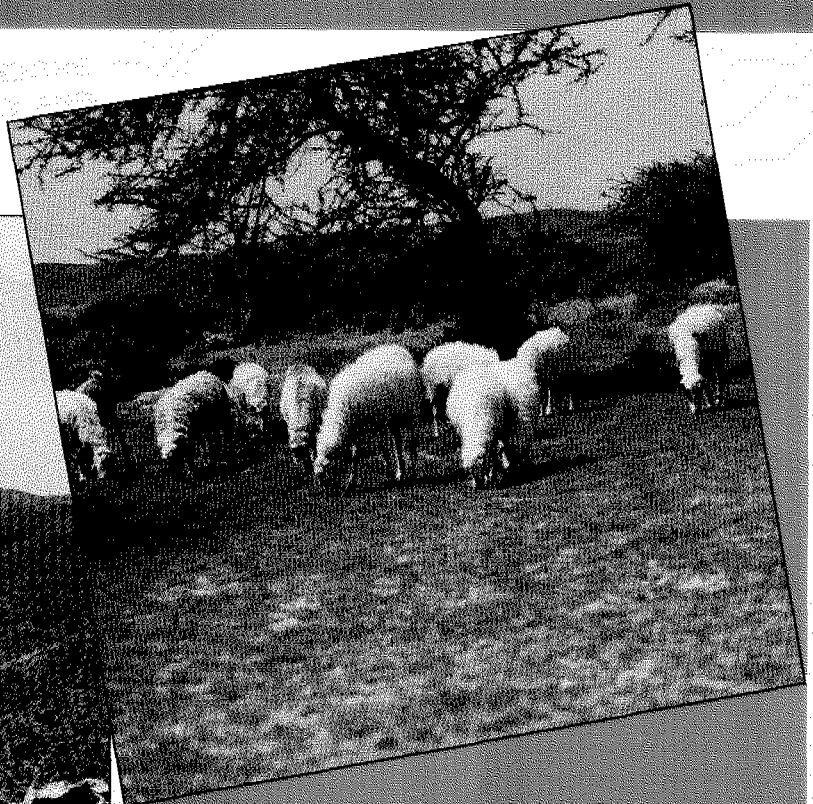
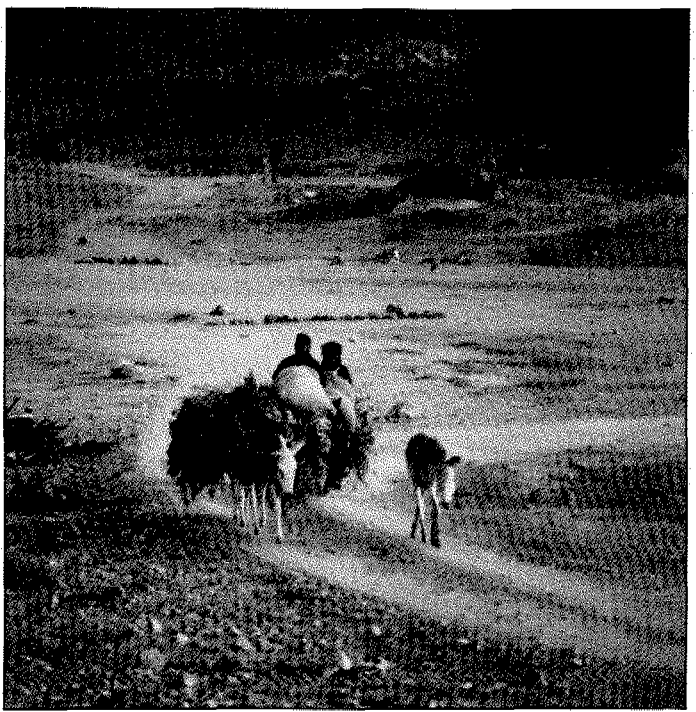
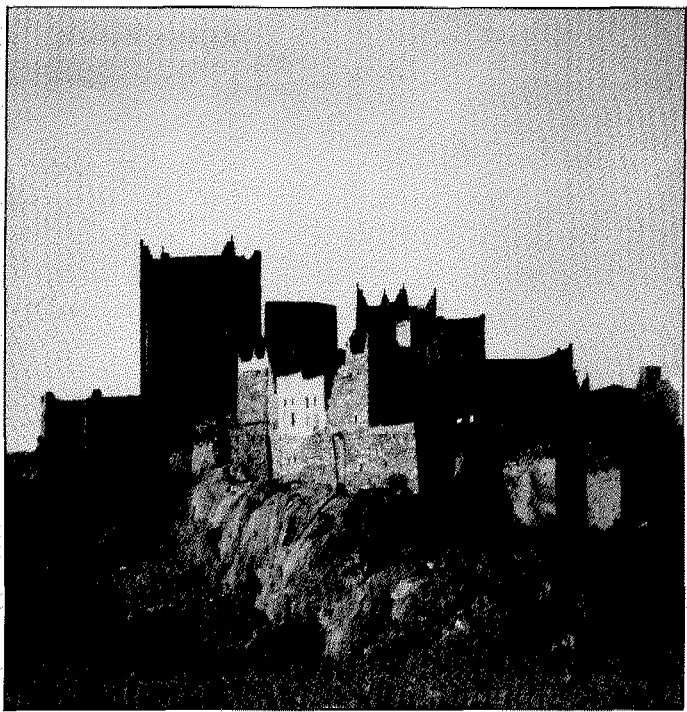


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Environmental Profile Al Bayda Governorate



Yemen Arab Republic



Environmental Profile Al Bayda Governorate

Yemen Arab Republic

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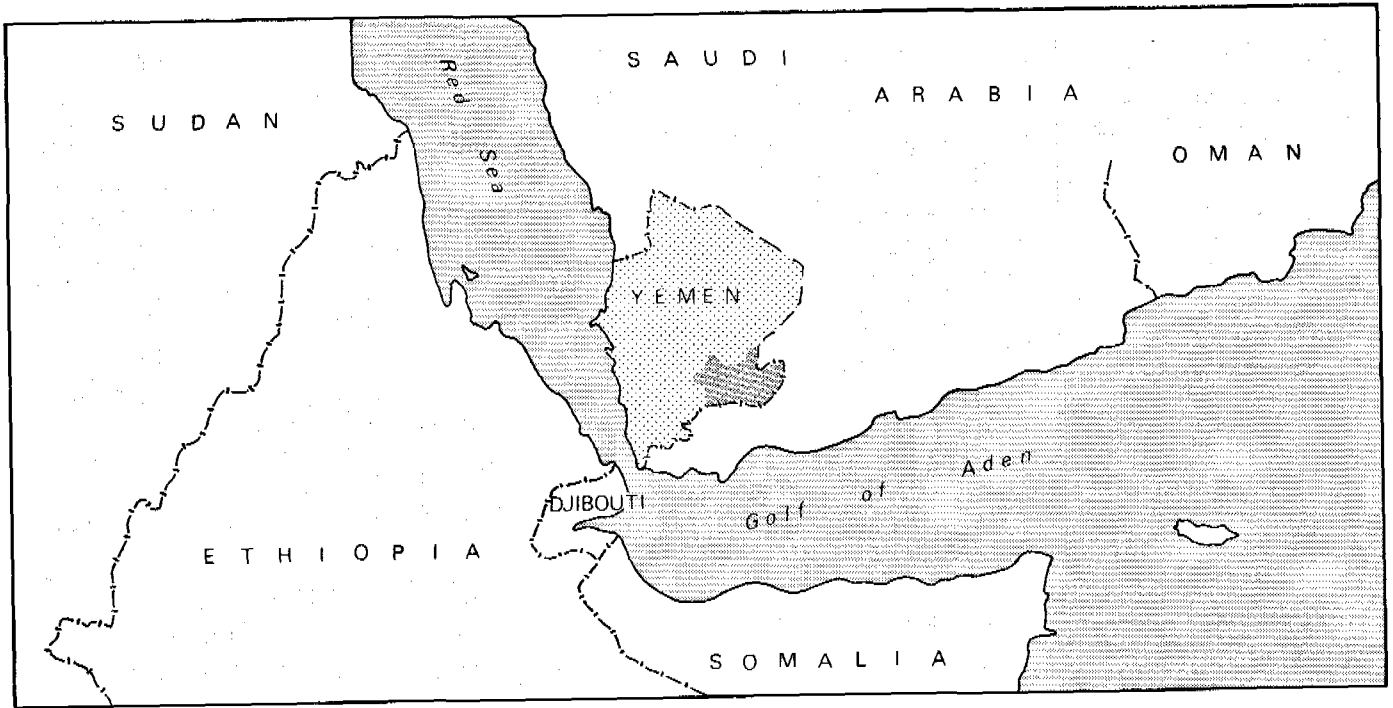
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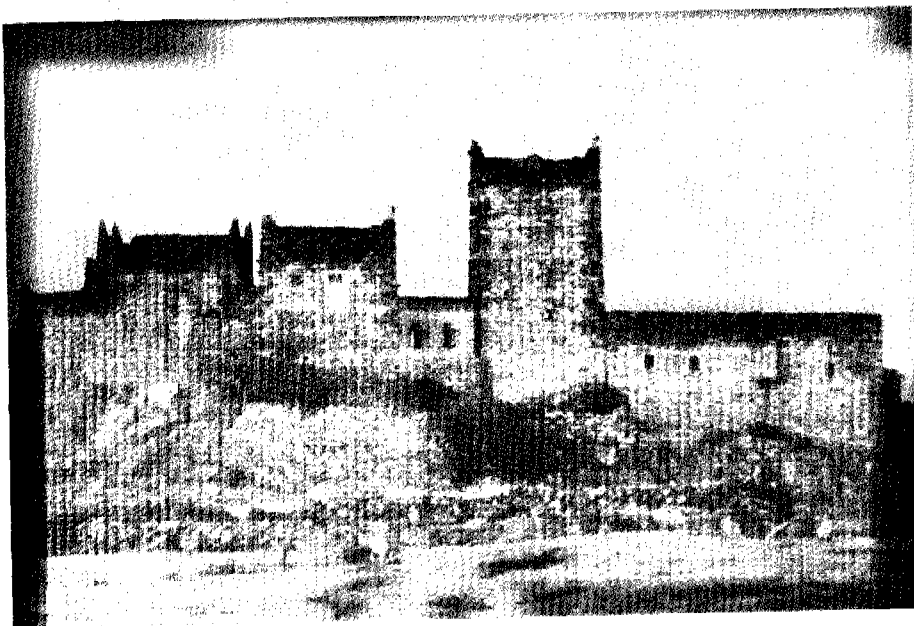
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The Al Bayda in the Yemen Arab Republic in the Middle East

Girls returning from the field with fodder for their animals



Traditional architecture still dominating the rural areas of Al Bayda Governorate

1. Introduction

1.1 Scope/Objective

This Environmental Profile describes the environment of the Al Bayda 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 Al Bayda Governorate use and manage the resources available and why do they do it the way they do?

By providing an overview of the environment and the state of resources in Al Bayda Governorate and by describing the motives, patterns and trends of resource use in regard to their sustainability, the Environmental Profile creates a framework of environmental constraints and possibilities for decision making by the authorities responsible for development in the Al Bayda 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 Al Bayda Governorate in 1988, information was collected on the environment and its use by man in the different areas. The team visited the area in October 1988. Interviews with farmers, nomads, authorities, both mo-

dern and traditional formed the basis for much of the information. Many descriptions of the state of the resources, including descriptions of 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 rather inaccessible 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. The Environmental Protection Council provides the framework in which these activities are carried out. It was carried out by specialists from the University of Sana', The Agricultural Research Authority in Yemen, the Netherlands Research Institute for Nature Management, the TNO Institute of Applied Geoscience, and DHV Consultants of the Netherlands.

During the study a seminar was held in Sana' during which team members held a

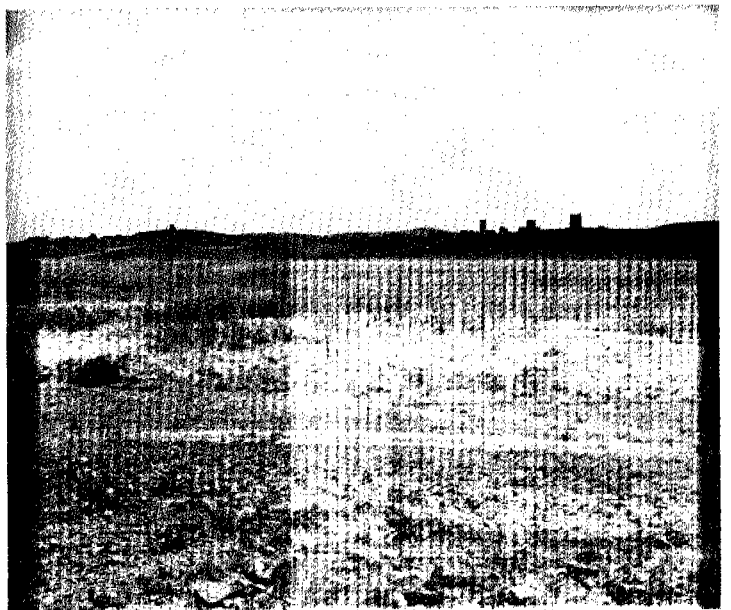
presentation for the authorities concerned. A number of statements was presented and discussed on this occasion, which are presented in the Recommendations of this Profile.

1.3 One of a series

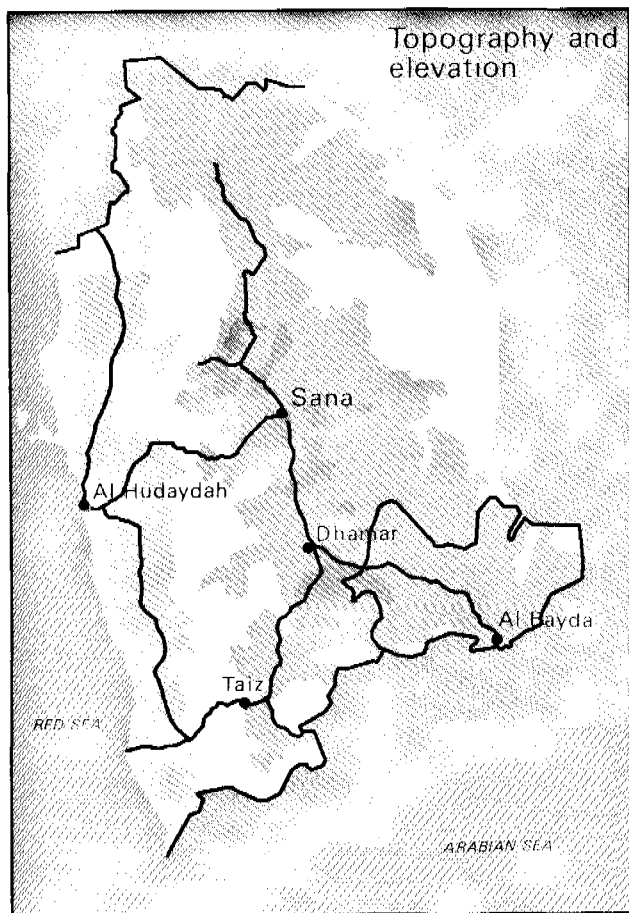
This Environmental Profile is one of a series of three. The other Volumes of this series discuss the environment and environmental problems in respectively Dhamar Governorate and the Tihama. These areas are chosen, because they are areas in which assistance from the Netherlands Ministry of Development Cooperation is concentrated. However, the three areas of study together cover an east-west cross-section of the Yemen Arab Republic, containing the main zones into which the country can be divided. The zones, which have a north-south orientation, are the Tihama bordering the Red Sea, the Mountain Belt, the Yemen Highlands and the Eastern Desert bordering the Rub al Khali. Consequently the three Profiles together may 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.



