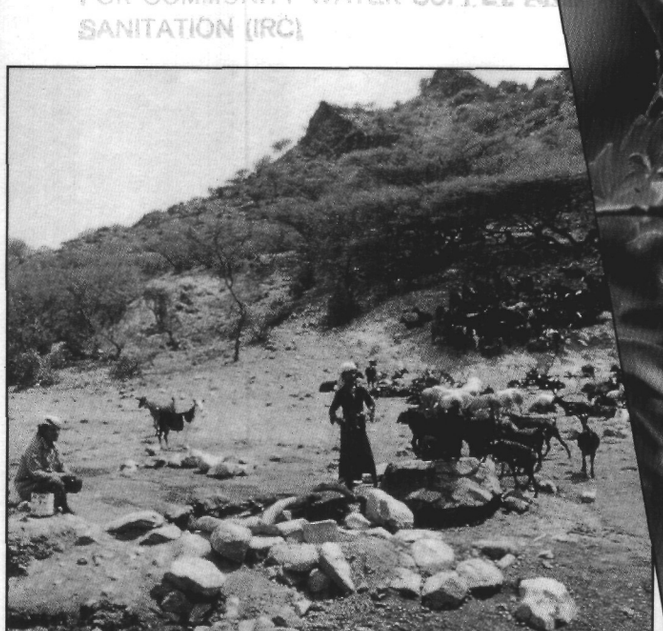
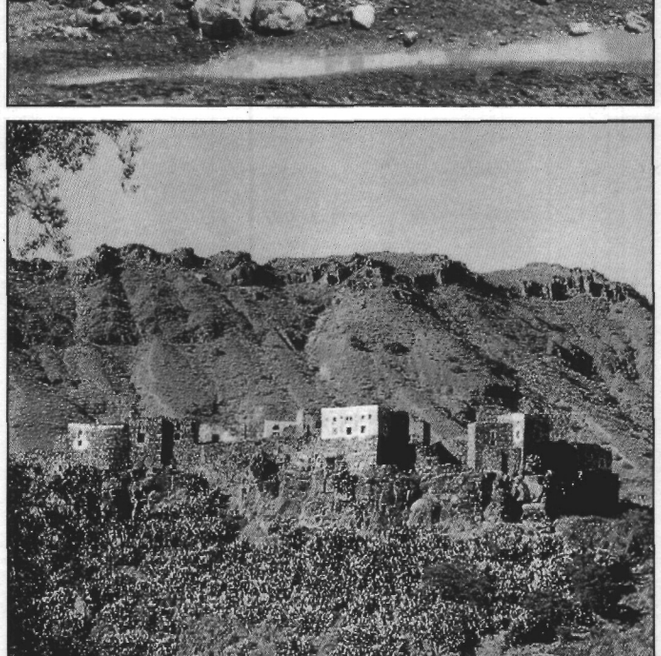
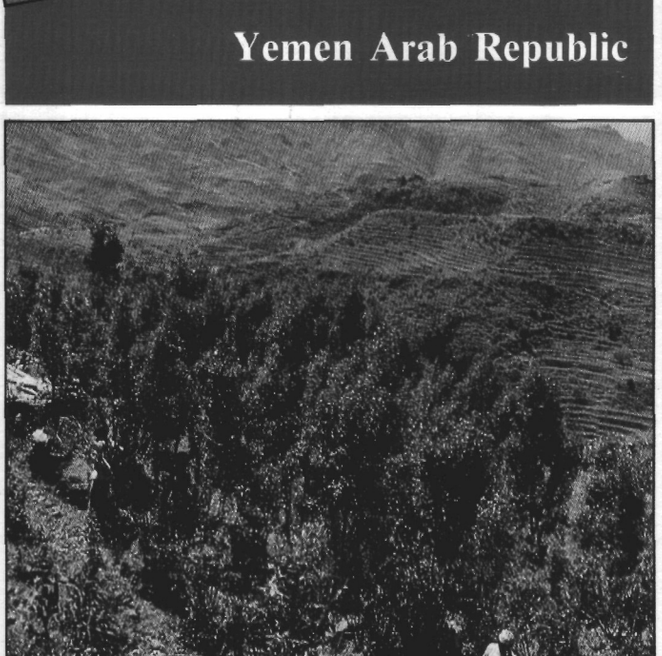
Environmental Profile
Dhamar Governorate



Yemen Arab Republic





Environmental Profile Dhamar Governorate

Yemen Arab Republic

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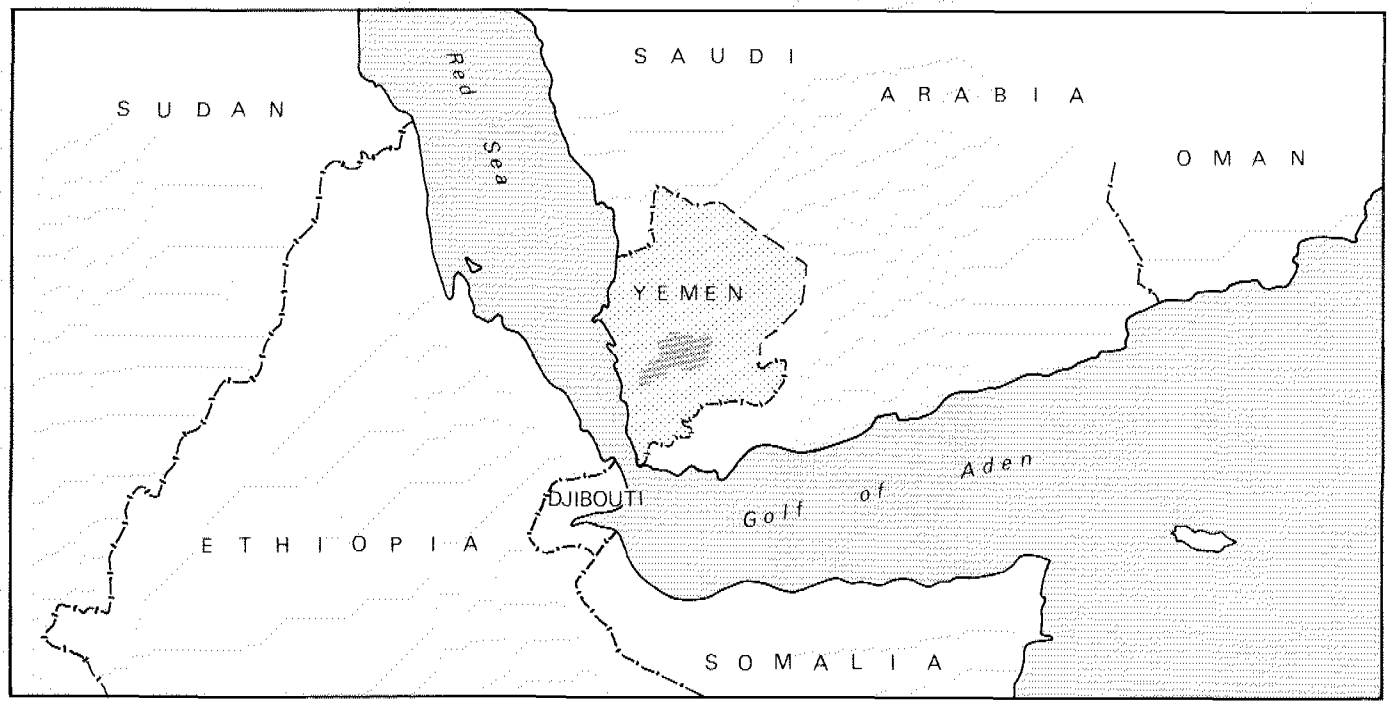


Dhamar Governorate in the Yemen Arab Republic in the Middle East.

View on the Montane Plains from the road Sana'-Taiz.

1. Introduction

1.1 Scope/Objective

This Environmental Profile describes the environment of the Dhamar Governorate in the Yemen Arab Republic. It also gives an analysis of environmental problems. Emphasis is placed on the role of man in his interaction with the environment: how do people in Dhamar Governorate use and manage the resources available and why do they do it the way they do?
The Environmental Profile provides an overview of the environment and the state of resources in Dhamar Governorate and describes the motives, patterns and trends of resource use in regard to their sustainability. This creates a framework of environmental constraints and possibilities for decision making by the authorities responsible for development in the Dhamar Governorate.

Use of the environment must be sustainable if it is to guarantee sound medium and long term conditions for existence and a good quality of life. Therefore, man's activities must fit within the environmental constraints of the area being used. To achieve this, knowledge and understanding of the environment is required and must be integrated into land use and planning activities.

1.2 How it is made

In our work in Dhamar Governorate in 1988, information was collected on the environment and its use by man in the different areas. Interviews with farmers and authorities, both modern and traditional, formed the basis for much of the information. Many descriptions of the state of the resources, including vegetation, land use, wildlife etc. were made. Our previous experience in the area, for some of us dating back to the sixties, combined with a study of literature allowed us to make a comparison with the past.

Another source of information to study the Governorate was satellite imagery.

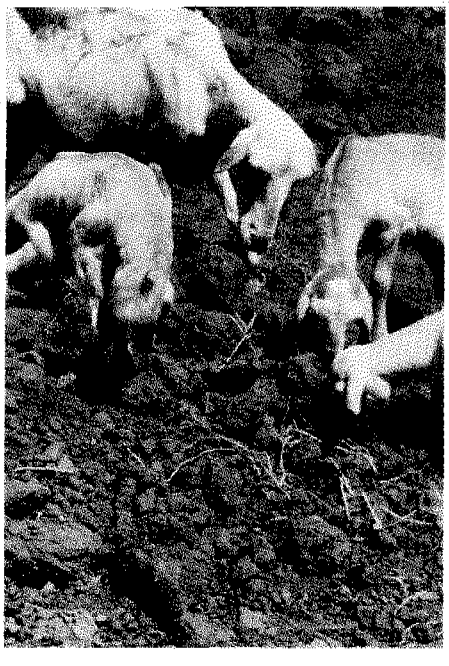
Due to the limited availability and reliability of existing information, and the very little time available for the preparation of the Profile, many shortcomings may be apparent when reading. This should lead to the conclusion that more attention to the subject is necessary in future.
The study was executed under the supervision of the Environmental Health Department of the Ministry of Housing and Municipalities in Sana' and financed by the Netherlands Ministry of Development Cooperation. It was carried out by specialists from the University of Sana', The Agricultural Research Authority in Yemen, the Research Institute for Nature Management, the TNO, Institute of Applied Geoscience and DHV Consultants from the Netherlands.

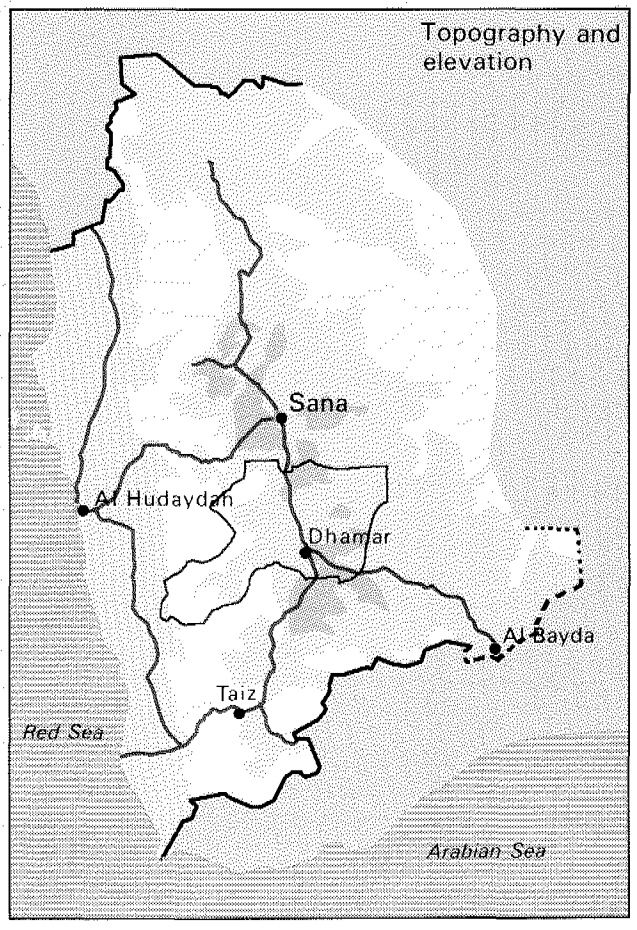
During the study a seminar was held in Sana' during which team members held a presentation for the authorities concerned. A number of statements was presented and discussed on this occasion, which are presented in the concluding chapter of this Profile.

1.3 One of a series

This Environmental Profile is one of a series of three. The other Volumes of this series discuss the environment and environmental problems in respectively Al Bayda Governorate and the Tihama. These areas are chosen, because they are areas in which assistance from the Netherlands Ministry of Development Cooperation is concentrated. However, the three areas of study together cover an east-west cross-section of the Yemen Arab Republic, containing the three main Zones in which the country can be divided. These Zones have a North South orientation. Consequently the three Profiles together should provide an insight into the environmental situation and problems for the Yemen Arab Republic as a whole. However, it is recognized that local situations outside the study areas may be quite different from those encountered within the study areas.

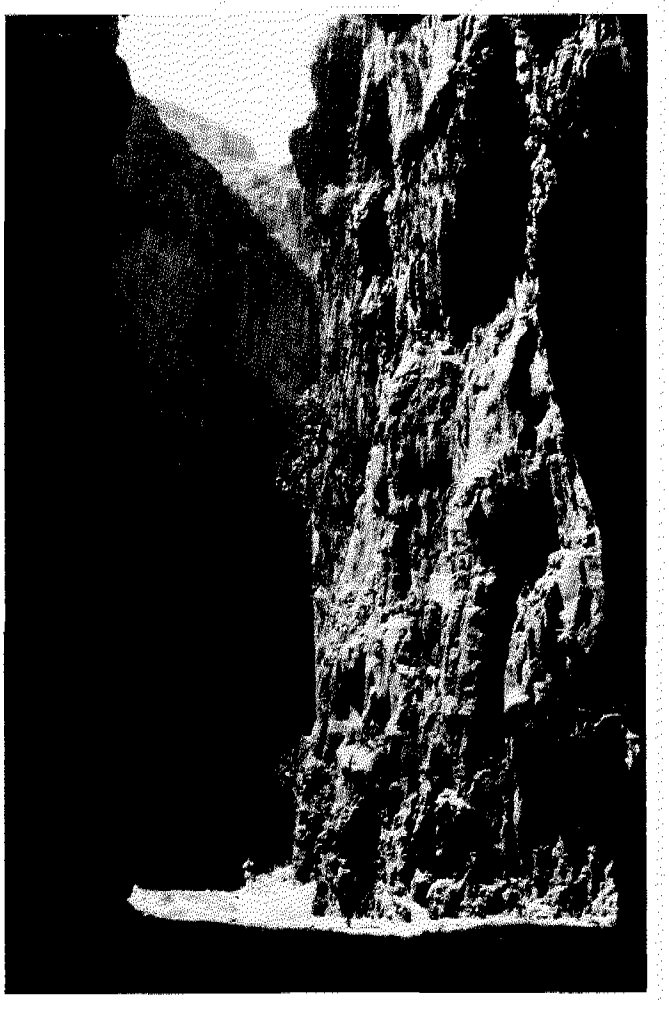
Dhamar has a reputation for its sheep.



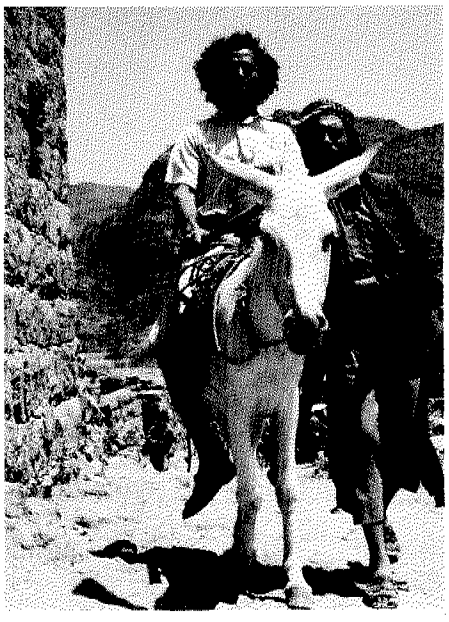


Bulls head in Himyar ruins. The bull was a sacred animal.

The Western Escarpment Zone is dissected by wadis that formed a very rough landscape, in this case a gorge in the upper reaches of Wadi Zabid.



In the mountains donkeys often are the only means of transport



2. Setting

2.1 History

Of the history of Dhamar Governorate relatively little is known. However, we know that the pre-islamic kingdoms of Saba', Qataban and Himyar extended their influence over the area that is Dhamar Governorate nowadays. The Himyar capital of Zafar, first described in the year 35 A.D., is situated near the Governorate's border at Yarim. Terracing of the hills began presumably with the Himyarite Kingdom from the first century A.D. onwards and extended after the decline of the eastern desert kingdoms, when the sea routes through the Red Sea gained importance and formed a serious competition for the caravan trade, along the famous Incense Route. The steady development of terraced agriculture over the centuries is in a very sharp contrast to the rapid agricultural development we find these days in the plains around Mabar and Dhamar.

The famous poet Nashwan Ibn Said al-Himyari who died in 1117 A.D. spent a great deal of his lifetime in the Al Hada area, northeast of Mabar. He was also an active scholar, historian and a politician gifted with a very sharp tongue. He was one of the most powerful men of his lifetime and almost became the sole ruler over the Yemen.

2.2 Topography and landscape

The Yemen Arab Republic is a mountainous country: a north-south running, strongly dissected mountain belt covers more than half of the national territory and separates the elongated lowland plain along the Red Sea (Tihama) from the gently rolling lands of the eastern desert. The highest peak is Jebel Nabi Shuayb (3660m), at approximately 25 km south-west of Sana' city. In this mountain belt the Western Escarpment, the Central Highlands and the Eastern Escarpment can be distinguished. Dhamar Governorate is located in the central part of the country. It covers an area of approximately 8,650 km2, corresponding to 6.5 % of the land surface of the Yemen Arab Republic.

Dhamar Governorate contains two major and very different landscapes. One is the landscape of the Central Highlands covering the eastern half of the Governorate. These Highlands consist of not very steep mountains, small wadis and very wide plains. A wadi is a mostly dry streambed, through which large floods sometimes drain. The other part of the Governorate belongs to the Western Escarpment, the extremely dissected mountain belt between the Highlands and the Tihama. The wadis flowing towards the Red Sea from the Highlands have created a most spectacular landscape in this part of Dhamar Governorate.

The main town in the Governorate is Dhamar, one of the six largest towns in the country. It is connected by tarmac roads to Sana', Taiz and Rada', while another tarmac road crosses the Governorate in the direction of Al Hudaydah. Despite these tarmac roads and all the other new dirt roads that have been made in recent years, many areas in the Escarpment Zone are still poorly accessible today. In fact, many places can still only be reached by donkey.
The western extremity of the Governorate can be reached from Dhamar only after a two-day journey with a four-wheel drive vehicle (although the distance is only 200 km).

The elevation of the land surface varies from 400 m above sea level, where Wadi Zabid enters the Tihama, to approximately 3200 meter at the mountain tops of Jebel Isbil near the eastern border of the Governorate.

