbal and FAO Country Representative, Dr Omar Salah Ahmed

4.1.84	Left San'a and arrived in Baghdad
5.1.84) to) 13.1.84)	Baghdad. Report preparation. The final draft could not be typed for want of typing facilities in JNEA, FAO/ECW
14.1.84	Mr G. Panayiotou and Mr M. Rafiq left Baghdad and arrived in home countries