Fully armed men chewing qat on their way to a wedding



The Governorate is much less densely populated than the Yemen Arab Republic as a whole



2. Setting

2.1 History

In the course of history Al Bayda Governorate must have gained a certain importance during the period in which the kingdoms of Saba' and Qataban flourished. The Kingdom of Saba' (with the Queen of Sheba) flourished in the period from the 8th century B.C. The Marib Dam of Saba', the greatest technical structure of antiquity in Arabia, finally collapsed around 600 A.D. Also Qataban from the Hadramawt with its famous capital Shabwa reigned over large areas including the Al Bayda area. These civilisations undertook irrigated agriculture on a large scale, based on the wadi flow into the eastern desert. Their position on the caravan routes along the desert fringes and their influence over the areas where frankincense and myrrh came from (*Boswellia sacra* and *Commifora myrrha*), gave them also an economic position of importance and a reputation from China to Europe. The Markhah area was already cultivated at the time and frankincense was produced from it.

The agricultural land use of the mountainous zone in the south west of the Governorate has extended very slowly. 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. This slow development of terraced agriculture is in a very sharp contrast to the rapid agricultural development we find these days in e.g. Rada' district.

2.2 Topography and landscape

The Yemen Arab Republic is a mountainous country: a north-south running strongly dissected mountain belt covers a large part 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. The Al Bayda Governorate is located in the south-western part of the country. To the south and east it borders the People's Democratic Republic of Yemen and the Kingdom of Saudi Arabia; the exact borders are not yet fixed. Al Bayda Governorate covers an area of approximately 11,170 km², corresponding to 8% of the land surface of the Yemen Arab Republic.

Al Bayda Governorate is largely located on a highland plateau, consisting of not very steep mountains, dissected by wadis and sometimes by wide plains. A wadi is a mostly dry streambed, through which sometimes large floods are drained. Large eastward flowing wadis descend into the Eastern Sand Desert, the Empty Quarter or Rub al Khali. Before reaching the desert these wadis have created large fertile plains, the locations where the oldest Yemeni civilizations had their habitat. The Rada' area and its extension to the North is a rather large basin, filled with alluvial sediments, into which relatively small wadis drain.

In Al Bayda Governorate the two main towns are Al Bayda and Rada', both connected by the tarmac road to other parts of the country. All other roads in the Governorate are dirt roads, through wadi beds, or roads opened by graders. Much has been improved in the accessibility of the area in recent years.

The elevation of the land surface varies from 1200 m above sea level (lowest parts of some wadi beds) to approximately 3180 m locally at the western border of the province.

2.3 Population

People in Al Bayda governorate are, like other Yemeni, for the majority involved in agriculture. Population

concentrations are found in the areas with the highest agricultural potential. Along the Eastern Desert fringes we also find a Bedouin population which is nomadic to some extent. This Bedouin population is relatively important in the Governorate, compared to Yemen as a whole. These people live from their herds of mostly sheep and camels. The urban part of the population (11.5%) is involved in administration, trade and for a minority in industrial activities.

The first population census in the Yemen Arab Republic was taken in 1975. In 1986 the second population census was taken. 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. In 1986 the total population was estimated at 9.4 million.

The population data in this Profile are based on the 1975 and 1986 census. However, the methods 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 Al Bayda Governorate as registered in 1975 was 174,652 inhabitants. In the 1986 census 295,658 inhabitants were registered. The annual growth rate of the population derived from these figures is 4.9%. However, given the absence of reliable data on birth, death, and migration, this figure cannot be confirmed. Most likely it is on the high side. However, it is without doubt that the life expectancy for adults has 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 safer drinking water.

The total resident population of Al

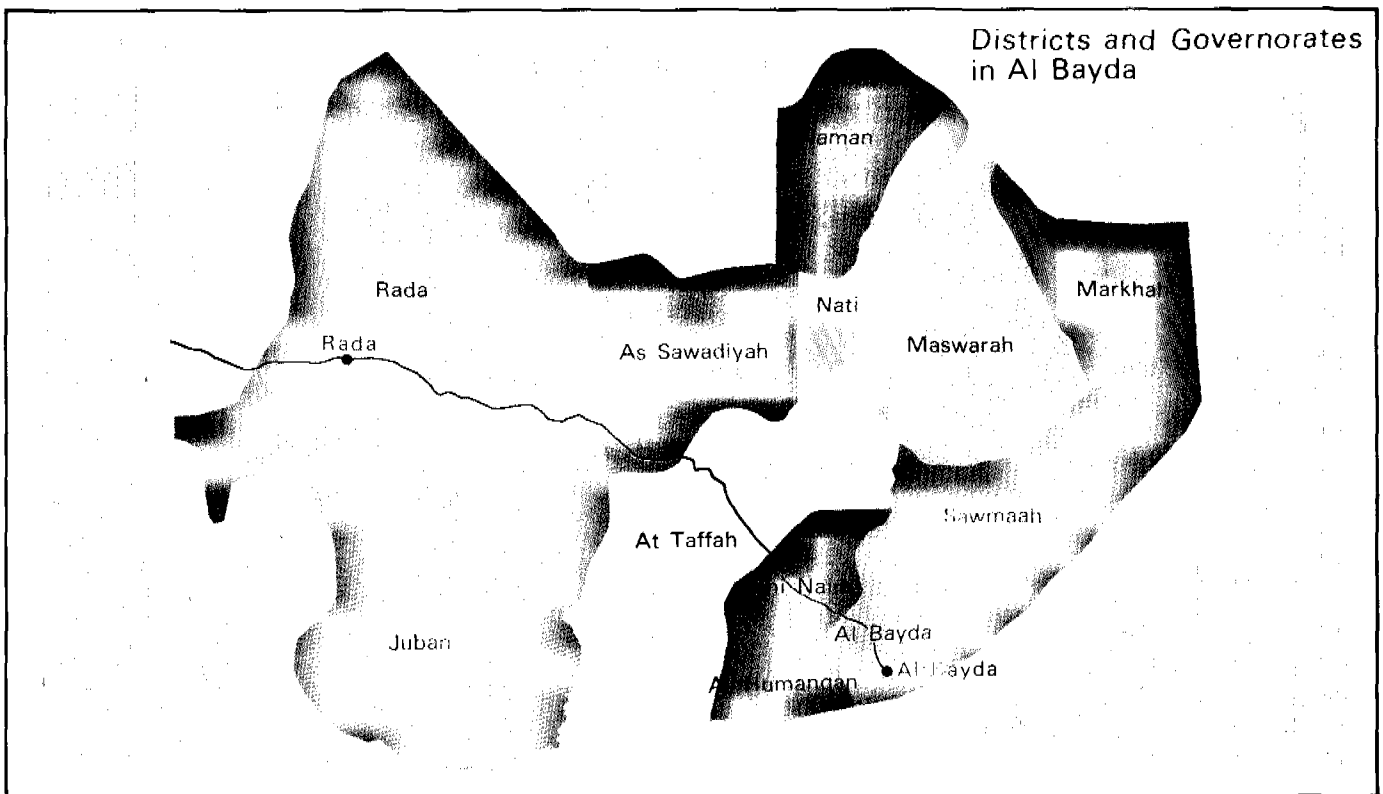
Population per district in Al Bayda Governorate

District	Population 1986	Population 1975	% of total 1986	Density 1986 person/km ²
Juban	19067	15456	6.5	34.0
Sawadiyah	33595	11176	11.4	26.5
Markhah	5527	2496	1.8	5.3
Naman	9110	1778	3.1	53.3
At Taffah	17682	10848	6.0	18.4
Dhi Naim	12037	6882	4.1	32.5
Al Humanqan/al Zaher	12197	8505	4.1	58.0
Al Bayda	35335	21432	12.0	62.0
As Sawma'ah	27522	19800	9.3	58.0
Maswarah	3732	3872	1.3	3.0
Rada'	114772	69475	38.9	29.0
Nati	5082	3021	1.7	8.9
	295658	174741	100	26.1

Sex ratio per district in Al Bayda Governorate in 1986 and 1975

District	Males 1986	Females 1986	Sex ratio 1986	Sex ratio 1975
Juban	8792	10275	86	81
Sawadiyah	16417	17178	96	85
Markhah	2674	2853	94	89
Naman	4942	4168	118	91
At Taffah	8406	9276	91	82
Dhi Naim	5598	6439	87	72
Al Humanqan/al Zaher	5615	6582	85	72
Al Bayda	16546	18789	88	79
As Sawma'ah	12756	14766	86	86
Maswarah	1830	1902	96	85
Rada'	55422	59350	93	81
Nati	2556	2526	101	85
	141554	154104	92	91

Districts and Governorates in Al Bayda



Bayda represents 4.1% of the population of the Yemen Arab Republic, while the Governorate occupies about 8.2% of its territory. It is less densely populated than the remainder of the country. Al Bayda Governorate consists of 12 districts of which Rada' District is the most populated (39%). A concentration of people is also found along the tarmac road that connects Al Bayda and Rada' towns with Dhamar and Sana'.

The increase in population growth has led to a relatively young population with a very strong dependency.

There are more women than men in Al Bayda Governorate. The districts that have more males than females are those that are the most isolated (Naman, Nati). From these districts migration is apparently less intensive than in locations which have more access to the world. Al Bayda is a governorate with even for Yemen a very high emigration, of about 15% emigrates. Al Bayda Governorate received

and receives high remittances, since about every family counts at least one emigrant.

The total manpower in Al Bayda constitutes about 60% of the population, about 40% of which is classified as labour force. The majority of the labour force of Al Bayda works in agriculture and related activities (70%) construction (7%), social services (5%), trade (5%), transportation (5%), others (8%).

2.4 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.

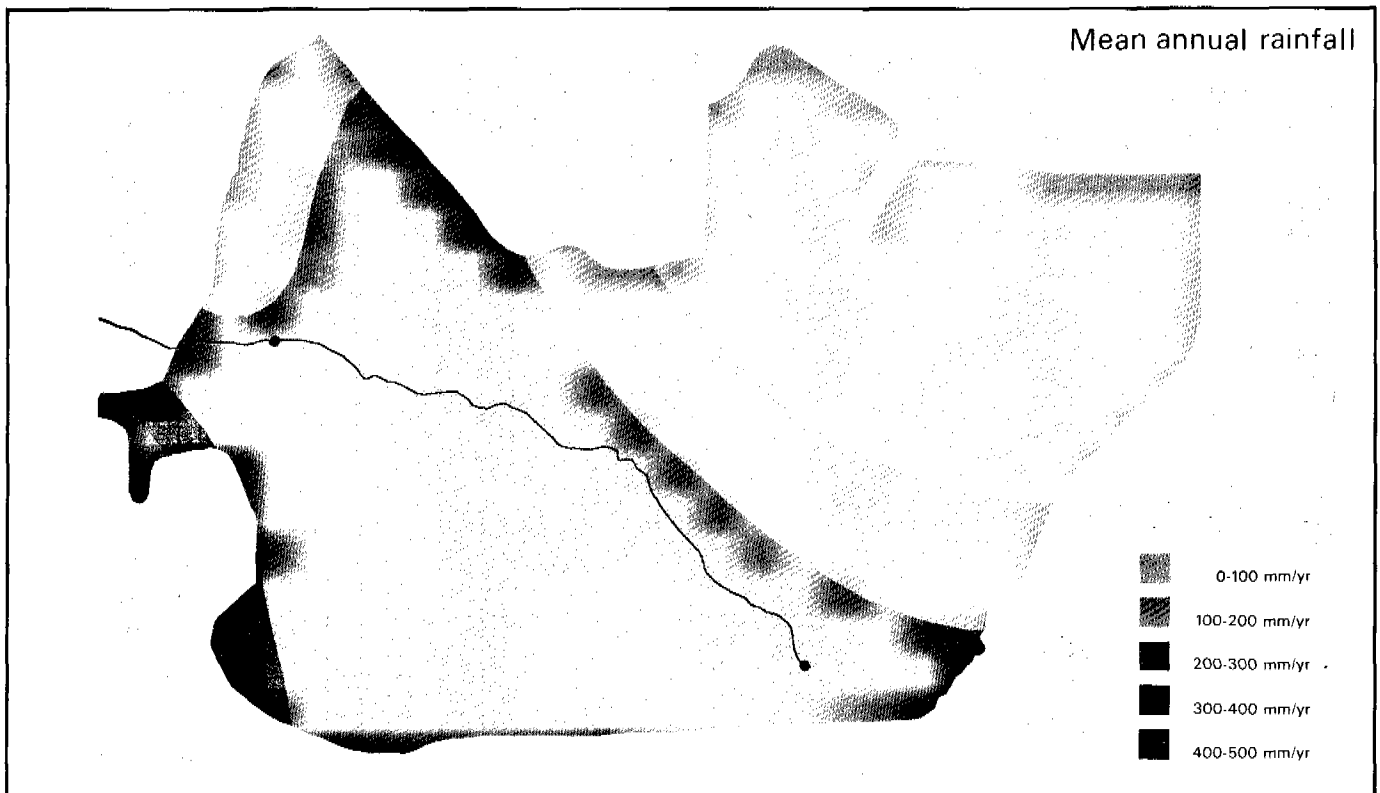
Most of the area is formed from very old material. About 80% of the surface of Al Bayda Governorate is occupied by Precambrian Ba-

sement rocks. This is reflected in the high degree of weathering of the rocks and the absence of steep mountain tops, but rounded-off ones instead.

Tertiary volcanic rocks are present along the western boundary of the Governorate. They are bounded to the east by a narrow belt of Tawilah sandstones. The Rada' area and its extension to the north is a rather large basin, filled with alluvial (Quaternary) sediments. The zone roughly north of the Rada'-Al Bayda road slopes north and north east. The remainder of the area has an overall slope southward.

2.5 Climate

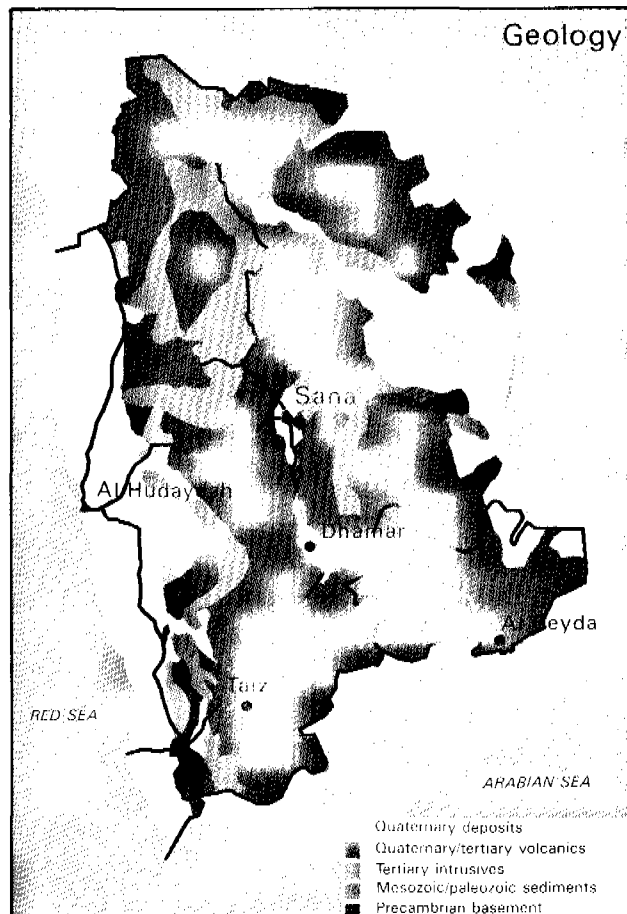
Yemen's climate is relatively favourable compared to other parts of the Arabian peninsula. The rainfall is not as scarce as in the deserts and the temperatures are relatively moderate. This is largely due to the presence of the mountains. However, the climate that prevails in Al Bayda Governorate is still cal-





The except for the rare rains always dry bed of Wadi Markhah. Nevertheless the water running through this wadi is an important source of a life for a vast area.