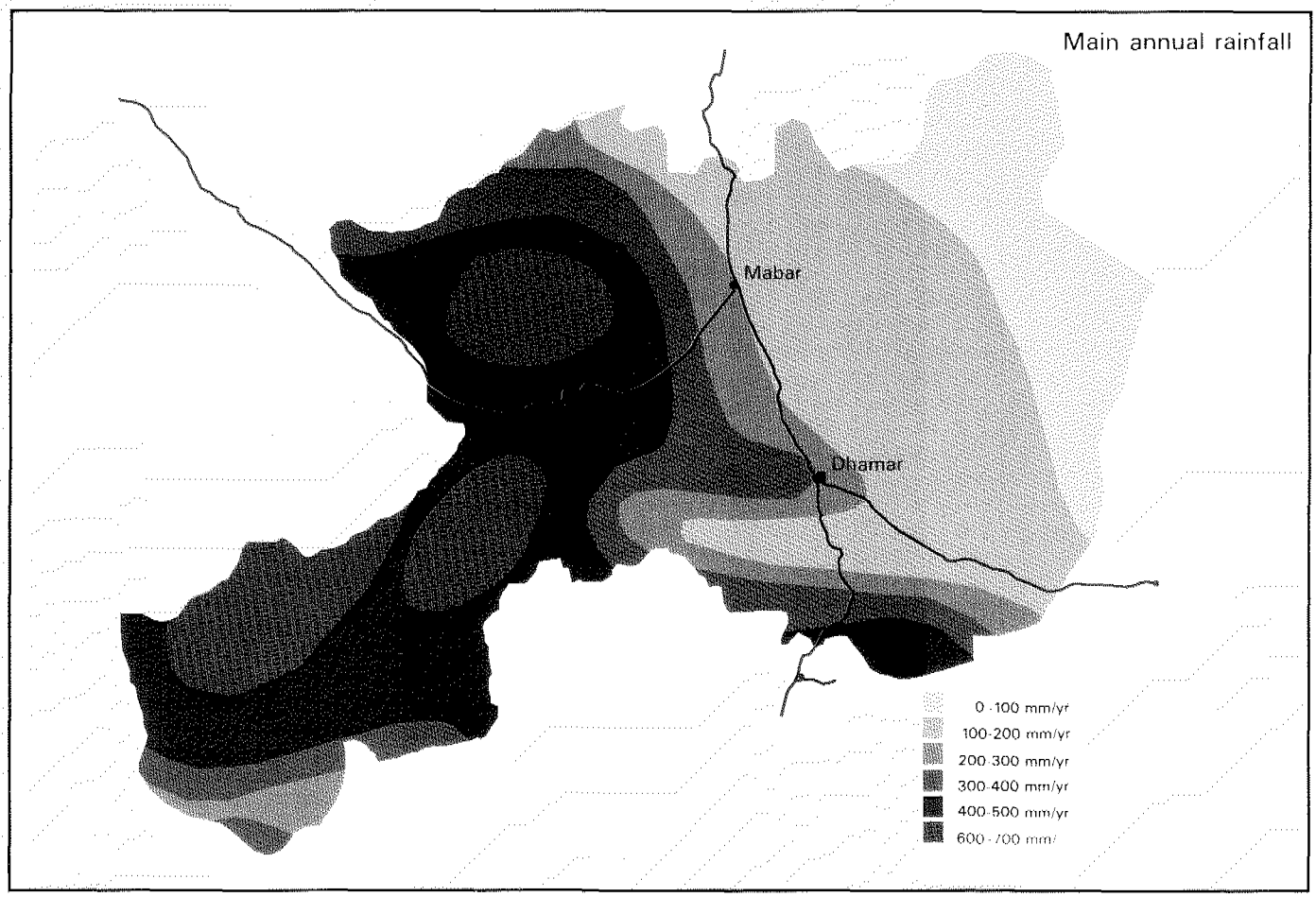
2.3 Population

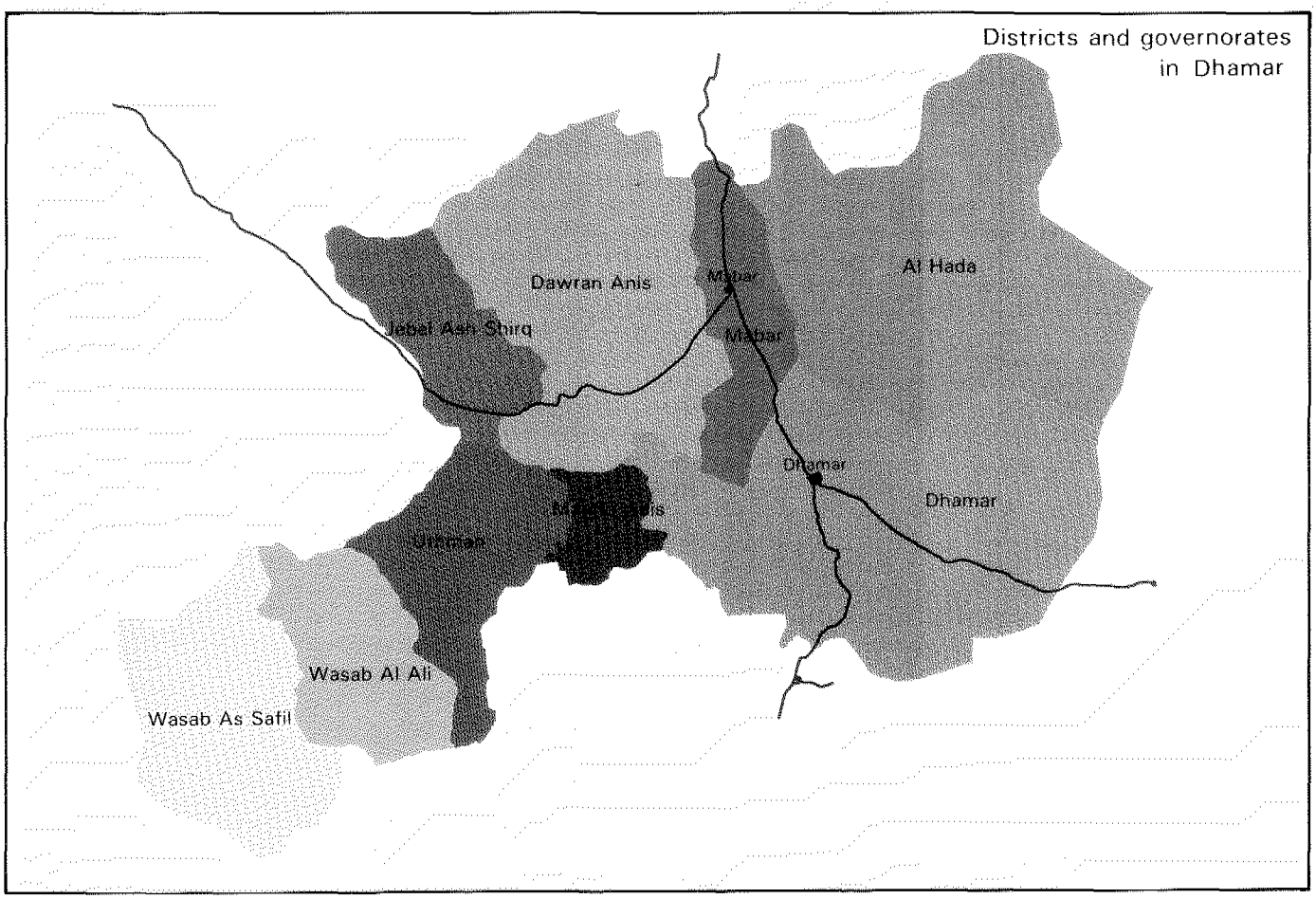
People in Dhamar Governorate are, not unlike the majority of the Yemeni, involved in agriculture. Population concentrations are found in rural areas with the highest agricultural potential and in urban centres (7.5 %). The urban population is involved in administration, trade and small business.

Before 1975, the Yemeni population was estimated by different bodies and varied between 4 and 9 million. In 1974 the United Nations Demographic Yearbook showed a figure of 6.5 million inhabitants. The population data in this Profile are based on the censuses of 1975 and 1986.
However, the means for these two censuses were different. The accessibility of the country has also much improved since 1975. This may have led to systematic differences between the two censuses.

The resident population of Dhamar Governorate as registered in 1975 was 473,786 inhabitants. In the 1986 census 696,771 inhabitants were registered. The annual growth rate of the population derived from these figures is 3.9%. However, given the absence of reliable data on births, deaths, and migration, this figure cannot be confirmed. It is without doubt that the life expectancy for adults increased and the child mortality has decreased. A reduction in isolation of urban centres and of more remote areas gave many people a better access to health care, medicine, and better drinking water. The population growth has led to a relatively young population with a very strong dependency.

The population density in the Governorate is slightly above the national average. Dhamar Governorate consists of 9 districts. The districts that have the highest agricultural potential have the highest population density. The population in Dhamar District is concentrated in the towns of Mabar and Dhamar along the tarmac road Sana' - Taiz. There are more women than men in Dhamar Governorate. However


Main annual rainfall
Mabar
Dhamar
0 -100 mm/yr
100-200 mm/yr
200-300 mm/yr
300-400 mm/yr
400-500 mm/yr
600 - 700 mm/


Districts and governorates in Dhamar
Dawran Anis
Jebal Ash Shirq
Mabar
Al Hada
Dhamar
Dhamar
Wasab Al Ali
Wasab As Safil

the sex ratio is nowadays more balanced than in 1975 or 1981, when the migration for labour abroad was even greater than it is today. The areas with more males than females are Dhamar and Mabar towns, with relatively good job opportunities. In the more isolated districts the female population outnumbers the male population.
Dhamar is a governorate with a strong emigration, relative to the country, with presumably as much as 20 % emigrants in 1981. Dhamar Governorate received and receives high remittances from these emigrants to the Gulf States and beyond, since more than every second household has one emigrant.

2.4 Climate

Yemen's climate is relatively favourable compared to other parts of the Arabian peninsula. The effect of the mountains is that rainfall is more abundant than elsewhere. Temperatures are moderate also because of the altitude: the average temperature drops 1 degree Celsius for 150-170 meter rise in elevation.

Average rainfall is more than 600 mm per year in a narrow belt at the west facing escarpment, where the orographic effects on rainfall are apparently maximal; northeastwards it decreases to less than 200 mm per year, similar to the rainshadow zones near the western border of the Governorate behind the first mountain range. Rainfall tends to be concentrated in two seasons: March-May (Saif) and July-August (Kharif). Also due to the presence of the very steep mountains neighbouring locations may have very different rainfall: the spatial variability in rainfall is extremely high.

The average annual temperature varies widely due to the differences in elevation. It may range from approximately 30 degrees Celsius at the Western border to 12 degrees at the highest peaks. The Central Highlands around Dhamar are known to be among the coldest in the Yemen; killing frosts are common.
Everywhere in the Governorate evaporation is higher than rainfall on an annual basis.

Total population and density per district in Dhamar Governorate

District	Total 1986	Total 1975	Density 1986 inhab./km2
Dhamar (Ans)	89,282	153,897	77.1
Al Hada	46,686	71,547	30.6
Magrib Anis	19,400	31,063	155.3
Uthmah	71,563	92,673	140.4
Wasab Al Ali	72,226	101,819	114.4
Wasah As Safil	64,462	89,160	174.8
Dauran Anis	59,985	88,964	80.9
Jebel Ash Shirq	29,920	36,271	62.5
Mabar	20,262	31,377	84.8
Governorate Total	473,786	696,771	80.6

Distribution of sexes in 1986 in Dhamar Governorate

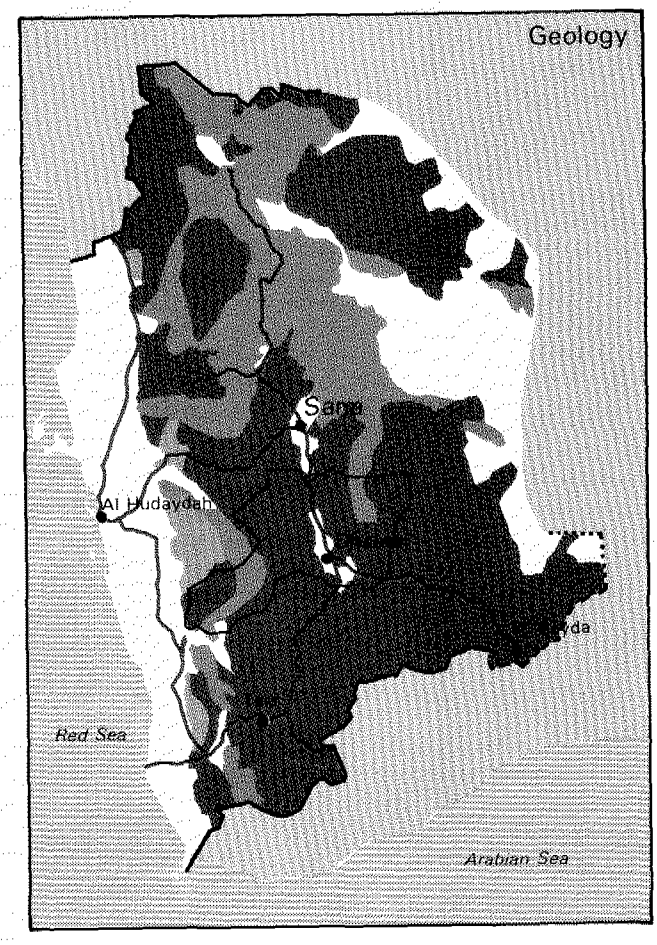
District	Males	Females	Sex Ratio males/100 females
Dhamar (Ans)	76,438	77,459	99
Al Hada	35,345	36,202	98
Magrib Anis	15,449	15,614	99
Uthmah	42,867	49,806	86
Wasab Al Ali	47,332	54,487	87
Wasah As Safil	40,940	48,220	85
Dauran Anis	44,402	44,562	100
Jebel Ash Shirq	17,681	18,590	95
Mabar	16,282	15,095	108
Governorate Total	336,736	360,035	95

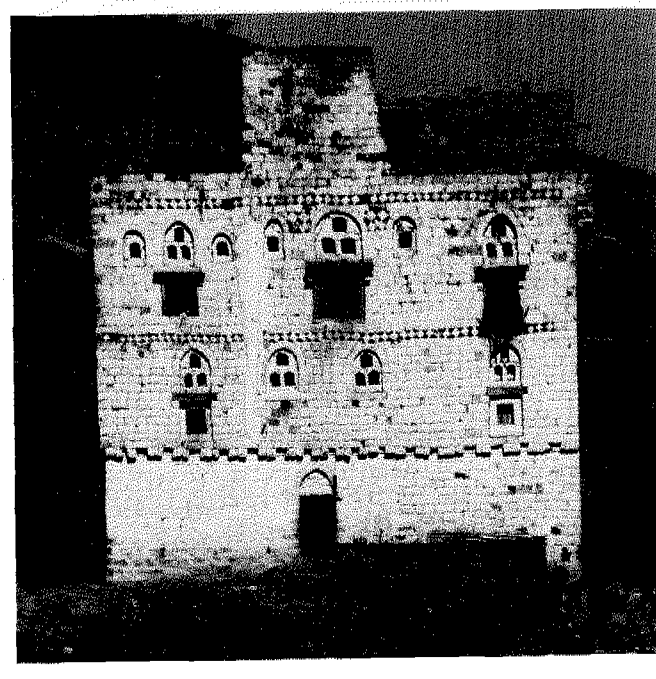
74-75	102,920,000
75-76	291,890,000
76-77	466,890,000
77-78	652,330,000
78-79	575,030,000
79-80	638,060,000

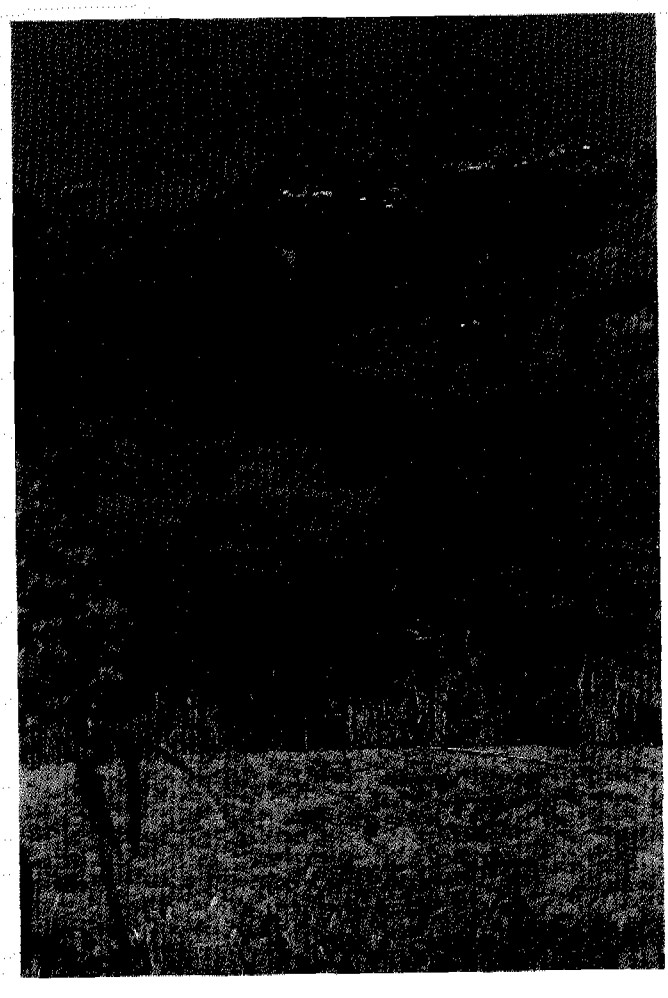
Distribution of private remittances in Yemen Rials in Dhamar Governorate in the period 1974-1980

Frost limits plant growth above 2200 meter. Strong, desiccating winds are another impediment for plant growth. The annual average temperature is in the range of 16 - 22 degrees Celsius for most of the area and average relative air humidity tends to be lower than 50%.

The population growth has led to a relatively young population







Neighbours in the Governorate may be close in horizontal distance but still far apart in altitude

2.5 Geology

Most of the country lies on a block that has been strongly uplifted, tilted slightly eastward, and faulted into numerous smaller blocks. These movements of the crust of the earth surface started in the Tertiary, simultaneously with the formation of the Red Sea graben. They were accompanied by widespread volcanic activity.

The geology of Dhamar Governorate is dominated by volcanic rocks: They cover approximately three quarters of its surface. Most of these volcanic rocks belong to the Tertiary Yemen Volcanics, but Quaternary Basalts are found along the eastern border of the Governorate, surrounding Jebel Isbil. The thickness of the Yemen Volcanics may be up to 2000 meter; the volcanic rocks in the steep sides of the westward draining wadis are at least 800 meter thick.
Quaternary sediments cover extensive areas in the Central Highlands. Depressions there have been filled with alluvial, pyroclastic and aeolic material to form separate sedimentary basins. In some cases these deposits are several hundreds of metres thick, such as in Qa' Al Bakil and Qa' Jahran in the northern part of the area; elsewhere they are thin (up to a few tens of meters, but mostly much less).

Mesozoic sedimentary rocks (Tawilah sandstones and Amran limestones) outcrop in areas in the northeast and south-west.

In December 1982 an earthquake with a magnitude of 6.4 on the Richter scale took place. The earthquake was particularly destructive in the Central Highlands of Dhamar and the areas bordering it in the Western Escarpment. This and other earthquakes are caused by the movement of the Arabian and African Plates, that meet in the Red Sea and cause instability in areas with much tectonic activity as in case of Dhamar Governorate.

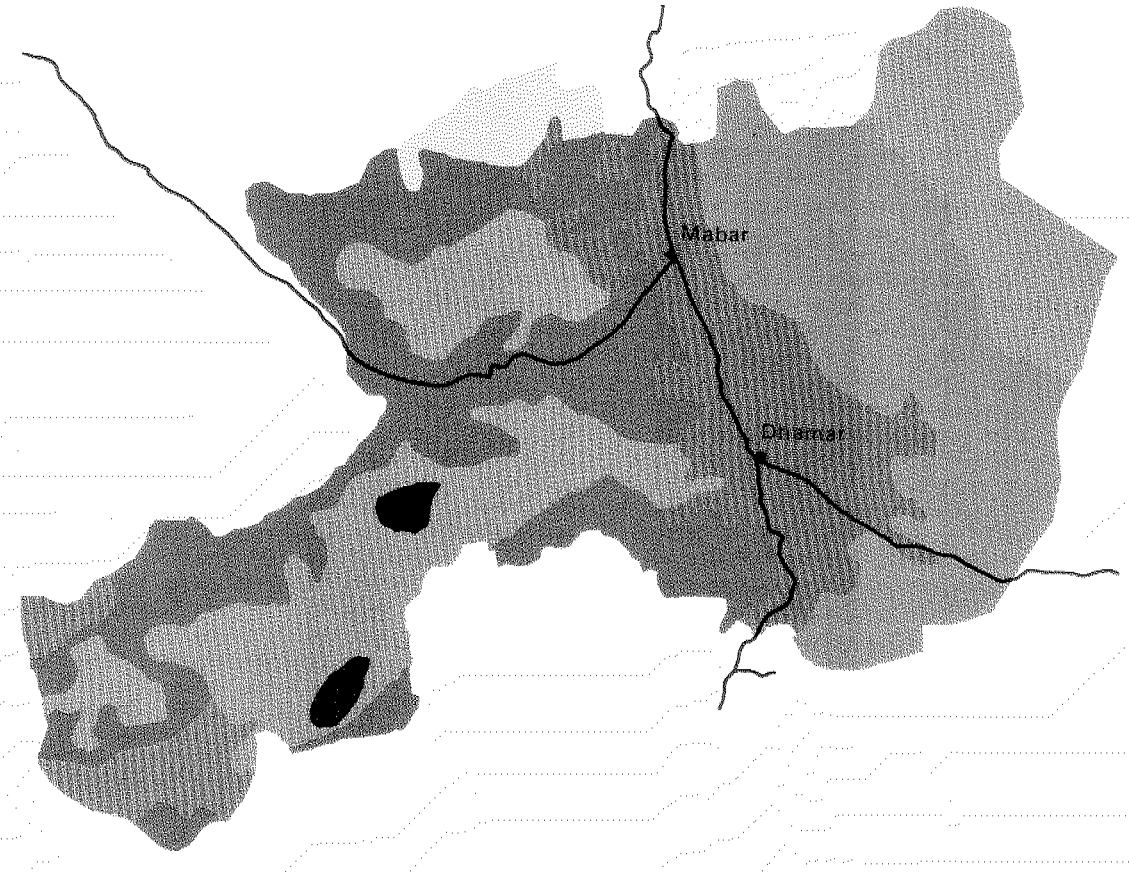
2.6 Legislative framework

In the framework of rules that together regulate the life of man in the Yemen, a distinction can be made between the laws that originate from Shari'a, the Qoranic law and the customary law, which is of course also in line with the foundations of Islam. The customary law, however, may vary from location to location, so that in case of e.g. water rights, many local particularities and regulations can be found.
In general, however, a law enforcing proper management of the environment is virtually nonexistent in modern legislation. This is not surprising, given the fact that the problems arising from modern life have only been felt recently. During the Imamate no attention was paid to legislation in this and many other fields. It is the task of the Environmental Protection Council established in 1987 to provide the framework for environmental legislation and of the Supreme Council for Water to provide this for management of water resources.

Simplified stratigraphic table of the Yemen Arab Republic

Chronostratigraphy	**Lithostratigraphy** (and max. thickness)	**brief description**
Cainozoic		
Quaternary	Quaternary (300 m.)	deposits unconsolidated sediments: sand, silt, clay, gravel
Quaternary	Quaternary basalts (500 m.)	basaltic lava flows, tuff and agglomerates
Tertiary	Tertiary Intrusives	alkali granites, diorites
Tertiary/Creataceous	Yemen Volcanics (>2000 m.)	basalt,andesite, trachyte tuffs, agglomerates with interbedded fluviolacustrine material
Mesozoic		
Cretaceous/Tertiary	Tawilah and Medj-zir Sandstones (350 m.)	coarse sandstones with lenses of conglomerate shale, etc.
Jurassic/Triassic	Amran and Kohlan Series (>900 m.)	limestones and marls, with shales, sandstones and conglomeratic bands; Amran Series (on top) dominantly calcareous, Kohlan largely sandstone/shale facies
Paleozoic		
Ordovician	Wajid sandstones (500 m.)	parly cross-bedded sandstone, locally conglomeratic
Precambrium		
Precambrium	Basement Complex	granite, diorite, gabbro, gneiss, schist, quartzite, marble

Land unit



Land units in Dhamar Governorate

Name	Main Source of water	Rainfall mm/yr	Relief and Elevation (amsl)	Soil	Natural Vegetation
Middle terraced mountainous land	rain	400-600	mountainous 1000-2000 m	stony loams	open shrubland
High terraced mountainous land	rain	600-900	mountainous 2000-3000 m	stony loams	dense shrubland
Low terraced mountainous land	rain	350-500	mountainous 500-1500 m	stony silty loams	open shrubland
Lower mountainous land and wadis	wadi	200-350	hilly 400-1000 m	fine silts bound	very open shrubland and waditrees
Mabar and Dhamar Montane Plains	ground-water	250-300	undulating 2200-2500 m	loess	dwarf-shrubland
Al Hada hills and valleys	rain and ground-water	300-350	undulating 2200-2500 m	silts and clays	dwarf-shrubland and swamp
Dry mountains of Ar Rus and Nahdan	run-off	200-300	mountainous 2500-2800 m	-	dwarf-shrubland
A'mas rangelands	run-off	< 200	undulating 2200-2400 m	-	dwarf-shrubland

3. Water and land

The landscapes in Dhamar Governorate can be divided into two major groups. The Central Highlands including the Montane Plains are a very old landscape, in which the mountain tops are eroded and where the (noncultivated) land is covered by stones (the eroded material). The valleys are also filled with stones and eroded soil material, the alluvium. The other major group of landscapes is quite variable. It is a young mountainous, steeply dissected landscape at the bottom of which wadis flow.

3.1 Soils

The soils in the Governorate are predominantly stony and calcareous. On the Montane Plains the soil has developed a usually very hard calcareous layer (calcic horizon). Nevertheless, in general, the soils in the Governorate are relatively young and fertile. On the other hand, on all non-terraced mountain slopes the soils are very thin or rather absent. On terraced slopes where man has trapped the eroded soil material from uphill behind terrace walls, or in valleys and wadis, where the soil material is deposited by wind and water, the soils may be very deep, but are always rather stony. Whether these deeper soils are cultivable or not, depends on the availability of water.