Even in this harsh and 'empty' land customary law and land tenure determine how the natural resources are used and by whom. It is most certainly not 'no man's land.'



led an Arid Dry Climate. Only in the mountains South West of Rada' and around Juban the rainfall is somewhat higher. Meteorological stations in Al Bayda Governorate are very scarce and the climatic data are extrapolated from adjacent regions.

Rainfall in Al Bayda during the summer months (July and August) is relatively little compared to western and central parts of the Yemen Arab Republic. The moist air causing these rains comes from the humid tropics and has already lost most of its humidity in the mountains to the west and southwest of Al Bayda Governorate.

Rainfall in the spring (March-May) is caused by the Red Sea Convergence effect, by which moist air arrives mainly from the south. The largest part of the precipitation falls in huge rain showers, which causes much rainfall to run off from the slopes and shallow soils, unless it is retained on terraced croplands.

Frost limits plant growth above 2200 meter. Strong desiccating winds are another hindrance 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 climate characteristics indicate that a depth of approximately 2400 mm of water would evaporate annually if sufficient water were continuously available at land surface (potential evaporation). Bearing in mind that the average rainfall is only 150 mm per year, a high degree of aridity is evident.

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. The customary law, however, may vary from location to location, and e.g. in

case of water rights, many local particularities and regulations can be found.

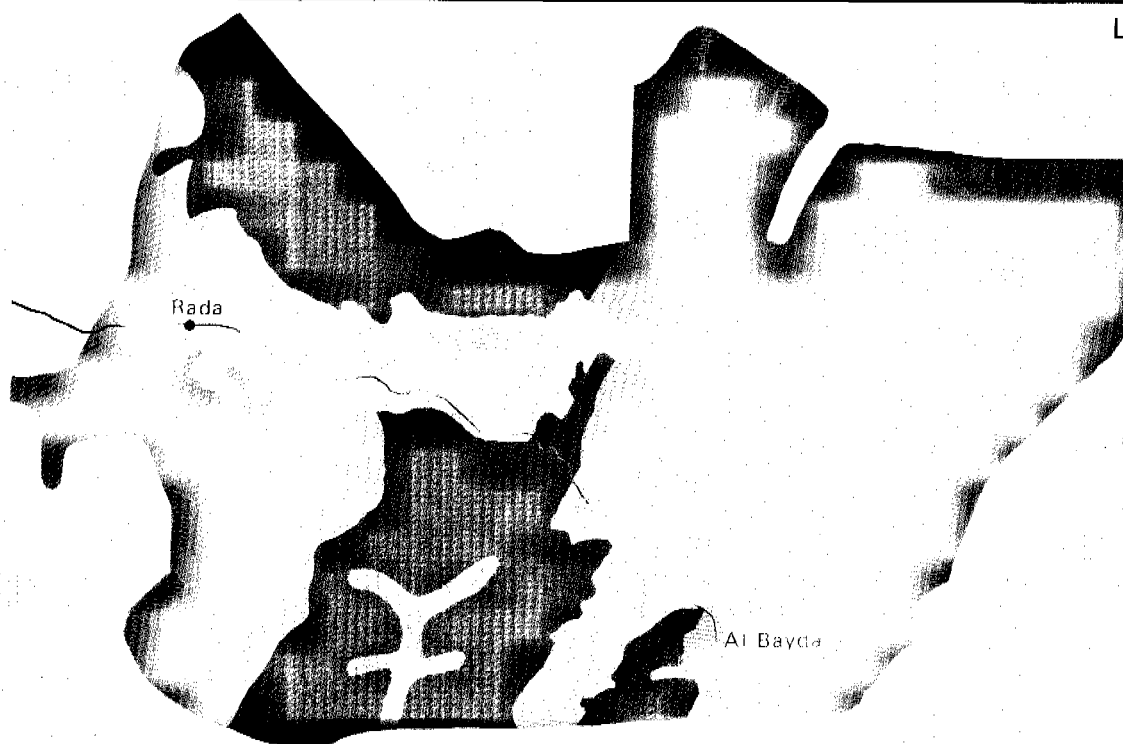
In general, however, modern law enforcing proper management of the environment is virtually nonexistent. This is not surprising, given the fact that the problems arising from modern life have only been felt recently. During the Imamate no attention was paid to legislation in this and many other fields. 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.











2.7 Water

It is evident that all human activities are enabled by the presence of water. First to drink and wash, secondly to water livestock and crops. In Al Bayda, water is a scarce resource. The rains determine the success of a cropping season or its failure. The rains also determine the replenishment of the aquifers, the subterranean water resources. The availability of water varies from location to location. This availability is the first important factor that determines and has determined the use of the natural resources. For this reason the subject of water availability recurs on many pages of this Profile.

Simplified Stratigraphic table of the Yemen Arab Republic

Chronostratigraphy (and max. thickness)	Lithostratigraphy	brief description
Cainozoic		
Quaternary	Quaternary deposits (300 m.)	unconsolidated sediments: sand, silt, clay, gravel
Quaternary	Quaternary basalts (500 m.)	basaltic lava flows, tuff and agglomerates
Tertiary	Tertiary Intrusives	alkali granites, diorites
Tertiary/Cretaceous (> 2000 m.)	Yemen Volcanics	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.)	partly cross-bedded sand- stone, locally conglomeratic
Precambrium		
Precambrium	Basement Complex	granite, diorite, gabbro, gneiss, schist, quartzite, marble



Name	% of area covered by alluvium	Access to water	Rain mm/year	Vegetation
 Rada' plains	50-75	wells wadis	200-300	grassland
 Wadi Markhah Valley	> 75	wells wadi	< 100	shrubland
 Terraced hills	25-50	wells run-off wadis	250-500	shrubland
 Undulating land with valleys	5-25	wells run-off wadi	200-300	open shrubland
 Dissected land with wadis	1-5	wells run-off	100-200	dwarf-shrubland
 Dissected land with steep and narrow wadis	< 1	wells run-off	200-300	open shrubland
 Dissected dry metamorphic rocky land	< 0.1	wells	100-300	dwarf-shrubland
 Dissected arid basaltic rocky land	< 1	wells	100-200	dwarf-shrubland
 Dissected arid metamorphic rocky land	< 0.1	wells	< 100	dwarf-shrubland
 Woodland valleys	< 5	wells	200-300	open woodland

3. Water and land

The landscape in Al Bayda Governorate as a whole is rather monotonous. It is a very old landscape, in which the mountain tops are eroded and where the land is covered by stones (the eroded material). The valleys are also filled with stones and eroded soil material, the alluvium.

There are three main landscapes to be distinguished in Al Bayda Governorate, namely the Montane Plains and Highlands at the western border of the Governorate, the Higher Escarpment at the southwestern extreme of the area around Juban, and the remainder which comprises the Eastern Plains and Highlands (90% of the area).

The area, appearing quite monotonous as a whole, contains quite some variation in vegetation, soils and human occupation, when studied in greater detail.

3.1 Soils

The soils in the Governorate are usually very shallow. The deeper soils are found on terraced slopes where man has retained the eroded soil material from uphill behind terrace walls. Deep soils are also found in valleys and wadis, where the soil material is deposited by wind and water. Only these deeper soils are suitable for cultivation. Whether they are cultivable or not, depends on the availability of water.

The ground surface is dominated in most parts of the Governorate by shallow rocks and bare rock-outcrops. The soils found are predominantly calcareous and alkaline. A process common in areas with an arid climate is that of salinization, often occurring in depression areas where water concentrates. Salinization occurs when salts in solution in moist soil are drawn upward by capillary action and are deposited at or near the soil surface, when the water evaporates. In the very calcareous soils of the

Governorate micronutrients are poorly available for plant growth. So despite the fact that the soils are relatively young and rich in minerals, these minerals are not of much value for plants. The combination of shallowness, alkalinity and calcareousness mean that the soils in Al Bayda Governorate are not so fertile as in Yemen as a whole.

3.2 Types of land

Terraced mountain-slopes

In the west and south west, the lower parts of the rain-exposed mountain slopes are cultivable and currently usually covered by man-made terraces. These terraces date back many hundreds of years. They contain accumulations of soil material retained behind terrace walls. The loamy soils on these slopes are made suitable for cultivation by man (manure, ploughing, removal of stones, collection of soil, etc).

The vegetation here has also been introduced by man.

Non-terraced hills and mountains

The Governorate is covered for over 95% of its area by this type of uncultivable land. At the same time, the land provides most of the ranges for livestock and fuelwood for man. The soils are very shallow, very stony and calcareous. Often there is actually no soil material at all (rock outcrop). The surface of these lands is covered by stones, a so-called "desert pavement or hammad surface".

Valleys

Rather large basins filled with alluvial sedimentation are found surrounding and north of Rada' and Wadi Markhah in the northeast. Smaller valleys are found along wadis in many parts of the Governorate, but these occupy very small surfaces. Both basins and valleys are filled with alluvial silty material during floods. The soil fertility in these areas is somewhat higher than on the hills but salinity

and micronutrient deficiencies limit cultivation. In the basins groundwater is relatively shallow. This has enabled a tremendous growth of motorpump irrigation. In well-irrigated farming, nutrient limitations are apparent within a few seasons of cultivation. The land is now privately owned and sharecropping takes place. Before, much of the vegetation in these valleys was an important source of forage for livestock and of fuelwood.

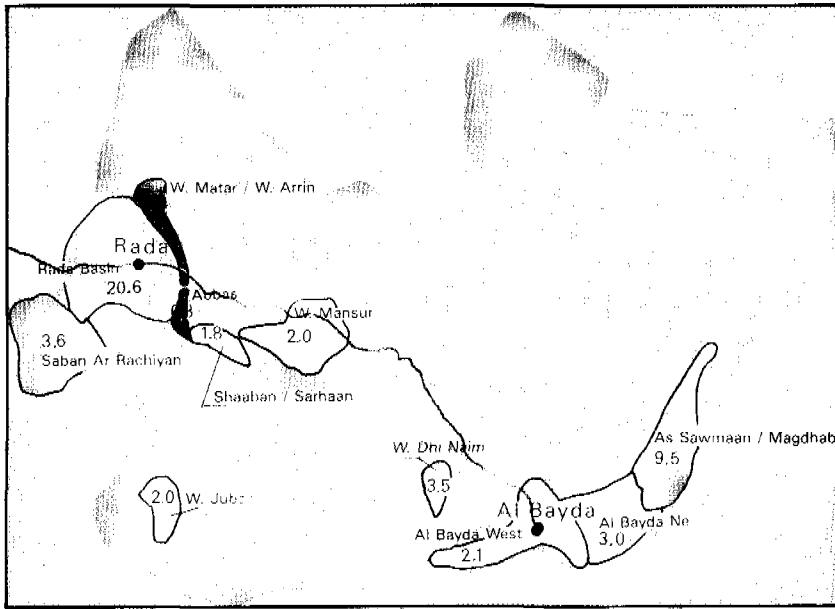
Wadis

The numerous wadis in the Governorate together comprise its drainage system, to which is referred in the following sections. The beds of these wadis transport water for very short periods, during and directly after a rain shower. They contain small amounts of groundwater for a much longer period of the year and are amazingly humid microenvironments in an environment that is otherwise arid. 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 somewhat larger wadis are tapped to provide irrigation water for fields along the wadi bed. On the main water divide running roughly from Al Bayda to Rada, these wadis are usually wide and flat and filled with alluvial deposits.

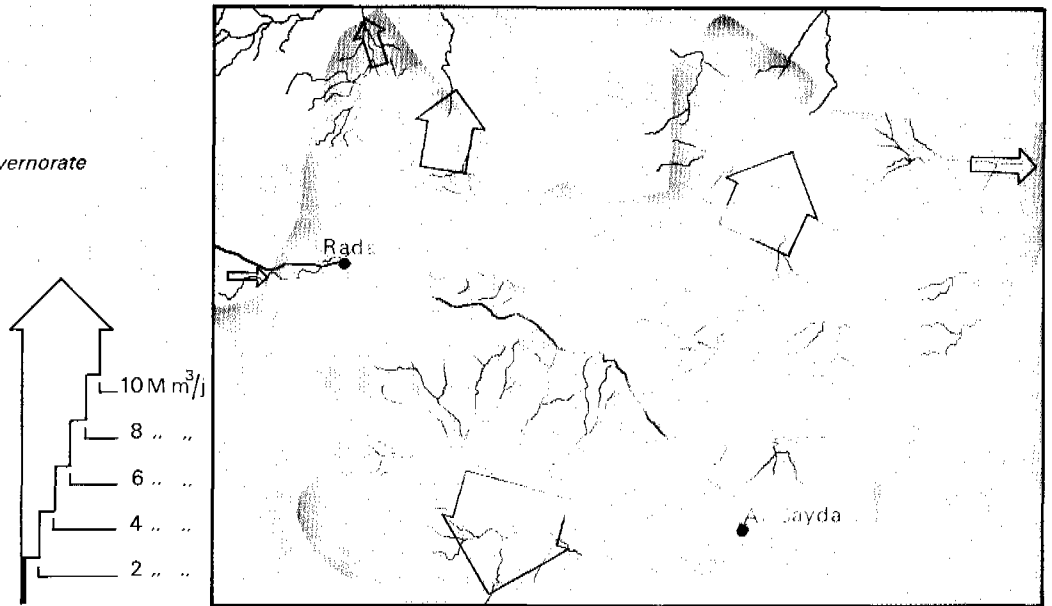
3.3 Drainage

Even though rainfall is scarce, rain storms often produce more water than the upper soil layers can absorb immediately. Hence, surface water runs off down-slope towards streams or their tributaries. The catchment areas of these drainage systems may be grouped into larger units with a common drainage basis. In the Yemen Arab Republic we may distinguish between the areas draining towards the Red Sea (Red Sea basin), towards the Gulf of Aden (Gulf of Aden basin), towards the Arabian Sea (Arabian Sea basin) and towards the great

Main groundwater development zones.



The annual outflow from the Governorate exceeds the inflow by far.



When the rain washes away the finer soil material, stones remain to cover the surface, a so-called desert pavement is created.

inland desert of the southern part of the Arabian Peninsula (Rub Al-Khali basin).

Al Bayda Governorate belongs partly to the Arabian Sea basin and partly to the Gulf of Aden basin. The main water divide almost coincides with the Rada-Al Bayda road.

The natural drainage system of Al Bayda Governorate is predominantly centrifugal. Different stream systems originate within the boundaries of the Governorate and convey surface water to topographically lower zones outside the boundaries. They contribute to respectively Wadi Adhana, Wadi Bayhan and Wadi Markhah (Arabian Sea basin) and to Wadi Bana (Gulf of Aden basin). Only a few minor wadis enter the province. According to a rough estimate, there is an average annual outflow of 60 million m^3 versus an inflow of only 3 million m^3 . Thus, the Governorate loses much more surface water than it gains.

Many of the wadi branches have been incised in barely permeable rocks and stream beds have relatively steep slopes (0.4 - 4.0%). These factors favour flash flow regimes with quickly rising peaks and little or no base flow. During and after occasional rains, water runs off quickly over the sloping terrains and reaches the beds of the wadis. In a very short time the usually dry wadi beds fill with water that is carried swiftly downstream. To reach peak flow, it takes only a few minutes to a few hours - depending on rainfall and catchment characteristics. After the rains have stopped the flow diminishes, usually within a day.

Some 3.5% of the total rainfall leaves the province in the form of runoff; most of the rainfall is intercepted at soil surface and evaporates subsequently. Hence, the average frequency of floods in the wadis is only four per year; some wadis may even remain completely dry for years.

The wadis carry substantial quantities of sediment during their floods.

However, data on sediment transport are not available.