On the Montane Plains areas with loess are found. These soils are very suitable for cultivation but they are also sensitive to wind erosion when they are left bare after harvesting grain and stubble.

3.2 Types of land

Terraced mountain slopes

Terraced mountain slopes are not a natural type of land. The terraces are made by man. Nevertheless, the activity of terrace construction, starting at least 2,000 years ago, has resulted in a very distinct type of land. The loamy soils on these slopes are made suitable for cultivation by man (manure, ploughing removal of stones, collection of soil, etc). The terraced mountain slopes are found especially on the the rain-exposed sides of the slopes where rain and run-off water can very well be intercepted. The vegetation on these lands is also a man-made vegetation, that is largely privately owned.

Non-terraced hills and mountains

Despite the effort of the Yemeni farmers in terrace construction, the majority of the area is still covered by this type of uncultivable land. At the same time this land provides fodder for livestock and firewood for man. The soils are very shallow, very stony and calcareous. Often even there is no soil material (rock outcrop). The slopes can be very steep, but they are rarely too steep for these purposes. The surface of the more gradual slopes are covered by stones, a so-called ''desert pavement or hammada surface''. The land is largely communally or tribally owned.

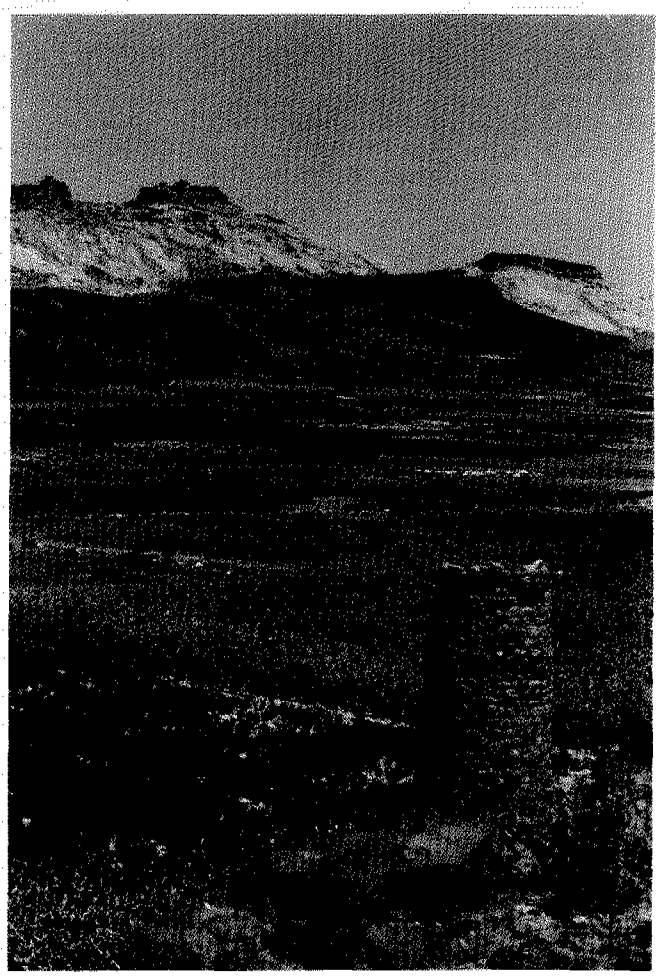
Valleys

Rather large basins filled with alluvial sedimentation are found in the Al Hada area, where the depressions sometimes have a swampy vegetation with reeds, etc. The alluvial silty material is deposited during floods. The soil fertility in these areas is relatively higher than on the adjacent hills, but salinity and micronutrient deficiencies form limitations for cultivation. In these basins groundwater is relatively shallow. This has enabled a tremendous growth of motorpump irrigation. In this cultivation nutrient limitations show within a few seasons of cultivation. Before, much of the vegetation in these valleys was an important source of forage for livestock and of fuelwood.

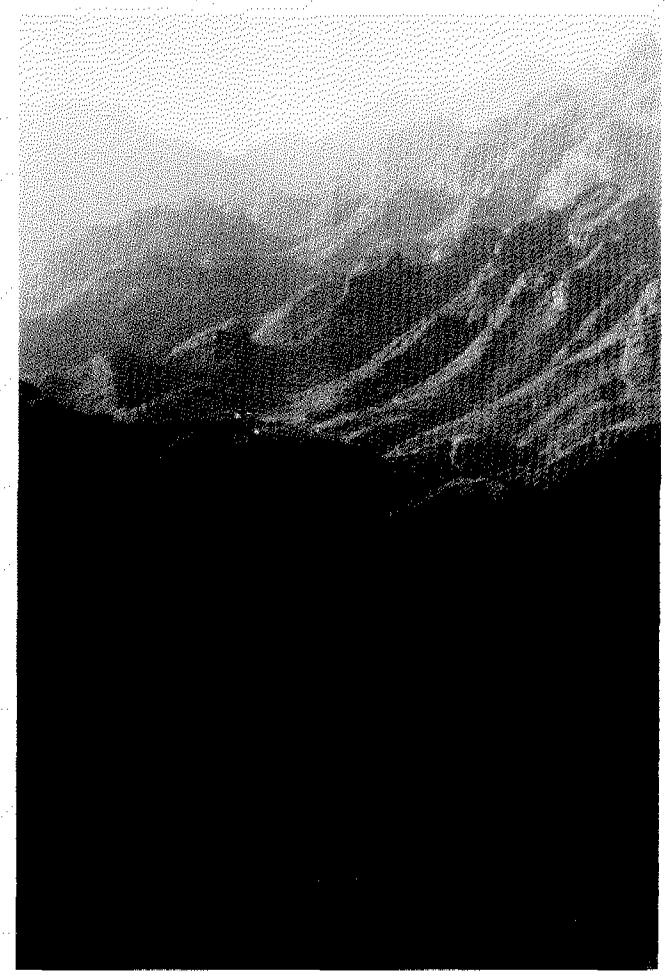
Wadis

Numerous wadis in the Governorate together form the drainage system of the Governorate, to which is referred in the following sections. The beds of these wadis transport water during very short periods, during and directly after a rainshower. They contain small amounts of groundwater during a much longer period of the year and are amazingly humid micro-environments. The density of trees along these wadis is much higher than elsewhere in the Governorate, unless they have been chopped for fuelwood or browsed intensively. The wadis are tapped to provide irrigation water for fields along the wadibed.

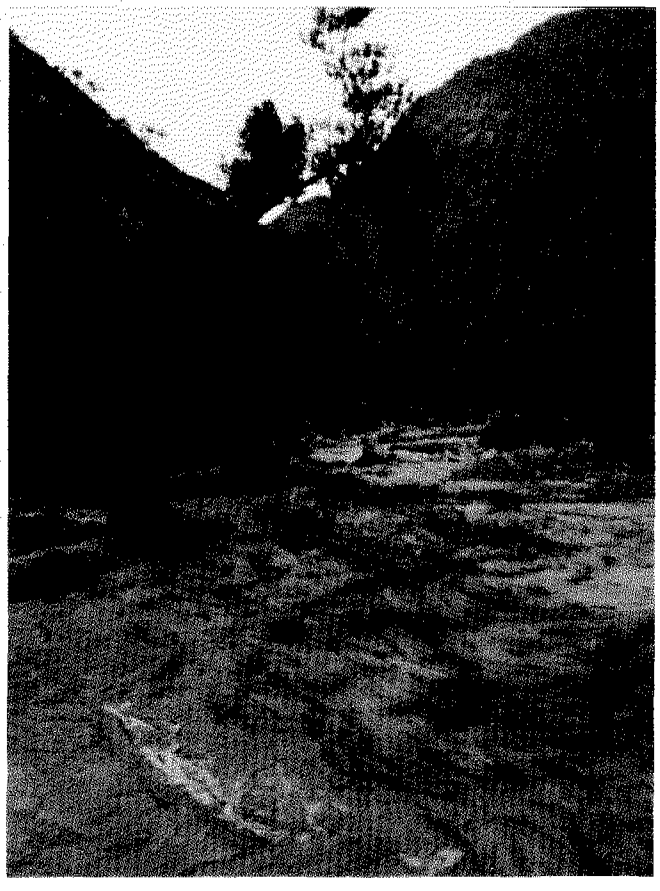
The wadis are rich in fish, where there is a more permanent flow of surface water



Wide valleys in Al Hada area



Very rugged terrain off the Escarpment near Dhamar



A tributary of Wadi Rima in flood

Montane Plains
The Montane Plains are characterized by deeper soils, also contained behind terraces, intensively fractured parent material and consequently by rather accessible groundwater. The development of these groundwater resources only occurred in the last twenty years, but has changed the landscape of the Montane Plains enormously, from an extensively cultivated, grazed and thinly populated area into an area where commercial agriculture has become very important.

3.3 Surface water systems

The main catchment areas in Dhamar Governorate are those of Wadi Siham, Wadi Rima and Wadi Zabid that belong to the Red Sea Basin. The Central Highlands drain by and large internally. Surface drainage patterns can be observed, but the wadis are small and often discontinuous due to losses of water. Some of them may remain entirely dry for years.

The sloping and highly dissected areas of the east and west, however, contribute to quickly rising flows in the wadis mentioned above. The regimes of those wadis are torrential: flash floods occur immediately upon rain storms, but most of the time the channels are inactive; even base flow is restricted to very limited portions of the main channels.

Averaged over larger areas, it is estimated that only 5 - 10 % of the annual rainfall is discharged by the main streams. In spite of steep slopes and rather impermeable surfaces over much of the area, a major part of the rainfall is intercepted at the surface and evaporates subsequently. This process is favoured by the intensive terracing of hillslopes in the southern and western parts of the Governorate.

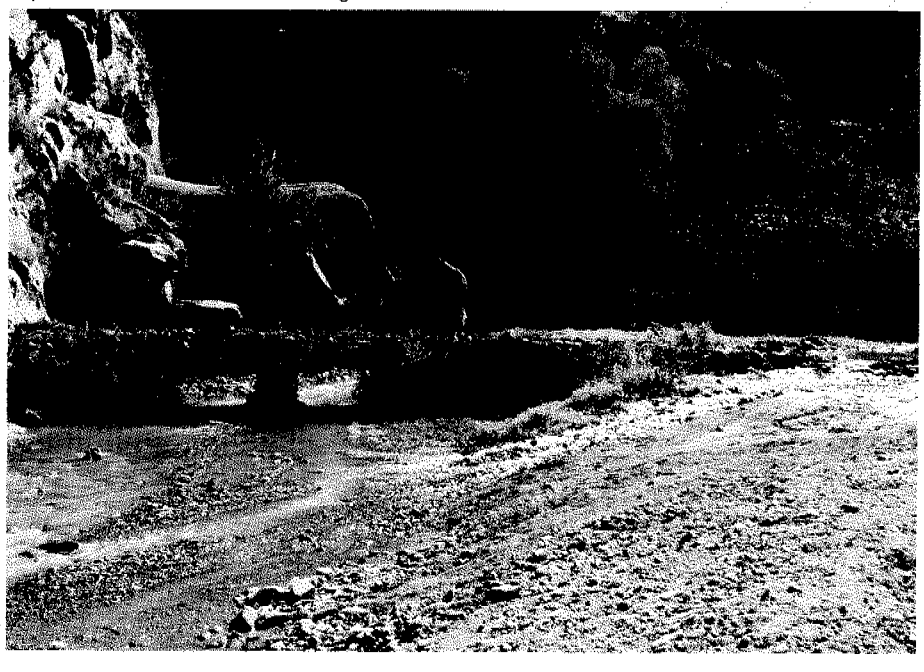
The wadis contribute substantially to the water balances of adjoining areas. For instance Wadi Siham, Rima and Zabid enable the cultivation of large areas in the Tihama and are responsible for approximately half of of the total inflow from the east into this area. Annually a few hundred millions of cubic meters of surface water leave the Governorate, while hardly any enters the Governorate.

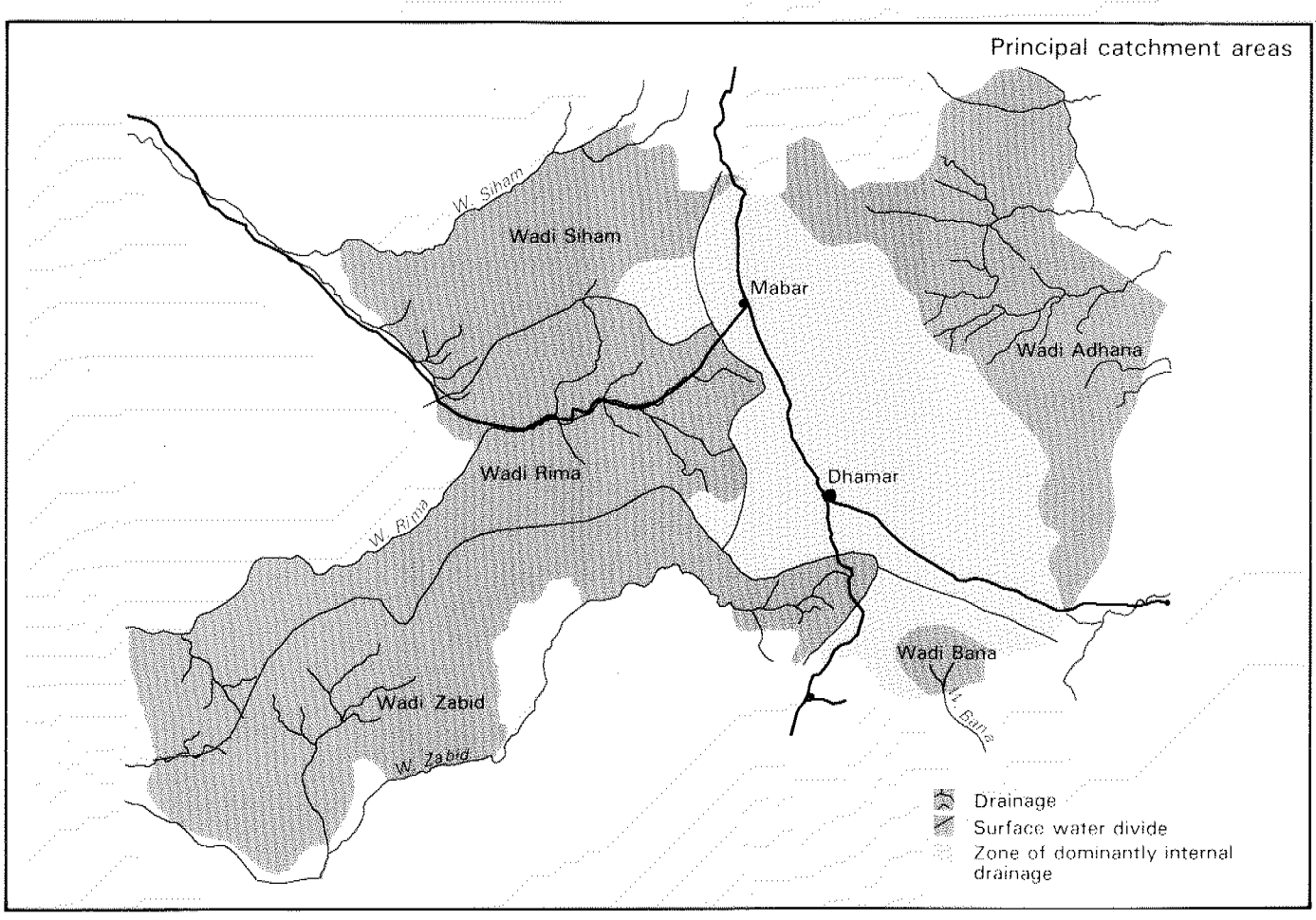
3.4 Occurrence and characteristics of groundwater

The extent and potential of groundwater reservoirs is limited in Dhamar Governorate. Most of the territory is underlain by basement rocks, where only local aquifer systems can be found in weathered, fractured and faulted zones or in the narrow alluvial fills of the wadi beds. Depth to groundwater is usually less than 15 m in these zones. Typical for such local aquifers is that groundwater moves only over limited distances and that stored volumes are only small, which may lead to seasonal depletion or exhaustion of groundwater.

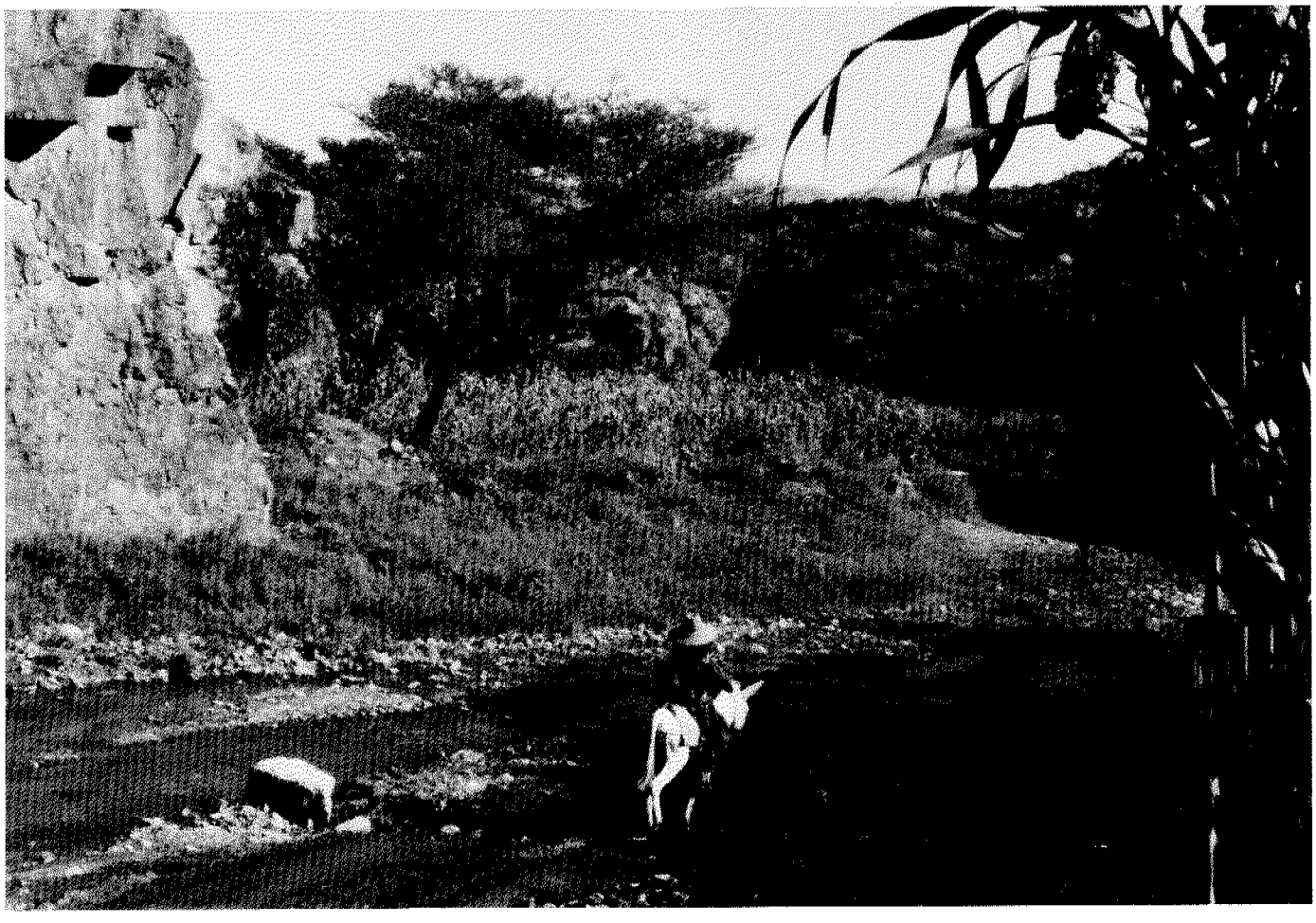
Groundwater quality is usually good, but brackish or salt water has been observed in a number of zones, often at the downstream end of aquifer zones. Springs are known to exist in the zones of volcanic rocks: the yields are less that 10 l/s and some of them are saline. Some boreholes in the Quaternary and Tertiary Volcanics show slightly thermal waters.

Aquaducts are constructed to irrigate from the baseflow in the wadis





Sorghum crops are sometimes irrigated from wadi base flow



4 The human factor

In this chapter the human occupation is projected over the physical environment described in the previous chapter. Attention is paid to agriculture, livestock production, firewood and water. How are the people in Dhamar Governorate using their natural resources?

4.1 Agriculture

Virtually all cultivable land in the Governorate is contained behind terraces. Terraces are found on the Montane Plains, in the valleys, on the mountain slopes and along the wadis. The terraces are sometimes very old, as the beginning of terrace construction dates back at least 2,000 years. Terraces are found in alluvial deposits in valleys, in the deeper soils on the Montane Plains and on the erodible volcanic mountain slopes that are turned into fertile arable land.

Virtually all land available for cultivation is under use. Terrace construction may never end, but the expansion of acreage by the construction of new terraces is minimal. Rainfed, well- and wadi irrigated agriculture can be distinguished in the Governorate. The rainfed agriculture depends on rainwater that falls on the surface of the field directly, or on nearby slopes and is subsequently led onto the field. Irrigated agriculture occurs in two forms. Well-irrigated agriculture is understood in the Governorate as a development of the last twenty years, based on pumped groundwater. The wadi irrigation is much more traditional. Old irrigation systems, such as those where fields are irrigated through a tunnel as a short-cut to the wadi water, as in the antique Baynoon capital along the Governorate's Eastern frontier, no longer function. These irrigation systems still illustrate the high level of technical knowledge of the old civilisations.

The estimations for cultivated acreage compared to the Yemen Arab Republic indicate that the Governorate, which covers approximately 7 % of the nation's surface also contains 7 % of its cultivated lands. Roughly one third of the land is irrigated and two-thirds is rainfed. The cultivated area fluctuates with the amount of rainfall in a rainy season. For the well-irrigated area, the fluctuations in area are only caused by break-down of motorpumps.

Types of Agriculture

Rainfed agriculture

Rainfed agriculture is mostly practised on the terraced mountain slopes in the Western Escarpment Zone. Depending on the altitude the farmers give preference to sorghum, wheat, coffee, pulses, some barley and qat. Sorghum is the most important. On the lower elevations fruit trees are also becoming more popular. Under these conditions an average yield for sorghum, wheat and barley is assumed of 800 kg per hectare.
The average plot size on these terraced slopes is usually in the order of 0.1 hectare or smaller. This indicates that the scope for mechanization is minimal. Almost all farmers rely on animal traction or manual labour for field preparation, terrace maintenance and the other cultural practices. In the period when migration reached its maximum, many terraces could not be cultivated due to lack of labour, while terrace maintenance was also a serious problem. Apparently the situation has improved a little, since the majority of the observed terraces are well maintained nowadays.