3.4 Occurrence and characteristics of groundwater

The extent and potential of groundwater reservoirs is limited in Al Bayda 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. It is typical for such local aquifers that groundwater moves only over limited distances and that the stored volumes are small, which may lead to seasonal depletion or exhaustion of groundwater.

Near the western border, however, more extensive aquifers occur in Tertiary and Quaternary volcanic rocks, in the Tawilah Sandstone Series and in alluvial deposits of the

plains. The larger horizontal and vertical dimensions give rise to larger variations in depth to groundwater (0 - 150 m). Another characteristic of this category of aquifers is that the stored volumes are much larger than annual groundwater renewal, thus there is not the threat of seasonal depletion. The most important groundwater reservoir is that of Rada' plain, which is covered by alluvial deposits (max. 30 m) underlain by Tawilah Sandstones. In the north-eastern part of the province, the alluvial deposits of Wadi Markhah offer relatively good aquifer conditions.

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 than 10 l/s and some of them are saline. Some boreholes in the Quaternary and Tertiary Volcanics show slightly thermal waters.

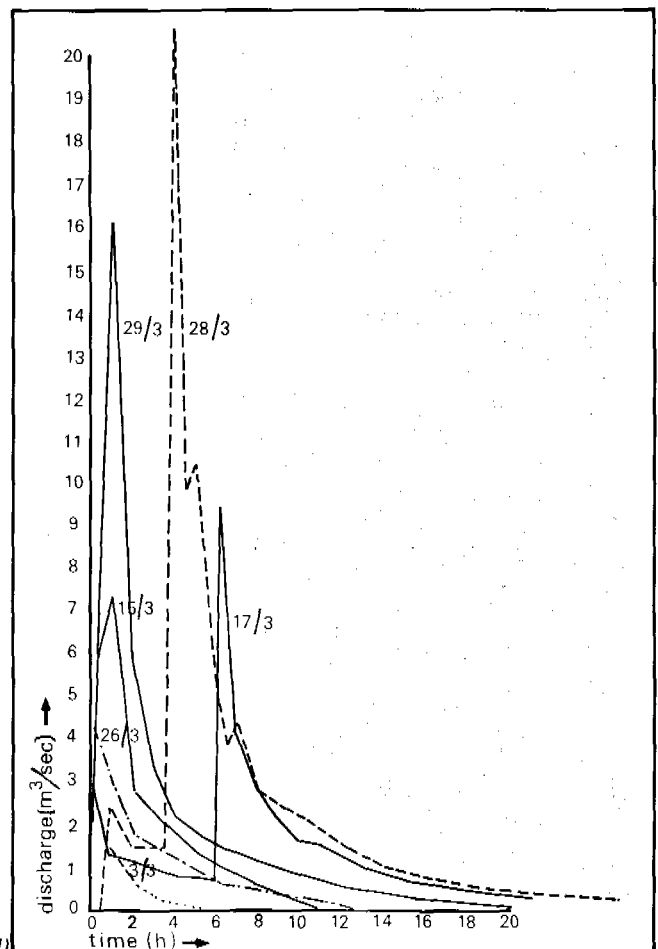
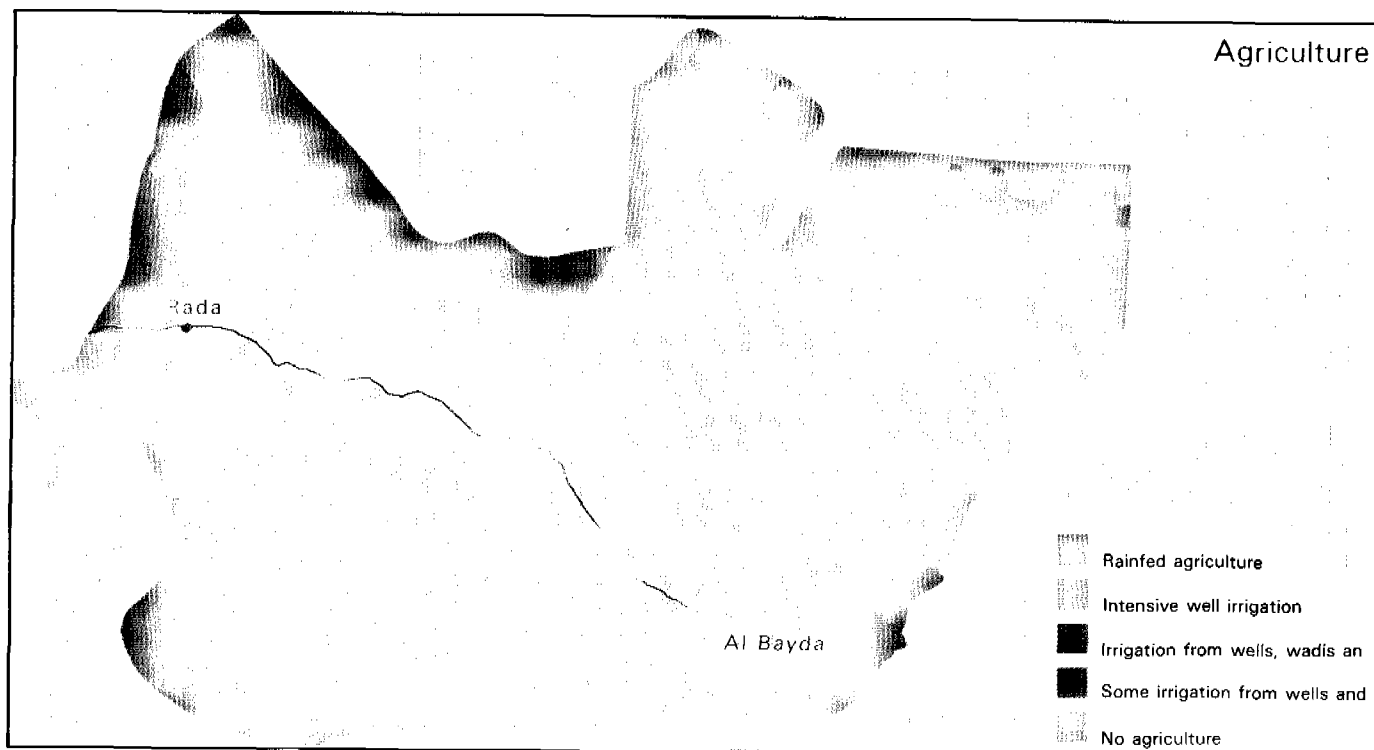


Illustration of a typical wadi flow regime in Al Bayda Province (Qarn Attah, March 1987)



Cultivated land under different farming systems in Al Bayda Governorate and in the YAR

Location		Rainfed and run-off area	Irrigated area	Fallow area	Total area
Al Bayda	ha	32,377	16,900	3,947	56,389
Governorate	%	62	32	6	100
Yemen Arab	ha	725,285	160,128	56,516	941,929
Republic	%	77	17	6	100

Compiled from Agricultural Statistics Yearbook, 1987



In many cases even for run-off agriculture irrigation water is used. The pump in this case is situated in the cabin in the middle of the field.

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 Al Bayda Governorate using their natural resources?

4.1 Agriculture

Alluvial deposits in valleys and plains are a precondition for agricultural land use, with the exception of the west where erodible volcanic mountain slope is turned into relatively fertile terraced land. Most of the land available for cultivation is under use, with the exception of a possible expansion of the terraced surface in the west and in the Wadi Markhah valley in the north east. Rainfed, run-off and irrigated agriculture are all found in the Governorate. Rainfed agriculture depends on rainwater that falls direct onto the surface of the field. In run-off agriculture rainwater from the immediate surroundings is led onto the fields and, together with the rain that falls onto the field direct, provides the water for cultivation: water is harvested from nearby slopes, flood water from small wadis is diverted onto the fields. In the Governorate, irrigated agriculture is defined as a new development based on pumped groundwater. The traditional wadi irrigation as found in the Tihama and in, for instance, the Dhamar Governorate where wadi base flow is also used or flood water is diverted over large distances, does not exist in this Governorate. Old irrigation systems such as those fed from the dam in Juban and the different small irrigation systems with subterranean canals no longer function. These irrigation systems are a testimony to the high level of technical knowledge of the old civilisations.

Roughly one third of the land is irrigated and two-thirds is rainfed and run-off. The cultivated area fluctuates with the amount of rain-

fall in a rainy season. For the irrigated area, the area fluctuations are only caused by break-downs of powered pumps, etc. The cultivated area in Al Bayda Governorate accounts for only 6% of the cultivated area of the country, of which relatively much (11%) is irrigated.

Supplementary irrigation is applied in more than half of the total farm holdings of the Governorate, while more than 80% of the holdings use supplementary irrigation for less than half its water requirements.

Types of Agriculture

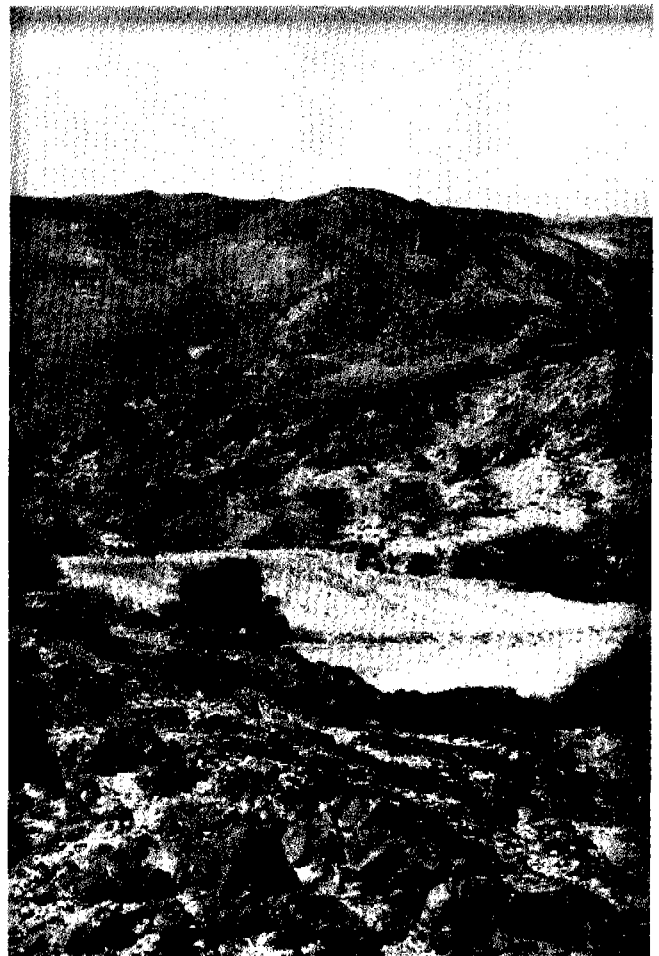
Rainfed agriculture

The western part (Sabah) is distinguished from all other areas by its altitude of about 2500 m above sea level and a relatively high rainfall. Rainfed agriculture is mainly

practised on well terraced mountain slopes. The main rainfed crops are sorghum, wheat, peas and some barley. The higher rainfall (350 mm) and good soils allow for self sufficiency in food crops, while it is possible to expand the cropping pattern with a wide range of annual crops and fruit tree crops. About 15% of the whole area of Sabah and Ar Riashyfah is under terraced cultivation, being about 50% of the total agricultural land in the Governorate. On these terraces an average yield for sorghum, wheat and barley is assumed of 800 kg per hectare.

Run-off agriculture

Flood irrigation is essential for agricultural production on the central plains and in larger wadis. Compartments, averaging 0.5 hectare, are interconnected by spillways, so that flood water is conducted from



In large areas in the Governorate the only cultivable land is a small zone alongside and in the wadi beds.

one field to another. Compartment building does not require high initial investments and is very effective for retaining surface water. The main cultivated crop is sorghum, which is grown on 90% of the area. It is difficult to estimate yields as these vary with the amount of water stored in the soil. Fields closest to the water inlet have been observed to produce 1500 kg per hectare of sorghum grain.

Temporary cross dams and guide bunds are used throughout the Governorate, where the wadi streams through alluvial deposits are sufficient. Flood water is diverted upstream of the field by a low dam of piled stones, and while the wadi bed slopes downward, water is led along the bund to the field. Usually guide bunds serve up to 10 hectares. Sometimes earth cross dams are built across the full width of a wadi by bulldozing, raising water to volumes that may serve much larger areas.

Three floodings are considered essential for a reasonable crop. Land preparation is started after the first flood at the beginning of the first rainy season (February/March). Sorghum is sown during May. After seeding no water is required until sorghum is high enough to withstand the next flooding. At the end of the rainy season (August/September), 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 completely.

Micro-catchments

Water harvesting techniques also belong to the traditional run-off farming techniques and improved micro catchments are in use in the Governorate. In the traditional system a slope is kept relatively barren by intensive grazing and the natural drainage of the slope leads the water onto the field. The Rada Rural Integrated Development project introduced micro-catchments on a trial basis in 1988. Barren sloping land of about 120 m² is surrounded by bunds. At the lowest point in the catchment a basin of

about 1 m³ is dug. The size of the basin is matched to the water harvest expected. The basins are fertilized with manure and trees are planted in them. On otherwise bare slopes (< 6%) micro catchments provide enough additional water to ensure the growth of fruit trees, forage shrubs or firewood.

Terraces in wadi beds are found mostly in the central, southern and south eastern part of the Governorate. Run-off water from floods flowing through the wadi and run-off water from the surrounding slopes generated by small rainstorms, is led onto the fields. On these terraces, an average yield of 800 kg per hectare for sorghum, wheat and barley is assumed.

Well-irrigated agriculture

Irrigated farming in the Governorate is a development of the last decades. Consequently, most farmers are new to irrigation techniques. Shallow wells initially served mostly alfalfa crops, while boreholes were developed to irrigate cash crops. 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. In the Rada' plains this provides a wide range of both home-consumed and cash crops. Here, livestock is increasingly linked to irrigated crop output, the animals being "processors of crop residues".

The efficiency of water use in irrigation was 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 of irrigation indicates the scope for its development in Al Bayda Governorate.

The price farmers in the Governorate pay for irrigation water is about 3 Rial per m³. With the exception of qat cultivation it seems that pump irrigation is not profitable to the farmer, in terms of the value of the produced crops (even horticultural crops). In fact, to many farmers the main purpose of crop production is not sale but home consumption and many Al Bayda farmers are quite willing to spend money on home-grown food.

The outlook for water saving practices in pump irrigation is positive for potato growers but negative for alfalfa and grain crop producers, whatever the irrigation method is. Powered pumps are found throughout the Governorate. However, a concentration of irrigated agriculture occurs on the Rada' plains.

Crop production and cultural practices

The yield per unit area in Al Bayda Governorate is relatively low, as mentioned above. This can be partly explained by limited soil fertility and water availability, but on the other hand cultivation is largely undertaken at a subsistence level. Simple tools and manual labour are the most important input in cultivation.

The introduction of farm machinery is new to Al Bayda Governorate. However, many new tractors can be seen. Most first ploughing is nowadays done by tractor, but working animals are still commonly used for secondary ploughing and seed bed preparation. The attractiveness of mechanization lies in labour shortage rather than in the economic aspects.

Fertilizers are still hardly used in the Governorate. In Yomen no inor-

Average holding size and number of parcels per holding

	Average holding size	Average number of parcels per holding	Average parcel size
Al Bayda	2.2 ha	4.7	.47 ha
Y.A.R.	2.3 ha	4.6	.50 ha

ganic fertilizers are produced, except for the chicken manure that is bought from the chicken farms. The rare fertilizer, which is locally sold at high prices, is imported. Data on the use of pesticides (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 are said to be scarcer than before. However, in many stores and small village markets the quantities of pesticides for sale are impressive.

Nor is there any comprehensive information available on the exposure of the population of the Governorate to pesticides, though some accidents including poisoning have been reported.

4.2 Livestock production

As everywhere in the Yemen, livestock and crops are closely integrated in the farming systems in Al Bayda Governorate. Almost every farmer has animals, to provide him with food, cash or traction power. 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 probably cannot continue for much longer since many more boys and girls will go to schools in the future.