Especially on the high mountains the transport of the crops to the market demands an amazing effort. Much of this transport is done by donkeys, skidding down the slippery mountain tracks. However, most of the Dhamari farmers still produce under these conditions. Except for qat and coffee, farming is almost exclusively subsistence oriented.

Wadi agriculture

Flood and base flow irrigation are relatively flourishing in this epoch. Compartments, averaging 0.4 hectares, are interconnected by spillways so that flood water is conducted from one field to another. The main cultivated crop is sorghum; others are vegetables, fruit trees and coffee. Sorghum crops are noted to yield 1500 kg of sorghum grain per hectare.

Three floodings are considered essential for a reasonable sorghum crop. Land preparation is started after the first flood at the beginning of the first rainy season (March). Sorghum is sown in May. After seeding no water is required until the sorghum is high enough to withstand the next flooding. At the end of the rainy season (August), another flood is required to enhance the growth of the grain. When soil moisture is insufficient the sorghum crop is gradually thinned out for animal feeding, or grazed altogether.

The areas along the wadi where base flow is available are turned into green oases with bananas, papaya, etc. The irrigation systems used to divert the small base flow onto the field are very ingeniously built. The systems do have to be repaired once a flood has passed.

Sometimes small motorpumps are placed in the wadi or in shallow wells near the wadi for supplementary irrigation.

Previously, a serious disadvantage of cultivating in the wadis was that the security of the family could not be defended as well as on the mountains.

Nowadays, wadi cultivation is more flourishing than before. Another reason for the increased interest in wadi cultivation is that the motorable tracks mostly lead through the wadis: the access to the market is much better from the wadi than from the mountains.

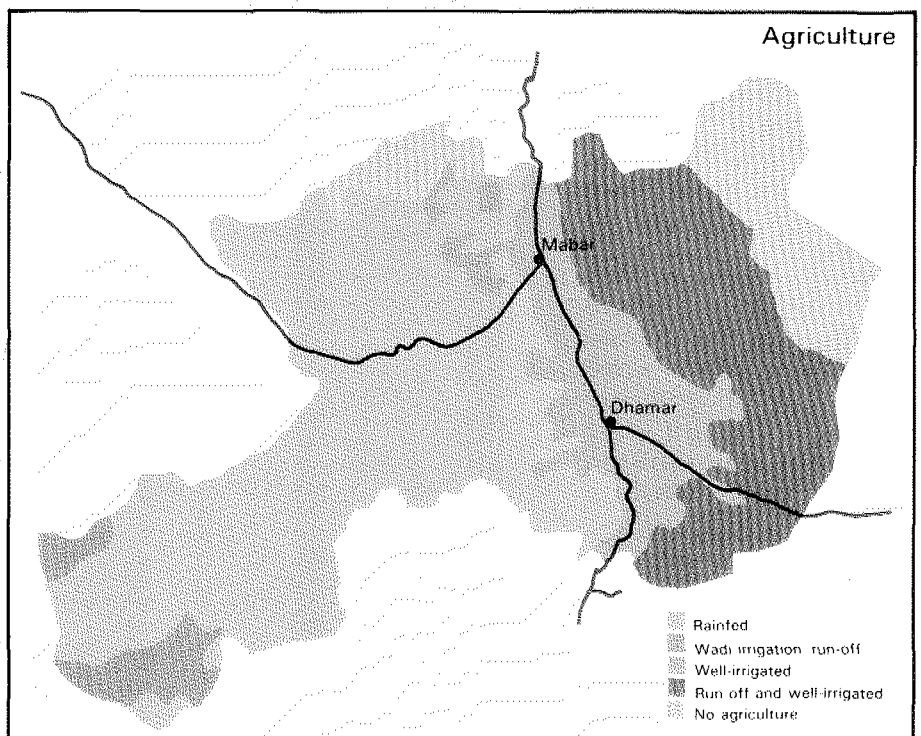
Well-irrigated agriculture

Well-irrigated farming in the Governorate is a development of the last decades. It occurs only on the Montane Plains. Consequently, irrigation techniques are new to most farmers.

Shallow wells initially served mostly alfalfa crops, while boreholes were developed to irrigate cash crops, mainly potatoes. The rapid expansion of this type of cultivation made the shallow wells dry up and nowadays well-irrigated agriculture is mainly fed from deep wells. The economics of well-irrigation necessitate the cultivation of cash crops. The most important cash crops on the Montane Plains nowadays are potatoes, while the cultivation of alfalfa has relatively declined. Nevertheless a wide range of both home-consumed and cash crops is cultivated. Livestock is increasingly combined with irrigated crop output, being "processors of crop residues".

The efficiency of water use in irrigation is found to be low to average. Usually over-irrigation takes place.
If irrigation water is not the limitation, the success of this type of farming depends on its economy. An analysis of costs and returns to irrigation indicates that the scope for development of irrigation in Dhamar Governorate is not very great, given the limited number of crops that can be grown successfully in view of the killing frost conditions, and the price that is paid for most crops. For example on most locations on the Montane Plains qat cannot be grown successfully due to frost. The same applies to many horticultural crops. In fact, to many farmers the main purpose of crop production is not sale but home consumption and many Dhamari farmers are quite willing to spend money on home-grown sorghum, wheat and other crops.

The outlook for well-irrigated cultivation, when water saving practices are incorporated, is positive for potato growers but negative for alfalfa and grain crop producers,



Agriculture in Dhamar Governorate per land unit

Name	Rainfall mm/yr	Type of Agriculture	Crops
Middle terraced mountainous land	400-600	rainfed	sorghum qat
High terraced mountainous land	600-900	rainfed	qat sorghum
Low terraced mountainous land	350-500	rainfed	coffee sorghum
Lower mountainous land and wadis	200-350	wadi-irrigated run-off	sorghum coffee
Mabar and Dhamar Montane Plains	250-300	well-irrigation	potatoes sorghum
Al Hada hills and valleys	300-350	run-off and well-irrigation	sorghum grapes qat
Dry mountains of Ar Rus and Nahdan	200-300	–	
A'mas rangelands	< 200	–	

Cultivated land under different farming systems in Dhamar Governorate relative to the Yemen Arab Republic

		Rainfed area	Irrigated area	Total area
Dhamar	ha	50,000	21,000	71,000
	%	70	30	100
Yemen Arab Republic	ha	782,000	160,000	942,000
	%	83	17	100

whatever the irrigation method will be.
The introduction of farm machinery is new to the Montane Plains, but many new tractors are observed. Most first ploughing is nowadays done by tractor, but still working animals are commonly used for secondary ploughing and seed bed preparation. On the terraced slopes and in the wadis still virtually all farmers employ animal traction or manual labour. The scope for mechanization in these areas is also rather small, given the small size of the plots.

Fertilizers are still hardly used in the Governorate. In Yemen no inorganic fertilizers are produced, except for the chicken manure that is bought from the chicken farms and used on the Montane Plains. The rare fertilizer that is locally sold at high prices, is imported.

Potatoes, a new crop for the Yemen are now widely cultivated on the Montane Plains

Data on the use of pesticides (herbicides, fungicides and herbicides) are not available. They are introduced by international agencies, by local merchants and to some extent by the Ministry of Agriculture. The import has been restricted recently and consequently pesticides seem to be scarcer than before.

Also no comprehensive information is available with respect to the exposure of the population of the Governorate to pesticides, though some accidents involving poisoning are reported.

4.2 Livestock production

As everywhere in the Yemen, livestock and crops are also closely integrated in the farming systems in Dhamar Governorate. Almost every farmer has animals, whether to provide him with food, cash, traction power or means of transportation. To the majority of the farmers livestock is a savings account: "the cash in the bank". This source of cash can be tapped when required. Usually women and children take care of the livestock. This most likely cannot continue for long since many more boys and girls will go to schools in the future.

Livestock, their use and management

Cattle

Cattle are of the small, short-horned Zebu type. They have an average body weight of 340 kg for males and 240 kg for females. They provide fresh milk, meat and draught power. Though cow milk is highly valued, milk yield is relatively low, declining from an average of 3.4 l/cow/day during the first two months of lactation to less than 1 l/cow/day from 9 months after lactation on. Milk and ghee (fluid butter) are rarely marketed. The "house-cow" is highly valued and most households will keep at least one for the regular provision of milk. Beef is readily consumed but less favoured than mutton.

Dhamari sheep from the Montane Plains have a reputation in the country and the size and number of the flocks that are observed are great. The flocks are larger than at most other locations in the country.

Also cattle, camel, goats, donkeys and poultry are kept and serve various purposes, depending on the livestock type, but also the household or farming system in which they are kept.

Cattle dung is mainly made into dungcakes by mixing with straw to be used in the oven for cooking. It is rarely used as manure.

Cattle are most commonly fed in the compound and are hand-fed with sorghum stalks and leaves and, if available, also with fresh or dried alfalfa. Cattle rarely leave the house to graze agricultural fields with crop-residues, stubble and weeds after the harvesting of crops. The feeding of cattle at home, the milking of cows, the preparation of dung cakes and the management of the stable, in the better houses situated downstairs, are all women's jobs.

Rinderpest is the most serious cattle disease, but vaccinations are effectively applied. Cattle being only stall-fed are usually in a rather poor shape, suffering from several disease, largely as a result of poor nutrition.

Bulls and oxen, used for draught power (ploughing, sowing, weeding and threshing) are commonly kept in Dhamar Governorate.

Sheep and goats

In Yemen many different sheep and goat breeds are kept. People in dif-

ferent corners of the country have their own preference for certain breeds. The Dhamari are famous for their sheep that are mostly of the fleeced, brown or white type. The sheep have an average weight of 20-25 kg and a short typical S-shaped fattail. Compared with the hair sheep of the mountains they are more favoured in the dry rangelands due to their smaller water requirement, their ability to move in rough and rocky terrain and because they can do with poor forage feed qualities.

Sheep are kept for meat, milk and wool. Milk yields are low (less than 500 ml/ sheep/day). Mutton is the favoured meat in the Governorate and priced accordingly. It is especially important for celebrations. For such occasions, castrates, especially fed for at least some months, are preferred to entire rams, for the tenderness and flavour of their meat. Households commonly keep a few sheep for fattening purposes. They are stable-fed.

The droppings of sheep and goats may be used as manure or to make dungcakes in combination with cattle dung and straw. The wool of fleeced sheep is traditionally spun and woven into a coarse fabric used for rugs, blankets, grain sacks and bags. The local wool trade is getting more and more depressed due to importation of cheaper alternatives.
The goats of Dhamar Governorate are of the short-eared type, long-haired and generally black. They are somewhat larger than the sheep. Goats provide milk, meat and hair. Milk yields are generally higher than of sheep (up to 1 l/goat/day). Goats are slaughtered at younger ages than sheep and their meat is less highly priced. The hair is used in combination with sheep's wool to provide a colour pattern in the woven fabric.

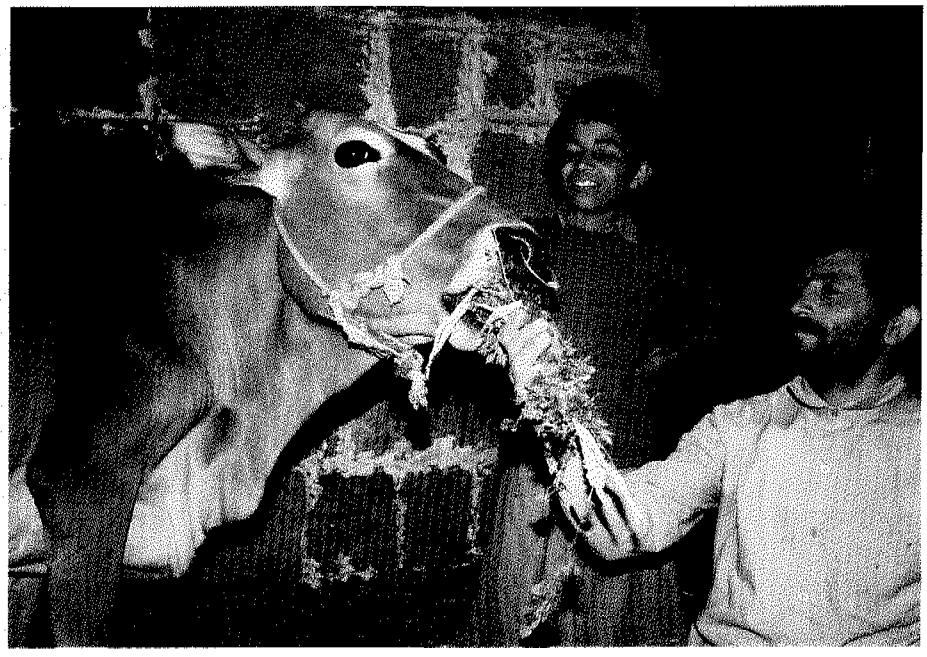
Flocks may be tended by any family member, nearby the house by women and children and further away by grown-up boys or elder men. Herding arrangements are commonly made by villages. This was usually done on a 50/50 basis

Collecting sorghum leaves as forage for the livestock that is kept in the house

Average holding size and number of parcels per holding in Dhamar Governorate relative to the country.

	Average holding size (ha)	Average number of parcels per holding
Dhamar	1.3	7.1
Yemen Arab Republic	2.3	4.6

Force feeding of the house cow. Usually this is a woman's job



for the offspring, but nowadays mostly involves payment of the herdsman in cash, generally not amounting to more than 20 Riyal per sheep per month.

In the cropland areas, both sheep and goats basically function as a financial buffer to meet cash requirements of the household.
Numerous diseases occur among sheep and goats, one of the most serious and common is pox. Pox vaccinations are so far applied irregularly and ineffectively. Liverfluke and related black disease occur in agricultural areas.

Other livestock
Most households keep at least one donkey and more than 50% of the households make use of donkeys as a means of transport. To transport coffee and qat from the high mountains to the road almost exclusive use is made of donkeys; because of this they are very important in this Governorate.

On the Montane Plains camels are used for fieldwork, and only rarely for long distance transport.
Approximately 10% of the farms of Dhamar Governorate were reported to make use of camels for transportation. Their use is currently declining. Camels may also provide milk and meat: the milk production varies from 1-3 l/camel/day. Camel management is a man's job. Dhamar is not a camel raising area.

Hens are kept in the backyard for their egg production, as well as brooders to hatch eggs and produce chickens that are sold at a much higher price than those produced in the fully automated broiler and egg production units. This modern meano of poultry production went through a tremendous growth in the past decade; apparently well over its top in 1989.

The local chicken (baladi) are the special food for women that give birth. The higher price for the traditional chicken once again underlines the importance a Yemeni attaches to home-grown food.

Distribution of labour in agriculture in Dhamar Governorate relative to the country.

	Type of labour (%)		
	family	other	total
Dhamar	58	42	100
Yemen Arab Republic	52	48	100

Livestock densities and distribution

The livestock densities are highest in areas with many people and much cultivation. Cattle and (hair) sheep are kept. Livestock densities are lower on the rangelands of the area, due to the smaller resource base (little forage).
In the Governorate, cows and donkeys are kept by one out of two farms, camels by one out of ten farms and sheep by all farms. Outside the cultivated areas goats are kept by few farms only, but when they are kept, this is usually in large numbers.
Livestock densities in Dhamar Governorate have in recent years remained relatively stable. In the cultivated areas, keeping livestock has become easier as forage resources have increased due to the larger volume of pumped irrigation water and consequently the increased cultivation of alfalfa, etc.

Livestock feed

Livestock feeds originate from three sources:
- cultivated fodder crops
- weeds and residues on crop land
- weeds on fallow land
- rangelands

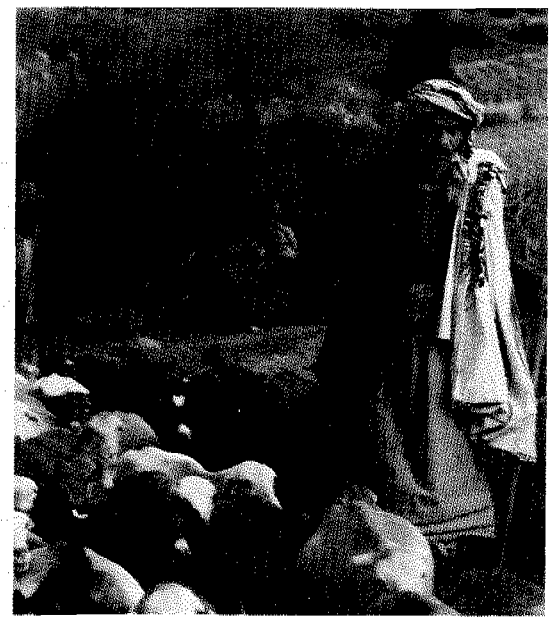
It is estimated that approximately 45% of the forage for sheep was obtained from the rangelands and fallow lands. It is obvious that around the cultivation centres the contribution of cultivated fodder is higher and for the large uncultivated areas much lower.

Practically all yearly produced green matter on the rangelands can be grazed by livestock, except for the unpalatable plant species (poisonous or too spiny). It is estimated that, taking the cultivated and inaccessible areas and fallow lands into account, about 0.3 million ton of dry matter is produced per year in the Governorate.

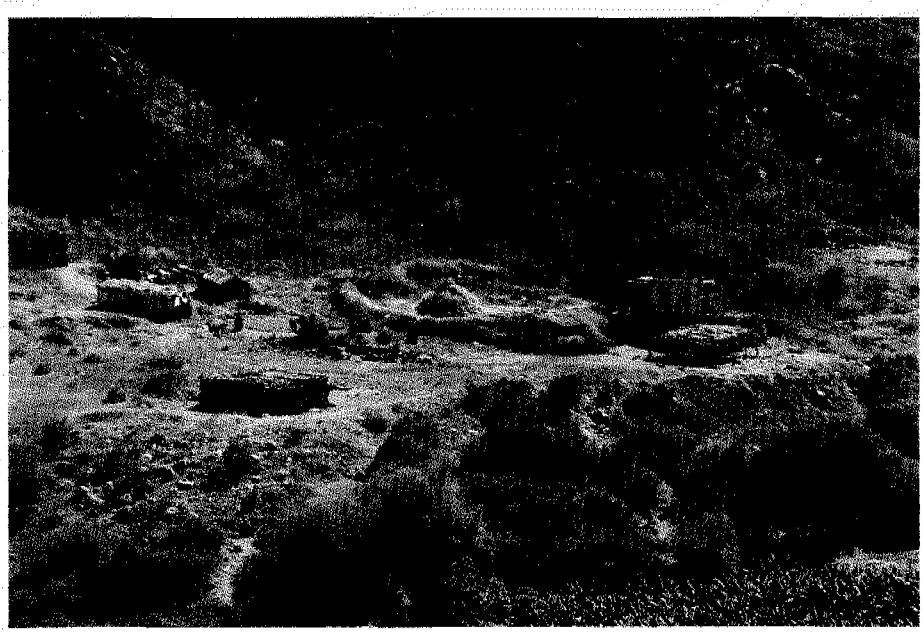
Food preference of different kinds of livestock

	Camel	cattle	sheep	goat	donkey
trees	+ +	--	--	+/-	--
shrubs	+ +	-	+/-	+	--
dwarf-shrubs	+	+/-	+	+ +	+/-
grasses	+/-	+ +	+ +	+	+ +

+ +	dominates in diet
+	important in diet
+/-	irregularly eaten
-	rarely eaten
--	not eaten



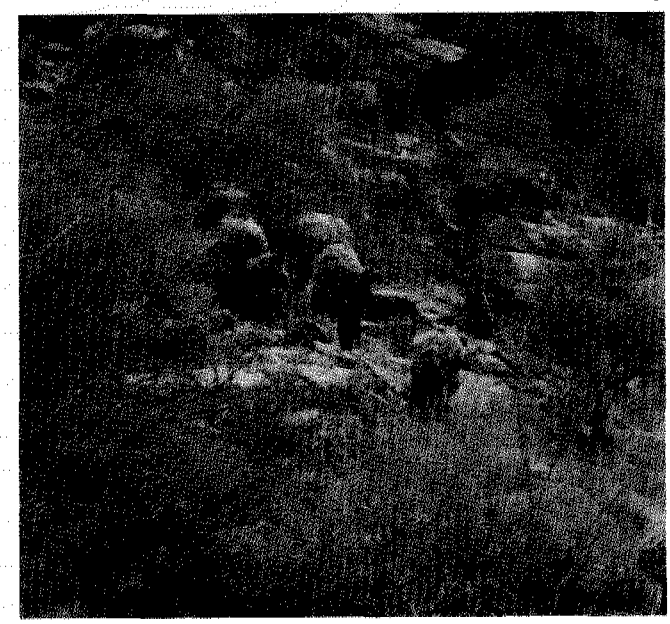
Herding of a mixed flock of sheep and goats



In the drier areas sorghum stalks are conserved as hay on the farm

The forage on much of the rangelands in the Governorate is not accessible to man or animal

Women collecting firewood and forage on mountainous rangeland



One fifth of this biomass is ''browse'', plant material on trees and shrubs that can be eaten by camels and to some extent by goats. The remainder, ''graze'', is more accessible to all livestock, but the many spiny dwarfshrubs on the range are not as palatable as grasses and forbs. The contribution of ''browse'' is very important, given the high quality of the browsed material, compared to the low quality (low protein content) of e.g. sorghum stover. Considering the estimated feed requirements of all livestock present in the Governorate, almost the entire yearly production should be utilised to cover the yearly livestock feed requirements.

In Yemen man has an impact on natural vegetation by three main activities:
- grazing of livestock
- cutting and collecting of wood for fuel and timber
- clearing of land for cultivation

Of course, the natural vegetation is used for many other purposes such as traditional medicine, production of caps, etc. but these uses do not have a major impact on landscape and productivity of the resource base, contrary to the three mentioned activities.

As indicated above, livestock pressure on the rangelands is moderately high. However locally, around settlements and cultivated areas, this pressure may be very high, resulting in the degradation of the range.

Rotational grazing occurs in areas where a person or a community has firm grazing rights. The herds rotate during the year over the whole area, leaving many parts unused till they are necessary. In the Governorate most villages keep ''mahjur'' areas to be grazed by sheep and goats of the village in the dry season only.

4.3 Use of wood resources

The large majority of the households in Dhamar Governorate uses firewood. Dhamari people have a clear idea about the quality of firewood. Roughly three categories are distinguished:
- Top quality, with a price of over 1500 Riyal per pick-up load or 3 Riyal/kg for talh, and Qarat (Acacia origena, A.pachyceras, and A.nilotica),
- Medium quality, with a price of approximately 1000 Riyal per pickup load or 2 Riyal/kg for suba and sidr (Acacia mellifera and Ziziphus spina-christi)
- Poor quality, which are usually not traded but will cost in the order of 1 Riyal/kg.

In the last ten years prices of firewood have annually increased at the rate of 15% (true costs, no inflation, etc.)!