Cattle, camels, sheep, 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.

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. Cattle mainly 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. Milk and ghee (fluid butter) are rarely marketed. The "house-cow" is highly valued and every household will try to keep at least one for the regular provision of milk. Beef is readily consumed but less favoured than mutton.

Bulls and oxen reared for traction (ploughing, sowing, weeding and threshing) are not commonly kept in Al Bayda Governorate. However, working animals are still commonly used (77% of all farms), especially for secondary light ploughing and for seed bed preparation.

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

Field egalization with the help of a camel.



The field size is sometimes enlarged to allow mechanization.



Cattle are most commonly fed in the compound and are hand-fed with sorghum stalks and leaves and, if available, with fresh or dried alfalfa. Exceptionally, cattle leave the house to graze on crop-residues, stubble and weeds in agricultural fields 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 rather poor shape and suffering from several diseases, largely as a result of poor nutrition.

Sheep and goats

In Yemen many different sheep and goat races are kept. People in differ-

ent parts of the country have their own preference for certain races.

In Al Bayda Governorate sheep are mostly of the fleeced, brown or white coloured type. The sheep have an average weight of 20-25 kg and a short, characteristically S-shaped fat-tail. Compared with the hair sheep of the mountains they are better off in the dry rangeland areas, 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.

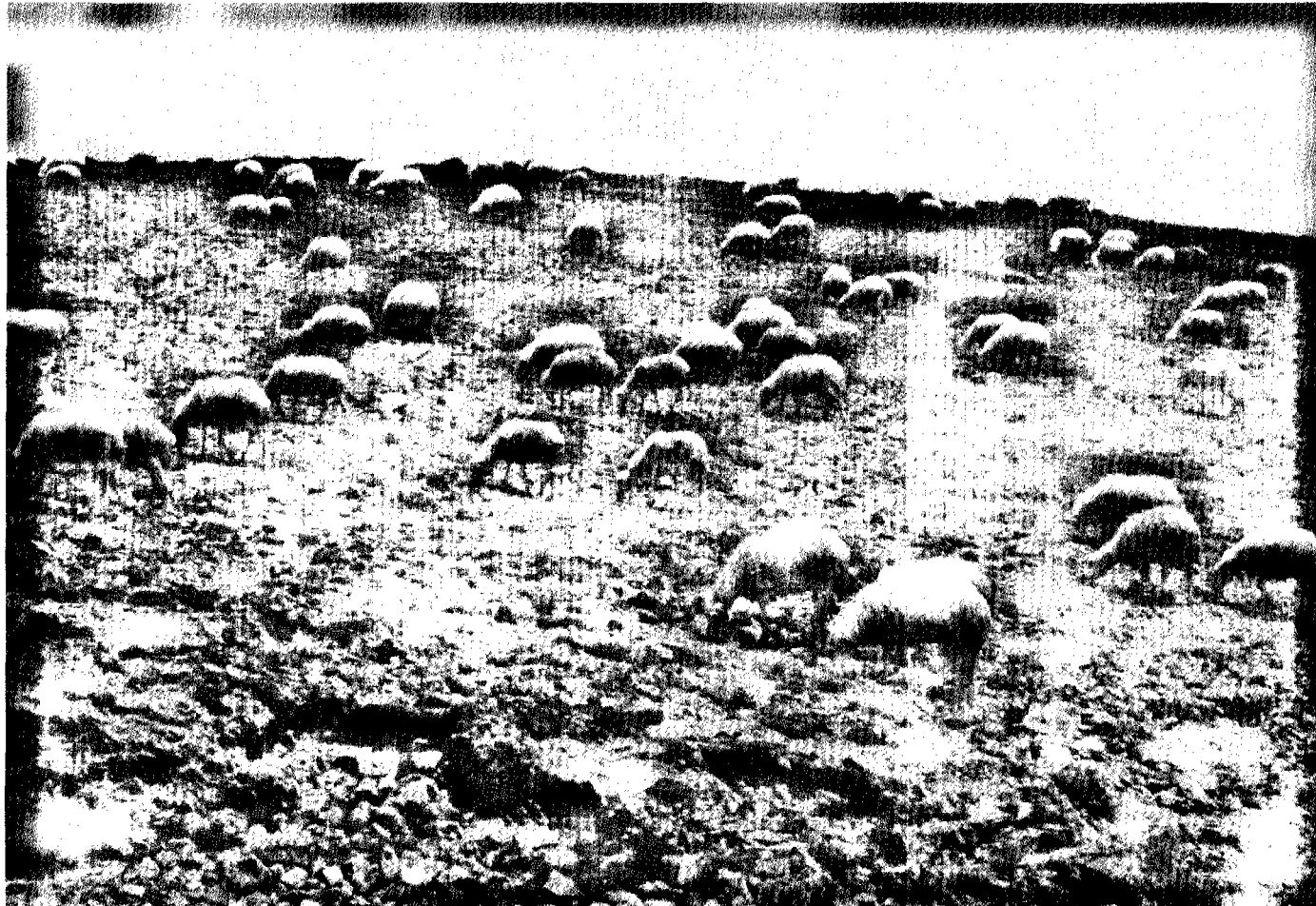
Sheep are kept for meat, milk and wool. Milk yields are low (less than 500 ml/ sheep/day). Mutton is the favoured meat in the Governorate and priced accordingly. It is especially important for celebrations. For such occasions, castrates, especially fed for at least several months, are preferred to entire 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 becoming more and more depressed due to importation of cheaper alternatives.

The goats of Al Bayda Governorate are of the short-eared type, long-haired and generally black coloured. They are somewhat larger than the sheep. Goats provide milk, meat and hair. Milk yields are generally higher than those 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.

Sheep grazing on rocky rangeland.



Sheep and goats are herded in mixed flocks although they may segregate into their own kind. A high proportion of sheep is related to a high percentage of croplands in the area; herds in cropland areas are usually not larger than 50 head. Flocks of semi-nomadic people generally have as many sheep as goats; the total flock size may be up to 200 heads.

Flocks may be attended by any member of the family, nearby the house by women and children and further away by grown-up boys or elder men. Herding arrangements are commonly made in villages. This was usually done on a 50/50 basis by the offspring, but nowadays it mostly involves payment of the herdsman in cash. The payment is generally about 20 Rial per sheep per month.

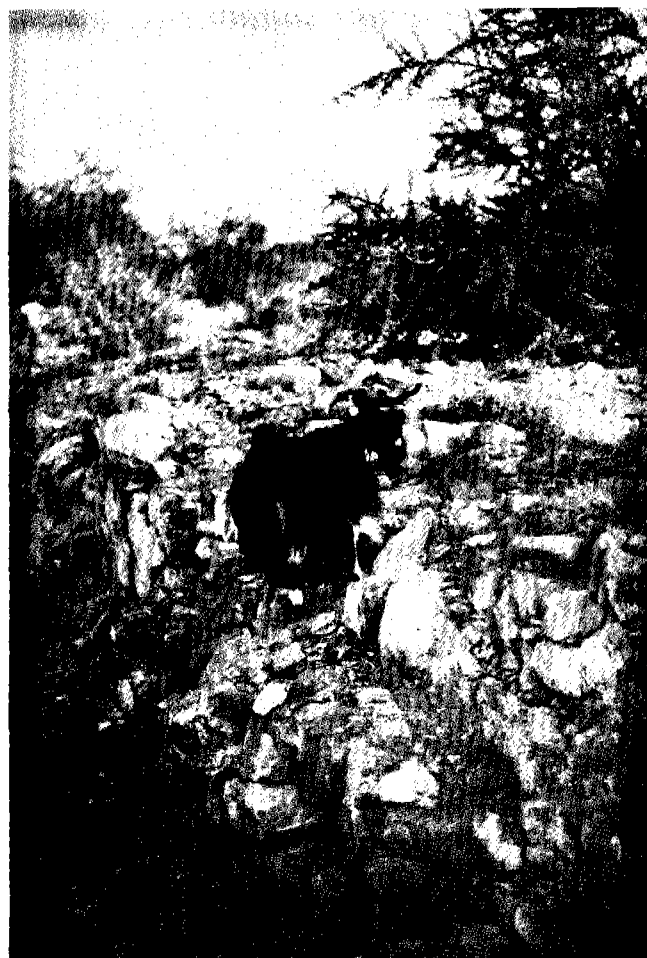
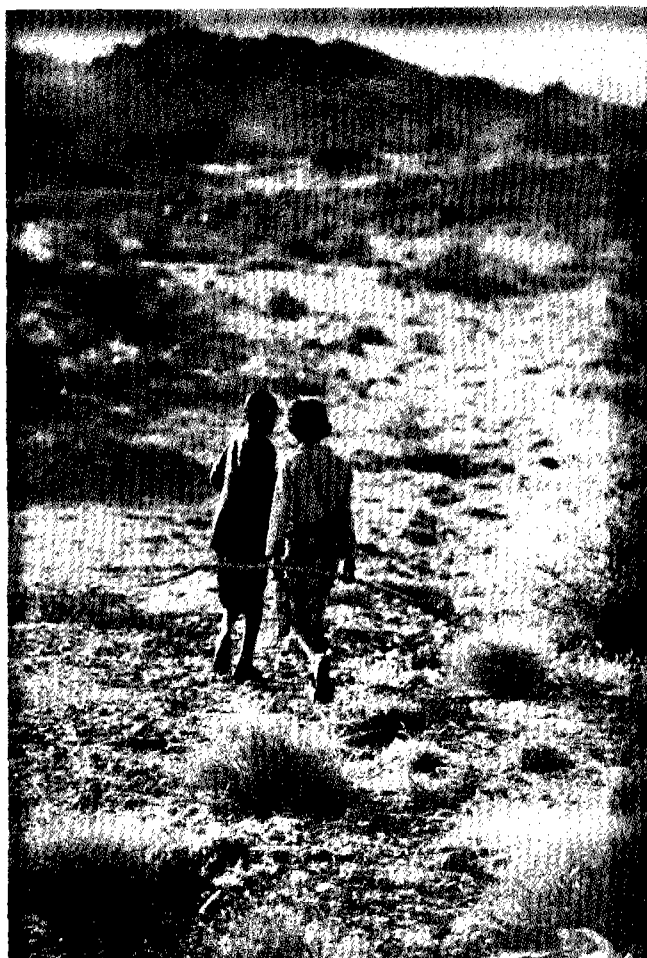
In the cropland areas, both sheep and goats basically function as a financial buffer to meet the cash requirements of the household. Semi-nomadic people in the dry areas tend to live more exclusively from the herd.

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 the related black disease occur in agricultural areas.

Numbers of livestock in the Governorate in 1988

Species	number
sheep	1,000,000
goats	300,000
cattle	40,000
camels	5,000
donkeys	25,000

The basis for determining the livestock numbers of Al Bayda Governorate are both the livestock census data of the Agricultural Census of 1983 and field data recently collected by the Rural Integrated Rada Development Project. In this case the data from the Agricultural Yearbook have not been followed in view of the availability of the RIRD data, which strongly deviate from the official figures.



Herdsman and Al Bayda goat.

Camels

Camels are one-humped dromedaries, predominantly short-haired and coloured black (highland plains) or a light to sandy red (lowland desert areas). Camels in the highland plains are used for fieldwork; elsewhere they are used for long distance transport. Approximately 10% of the farms of Al Bayda Governorate were reported to make use of camels. Their use is currently declining. Camels may also provide milk and meat: the milk production varies from 1-3 l/camel/day. Camel milk is highly appreciated by semi-nomadic people. Camels can be fed at home, but more commonly they remain unattended on the rangelands, staying in the vicinity of the village or tented camps. Camel management is a man's job.

Al Bayda Governorate is a camel raising area along its northern and eastern border. These camels are herded by semi-nomadic people, who stay north east of the Governorate for those periods of the year when there is grazing and water along the border with the sand desert, the Rub al Khali.

Poultry

Hens, including brooders, are kept in the backyard for their egg production, 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 method of poultry production went through a period of tremendous growth in the last decade; this was apparently well over the 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.

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



*The firewood trade 1.
Firewood is cut with simple means.*

are lower on the vast rangelands of the area, due to a smaller resource base (little forage, little water). On these rangelands most goats, fleeced sheep and camels are kept. On average, in the cultivated areas 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 they are usually kept in large numbers. Livestock densities in Al Bayda Governorate have in recent years remained relatively stable. In the cultivated areas, keeping livestock has become easier as forage resources have increased; this is due to a rise in the volume of

pumped irrigation water, leading to the increased production of alfalfa, etc.

Livestock densities on the rangeland areas tend to fluctuate with the annual rainfall. In dry years livestock is sold or dies and in wet years their numbers increase again. The improved possibilities for obtaining supplementary feed has to some extent reduced the fluctuations.

Livestock feed

Livestock feed originates 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). Taking the cultivated and inaccessible areas and fallow lands into account, it is estimated that about 0.3 million tons of dry matter is produced per year in the Governorate.

One fifth of this biomass is "browse", i.e. 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 dwarf-shrubs on the range are not as palatable as grasses and herbs.

The contribution from "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.

Use of natural vegetation

In Yemen man has an impact on natural vegetation due to 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 and especially on the Rada' plains, this pressure may be very high, resulting in degradation of the range.

Three different grazing systems can

be identified in the Governorate. Continuous grazing is practised in the densely populated and cultivated areas and nowadays also in large parts of the areas with little cultivation. Farmers and settled bedouins send their children with the whole herd to graze in the surroundings of the village. Seasonal (fat)grazing is still being practised in the more arid areas in the northern and eastern extremes of the Governorate. Parts of the herds are sent away for several days or weeks to graze in areas with good grazing, often far away from the remaining family. Typical grazing areas are the desert fringes, while dry season grazing areas can be found in the narrow wadis, which are rich in trees. 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 it is necessary. In the Governorate most villages keep "mahjur" areas to be

grazed by sheep and goats of the village in the dry season only. In the most arid parts of the Governorate, bedouin tribes have the grazing rights over the rangelands and apply strict boundaries with adjacent tribes. It is reported that formerly areas of no-man's land were established between tribal lands, where nobody was allowed to graze his animals. These tribes apply systems of grazing that resemble rotational grazing. Depending upon the relation between livestock numbers and the area of rangeland owned by a tribe, the rangelands are grazed more or less intensively. This also depends upon the rainfall of the year and the wealth of the tribe, enabling them to purchase supplementary feed in the dry season.

The type of livestock is correlated with this difference in grazing system: mainly sheep and cows are kept in the cultivated area and goats and camels in the drier zones. Donkeys can be found anywhere.

The firewood trade 2.

Firewood is transported to a village on camelback.



4.3 Use of wood resources

Firewood is still the single most important source of energy in the Governorate and for many people the only source.

In the rural areas of Al Bayda less use is made of wood and more of dung and crop residues than in any other part of the country. This is remarkable considering the limited extent of cultivated land. However, the densely populated and cultiva-

ted areas outweigh the relatively unpopulated eastern and north western parts, where the more nomadic way of life practically excludes the use of energy sources other than firewood. Another striking aspect is that the percentage of people in the Governorate buying firewood is the highest in the country.

Most of the energy used in Yemeni households is used for cooking.

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 (which is still burning) is cleaned with a 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 use dung as their main fuel sometimes state the contrary.

People have a clear idea about the quality of firewood. Roughly three categories are distinguished:

- Top quality, with a price of over 1500 Rial per pick-up load or 3 Rial/kg for talh, and Qarat (*Acacia origena*, *A.pachyceras*, and *A.nilotica*),
- Medium quality, with a price of approximately 1000 Rial per pick-up load or 2 Rial/kg for suba and sidr (*Acacia mellifera* and *Ziziphus spina-christi*)
- Poor quality, these are usually not traded but will cost in the order of 1 Rial/kg.