The majority of the purchased firewood comes from the eastern part of the country.

Local collected wood consisted in former times only of dead wood. With the increased population, transportation facilities and development of the money economy, firewood from trees has become an important commodity. However, we can distinguish different types of firewood collection. Firewood is obtained by:
- cutting whole trees and shrubs
- pruning and lopping of trees
- uprooting or cutting of dwarfshrubs

The cutting of whole trees and shrubs is a commercial activity. The others are practised on a subsistence level. The cutting of trees and their transportation to the market is nowadays an organized trade, that does take place in Dhamar Governorate but only on a much smaller scale than e.g. in the Tihama and along the fringes of the Eastern Desert. The distribution and retail of the collected wood takes place in the main urban centres of Dhamar but also in Sana', Taiz and al Hudaydah.

Pruning and lopping of trees takes place on trees that are generally privately owned or owned by the village. Severe penalties exist on the cutting of these live trees. The dominant tree species sidr and talh in the densely populated areas can stand this treatment very well.

Dwarfshrubs are collected by either uprooting or by cutting them at ground level (with the sickle, sharim). This collection of small firewood is entirely done by women. On the Montane Plains they usually leave their houses in the early morning to walk up to five kilometres and uproot or cut the quantity they can carry. Once home the firewood is sun-dried. The collection of firewood has a social stigma these days, since women of richer families can afford to buy firewood.

Wood for construction

Trees can also be used for construction of houses, production of ploughs, beehives, etc.
For roof construction Athl (Tamarix spec.) is very suitable, due to its favourable strength-weight ratio. Nearly all the houses in the Highlands have their roofs built out of these trees. There is some trade in this wood as in other timber. In the urban areas, however, virtually all timber is imported nowadays from Malaysia, India and East Africa. This timber trade has of course increased tremendously with improved transportation facilities etc, but the trade has already been practised for many centuries on a small scale.

4.4 Energy balance

Most of the energy used in Yemeni households is for cooking purposes. Traditional cooking is done on a tannur, a cone-shaped stove, locally made of baked clay or a mixture of mud, dung and ground shale. The tannur is used for cooking and baking bread. Cooking is done on top of the tannur, baking bread is done inside after cooking.

As soon as cooking is finished, the inside wall of the tannur (still burning) is cleaned with a wet cloth. The bread is baked by sticking the flattened dough to the inside wall. People are convinced of the positive effect of the use of firewood on the smell and taste of the baked bread. Dung is less valued for this reason. However, people who

Percentage of total energy input supplied by each fuel:

Area		wood	residues	dung	charcoal	kerosine	lpg
Dhamar	rural	66	11	10	0	4	9
Dhamar	urban	72	0	3	1	4	20
Al Bayda	rural	52	13	16	1	10	8
Al Bayda	urban	55	1	7	3	6	28
Al Hudayda	rural	73	6	3	2	16	0
Al Hudayda	urban	26	0	0	17	27	31

Source: Ferguson, 1988

Fuelwood in Dhamar Governorate, percentage of households, using, buying and/or collecting it.

Area		**use** %	**buy** %	**collect** %
Dhamar	rural	97	51	81
Dhamar	urban	95	90	5
Al Bayda	rural	97	79	53
Al Bayda	urban	56	44	11
Al Hudayda	rural	99	8	94
Al Hudayda	urban	19	11	9

Source: Ferguson, 1988

Average annual costs of energy in Yemen Rial per household

Area		**wood**	**charcoal**	**kerosene**	**lpg**	**total**
Dhamar	rural	4020	.	57	1287	5864
Dhamar	urban	5074	54	261	1127	6515
Al Bayda	rural	2439	168	1090	909	4606
Al Bayda	urban	2082	248	450	1466	4246
Al Hudayda	rural	326	286	1571	.	2183
Al Hudayda	urban	399	753	479	465	2096

Source Ferguson 1988

Energy prices

Fuel	**heat of combustion MJ/kg**	**retail prices urban YR/GJ**	**rural YR/GJ**
firewood	15	85-190	65-170
charcoal	29.3	170-280	190-330
dung	12.1		
kerosine	43.1	90-200	130-200
lpg	44.0	80-130	95-155
gasoline	42.7	95	95
diesel oil	42.7	55	55
electricity		350	420

Source: Ferguson 1988 & Govers 1985

On the Montane Plains locally dung cakes may provide up to 70% of the energy required by a rural household

use dung as main fuel sometimes state the contrary.

Recently, a number of studies have been undertaken on the fuel consumption patterns in the country. These studies show that firewood is still by far the most important source of fuel in the Yemeni households, supplying more than half of the energy demands. Other sources of fuel can be important as well; crop residues, dung, charcoal, kerosine and lpg are the others.

In the rural areas nearly twice as much firewood is used as in the urban areas. The people of Dhamar town buy relatively more firewood than anywhere else in the studied regions. The urban people of Dhamar are still ''rurally minded''. The division between the three mentioned sources of firewood is unknown (locally collected, pruned or lopped, or purchased).

On the villages on the Montane Plains dried dung is sometimes more important than firewood. There are examples of up to 70 % of the energy supply of a household coming from dried dung. Dung is manufactured into dungcakes. These 'damsj' or dungcakes are not really a commodity, yet the price of dungcakes has increased almost ten times in the last ten years.

It is estimated that an average Dhamari household spends every year around 6000 YR (or 625 u$) on energy costs; somewhat less in rural areas and somewhat more in urban areas. The price for firewood accounts for 80% of this very high amount. The fact that firewood is more expensive in Dhamar than in e.g. the Tihama or Al Bayda makes this situation even more extreme for the Dhamari households.

It is remarkable that firewood prices have not yet stimulated the agricultural production of firewood. It is thought that the moment that this situation will arise is quite near and that forestry projects may already focus on this aspect.

Sunlight is free of charge. Here it is used to dry maize on a roof

Fishing is also a use of water resources. However, the catch in Dhamar is very small

4.5 Use of water resources

Water in the Governorate is largely used for three purposes: domestic water, livestock water use and irrigation.

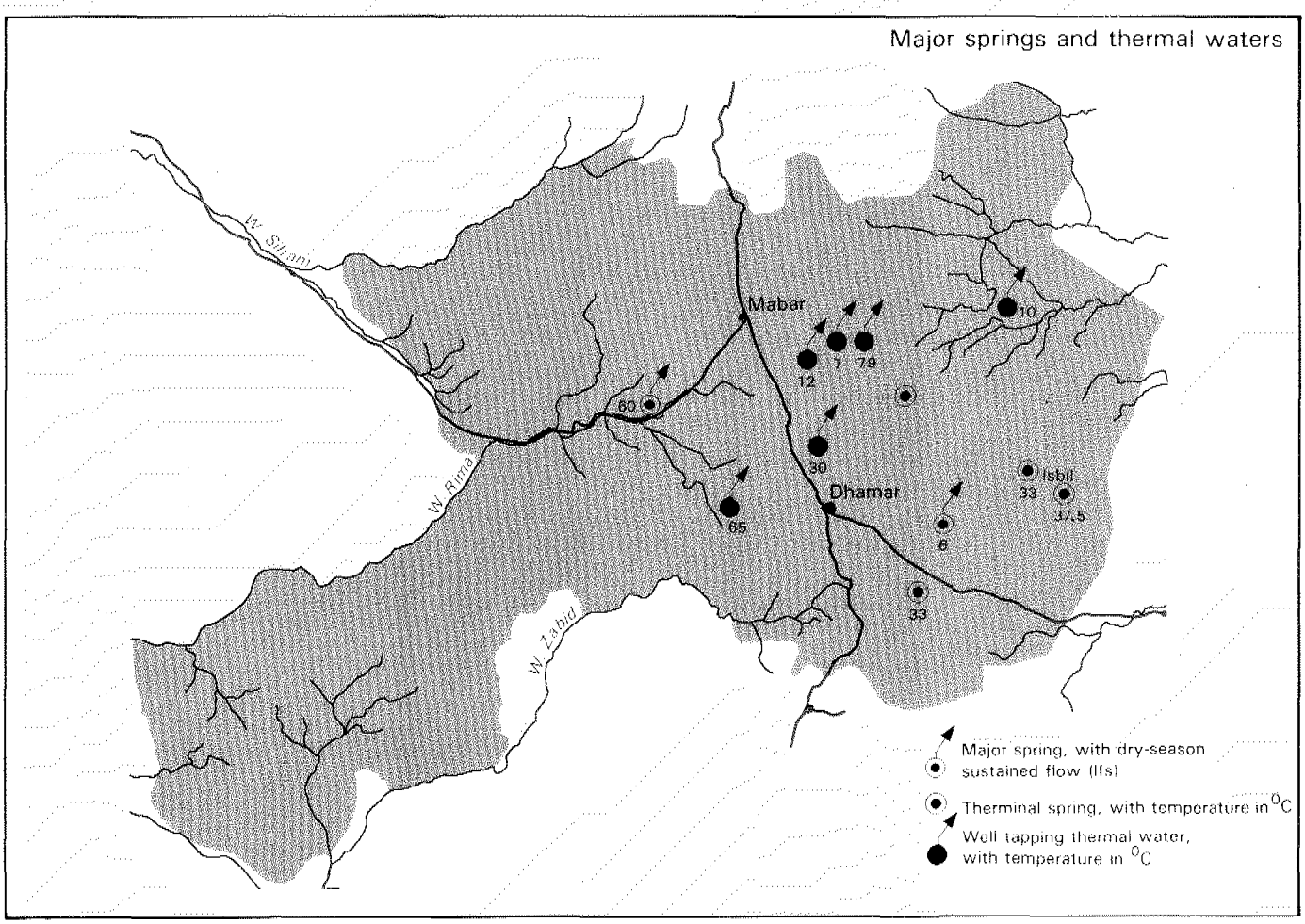
Domestic water use in Dhamar Governorate is largely based on wells. Government-supported programmes are being carried out to improve rural water supply, usually by schemes based on groundwater abstraction. The 1982 earthquake affected many of the rural water supply schemes: 120 village systems were destroyed, affecting approximately 51,000 people.

In the Montane Plains well-irrigated agriculture uses the most groundwater in the Montane Plains; it is estimated that there are currently between 1,000 and 2,000 pumped wells in this area. A marked seasonal variation of groundwater pumping can be observed, due to the cold period November-February during which crop growth stagnates and little water is pumped up.

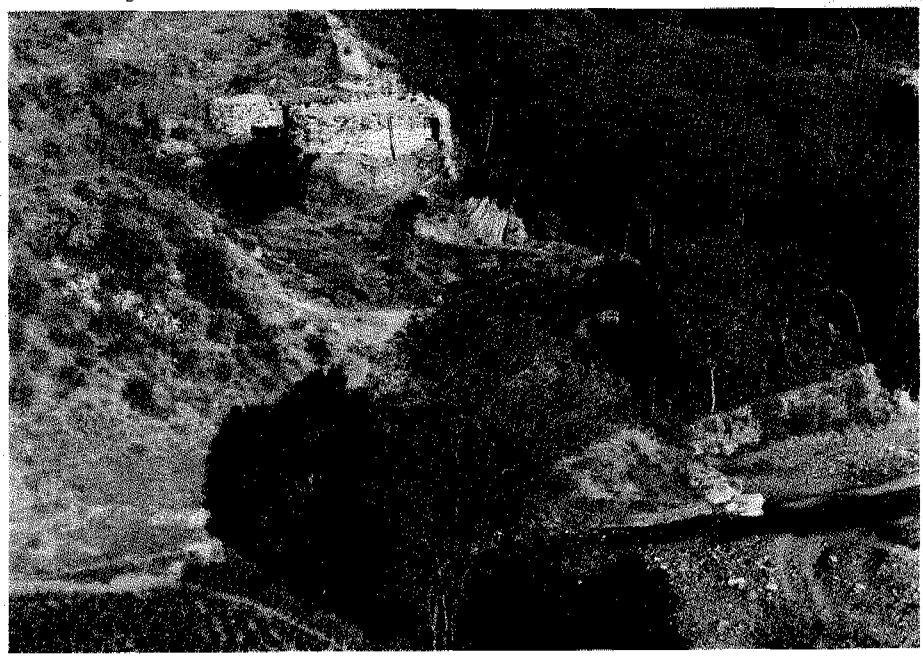
The importance of groundwater abstraction for irrigation has increased greatly during the last 10 - 15 years as a consequence of the introduction of powered pumps and modern drilling technology.

However, the more traditional forms of agricultural water use are still widely practised. Prominent among these is ''water harvesting'' by diverting mountain slope run-off and sheetflow to cultivated lands on plains and terraces. Heavy rains may cause flood run-off to cascade in an uncontrolled way over the terrace walls, thus inflicting damage to the terraces. Farmers take care of the repair and maintenance of the terraces after such events, spending considerable effort on their conservation. Labour shortage has a negative impact on terrace maintenance. However, terrace maintenance is so critical for the farm holding and the family, that mostly good care is taken to maintain and improve the terraces.

Along the major wadis, base flows are diverted for irrigation on the terrains situated in or along the river beds. The related irrigation systems are generally small and traditional and surplus water flows back to the wadi downstream of the irrigated zones, to be re-used on other fields.



Farm holdings in the Governorate are even for Yemeni standards very small



5. Land and water use ecology

Nature provides the natural resources that allow mankind to grow food, raise livestock, collect fuelwood, hunt, etc. Man uses the resources and tries to maximize their output. In this sense every producer in Dhamar Governorate is managing the natural resources at his disposal.

Everyone has his own way of surviving and obtaining economic results, made up by different land use activities. In this chapter the driving forces behind the use of the resources and their management are described.

5.1 Land tenure

The way in which land and water resources are managed by the people who use them is largely determined by whether these people have had the right to use these resources for many generations or, for example, for one cropping season only.
From an environmental point of view a system of resource management in which people are motivated to improve the quality of the resources that are at their disposal is most appropriate.

Information regarding land tenure and water rights with respect to their practical application in allocating and distributing soil and water is meagre. No specific studies on Dhamar Governorate or parts thereof are available as yet.

In Islamic law land can be owned or used (Milk) or not (Mawat). Likewise, two categories of water are distinguished, i.e. owned and not owned. However, most jurists consider water as an object which cannot be owned (Mubah). It is mubah because the Prophet said ''Mankind are co-owners in three things, namely water, fire and pasture''.

Farm holdings

There are 50,600 farm holdings in Dhamar Governorate extending over 71,000 hectares of cultivated land. These represent 10% of all farm holdings and 5% of the country's cultivated land. The holding size varies around an average size of 1.4 hectares. Of the Governorate's total farm holdings 73% are less than one hectare in size, 23% between 1 and 5 hectares and 4% has an area that exceeds 5 hectares. The average holding sizes in Dhamar Governorate are the smallest in the Yemen Arab Republic. The holdings are commonly fragmented into numerous small plots. The average number of parcels per holding is 7.1 in Dhamar Governorate, the highest numbers of parcels in the country. Small and fragmented farms are still characteristic for Yemeni agriculture in general and most pronounced in this steeply dissected area.

Tenure system

There are three types of tenancy on agricultural lands, i.e. totally owned, rented and share cropped. Tenancy agreements are usually oral and continue between the two parties as long as there is mutual understanding. A holding can be operated under one form (single type) or under more than one form (mixed type) of land tenure. A combination of two or more of the these forms ($\geq$50% owned, $<$50% owned or not owned) represents a mixed tenancy.

Farm holdings in Dhamar are about equally operated under single land and mixed land tenancy. This, relative to the country as a whole, high percentage of mixed tenancies could be attributed to land fragmentation due to the rugged topography. In the rugged areas mechanization is totally impossible and cultivation demands high inputs in labour. Land owners may tend to lease (share crop) their land or a part of it, to avoid problems with labour.

Share cropping arrangements are similar to those elsewhere in Yemen. The crop is divided equally between land owner and tenant. Under irrigated conditions the division of the crop depends on who pays for the water. If the tenant pays for the irrigation water he receives more than half of the crop and vice versa. The costs of other inputs are the responsibility of the tenant. It is obvious that, due to the small plot sizes and the high percentage of sharecropping, there is very little scope for modernization of agriculture in large parts of the Governorate, except for the Montane Plains where plot sizes are bigger.

Non-arable land

The statements above apply especially to privately owned agricultural land. Rangelands and tree resources may also be communally owned. Whether this form of land tenure is still functioning, and providing protection for the resources, depends on the degree of organization and strength of the community using these ''Mawat'' lands. Specific forms of rights on fallow grazing, collection of dead wood and cutting of live wood do exist in a great variety on the communally owned lands. Resources for which there is no claim from private persons or communities are very rare in the Governorate. The existence of so-called ''Mahjur'' areas or communally owned grazing reserves in the Governorate is well known.

5.2 Water rights

The system of water rights in Dhamar and in other regions of the Yemen is based upon a mixture of Islamic legal principles and local customary practices. The term right (huq) denotes a multitude of obligations arising from contracts between parties and from moral and ethical standards. Within the guidelines of Islamic law (Shari'a) priorities in the allocation of water are domestic, agricultural and industrial uses.
The distribution of surface water generally follows rules which pro-

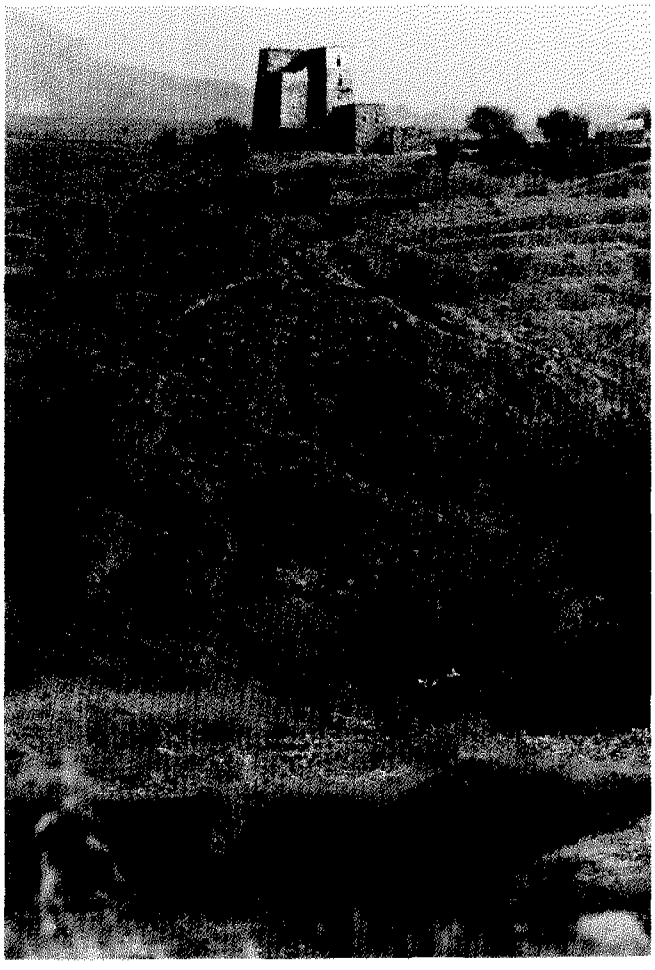
Absolute and relative number and areas of farm holdings under two or more types of land tenure in Dhamar Governorate

Holdings	owned land 50% or more of total area	owned land less than 50% of total area	no owned land in holding	total
number	10,730	10,297	182	21,209
% of total	28.5	18.7	.3	48
area (ha)	25,029	8,435	115	33,579
% of total	35.2	11.9	0.2	47
average holdings size	2.33	0.82	0.63	1.58

Absolute and relative number and areas of farm holdings under one type of land tenure in Dhamar Governorate

Holdings	Owned	Sharecrop	Rented waqf	Rented individuals	total
number	22,387	6614	451	0	29,452
% of total	39.5	11.7	.8	0	52
area (ha)	33,760	3700	142	0	37,602
% of total	35.2	11.9	.2	0	53
average holding size	1.51	0.56	.31	0	1.28

Mechanization on this type of farm does not offer a a remedy for the shortage of farm labour



Dhamar farmers can be counted among the best soil conservators in the world

vide for upstream areas to take water first, and for plots of land nearest to the water-course to take water first. Local practices intervene once the water has been distributed. The first user can take as much as he wants regardless of the amount available to downstream users. There are always exceptions to the rule. Such practices conform to the Islamic law in theory, but in practice the law does not guarantee equity within the secondary distribution system.

According to custom and Islamic law, every landowner is entitled to dig a well in his own land or ''mawat'' land intended for development. Thus, legally, extraction of groundwater is at the owner's discretion. However, continued use of the newly dug well is prohibited if it proves to be detrimental to an already established well.
In other words, the owner of the land or the well has primary right to use and can own the water he withdraws, but the groundwater system remains common ownership.

Groundwater development has been generally carried out privately, and there is no control over its exploitation either from the national government or from local authorities.
Although the government has undertaken a number of water resources development projects which are gradually changing the traditional water use pattern, there has not yet been any legal enactment.

5.3 Incentives in agricultural production

Access to land is only one of the factors for the Dhamari farmer to be able to cultivate. Access to water is another and a most crucial one. In the traditional society the rule ''upstream first'' is applied. This means that a farmer at a long distance from the source of the water, whether this comes from surface run-off, groundwater or the wadi, is very uncertain of his yield or any yield at all, till the end of the rainy season.
From previous sections it is clear that investments in groundwater exploration may not be directly profitable. However, groundwater exploration offers a way out of the traditional water rights situation and provides a much larger certainty of success of a crop to farmers than before. The access to groundwater greatly increases the value of a holding. In this sense investments in the exploitation of groundwater are considered to be very important.

Nowadays most of the farmers in the dry areas on the Montane Plains have access to groundwater, either by ownership of well and pump, or by hiring one of the two, or by buying water. This causes a tremendous demand for groundwater, has given rise to lowered groundwater tables in many areas, and has and will presumably cause a great loss of capital in the form of wells which have become or will become dry.

The cultivation of crops for urban communities is not new in the Yemen. Cities and small towns have existed for centuries and there has been a demand for fruits and vegetables in towns since time immemorial, as they are an essential part of the Yemeni diet, whether rural or urban. The extreme importance of qat is quite recent. With the increased accessibility of the Governorate and the expansion of the urban population the demand for cash crops has tremendously increased. Many more farmers than before are involved in the production of cash crops.

However, a large part of the agricultural production in the Governorate still serves for home consumption. Dhamaris attach a very high value to home grown foodstuffs. For this reason they are also reluctant to use agro-chemicals (pesticides, fertilizers, etc.) on the crops that are grown for auto-consumption. Urban people would also be very reluctant to buy foodstuffs that have been treated with chemicals, if they knew.

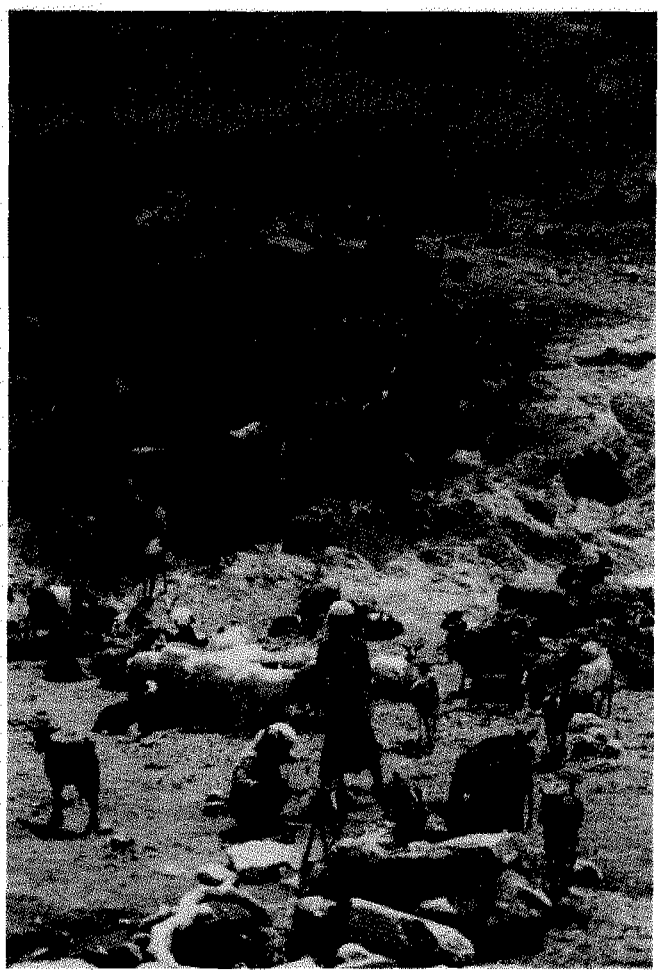
Since the cultivation of cash crops has become more important to most farmers, the use of agro-chemicals is increasing, despite their low availability on the markets. Agricultural extension with respect to their use is very important.

On the Montane Plains the use of tractors has tremendously increased. Despite the small plot size, mechanization is rapidly being introduced in this area, while animal traction has not been abandoned completely by most farmers. The obvious attraction for mechanization is caused by the scarcity of labour, rather than its economic advantages.

The increase of the use of agro-chemicals, tractors, pumps and the growth of internal markets all illustrate the sudden shift from a type of agriculture which, until twenty years ago, was by and large oriented on subsistence, to an agriculture which is very much monetarized. Also the cultivation of crops for auto-consumption is apparently partly financed by the sale of cashcrops. Many farmers in Dhamar Governorate are quite willing to finance the production of their own food with money from other sources or from qat prodution, given the very high value they attach to home grown food. Their strategy is based on the will to continue cultivation and maintain their land holdings whether this is economically attractive or not.

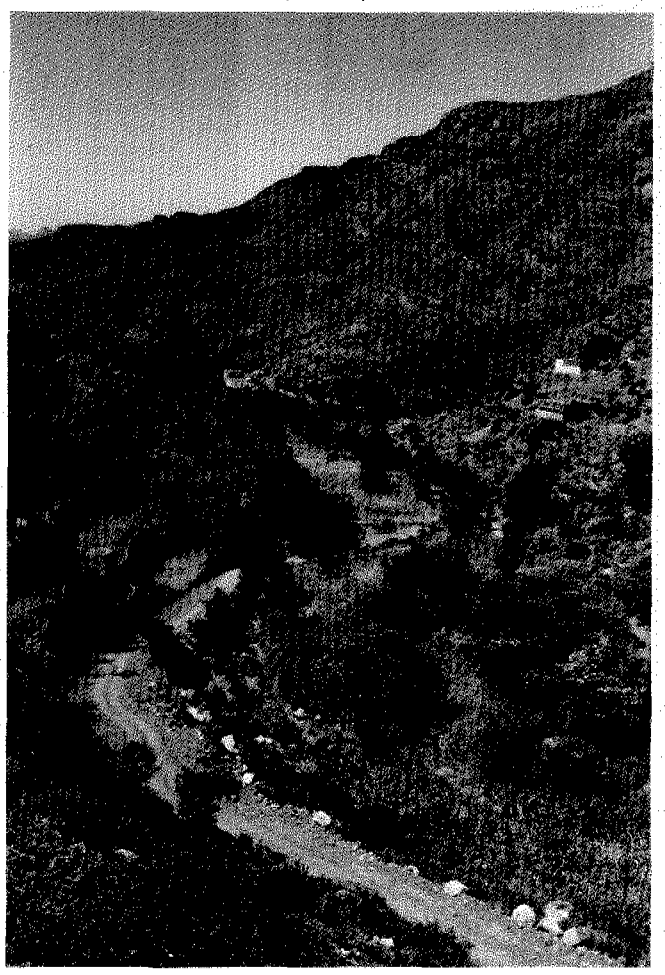
5.4 Incentives in livestock production

The livestock that is kept around the house, the chicken, the sheep, goats, donkeys and house cows are kept for the well-being of the family. They provide them with cash, milk and meat. In commercial terms the activity of livestock production in the Governorate provides a surplus to the income, varying between a very modest or negative contribution to a relatively large one. There is some specialization for different farmers in this respect. When valuable land holdings and water are available relatively less emphasis is put on livestock production, while for the



Valley farmers in the more arid parts of the Governorate depend very much on their livestock for subsistence

All trees in these areas are privately owned



In the mountain villages only very small numbers of livestock are kept, this stable holds one cow and five sheep.

less well-off farmers livestock provides a more important part of their income. This applies especially to sheep raising. In the mountainous parts of the Governorate little rangeland is available and the herds of sheep are very small. On the Montane Plains rangelands are largely a communal property. For farmers with small agricultural land holdings, a large proportion of the diet of their livestock comes from the range, which they use in competition with others. For many of the villages on the plains with meagre agricultural resources this leads to a very intensive exploitation of the rangelands both in the vicinity of the village and further away. Relatively landless families now also make an income since paid herdsmen have been introduced.

The poultry factories which underwent such a dramatic growth in the period '80 - '87 are well over their peak. The investment in these plants is not so profitable any more. The activity must be seen as an investment in agriculture by people who generate their income largely from trade, their sharecroppers, etc., in short the merchants.

The cattle meat consumption of the urban centres has grown considerably in recent years. The cattle is transported from the Tihama or more frequently imported from across the Red Sea. Calves are sometimes slaughtered as well given the high price for veal. This leads to a situation in which importation of cattle will remain important, provided it is not limited as in the case of fruits.

5.5 Incentives for the management of wood resources

The firewood that is consumed by families in the rural areas is largely collected locally. For the urban centre of Dhamar large quantities are imported from Al Bayda Governorate. In the dissected western half of the Governorate firewood comes partly from the farm, by lopping privately owned trees. Elsewhere it is collected on the range, from communally owned lands. In this area, the fact whether proper management of firewood resources occurs depends on the strength and degree of organization of the local communities. Degradation takes place when more is consumed than is locally produced, which is now more often the case than before.
In general it can be said that the strength and organization of the local communities is still largely sufficient to prevent serious degradation beyond the level that was already reached a long time ago. Exceptions to this general rule are large parts of the Montane Plains where degradation is obvious, due to intensive firewood collection.

5.6 Categories of resource users

From the previous descriptions it is clear that different types of resource users can be distinguished in the Governorate:

The majority of the population of the Governorate can be described as small farmers whose farming activities are largely subsistence oriented. They still form a majority in the Governorate. Their use of the resources focuses on:
- the increase of the value of their land holdings by additional supplies of groundwater, by mechanization etc. as their most valuable asset for the future
- the maintenance of a certain number of livestock as their source of milk and meat in a rather subsistence oriented way
- provision of the family with enough firewood

This very wide category of resource users can be subdivided according to the physiographic or agroclimatic zone in which they operate.

Mountain farmers

In the more humid and higher mountain zones the claim on resources beyond the farm holding is relatively small. The resource use of these mountain farmers can be described as non-threatening for the resource base.
Their livestock production is traditionally fairly small, also since rangelands in their area are relatively scarce. The crops are largely rainfed and sometimes supplementary irrigation is applied from small wadis or shallow aquifers. However, their dependency on groundwater resources for cultivation is rather small. Qat and sometimes coffee is produced as a marketable crop, the other crops are by and large subsistence oriented.

Valley farmers

The valley farmers depend on small aquifers near wadis and the permanent baseflow in some of the larger wadis. This group of farmers occupies the lower more arid western part of the Governorate and some of the wider valleys along the wadis in the central area of the Governorate. They depend for a large part on surface and groundwater resources, but given their isolation (long distance from markets, etc) investments in dieselpumps and their maintenance are virtually impossible. Coffee and bananas are grown for the market in small quantities, the other produce is subsistence oriented. The production of livestock is somewhat more important to these people. They maintain a rather stable position vis a vis the resources. Land resources do not allow for a population to become so dense that natural resources become exhausted. The groundwater to which they have gained or may gain access, can only assist them in stabilizing their life; it will increase their access to the water resources that were difficult and hazardous to exploit in the past, but not allow for a larger cultivable area since all cultivable land is in use already.

Montane Plain farm-owners

These monetarized farmers depend on the Governorate's largest aquifers under the Montane Plains between Mabar and Dhamar. Their use of groundwater resources has considerably enhanced agricultural productivity. This, however, may not be a lasting enhancement and they find themselves very uncertain of the future in view of the lowering groundwater tables. Given the

money oriented type of cultivation that is currently undertaken, they think very much in terms of return on investment in future groundwater exploitation. In this sense their interest in diversification of their activities in agriculture or beyond is great. Much emphasis is given to the net return they will get from investments already made, e.g. preventing others from mining groundwater, denying land purchases to newcomers etc. The livestock of these farmers is fed largely from agricultural residues and fodder crops. Also in regard to livestock production, the question whether the production is economically sustainable or not is an important one for each farmer. The incentive for management of pastoral and firewood resources is relatively small and follows from the financial margins they have.

Montane Plain share croppers

Share cropping is a common practice in the Governorate. In the case of the mountain and valley farmers it is not necessary to distinguish between farm owners and share croppers, since they are both confronted with much the same problem of scarce land resources in a very inaccessible terain. Their incentives in resource management may be somewhat different; their impact on the environment is comparable. On the Montane Plains this is not so much the case. Since the agricultural land holdings of the share croppers are even smaller than those of the farm owners, their livestock depends to a larger extent on the forage the rangelands offer. Their degree of dependency on the communally owned lands is larger. The communal resources such as groundwater, range and pasture tend to be used as intensively as possible. Each share cropper is competing with the others to gain the largest share of these resources. The local organization that is supposed to take care of the communal resources is disappearing.

Urban population

The urban population and the larger merchants in the villages form another group of resource users. They look upon the exploitation of groundwater resources and agro-industry as investment opportunities. They are no longer closely attached to the land nor do they bear a responsibility towards the rural communities of farmers and landless people. They have greatly stimulated the introduction of new technologies in Yemen, but they have not succeeded in providing a framework for a sustainable profit on their investments. As consumers, they provide an important stimulus for agricultural development in the Governorate by creating a market for agricultural products and the diversification of the economy.

Not so long ago security was most important for the villages. his fortress hidden in the mountain could hous a complee village for a number of days, when under siege

Woman with sickle (sharim)

6. Present state of land and water resources

In this chapter the overall effect of man's use of the natural resources is described for the different categories of resources.

6.1 Land resources

It is clear from the previous sections that the land resources of the Governorate for agriculture and rangeland are rather meagre. However, Dhamari farmers are among the best soil conservators in the world. The degree to which newly formed soil is contained behind terraces on a scale as seen in Dhamar Governorate, is quite unmatched. Dhamari farms are very valuable holdings and their value is in fact only increasing with time.

Soil erosion is a natural process: in the arid climate, with its enormous changes in temperature over the day, weathering of rock takes place rapidly and heavy rainfall and winds take away the newly formed material rather easily. However, on the Montane Plains the cutting of trees, the uprooting of dwarf-shrub and intensive grazing has increased soil erosion. This erosion gives rise to the formation of ''hammada'' surfaces, the desert pavement. These pavements at the same time protect the underlying soil material.

However, on the Montane Plains it is clear that more soil is lost in the intensive use of the communal lands than is gained by weathering. The impact of the use of man of these areas is a slow but certain decrease in productivity: the resource base is in this case deteriorating slowly, but more rapidly than 20 years ago.

Some communally owned lands are managed adequately by local communities, and others are not. The parts where no adequate care is taken of the land are the rangelands on the Montane Plains. Here, the increase in well irrigation has led to an enormous increase in cultivated area, a shortage of firewood and forage and a break-down of the traditional organization that previously managed these resources much more strictly. In these areas due to lack of management there is accelerated erosion of the natural resources.

6.2 Agricultural resources

Receiving wages has encouraged farmers to take an individualistic view of investments and profits. The attraction of the private boreholes for which the farmers opt is that these bring farming more closely under the individual's control, making it not only less subject to difficult climatic conditions, but also independent of the local situation governing water rights. It is evident from the increasing number of tractors and the expansion of the pump-irrigated area that Yemeni farmers are active, and quick to exploit new production means. Agricultural development is therefore facing an important period and many difficult choices have to be made at national and governorate level with respect to the selection of methods, areas etc. that will allow an increase in production.

Despite the small parcel size on the Montane Plains an increase in tractor ploughing is witnessed. This does not seem appropriate from an environmental point of view, because in drier soil this type of ploughing will increase exposure to wind and thus soil erosion. In fact, the only attraction of tractor ploughing is that the labour shortage is felt less seriously.

6.3 Firewood and forage resources

The present vegetation evolved as a result of centuries of use by man. Since there is very little written information on this subject, it can be only be speculated if and to what extent the mountains used to be covered by forests. On mountains bordering the Montane Plains some remnants of *Juniperus* woodland are left. Mainly individual trees on inaccessible mountains remain. No traces of real woodlands or forests occurring in Dhamar Governorate can be remembered by people nor found in any travel description. If *Juniperus* forests have ever occurred, which is not unlikely, then they were chopped down a long time ago.

Stories by the people indicate that the grass cover used to be much higher: ''grasses so tall that you could not see the hidden gazelles''. It is quite unlikely that anywhere in the recent past this statement applies to the Montane Plains or the high mountains, but it is possible that in the time when the wadis where still uncultivated (security reasons) a dense vegetation of grass and trees occurred along the wadis. Harris describes this case for Qa Jahran, north of Dhamar town, in 1893. Nowadays all land with a potential for cultivation in the valleys and along the wadis is taken into cultivation. It is concluded that a possibly denser tree cover on footslopes and in wadis disappeared between 200 and 50 years ago. The current remainding dwarfshrub vegetation on the plains and mountains has gradually developed since.

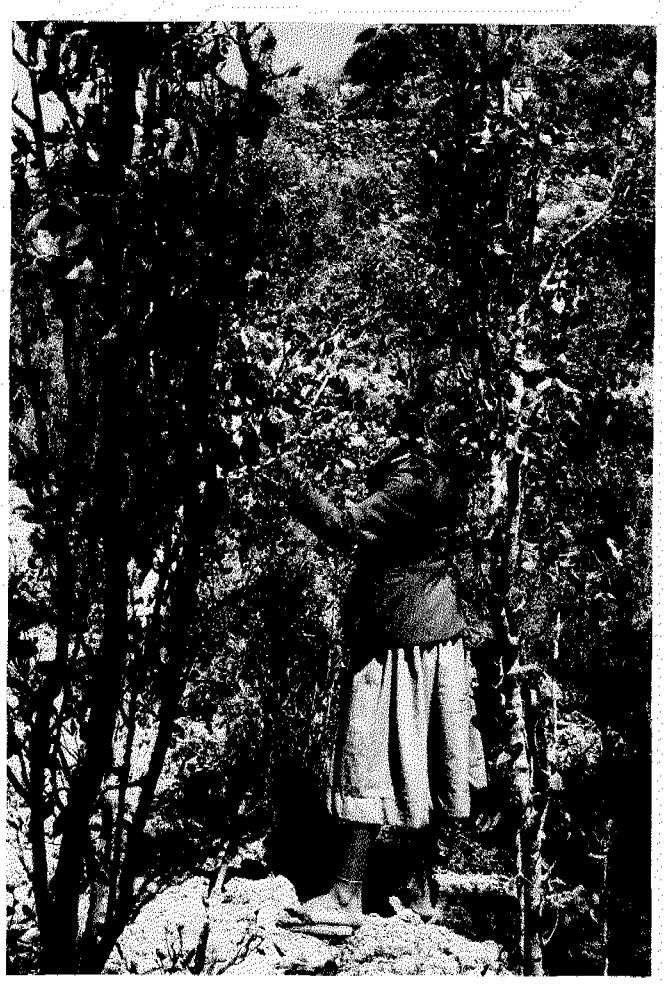
Only few trees can be found in most vegetation types occurring in the Governorate. The regular frosts above 2400 m that limit tree growth partly explain this feature.

The remaining trees on the farms are private property and well maintained. The uprooting of dwarf-shrubs is certainly damaging the productive capacity of the rangelands, due to the intensity with which it is practised and the reduction of water holding capacity of the land that it causes. An unexperienced observer would even describe the landscape as bare. On the rangelands, the grasses and herbs rarely reach higher than a few centimetres above ground level. Low spreading grasses and unpalatable dwarf-shrubs dominate,

clearly a sign of adaptation to the heavy grazing that has prevailed over the centuries. Doubtless, more restricted grazing would lead to higher vegetation covers and a somewhat higher forage productivity.

The most severely degraded rangelands are found in the densely populated zones on the Montane Plains, often in areas where fallow periods are practised. The combination of cropping, ploughing, grazing of fallow lands and the collection of dwarf-shrubs for firewood, has at some places led to the removal of topsoil by erosion.

Qat cultivated high on the high mountain. Such a field can provide the income for a large family



6.4 Water resources

Already in 1980 there were indications of regional over-exploitation of groundwater (falling water tables). Increasing groundwater abstraction since then has aggravated the situation, but no systematic groundwater level monitoring has been done to confirm this assumption.

The 1982 earthquake has changed the conditions in many wells: some

Wadi Rima near the Tihama. Bananas are a new crop to this area, irrigated with wadi water: a lot more wadi baseflow is intercepted than before in the mountains before it reaches the Tihama.

nonartesian wells have become artesian, others are not artesian anymore or have deeper groundwater levels now. In addition, water quality has changed in any cases by tapping or loosing deep-seated hot mineralized water.

Over-exploitation of groundwater in several parts of the Montane Plains is seriously threatening domestic water supply and groundwater-fed irrigation. If over-exploitation is not stopped within a reasonable time frame, wells will dry up, costs of pumped water will become higher, and eventually some aquifer zones will be exhausted.

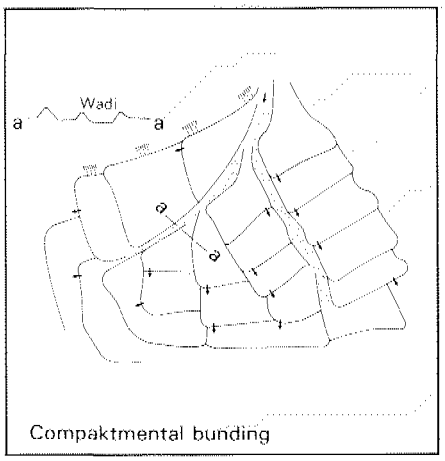
To detect such problems in an early stage, groundwater levels should be monitored; next, adequate measures should be designed and implemented to control groundwater abstraction in the Montane Plains.

Conservation of hill-slope terraces deserves special attention. The rural labour force has become much more mobile than it used to be. This involves the risk that the necessary maintenance of the terraces during and after the rainy seasons is neglected to some extent, which may lead to permanent losses of valuable land.

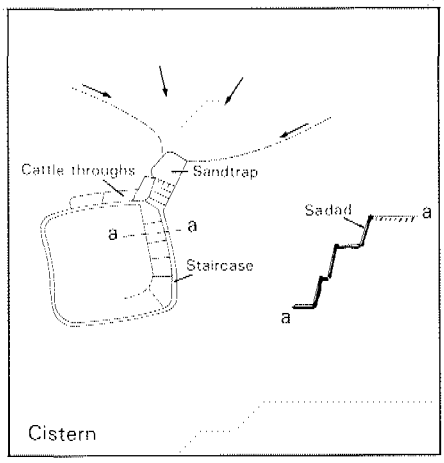
Water resources contamination is not yet an issue in Dhamar Governorate. Increasing urbanization and the change to modern consumption, however, may in principle trigger pollution problems. Identifying the main sources of pollutants and analysing the vulnerability of the specific wadi and aquifer problems are essential to stay ahead of pollution problems.

Groundwater development has been generally carried out privately, and there is no control over its exploitation either from the national government or from local authorities.

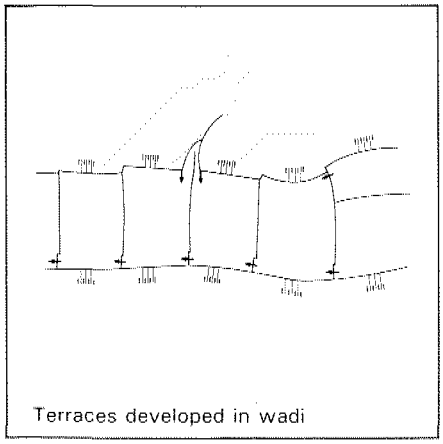
Although the government has undertaken a number of water resources development projects which are gradually changing the traditional water use pattern, no legal enactment has yet taken place.