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

Fuel wood collection and trade

In former times only dead wood of trees and shrubs was collected. With the increased population, improved transportation facilities and development of the money economy, firewood from trees has become an important commodity. However, we can distinguish different types of fuelwood collection. Firewood is obtained by:

- cutting whole trees and shrub
- pruning and lopping of trees
- uprooting or cutting of dwarf-shrubs

The cutting of whole trees and shrubs is a commercial activity.

The firewood trade 3.

The last of the caravans are used for firewood transport.



The firewood trade 4.

By a pick-up it is transported to a larger market.



The others are practised on a subsistence level.

The cutting of trees and their transportation to the market is nowadays an organized trade, with different people involved in:

- cutting and transportation to a distribution point or village market,
- collection at distribution points and transportation to main urban centres,
- distribution and retail in the main urban centres

In this trade fuelwood is collected in production areas and transported and distributed in the large urban centres of Rada', Dhamar and Sana'.

The fringes with the Eastern Desert are among the very few remaining production areas for fuelwood in the country. A large proportion of the relatively uninhabited areas of the Governorate are considered to be important production areas for the fuelwood trade. Despite the very low tree cover as a whole and despite the fact that the trees are rather small, the remaining trees growing along narrow wadi's are chopped down and transported.

The first transport is usually on camelback and most of the further transport is done with 4-wheel drive pick-ups and sometimes lorries and two-wheel drive pick-ups.

Transportation makes fuelwood expensive, thus the trade is very lucrative. The price of a pick-up load in the production area near Wadi Markhah is about 200 Rial (top quality), whereas at the local market centres nearby it costs roughly 400 Rial. At the Al Bayda market a price of about 800 Rial is asked, after twelve hours driving from the production area over a rough road (150 km). In the urban centres of Rada', Dhamar and Sana' the same pick-up load may yield 1000 to 1500 Rial. A trip on camelback of two days triples the price as well: 50-75 Rial in the source area to 150-250 Rial on the local market.

Pruning and lopping of growing trees takes place on trees that are

The firewood trade 5. Along the tarmac road firewood is stored and sold in large quantities.



generally privately owned or owned by the village. Severe penalties exist for cutting from these live trees. However, the dominant tree species sidr and talh in the densely populated areas can stand this treatment very well.

Dwarf-shrubs are collected either by uprooting or by cutting them at ground level (with the sickle, sharim). This collection of small firewood is entirely done by women. 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 dried. These days, the collection of firewood has a social stigma, since women of richer families can afford to buy fuelwood.

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. Some trade in this wood exists 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 had already been practised for many centuries on a small scale.

An example of the use of wood for other purposes is that of the *Draceana ombot*, a very conspicuous tree. It only still occurs in the most remote corners of the Governorate, e.g. not within a radius of 100 km around Rada' or Al Bayda towns. It has been intensively cut for the construction of beehives and used to be much more frequent. An interesting detail is that this plant is known to derive part of its water from fog. This

means in practice that in the immediate surroundings of the tree an extra amount of water is available to other plants as well. When such a tree is removed a drier environment is the result. *Dracaena ombet* occurs on the lists of the IUCN for endangered plant species.

4.4 Use of water resources

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

Over the centuries, different techniques have been developed to conserve and abstract the required water. Traditional means for water supply to people and cattle are shallow dug wells to abstract groundwater and cisterns to collect and store surface water. Until very recently, no power-driven pumps were being used, which means that groundwater was lifted to the surface by bucket-and-rope operated by people or animals.

Skilful water conservation techniques have been applied for time immemorial. They include run-off harvesting by hill-slope terracing in the western part of the province, or terraces in wadi beds, and - in olden times - many small dams. In these cases, water conservation and soil conservation are often combined.

The introduction of powered pumps during recent years has changed the picture substantially. It has caused an enormous increase in groundwater abstraction. By 1983/1984, approximately 1250 wells were present - most of them shallow wells - with pumped yields of 4-9 l/s. For the entire area a total abstraction of some 49 million cubic metres per year has been estimated. A major part is used for irrigation.

Urban water supply in the towns of Al Bayda and Rada' does not meet the current requirements; Al Bayda town has suffered from serious shortages of water during the last few years. Projects are being carried out currently to alleviate this problem.

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

Percentage of total energy input supplied by each fuel (Ferguson, 1988)

Area	wood	residues	dung	charcoal	kerosine	lpg	Total
Al Bayda rural	52	13	16	1	10	8	100
Al Bayda urban	55	1	7	3	6	28	100
YAR rural	64	10	6	1	10	8	100
YAR urban	51	2	3	7	12	26	100

Percentages of households in Al Bayda Governorate using, buying and/or collecting firewood (Ferguson, 1988)

Area	Use %	Buy %	Collect %
Al Bayda rural	97	79	53
Al Bayda urban	56	44	11
YAR rural	98	46	76
YAR urban	57	48	8

The firewood trade 6.

By trucks the firewood is transported to Dhamar, Sana' and other large towns.



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 Al Bayda 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 Al Bayda 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 23,400 farm holdings in Al Bayda Governorate extending

over 52,000 hectares of cultivated land. These represent 4.0% of all farm holdings and 3.9% of the country's cultivated land. The holding size varies around an average size of 2.2 hectares. Of the Governorate's total farm holdings 44% are less in size than one hectare, 46% between 1 and 5 hectare and 10% has an area that exceeds 5 hectare. The holding sizes in Al Bayda Governorate are larger than in Dhamar Governorate and smaller than in the Tihama. The holdings are commonly fragmented into numerous small plots. The average number of parcels per holding is 4.7 in Al Bayda Governorate. Small and fragmented farms are still characteristic for Yemeni agriculture in general.

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 these forms (>50% owned, >50% owned or not owned) represents a mixed tenancy.

Farm holdings in Al Bayda are predominantly operated under single land tenancy. More than 88% of the cultivated land area is totally owned, 1.8% is sharecropped and less than 0.1% is rented from waqf land. On the other hand mixed tenancy is not common; only 10% of the cultivated area is operated under this type of land tenancy.

Share cropping is more common for irrigated land than for rainfed lands in the Governorate. The landlord provides land and sometimes water. All other inputs are the responsibility of the tenant. If the landowner provided water, he receives 50% of the total produce, otherwise he gets only 25%. In

rainfed areas, the landowner's share is 1/3 of the total production. In this system sharecroppers do not have the means or the incentive to make renovations to increase the productivity of the land.

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.

5.2 Water rights

The system of water rights in Al Bayda 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 provide 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 ground water 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 ground water system remains common ownership.

Ground water 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.

Absolute and relative number and areas of farm holdings under two or more types of land tenure in Al Bayda 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	1858	292	50	2200
% of total	8.0	1.3	.2	
area (ha)	4977	255	38	5270
% of total	9.5	.5	0	10

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

Holdings	Owned	Sharecrop	Rented		total
			waqf	individuals	
number	20360	546	40	0	20946
% of total	88.0	2.4	.2	0	90.7
area (ha)	46204	953	15	0	47172
% of total	88.1	1.8	0	0	89.9
average holding size	2.27	1.75	.38		2.25

Though the demand for firewood is great, man did not yet completely destruct the bushland as here in the Wadi Markhah valley.



5.3 Incentives in agricultural production

Most of the agricultural land holdings are privately owned and cropped. However, for the Al Bayda farmer access to land is only one of the factors for cultivation. 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 are not 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 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 on groundwater and has given rise to lowering 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 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 in-

involved in the production of cash crops.

However a large part of the agricultural production in the Governorate still serves for home consumption. Al Bayda farmers 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. The use of tractors has also tremendously increased in the Governorate. Despite the small plot size, mechanization is rapidly being introduced, 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 cash-crops. Many farmers in Al Bayda Governorate are quite willing to finance the production of their own food with money from other sources, 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 a 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 less well-off farmers livestock provides a more important part of their income. This applies especially to sheep raising. 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 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 in the management of wood resources

The fuelwood that is consumed by families in the rural areas is largely collected locally. In the western part of the Governorate this fuelwood 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 fuelwood 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. For the Bedouin part of the population fuelwood collection as a commercial activity takes place on the areas they consider as theirs, by tradition or because of permission from another tribal authority. This activity has a rather devastating impact on the remainder of the trees on the rangelands in the north eastern and eastern part of the Governorate. Given the marginal subsistence of most of the Bedouin population, and the relatively loose attachment to the land they are harvesting fuelwood from, there is no incentive to protect the fuelwood resources from degradation.

5.6 Categories of resource users

From the previous descriptions it can be observed 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

- ce of cash in a more or less 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 agro-climatic zone in which they operate.

Mountain farmers

In the more humid mountain zones the claim on resources beyond the farm holding is relatively small. Their resource use can be described as nonthreatening for the resource base. Their livestock production is traditionally fairly small, also since rangelands in this area are relatively scarce.

Valley farmers

The valley farmers depend on small aquifers near wadis and small depressions that are not connected to the larger aquifer around Rada'. Their dependency on groundwater resources is not and will not be complete, given the scarcity of groundwater resources in their areas. The production of livestock is relatively important to these people and so is the condition of the range. They maintain a somewhat stable position vis a vis the

resources: It is almost impossible to make more efficient use of the resources that they have at their disposal than they do already. The groundwater to which they have gained or will gain access soon, 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. Livestock production is seen as a major part of the activities generating a more important part of the family budget. Their incentive for a wise use of the rangeland and fuelwood resources is relatively high and actions have been taken in this respect: so-called Mahjur areas are now set aside as forage reserves for dry season grazing.

Monetarized farmers

The monetarized farmers depend on the Governorate's largest aquifers near Rada'. 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 are thinking very much in terms of return on investment in future

The firewood trade 7.

Empoverished Bedu living from their small herds and the sale of firewood, they cut themselves.

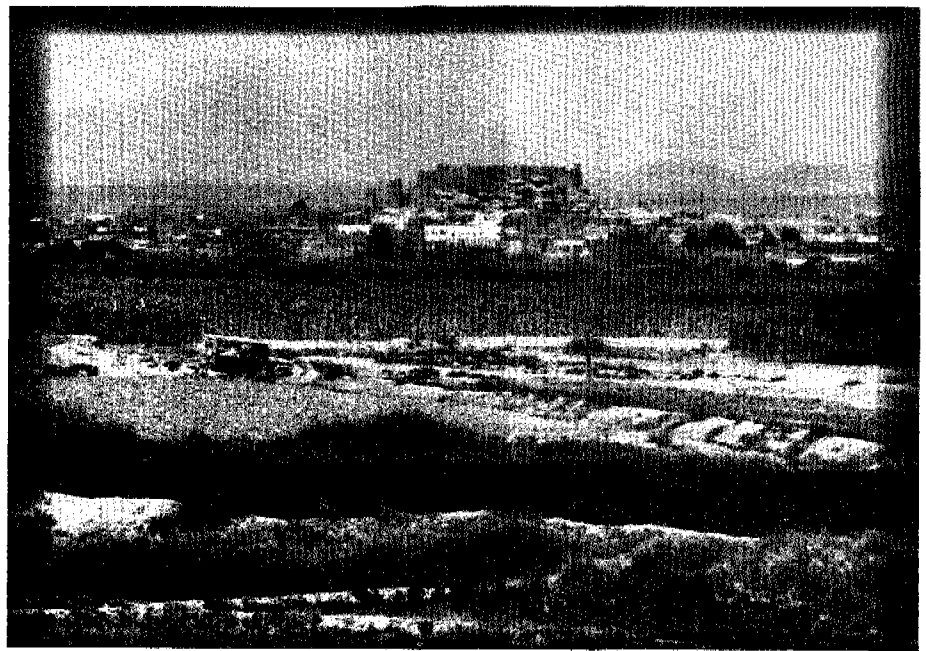


groundwater exploitation. In this sense their interest in diversification of their activities in agriculture or beyond is great. Much emphasis is given to the net return they will get from investments already made, e.g. preventing others from mining groundwater, denying land purchases to newcomers etc. The livestock of these farmers is fed largely from agricultural residues and fodder crops, since rangelands are scarce and already overcrowded. 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 fuelwood resources is relatively small and follows from the financial margins they have. The communal resources such as groundwater, range and pasture tend to be used as intensively as possible. Each farmer 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.

Bedouin

People without agricultural land holdings are numerous in the Governorate. Many of the semi-nomadic Bedouin have associated themselves with certain tribes to gain access to grazing and sometimes to agricultural lands. Other Bedouin tribes still roam the free areas that are found along the eastern fringes of the Governorate and in the Rub Al Khali. The resource use of these people is based on animal production and nowadays, for a small proportion of the family budget, on fuelwood collection. Labour is another source of income.

Their semi-permanent stay, the relatively small diversification in activities (animal production and firewood collection) and the fact that many of them live on a very marginal basis, has made them into resource users that will cut a tree when it can be sold, or graze a range whenever it can provide food to their livestock. In general, their right to grazing and water resources



On the Rada' plains cultivation is primarily a commercial activity. This is different in other areas of the Governorate.



Woman in Rada' dress. The urban consumers provide an important stimulus for market oriented agricultural production.

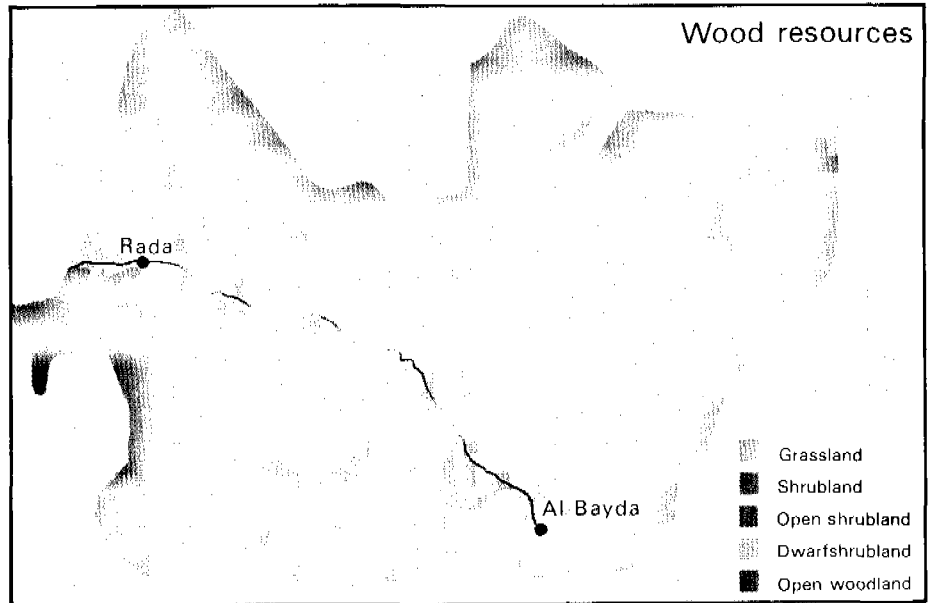
is much weaker than in the past and consequently they are permanently in competition with an expanding sedentary population.

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.

Overgrazing is only occurring on a large scale on the Rada' plains and around the larger towns.



The Al Quwwah valley, part of the Wadi Markhah catchment area.



6. Present state of natural resources

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

6.1 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.

It is thought that future agricultural development in the Governorate is situated rather in intensification than in increases of the cultivated acreage. From an environmental point of view this is a good development, since expansion of cultivation on more marginal lands will result in deterioration of the quality of the environment; it may cause more erosion and loss of natural vegetation.

There are only restricted zones in the province where enough soil material is available to allow for agricultural use, but the limits of water availability are more critical than the availability of suitable soils.

The increase in tractor ploughing is not so justified from an environmental point of view, because in drier soil this type of ploughing will increase exposure to wind and

thus soil erosion. Moreover, land holdings are often so fragmented and small in size that mechanization cannot be economically applied.

6.2 Fuelwood and forage resources

Only few trees can be found in most vegetation types occurring in the Governorate. Some natural circumstances explain this feature. At least at altitudes above 2400 m tree growth is limited due to the regular frosts. Secondly the aridity of the region does not support a dense tree cover.

The remaining trees in the cultivated areas of the Governorate 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. In the uncultivated areas a tremendous reduction in tree cover has been caused by fuelwood collection as a commercial activity over the last few years.

This is certainly very damaging to the water retention capacity of the rangelands and will therefore have a negative impact on the already very barren landscapes. 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.

In the Governorate severely degraded rangelands are found in the densely populated zones around Rada', often having been cultivated

formerly. 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, so that gravelly plains or rock outcrops remain.

6.3 Water resources

Water is far from abundant in Al Bayda Province. In this respect, several constraints and problems have been identified: the main ones can be described as follows:

- there are many zones *without appreciable water resources*, hence the development potential of these zones is limited;
- especially in the areas where rock from Precambrian age crops out, there are "*seasonal deficits of water*" (shallow and local aquifers, almost no surface storage) which limit the development potential;
- *over-exploitation of the main aquifers* is evident: this will create problems in the future (higher costs of water and drying-up of wells), unless the abstractions are controlled in time; given the relative scarcity of water and the steadily increasing water demands, *there is an increasing need for rational allocation of water*; finally, many of the Governorate's water resources are highly vulnerable from the point of view of *contamination*; the production of more and more waste as a consequence of modernizing consumption patterns calls for attention.

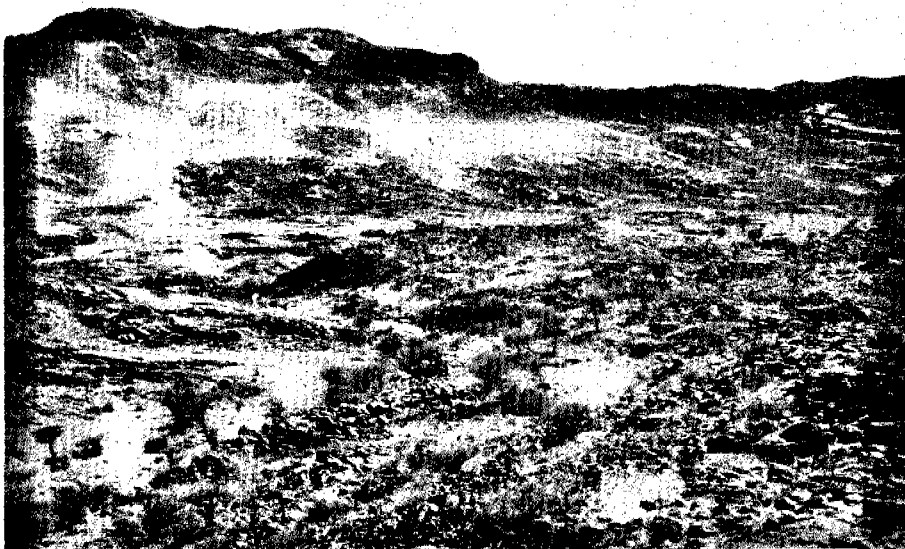
Ground water development has been generally carried out privately, and there is no control over its exploitation either from the national government or from local authorities.

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.



Al Bayda Governorate is still a source area for firewood to the country. However, this will not continue for long.

When soil material is formed in the Government it runs off with the rains. Soil erosion is an intensive but normal process in this climate. It also provides the cultivable soil material to the farmers in the valleys.



6.4 Land resources

It is rather clear from the previous sections that for both cultivated and non-cultivated lands there are problems. However, many people do manage the land resources at their disposal to the best of their abilities. Farms are very valuable holdings and their value is in fact only increasing with time. Parts of the 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 on the one hand the most arid and remote areas of the Governorate and on the other hand the Rada' plains. Here, the increase in well irrigation has led to an enormous increase in cultivated area, a shortage of firewood and forage and a breakdown 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.

Soil erosion in the Governorate is a normal process: in the arid climate, with its enormous changes in temperature over the day, weathering of rock takes place rapidly. On the other hand soil, the cutting of trees, the uprooting of dwarf-shrub and intensive grazing has increased soil erosion. The erosion gives rise to the formation of hammada surfaces, the desert pavement. These pavements at the same time protect the underlying soil material. However, 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 slowly deteriorating.

Soil conservation on cultivated lands can be considered a specialty of the Yemeni farmer. The degree to which newly formed soil is trapped behind terraces on a scale as also seen in Al Bayda Governorate, is quite unmatched in the world.

7. Conservation

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

The Yemen Arab Republic is 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 further diversification of habitats and the introduction of new (exotic) species.

In the Yemen the Holarctic and Palearctic Regions meet. Generally speaking the Saharo-Arabian (Holarctic) and Sudanian species (Palearctic) dominate in Al Bayda Governorate. Irano-Turanian elements (Holarctic) are found along the eastern border.



Dracaena ombet is an endangered species. In remote places in the Governorate still some specimen can be found.

7.2 Flora and fauna

The vegetation in the Governorate is used by man for fuelwood and as ranges for his or her livestock. The vegetation types that are found these days are largely introduced by man. Despite the fact that population densities are relatively low for Yemen, every corner of the area is well accessible to fuelwood collectors and grazing animals. Thus, virtually no places

remain where the vegetation has not been influenced by man: the vegetation that is found currently is not "natural".

How would the Governorate look without the presence of man? Unfortunately, for Al Bayda Governorate no documentation was accessible to the team. For other parts of Yemen, it is obvious that large trees which are a rarity in Yemen

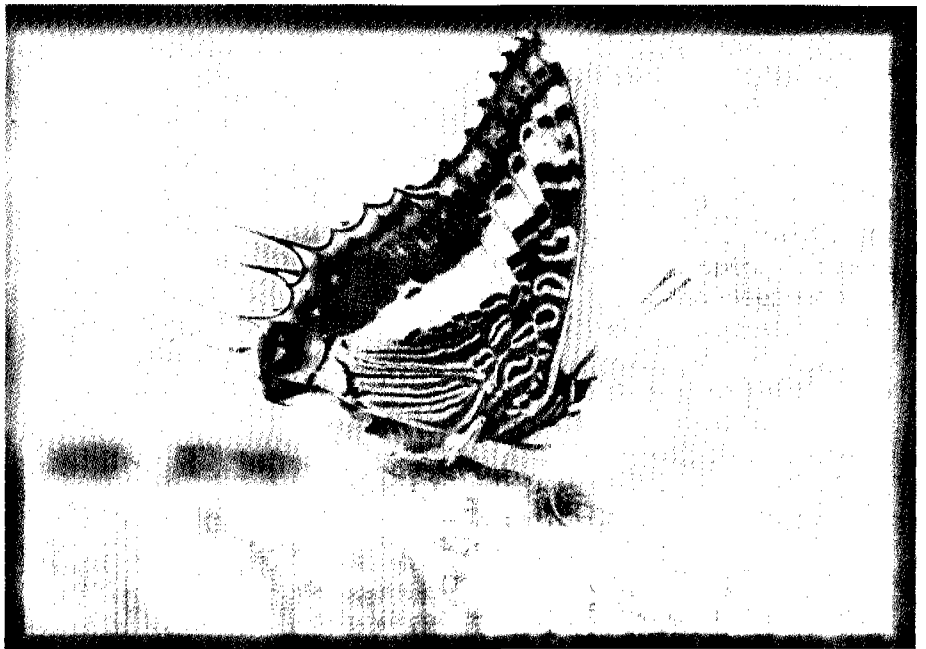
now, were rather general some centuries ago. Enormous tree trunks are still found in the older houses in Rada'.

The highlands themselves will have supported many small trees, together a woodland, but presumably still very open. Of course, rock outcrops and steep slopes presumably were as bare as they are these days.

It is estimated that the actual tree cover is only a thousandst of what it could be without man and live-stock.

Draceana ombet, the tree used for making beehives, is mentioned in the IUCN Nature Conservation Red Book as threatened with extinction. In the remote corners of the Governorate a few specimens can still be found.

With respect to the fauna of the Governorate only a fragmented and incomplete picture can be presented, because the only information on the subject which is available specifically for Al Bayda Governorate was collected during the brief fieldtrip in October 1988 of the Environmental Profile team. 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

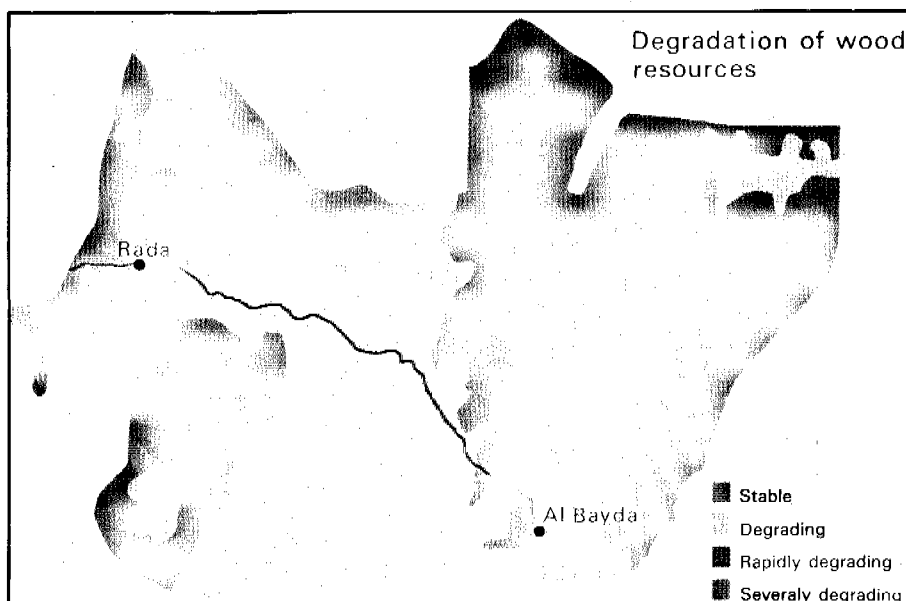


Arid and harsh is the Governorate but always very beautiful as this butterfly

Gazelle (*G. Gazella*) were still abundant till 15 years ago. No evidence of present occurrence was found. 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 striped hyaena, the wolf, 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. Hints were given that a few Arabian leopards and caracals may still be present in the Governorate, although no conclusive evidence was obtained. No data for the Governorate are available for other mammals. However, the Arabian hare can still be considered a common mammal.

Except for the Marib area, no ornithological data have ever been collected in the eastern 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 Al Bayda. The almost complete disappearance of the last remnants of larger mammals in even the relatively uninhabited areas of Al Bayda indicate that the need for conservation of what is left is extremely high for this area, because in many respects the Al Bayda area is one of the last pockets on the Peninsula where this wildlife occurs or could occur.

7.3 Patterns of change

Al Bayda Governorate harboured a population of large wild herbivores and carnivores. Nowadays virtually nothing remains; during the last twenty years 4-wheel drive vehicles and automatic weapons have had a disastrous effect. However, the Ibex populations already disappeared a long time ago. This indicates that the natural resources in Al Bayda Governorate have been used intensively for a long time. Nevertheless due to the relatively small human population, wildlife existed in the Governorate much longer than it did in most other areas in the Yemen.

In this area there are still possibilities for reintroduction of species that have disappeared, while in most other locations in the Yemen the habitats for wildlife no longer exist.

There is as yet no apparent interest of the population of the Governorate to support conservation measures.

7.4 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.

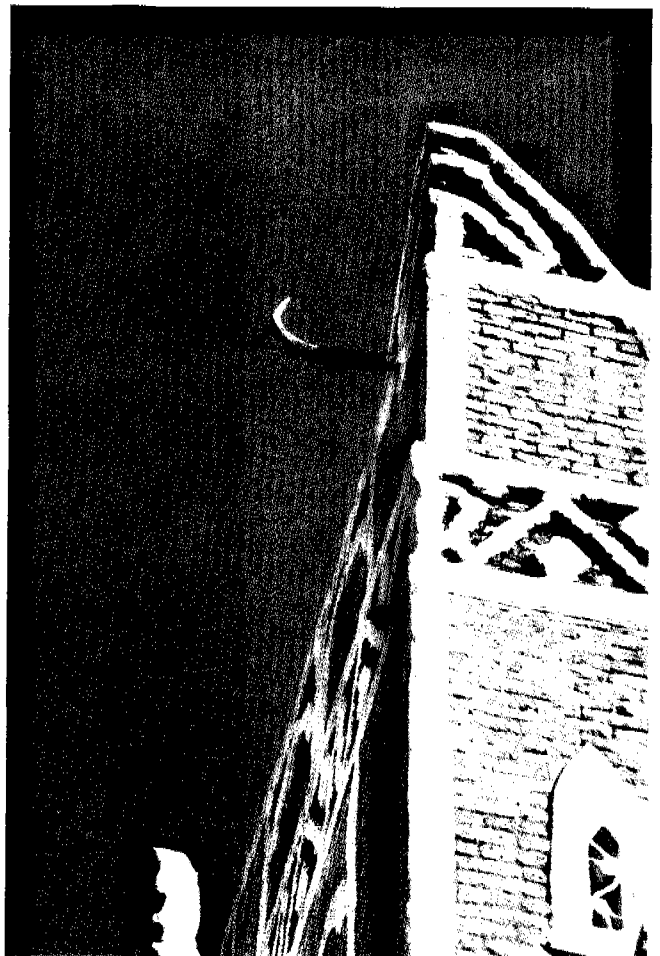
Conservation in the Yemen could be pursued through three lines of action:

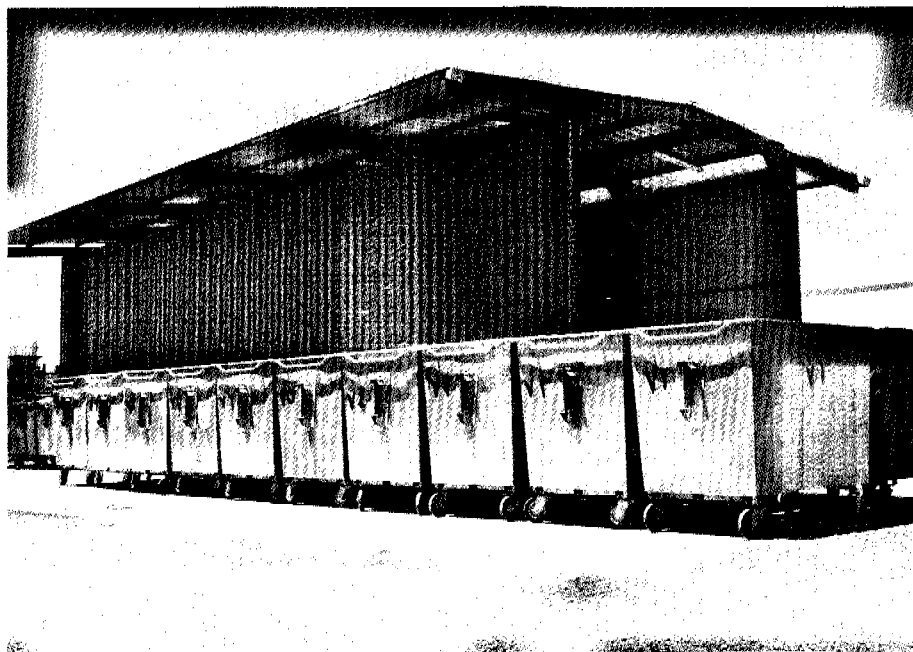
- Organism protection. This requires amongst other things, law enforcement on hunting of animals and gathering of plant species. It should also include habitat rules for trade such as are enforced now with respect to the importation of Rhinoceros horns.
- Habitat conservation. This should include area 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 general awareness of the general public.

Long-term wildlife conservation can only be achieved with the people's consent and support. 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.