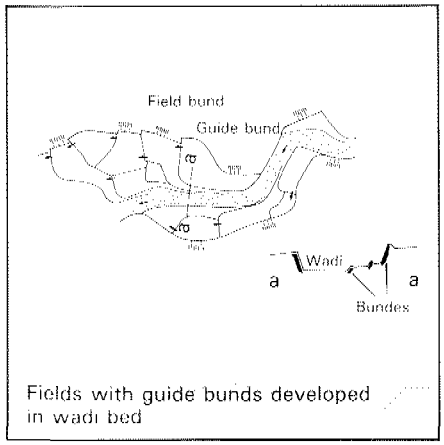


Compaktmental bunding

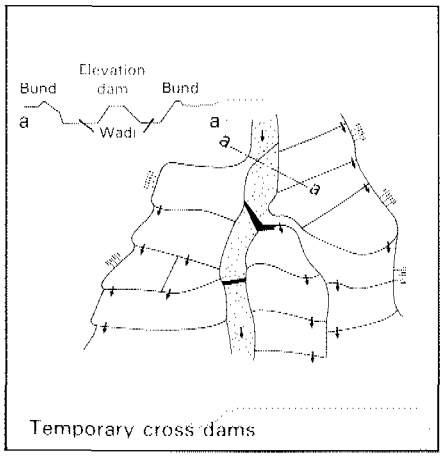


Cistern

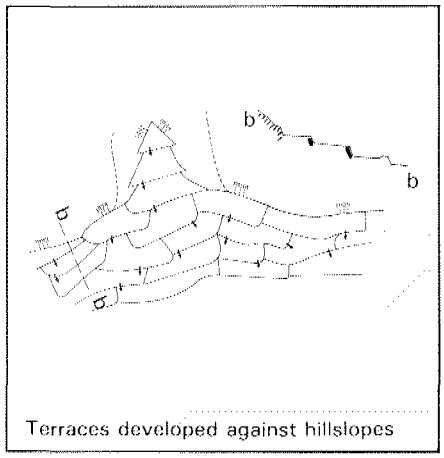

Terraces developed in wadi



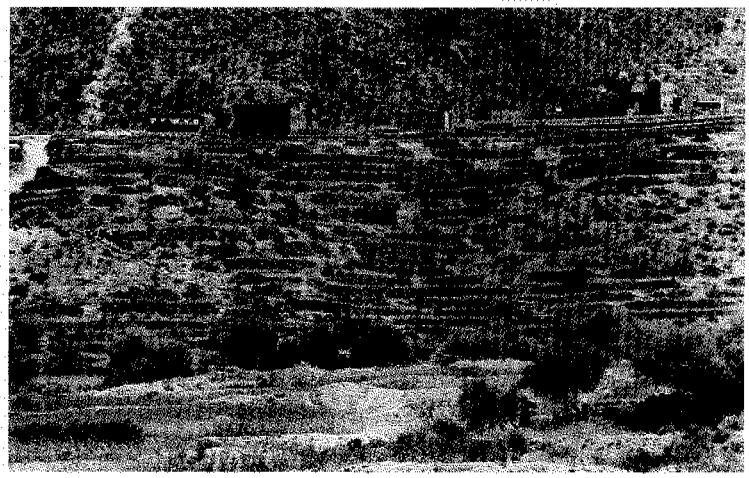
Fields with guide bunds developed in wadi bed



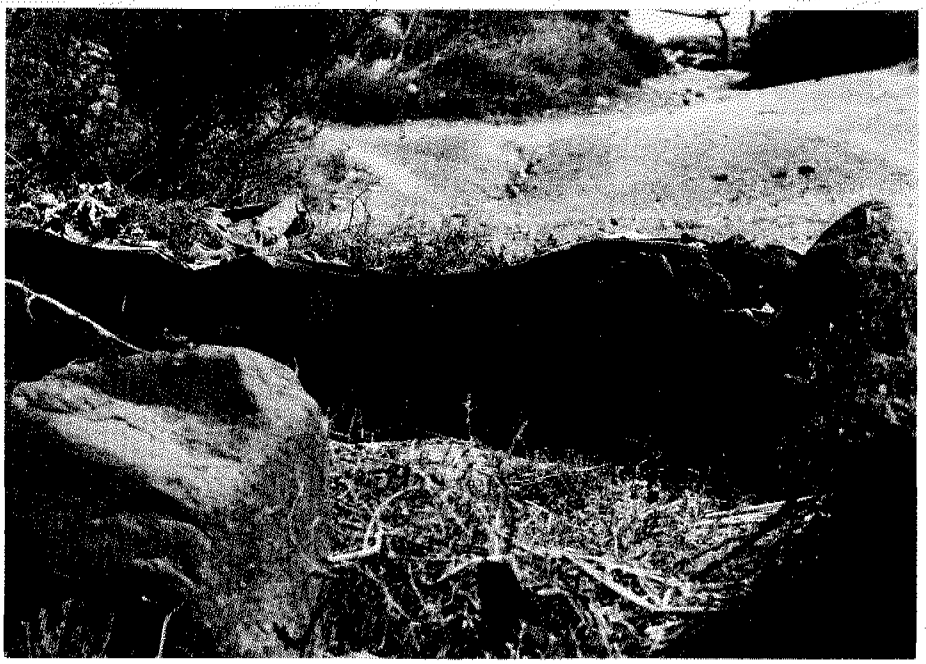
Temporary cross dams


Terraces developed against hillslopes

Traditional soil and water conservation techniques



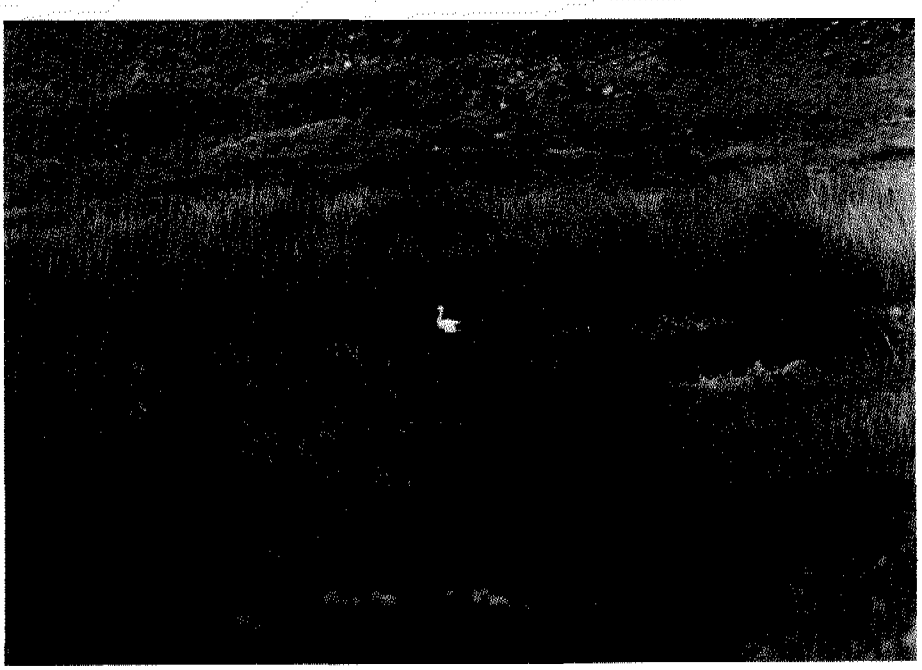
On some locations abandoned terraces are found, but this is certainly not a general phenomenon. However, care should be taken in monitoring terrace maintenance.



Beehives in the lower reaches of Wadi Zabid, an area with a reputation for its honey. The beehives are made of Dracaena ombet, an endangered tree spesies

Baboon near Jebel Bura

Cameleon



White stork in Al Hada area

7. Conservation

In this part of the Profile attention is paid to the natural vegetation and wild fauna of Dhamar Governorate. It is evident that much of the wildlife that lived in Yemen in earlier centuries has completely disappeared.

The Yemen Arab Republic is still very rich in plant and animal species. Already some 2000 plant species have been ascribed to the country, but the real figure may well be a few hundreds higher. The more systematic inventory of some animal groups has started only recently and the number of invertebrates (insects, etc.) but also of vertebrates is continuously growing.

This high species diversity, certainly in relation to other parts of the Arabian Peninsula, is due on the one hand to the geographical position of the country. On the other hand, the great variation in climate and topography leads to a wide range of habitats (environments that create the living conditions for a certain animal or plant).

7.1 Biogeographical position

The Yemen Arab Republic is the meeting point for African, Mediterranean and Oriental species. In addition it holds a key position for a number of migratory organisms, such as birds. Man's action, the creation of various land-use patterns and locally new surface water conditions, has finally not only resulted in degradation of local land resources (including plants and animals), but sometimes also in creation of new (seminatural) habitats and the introduction of new (exotic) species.

In the Yemen the Holarctic and Paleotropic Regions meet. Generally speaking the Saharo-Arabian (Holarctic) and Sudanian species (Paleotropic) dominate in Dhamar Governorate.

7.2 Flora and fauna

The vegetation in the Governorate is used by man for firewood and as rangeland for livestock. The vegetation types that are found these days are largely modified by man, despite the low accessibility of the area in general. Virtually no places remain where the vegetation has not been influenced by man: the vegetation that is found currently is not "natural".

It is estimated that the actual tree cover is only a thousandth of what it could be without man and livestock, but it would take a very long time before such a vegetation were restored, in the hypothetical case that all men and animals are removed.

With respect to the fauna of the Governorate only a fragmented and incomplete picture can be presented, because very little information on the subject is available for this area. In the more remote corners of the Governorate, the Hamadryas baboon is still raiding sorghum and other crops and is therefore hunted.
The Mountain Gazelle and the Dorcas Gazelle are not yet completely extinct but occur in only very small numbers. East of the Governorate border one older person interviewed mentioned that he personally had shot some 600 in his lifetime. There can be little doubt on the occurrence still of the Asiatic jackal and foxes, species mentioned as regularly observed. In none of the interviews was mention made of the wild Ibex, a species that was probably exterminated through hunting in this area many decades ago. It is not considered possible that Arabian leopards and caracals are still present in the Governorate, although no conclusive evidence is available. The Arabian hare can still be considered a common mammal. No data for the Governorate are available for other mammals.

Very little ornithological and entomological data have been collected in this part of the country. The same applies to amphibians and reptiles. Recent M.Sc. theses provide information for other parts of the country.

In conclusion it can be stated that very little is known on the flora and fauna of Dhamar. The almost complete disappearance of the last remnants of larger mammals in even the relatively uninhabited areas of Dhamar indicate that the need for conservation of what is left is extremely high for the country as a whole. In some of the small uninhabited areas of the Governorate much more wildlife could occur if appropriate measures were taken in this respect.

7.3 Requirements for nature conservation

Yemen is an important area for many plant and animal species. Even the most basic information such as distribution patterns, numbers, life histories and conservation requirements, is still lacking for most species. There is therefore an urgent need for more detailed information on the present status of plant and animal species and their habitat requirements.

Conservation in the Yemen could be pursued through three lines of action:

- Organism protection. This requires, amongst other things, law enforcement on hunting of animals and gathering of plant species. It should also include habitat rules for trade, such as are now enforced with respect to the importation of Rhinoceros horns.
- Habitat conservation. This should include area protection and monitoring.
- Environmental education. This should aim at the technical training of professional staff and of administrators in governmental offices, and at increasing the awareness of the general public.

Long-term wildlife conservation can only be achieved with the people's consent and support. As yet, there is no apparent interest of the population of the Governorate to support conservation measures.

The species (and ecosystem) concept should therefore be promoted through the media. A related action could be to reintroduce, with the consent of a local population, particular species in areas where they disappeared through direct human action such as hunting and trapping, rather than through habitat destruction. In other Arab countries such initiatives have been carried out with great success.

In the villages the difference in style and used materials between the old and new houses is very great

Child mortality is still high in Dhamar Governorate

Water supply in Dhamar town

8. Urban environment and environmental health

The rapid rate of development during the last few decades, the introduction of modern technologies and other blessings of affluent societies, have left a distinct mark on the urban and rural environment in Yemen. Clearly, the development of adequate structures to process waste and effluent has seriously lagged behind. Sanitation, including the adequate disposal of excreta and waste, is essential for the well-being of urban dwellers. Many human diseases are directly related to unhygienic conditions, unsanitary disposal of excreta and waste and impeded drainage of surface water. Many diseases, such as diarrhoea, hepatitis, amoebic dysentery, helminthic disease and protozoal worm infections are found. Polluted sites also favour the spread of animal-vectors of serious diseases, such as rats, flies and mosquitos.

The main urban centre of the Dhamar Governorate is Dhamar town. Preliminary results of the 1986 population census indicate that the town contains 47,733 inhabitants. Average annual population growth over the last ten years is 8.5%.

Apart from the lack of staff and funds, major constraints are the limited contributions both in funds and in kind most villages communities can afford, even if they receive financial support from the Local Coordinating Committee on Development (LCCD). A further problem is that it will take considerable time to create general public awareness of the need to keep their village environment clean and to motivate people to participate actively in sanitation activities. Much work needs to be done in the fields of hygiene education, sanitation extension and in programmes aiming at involvement of women in improving hygienic and sanitary conditions.

8.1 Health situation

The general health situation is gradually improving. Not long ago, health facilities outside the central hospitals were rather limited or not available. Now regional health centres at five locations in the Governorate have been implemented. Of course, the mere establishment of Public Health Centres does not guarantee an improvement of the situation. Active community participation in hygiene, sanitary and nutrition programmes is also required if lasting improvements are to be achieved. Currently, training of village health workers is being undertaken. The training is focused on preventive health care, including subjects such as water quality, sanitation, household hygiene, early detection of child's diseases, vaccinations.

Infant and child mortality in the Governorate is still high, a mortality rate of 222/1000 for children (0 - 12 months) was reported in 1988 (DRHP, 1988). A study on the causes of malnutrition of rural children in the Dhamar Governorate concluded that of the examined children between 3 to 36 months of age nearly half were malnourished. Among the nine factors identified as principal causes, the frequency of infectious diseases, especially diarrhoea, ranked highest. The study concludes that most factors responsible for malnutrition are social and environmental. Among the latter, water supply, hygiene and sanitation are the most important.

The Infant (birth - 12 months) and Child (13 - 60 months) Mortality Rate are among the highest in the world. Although statistics on the cause of death and incidence of disease are not very reliable, it is generally accepted that poor nutritional status and infectious diseases are among the principal death causes. Obviously, the incidence of some of these diseases is directly related to sanitary conditions. Also, the rate of immunization among children is still very low. Trends in infection rates are difficult to assess as reliable earlier statistics are lacking.

8.2 Water supply

Like in most parts of the world an important factor in locating early settlements and the development of early cultures was the availability of reliable water resources, both for human uses and agricultural production. Ironically, in many urban centres of Yemen water is now a limiting and threatening factor in modern development. Aquifers are seriously over-exploited and an alarming drop in groundwater tables imposes major constraints to water supply authorities, both in rural and urban areas. On the other hand, because of impeded drainage of surface waters, old parts of towns are flooded after heavy storms, damaging houses and buildings and affecting the health of many people, as puddles of polluted water are favourable breeding grounds for many diseasevectors.

When disturbance in sustainable use of natural water systems occur, for instance as a result of increased water demands and urban expansion, the correction of the disturbance may prove many times more expensive than the initial constructions. Considering the rapid rate of urban development and the state of urban planning in Yemen, this issue should have the utmost attention of water supply authorities.

Domestic water use in the Governorate is mainly based on wells. Government-supported programmes are being carried out to improve rural water supply, usually by schemes based on groundwater abstraction with diesel pumps. The 1982 earthquake affected many of the rural water supply schemes: 120 village systems were destroyed, affecting approximately 51,000 people.

8.3 Environmental problems of Dhamar town

Dhamar is situated on the Montane Plains, near the epicentre of the 1982 earthquake that caused im-

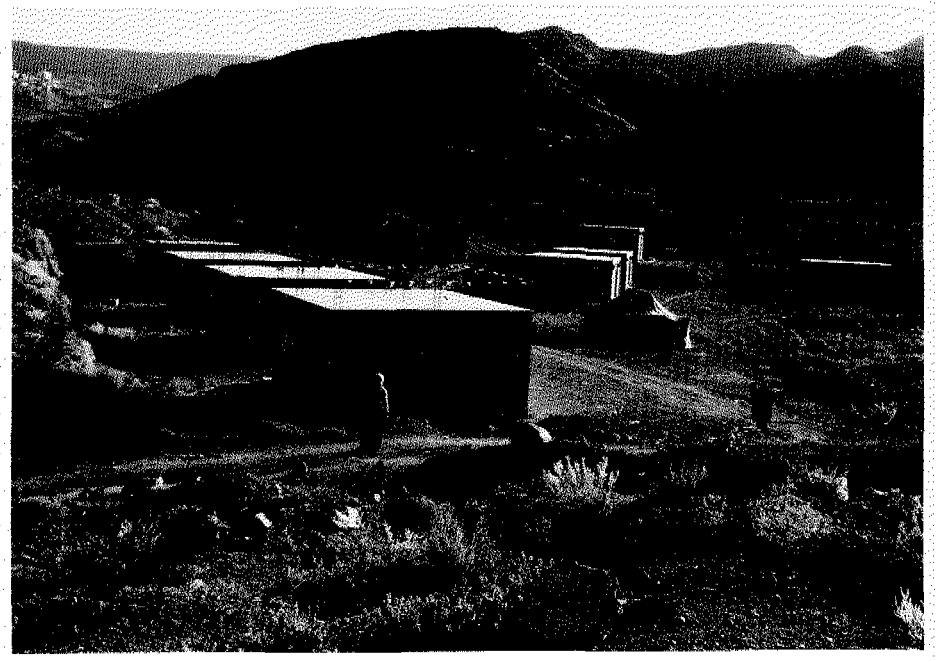
mense human and material losses inside as well as outside the town. The epicentre was located 20 kilometers southwest of Mabar.

Wide fluctuations in annual precipitation threaten water supply to the town. For instance, in 1975 total rainfall amounted to 500 mm whereas in 1984 only 200 mm was recorded.
The city suffers from inadequate water supply, and also from pollution by solid waste and lack of wastewater treatment. The town also suffers from impeded surface drainage. Existing channels are blocked by recent constructions and accumulation of solid and human wastes.
In the old centre of the town waste pollution is a serious problem, threatening public health, in particular the health of children. Rats, mosquitos, flies and other disease vectors find favourable conditions, in particular in and near pools of stagnant water.
As a result of a rapid increase of groundwater use for agricultural and other purposes, the groundwater table has dropped considerably and water is now being tapped from boreholes as deep as 160 m. Waterpipes are mostly constructed above the surface, because of the rocky substrate. Surface drainage is impeded and floods occur after heavy rainfall in the lower parts of the town.
Waste is now being taken to collecting points and dumped regularly. However, solid waste pollution and flooding during rains are still recurring problems. Older houses in lower parts of the town suffer most flood damage, as basements are gradually weakened.

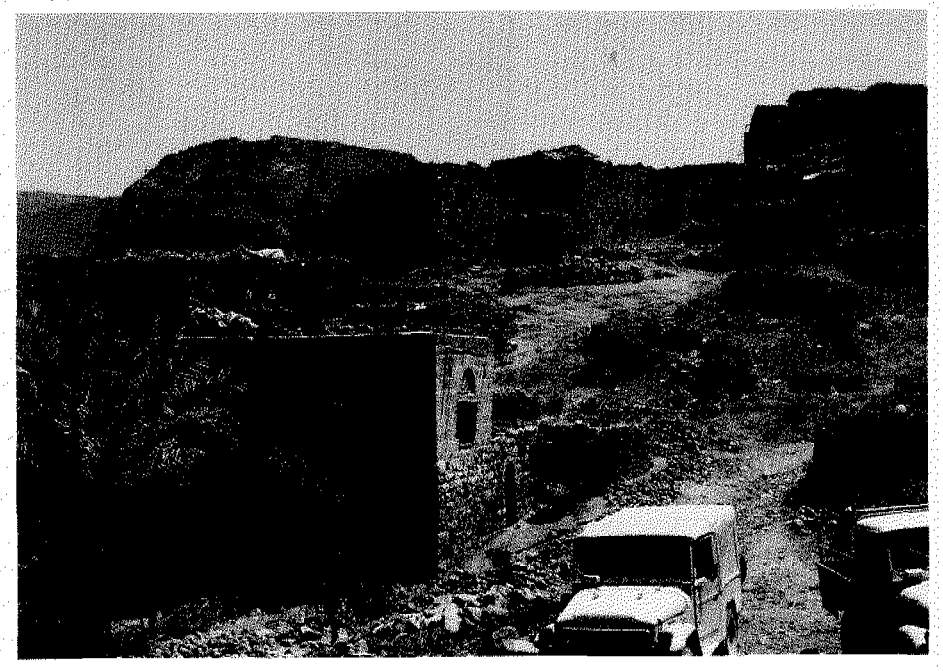
8.4 Regreening

There is a great demand for tree seedlings for homestead planting and other regreening activities. In most towns, shade trees, ornamental trees and shrubs and town parks are markedly scarce or absent. In Dhamar the choice of species is limited because of frost (temperatures as low as -14 degrees centigrade have been recorded). Nurseries for tree seedlings have been established and more and more tree seedlings are produced, for an increasingly large group of clients. Many people do not know where seedlings can be obtained nor how to treat them afterwards. Extension work on this subject has increased and technical assistance is being provided to the public to improve this knowledge and to stimulate the participation of the population. A practical, well illustrated booklet has been prepared and distributed among target groups. Tree planting campaigns by schoolchildren are particularly successful. Once seedlings have been suplied to the population, many return for more seedlings. Fruit tree species in particular are in high demand.

In Dhamar Governorate many new villages are constructed after the 1982 earthquake next to the old ones. Unfortunately, very little of the character of the Yemeni village remains, but new houses had to be constructed urgently



In the villages water is taken from the wadi and transported uphill by donkeys. This is work for women



9. Concluding statements for further action

As in all intensively used areas of the world mankind causes degradation of the resource base. There is no doubt that the degradation, as observed in particular on the Montane Plains, of the resource base in the Governorate is also man-made. It is the result of a complex of human activities in the area, particularly in the last twenty years. However, the impact of human use of the resources is rather different for the varied natural resources of the Governorate; some are reversible, some have been permanently degraded, or changed centuries ago. The following statements indicate the conditions for a more sustainable development in Dhamar Governorate.

9.1 Sustainable development

The ''World Commission on Environment and Development (1987)'' of the UN defined sustainable development as **''development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs''**. In Dhamar Governorate it means that man, in requiring an enduring by good quality of life, has to formulate and enforce rules and regulations to prevent further degradation of the environment; this being a threat to both the present and future generations.

9.2 Socio-economic factors

Population growth and quality of life

The population of the Governorate grows rapidly. The increasing needs of this growing population may accelerate degradation of the environment for resources that are already under high pressure. Child mortality is very high and the nutritional status of children is often poor. **To improve the quality of life and prevent environmental degradation is a very difficult but most challenging task, that the government should consider as one of their most urgent problems.**

Urban development

The towns in the Governorate are some of the secondary and tertiary towns in the Yemen. The emphasis of the national government and foreign assistance is focused on primary and to some extent on secondary towns. Of course these towns are the motors for the national economy of the whole country and many problems, including environmental ones, have to be solved urgently. **However, the planned development of the towns in the Governorate is as important and may provide a more sustainable infrastructure for development.**

Services and Access

The present health and educational services do not yet meet the needs of the population. In Dhamar Governorate the accessibility of the areas to the west of the Montane Plains is extremely difficult. It is most likely, that only relatively small changes in this accessibility will be achieved in future years, while a lot has been improved in the last twenty years. **Improvement of the geographical distribution and level of services will strengthen the basis for a more sustainable development and encourage the people to take part in the development of the modern Yemen as well.**

Environmental health

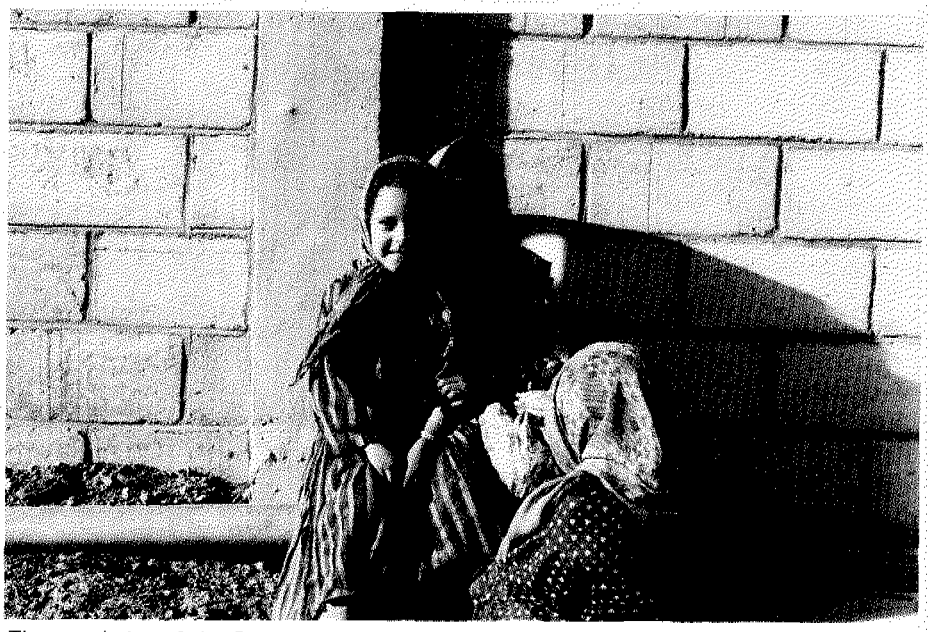
Child mortality is high and the nutritional status of children is often poor. Health in the towns and villages is threatened by poor sanitation. **Environmental health education is of great importance for improvement of the quality of life. Also extension to farmers in wise use of pesticides is a point of major concern in this respect.**

Yemen coffee is among the best coffee in the world. However, it finds its way to the market only with great difficulty, since most of it is transported downhill by donkey

Diversification of economy

There are many indications for the rapid economic development of the Yemen Arab Republic. Wage remittances and improved individual returns are driving forces for agricultural development: Money earned abroad or in other sectors of the economy than agriculture is used to buy agricultural products. Farmers may (or may not) invest their earnings in their farms in a way that leads to greater sustainability. **It is crucial for the future that the government gives close guidance to agricultural development in this sense, more than is the case at the moment.**

The development of Dhamar and Mabar towns has only partly been triggered by economic development. Many young people come to the towns, hoping to built up a new life, but become disappointed, since the opportunities for jobs are still not adequate. The presence of people who do not participate in economic growth adds to the problems of the towns. However, these people left their rural environment because there were no jobs either; there is no way back for them. **Emphasis on economic diversification is important, not only for urban development but indirectly, and perhaps even more, for agricultural development.**



The population of the Governorate continues to grow rapidly. Child mortality is high and nutritional status of children is poor, but obviously not in all cases

9.3 Changes in resource use and management

Agricultural land use

Agricultural development on the Montane Plains depends to a major degree on groundwater resources. A sustainable development of groundwater based agriculture depends on the permanent availability of fresh groundwater. **A framework of regulations for controlled groundwater exploration and exploitation is urgently required and so is actual monitoring of the groundwater resources.**

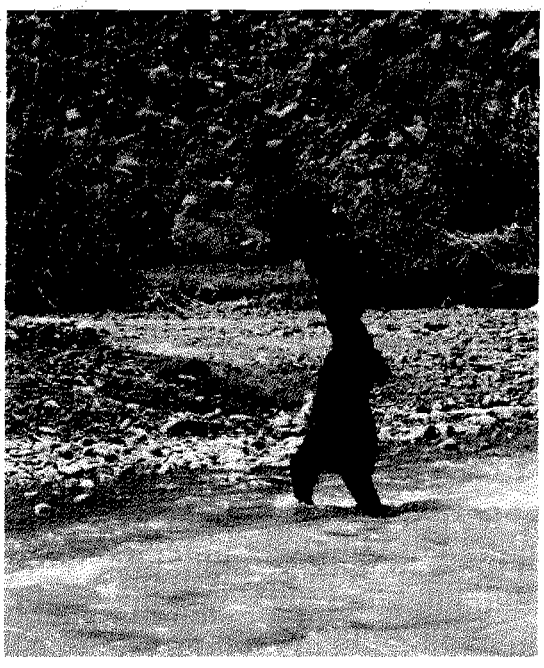
The migration of labour towards the large towns outside the Governorate and abroad is maybe not as intensive as in the early 1980's, but continues to create problems in keeping the agricultural production at the required level. The measures prohibiting importation of fruits and vegetables may well have created an important stimulus to agricultural production and perhaps even to the reduction of migration.

Range management and livestock production

Livestock production is rather well integrated within the agricultural production: grown fodder is an important animal feed resource. For management of the rangelands it is crucial that this integration of livestock and crop production is continued, as otherwise there is a risk of further overgrazing. **Planning of the use of rangeland resources and a strong attachment of individuals or village communities to certain rangelands is the only way in which incentives are created for adequate use and management of the rangelands.**

Tree resources

Firewood has for many years been a scarce and expensive commodity in the Governorate. Firewood is imported to the region (from the east), especially to the the Mon-



Poor accessibility is still one of the major constraints for development for many areas in the Governorate

tane Plains area. However, in the west too the availability of firewood will decline further. Energy requirements of urban people in the Governorate and beyond are and will increasingly be met by the use of other fuels for cooking, such as gas and electricity. **The government can stimulate this shift in energy resources. From a point of view of nature conservation it is important to set areas aside where natural vegetation may regenerate and can be witnessed by future generations.**

Wildlife resources
Small pockets of wildlife remain in the Governorate. These areas **should gain an official status to conserve this wildlife. Legislation concerning wildlife conservation must be established urgently.**

Groundwater resources
Over-exploitation of groundwater in several parts of the Montane Plains is seriously threatening domestic water supply and groundwater-fed irrigation. If over-exploitation is not stopped soon, wells will dry up, costs of pumped water will become higher and higher and eventually some aquifer zones will be exhausted. **To detect such problems in an early stage, groundwater levels should be designed and implemented to control groundwater abstraction in the Montane Plains.**

Terrace maintenance will remain an important issue in view of the labour shortage that may become more serious again

Wadi Zabid starts as a small stream.....

Water resources contamination is not yet an issue in the area. Increasing urbanization and the change to modern consumption, however, may in principle trigger pollution problems. Identifying the main sources of pollutants and analysing the vulnerability of the specific wadi and aquifer systems are essential to staying ahead of pollution problems.

Changing water resources development practices in the upland plateaux does influence the water resources of the downstream areas, in particular those of the Tihama zone and the Marib area. **It is very important to recognize these effects and to establish, via regional planning, a sufficient degree of co-ordination between water development in the upstream and downstream areas.**

Soil resources
Conservation of hill-slope terraces deserves special attention. The rural labour force has become much more mobile than it used to be. This involves the risk that the necessary maintenance of the terraces during and after the rainy seasons is neglected to some extent, which may lead to permanent losses of valuable land.

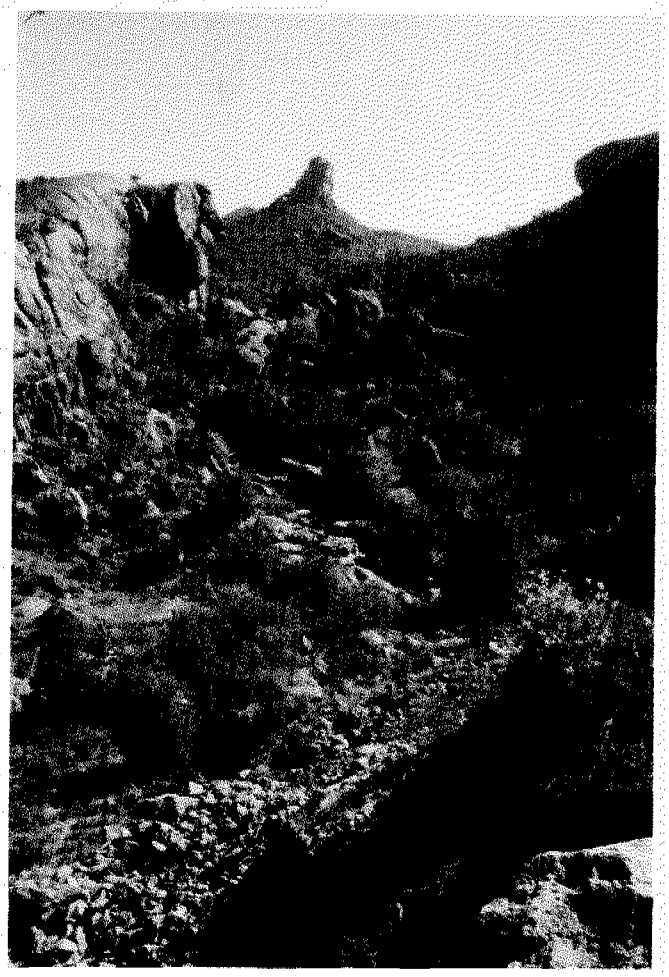
9.4 Implementation of environmental policies

Legislative aspects
Coherent laws and regulations, their implementation and particularly their enforcement are lacking or not functioning. **Considering the pace of development in the Yemen Arab Republic, priority should be given to the formulation of a coherent, modern environmental legislation, dealing with groundwater related issues, land use and pollution. Enforcement of these laws is a second indispensable step.**

Institutional aspects
The traditional institutional system is no longer as capable of dealing with the problems of the environ-

ment as in the past. On a local scale, the traditional system is of utmost importance, but it cannot function without a comprehensive framework of rules and regulations to be set forth by the national government. Local, traditional administration may have an important role in law enforcement. Institutional improvements should concern issues such as:

- strengthening of the planning capabilities of the provincial government and the Local Coordinating Committees on Development with respect to land use planning of urban and rural environments, monitoring and environmental assessments of development,
- sensible coordination of activities controlled by central and provincial governments
- use of existing traditional administrative structures at the local level.
- making the responsibilities for environmental management clear at all levels of administration. Each ministry has to recognize its own responsibilities towards activities that have or may have consequences for the environment.

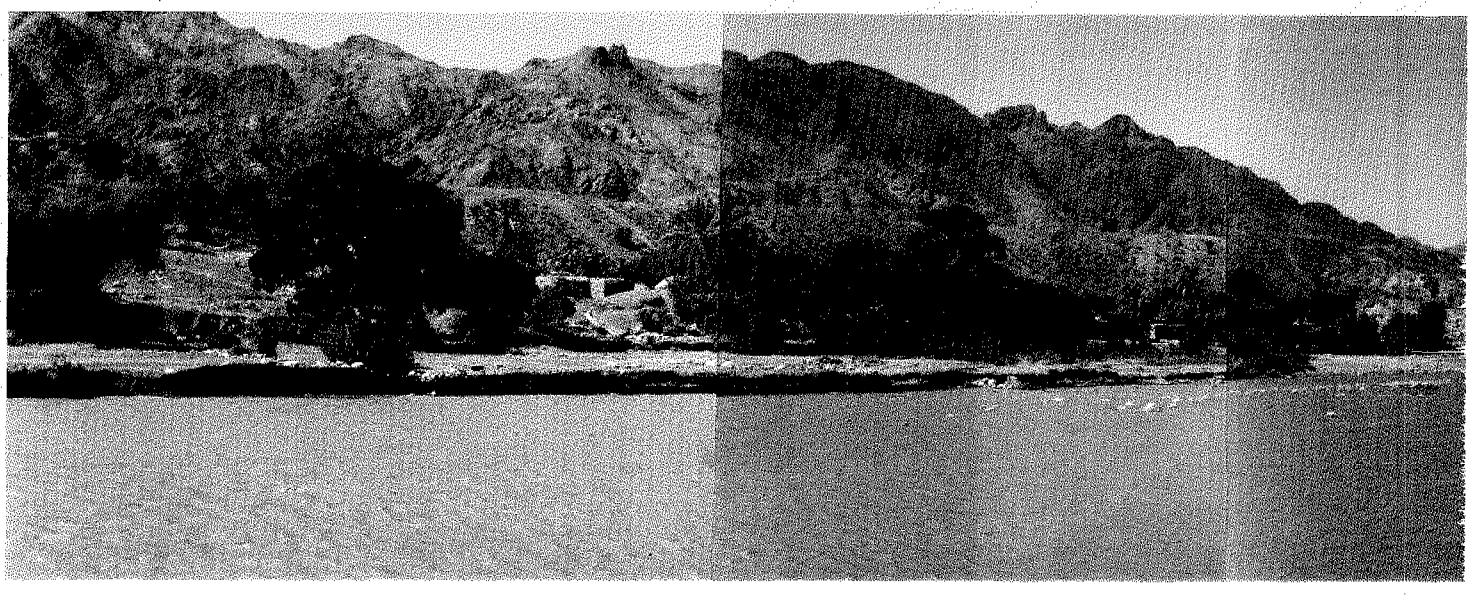


Wilderness near one of the characteristic mountain peaks in Dhamar

Conflicting objectives

There is of course a conflict between short term commercial opportunities and sustainable use of the environment. The government

.... but it is very wide when it reaches the Tihama



is the only body which may be able to protect the environment in such a way that sustainable use is achieved. **A balance has to be achieved between the economic goals in the short term and the long term.**

Extension, raising awareness and environmental education
Private initiative in resource management is vital. Therefore it has to be stimulated and guided. The development of environmental awareness requires targeted well-aimed extension services in both rural and urban environments as well as societies for environmental conservation. **Environmental education needs to be incorporated in education at all levels.**

Role of women
Because of their social and cultural position women have a specific and strong perception of environmental problems and accordingly their own set of priorities towards environmental problems. **This makes them an important target group for resource management and rehabilitation strategies.**

9.5 The environment in urban development

The rapid growth of the urban population and the introduction of modern technologies, combined with a lack of urban planning, has created environmental problems in the towns. The main reasons are that the development of structures to deal with waste and effluent has not kept pace with the rapid increase of the volume of these waste products. The situation could be worsened when industrial development expands, unless strict measures are taken to avoid air, water and noise pollution.

The rapid increase in the number of cars in cities not only causes air pollution from exhausts, but also soil and water pollution from oil and petrol spills and the dumping of used oil at repair and service stations.

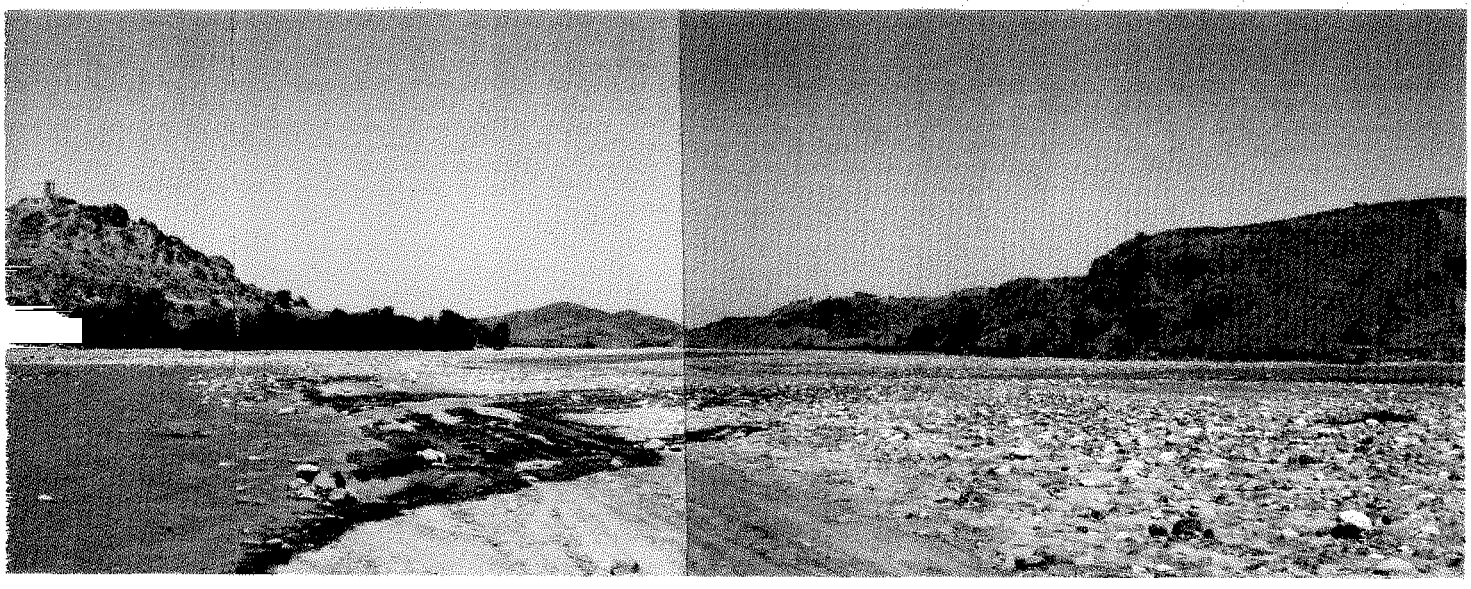
For the well-being of city dwellers, it is essential that environmental issues are taken into account in the planning and management of urban territories. If these issues arising from the development process and urban growth are neglected, subsequent environmental constraints could become major obstacles to economic development, impairing development targets and causing serious social and health problems.
Ideally, concepts and approach to environmental planning must be clearly defined before the design and appraisal of development activities. Standard procedures for environmental impact assessment should be available and institutionalised structures will be needed to check and enforce regulations and environmental legislation.

9.6 Research

The environmental study has encountered limited data availability on every important issue. **In order to establish sound natural resource management, research is needed, both to compile existing information and to supply the missing information. This should result in a suitable monitoring system.**

A better insight is needed into the socio-economic and environmental aspects of the major farming systems, in order to define suitable starting points for environmental management by the resource users.

Agricultural development is facing an important period and many difficult choices have to be made at national and governorate level with respect to the selection of methods for water saving, mechanization, choice of crops etc. **An expansion of agricultural research and extension is therefore most necessary.**



10. Summary

This Environmental Profile describes the environment of the Al Bayda Governorate in the Yemen Arab republic. It also gives an analysis of the environmental problems.
Emphasis is placed on the role of man in his interaction with the environment: how do the people in the Governorate use and manage the available natural resources, and why do they do it the way they do?
By describing the motives, patterns and trends of use of natural resources in regard to their sustainability, the Environmental Profile creates a framework for decision making by the authorities.

The Environmental Profile introduces the ecological principles of the area as well as the most important demographic, socioeconomic, historic, cultural, legislative and institutional features and trends.

Much attention is given to the balance between the use of the resources and the natural productivity. For this reason, land use in the Governorate has been studied with respect to agriculture, livestock production, use of rangelands and wood. Their development in space and time is taken into account. The present state of the natural resources is assessed at the level of land units. These land units are delineated with the help of satellite imagery and field verification. They are based on the natural characteristics, predominant human activities and changes associated with these activities. The state of the resources is described in terms of sustainability, use or misuse, degradation and desertification. Attention is given to the present resource management practices and the incentives and disincentives for separate groups of resource users. The problems of nature conservation, environmental health and urban development are discussed in view of the scale and pace of development in the Governorate. The Profile concludes with a series of statements that affect sustainable use and management of the natural resources.

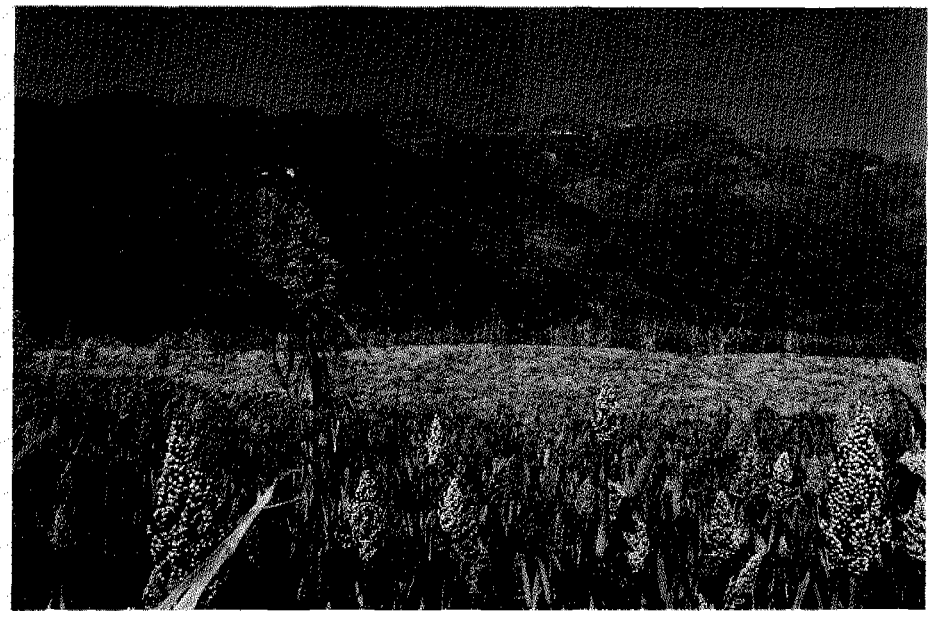
Dhamar Governorate contains two very different landscapes. The eastern part is covered by the Montane Plains with not very steep mountains, small wadis and wide plains. The western part is extremely dissected and mountainous. The wadis flowing through this Western Escarpment Zone into the Tihama, have created a most spectacular landscape, that at the same time is very inaccessible. Many places can still only be reached by donkey. In 1982 a strong earthquake had its epicentrum in the Governorate. It was particularly destructive in the area north of Dhamar.

By the year 2000 the Governorate will contain more than 1.1 million people with the present growth rate, instead of the 697,000 registered in 1986. Dhamar town contains some 50,000 people and has relatively good job opportunities, due to its position along the tarmac road between Sana', Taiz and Rada'- Al Bayda.

High population densities occur on the terraced mountainslopes with the typical small plot sizes of 0.1 ha and smaller. Under rainfed conditions on the highest mountains qat and coffee are produed. Along the wadis more recent culivation has developed of sorghum and many other crops. Before, the wadi bottom was considered as a strategically unfavourable location. On the Montane Plains rainfall is more scanty and especially potatoes and alfalfa are produced under irrigated conditions. This well irrigation developed rapidly in recent years. Currently groundwater tables are lowering and control over the use of this resource is urgently required in order to use the water in a sustainable manner.

Hill-slope terracing is the traditional soil conservation technique and practised since antiquity. Dhamar contains some of the most intensively terraced areas in the country. However, terrace maintenance is labour intensive. The rural labour force has become much more mobile than it used to be. Consequently, labour shortage is felt in terrace maintenance nowadays and losses of valuable agricultural land are at stake. This issue will remain important for many years to come and deserves special attention and monitoring.

Terraced fields are found on the high mountains in the background as well as at low elevation



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