Horn of the Ibex on the corner of Sana' high rise traditional buildings. A symbol of peace for the house, and one of the reasons that the Ibex is extinct in the Yemen since a generation.

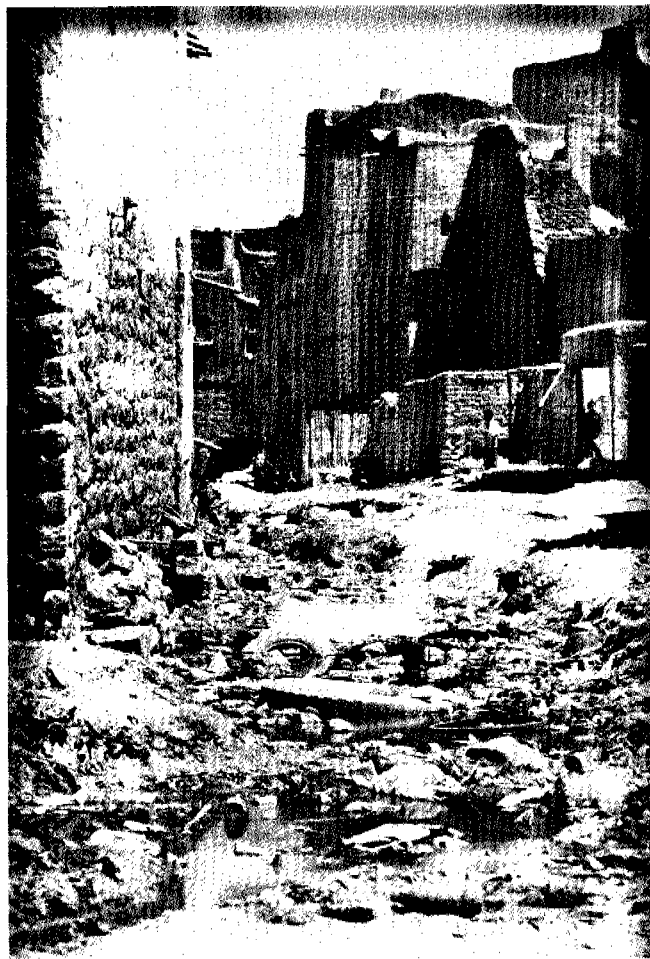




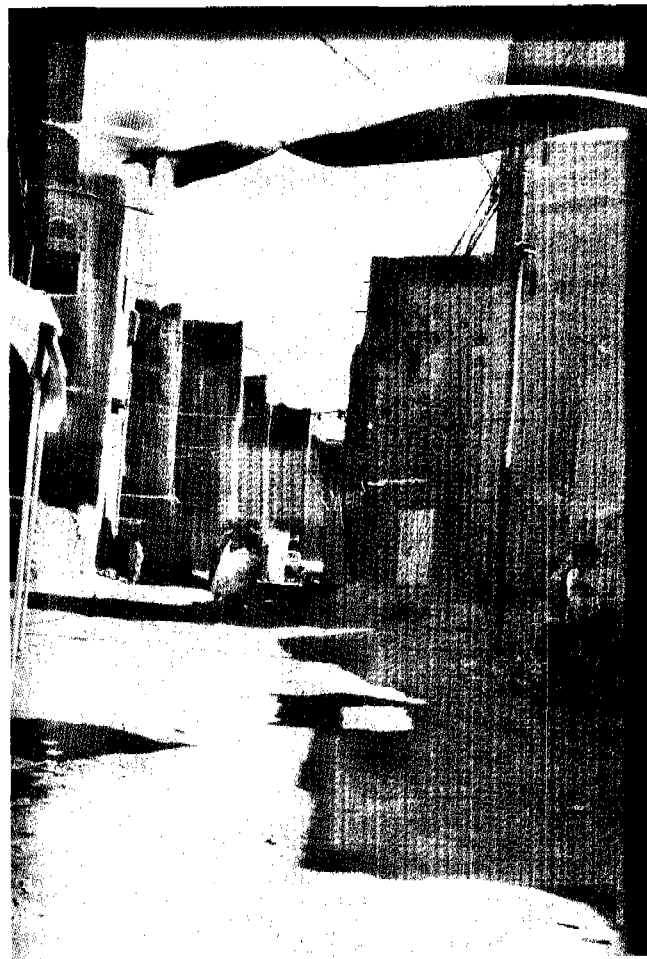
Waste collection is a new activity in the Yemen as can be observed from these brand new bins in Rada'.

In Al Bayda town the very rocky substrate makes it extremely difficult and expensive to construct water supply and sewerage systems.

Streets in the centre of Rada' may look like this...



... or like this when the dirt is removed regularly.



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 wellbeing 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 mosquitoes.

The main urban centres in Al Bayda governorate are the cities of Rada' and Al Bayda. The population in 1986 of these small towns was:

- Rada' 21 641
- Al Bayda 11 920

Population growth of these towns is high. For Al Bayda for instance, the population increased by 6.8 % per year over the last decade. Both urban centres suffer from inadequate water supply, pollution by solid waste and lack of waste water treatment.

Improvement of sanitation in rural communities is urgently needed. 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. In urban centres, many people are still exposed to infectious diseases related to poor sanitation. Apart from institutional constraints, the supply of medicine to remote areas is often irregular and unreliable.

The nutritional status of young children is, in general, sub-optimal. A National Nutrition Survey, carried out in 1979, indicated that only 33 % of rural children between three and 60 months of age could be classified as nutritionally healthy. Anaemia was found in 56 % of the sampled population, rickets in 11%. Although exact figures are not available, certain vitamin deficiencies may also contribute to the poor nutritional status of children. These findings are supported by recent mortality figures of the Ministry of Health, indicating an

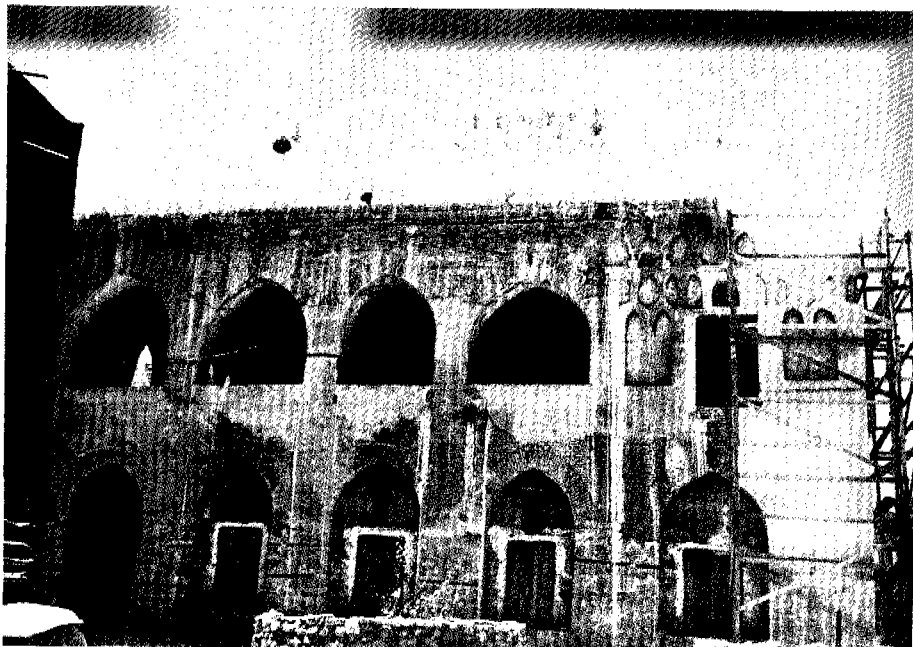
Infant Mortality Rate (birth-12 months) of 160 per 1000 and a Child Mortality Rate (13 - 60 months) of 50 per 1000. These rates are among the highest in the world. Although statistics on the cause of death and incidence of disease are not very reliable, it is generally accepted that poor nutritional status and infectious diseases such as gastro-enteritis, measles, pneumonia, intestinal parasites, malaria, anaemia and respiratory tract infections including whooping cough 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 Urban Hydrology

An essential element in the hydrological cycle of modern urban areas is that the natural drainage system is altered and impeded by constructions and sewerage. This results in flooding and pollution, problems which can be partly alle-

Since some years, the restoration of the Rada' mosque is underway.



viated by technical solutions: storm sewers, detention ponds, septic tanks, treatment plants, garbage collection. Water supply is initially cheaply provided by local surface and groundwater resources. But as population increases and towns expand, more costly solutions are required. Both the tapping of water and the disposal of wastes extends beyond the urban areas. Four major hydrological problems are encountered:

- adequate supply of good quality water;
- flood prevention;
- disposal of wastes without impairing the quality of local water resources;
- changes in the urban microclimate, including impacts on public health and urban flora and fauna.

8.3 Environmental problems of Rada' and Al Bayda towns

Rada' is larger and even more fast growing than Al Bayda. Below some of the environmental problems of Rada' are described. The same problems on a smaller scale exist in Al Bayda, with the extra problem that the very rocky ground on which the town is built makes the construction of an infrastructure for water supply or a sewerage system much more expensive.

Water supply in Rada' is threatened by rapidly increasing demands, in particular for agricultural uses in the periphery of the town. In fact 60 to 90 wells are available for public water supply whereas about 6000 wells are currently in use for agricultural production. The rapid increase in the number of wells has led to a considerable lowering of the ground water table, a common feature in many parts of the country. Also the quality of the water has dropped considerably during the last five years. Salinity levels have increased from 1000 to 2500 ms/cm, making it non-potable according to international standards. Groundwater is also increasingly being polluted. Both aquifers, the first situated at 10-15 m, the second at 60-200 m, are polluted to a certain extent.

Some wells in Rada can no longer be used because of salinity and pollution, others are falling dry. Rehabilitation of Rada's water supply would require tapping of water resources in mountainous areas away from town pollutants. Total costs for connecting 7500 houses would amount to \pm 65 million Rial. Users will have to pay a contribution, for which purpose a progressive system has been designed: the first 10 cubic meters at reasonable charges, with a 25% rise for each additional cubic meter. Water use has been taken at 50 litres per person per day for all purposes. One quality standard will be maintained. Most people already pay for water. For instance, a cubic meter price of Rial 10/ cubic meter is currently being paid for water provided by water trucks.

Improvement of surface drainage and the construction of structures for flood protection has a high priority in Rada'. Storm water flows in obstructed channels and large amounts of solid waste fill these channels and accumulate in depressions.

The situation has worsened mainly because of road and building constructions obstructing existing drainage channels. After heavy rains, floods threaten the lower parts of the old town. In April 1988, a major flood swept the town, causing many traditional houses and buildings to collapse, weakening the basements of other buildings and killing two people. In some places floodwater reached a depth of 1.5 m. Improvement of surface drainage and flood protection are urgently needed if the old town is to be saved and the living environment of its people is to be maintained at an acceptable level. Rehabilitation of the traditional sewerage systems is no option. Considering the quantities of waste and the degree of disruption of the old drainage system, more permanent solutions will be required. Closed culverts are to be avoided, as these will be quickly obstructed by accumulated waste material, silt and sand from dirt roads etc. The best solution seems a combination

of reprofiling and surfacing (asphalting, cementing or tiling) of roads, construction of v-shaped side ditches and two storm water ponds. In this way road surface drainage will greatly improve and ditches and ponds can be easily cleaned. A total of 75 km of road needs to be upgraded.

The population of Rada will increase from 30,000 at present to 50,000 in 1995. Also the use of plastic bottles and bags, tins and other modern packing materials is still dramatically increasing. Until recently, no proper garbage collection system existed and tremendous amounts of trash littered most streets. In 1988 a crash programme for cleaning the city of solid waste was performed. In this campaign 2000 tons of solid waste (4000 to 5000 cubic meters) were collected. Available equipment includes containers, compacter trucks, vacuum and dipper trucks and a shovel. In addition, dumping sites have been selected and teams of sweepers regularly clean the streets. Garbage is collected once a day or 2 or 3 times a week, depending on the collecting site. Chemical waste (hospitals, garages) and liquid waste is collected and treated separately.

The contribution paid for water supply includes an amount for waste water treatment. Although up till now no tariffs have been set for solid waste collection and disposal, some additional charge is added to electricity bills for this purpose. Also, shopkeepers renewing their licences are asked to pay a contribution.

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 of the resource base in Al Bayda 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 all natural resources of the Governorate, some are reversible, some are permanently degraded or changed since centuries. The situation around groundwater resources in particular in the Rada' district may be called rather alarming both for urban and agricultural development. The following statements indicate the conditions for a more sustainable development in Al Bayda Governorate.

9.1 Sustainable development

The "World Commission on Environment and Development (1987)" of the UN has 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 Al Bayda Governorate it means that man in requiring an enduring good quality of life has to formulate and enforce rules and regulations in order to prevent further degradation of the environment, which is not only a threat to future generations but already to the present one.

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 still very high and the nutritional status of children is often rather 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 secondary or maybe even 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

The present health and educational services do not yet meet the needs of the population. **Improvement of the geographical distribution and level of services will strengthen the basis for a more sustainable development.**

Environmental health

Child mortality is high and the nutritional status of children is rather poor. Health in the towns and villages is threatened by heaps of waste. **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.**

Diversification of economy

There are many indications for the rapid economic development of the Yemen Arab Republic. Wage remit-



Yemen coffee on the Al Bayda suq.

tances and the own economy are a driving force 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 urban development is only partly triggered by economic development. Many young people come to the towns, hoping to built up a new life, but become disappointed, since the opportunity for jobs is still not good enough. The presence of people that do not participate in economic growth adds to the problems of the towns. However, these people left their rural environment since their are no jobs either; there is no way back to

them. **Emphasis on economic diversification is important, not only for urban development, but indirectly maybe even more for agricultural development.**

9.3 Changes in resource use and management

Agricultural land use

Agricultural development in Al Bayda Governorate depends for an important part 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 monitoring of the groundwater resources itself.**

The migration of labour towards the large towns outside the Governorate and abroad is maybe not as intensive as in the beginning of the 1980's, but will continue to create

problems in keeping the agricultural production at the required level. The measures in prohibiting importation of fruits and vegetables may well have created an important stimulans in agricultural production and maybe even in 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. There is a risk of further overgrazing if this integration is loosened.

In land use planning with respect to livestock production the role of nomadic livestock is of importance. The nomadic lifestyle offers still a most versalile livestock production system, since even far outlying ran-

The accessibility of the Governorate is much improved, but travelling off the tarmac road is never easy.



glands can be exploited when there is forage and water.

On the long term however, there is not much hope that a nomadic lifestyle can be maintained, when the dry season rangelands are exploited by sedentary livestock.

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

Fuelwood is already a scarce and expensive commodity in the Governorate. It will become more scarce eventually. Currently, the Governorate is still an exporting area of fuelwood, but it is likely that the low degree of self-sufficiency will even further decline. The exports will not continue for more than 5 years, when deforestation continues at the present rate. Energy requirements of urban people in the Governorate and beyond will increasingly be fulfilled by use of other fuels for cooking as gas and electricity. **The government can assist in stimulating 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

It is important to set aside areas for wildlife conservation, while there is still room for them in the Governorate. The possibilities for nature reserves in the departments of Maswarah and At Tuffah need to be investigated. **Legislation concerning wildlife conservation must be established urgently.**

Groundwater resources

The groundwater is the fundament for both agricultural and urban development of the Governorate. Traditionally the "upstream first" rule is respected in spate irrigation. For groundwater abstraction and protection there are no generally ac-



In the more densely populated areas of the Governorate it is very clear that soil and (ground)-water resources are not enough to supply its inhabitants on a sustainable way with water, food, firewood, etc.

cepted principles or measures yet for control; under past conditions there was little need for them but under present conditions they become extremely urgent. **Issues for the management of Al Bayda Governorate's groundwater are:**

- reduction of water losses by improvement of the conveyance and farm irrigation efficiencies,
- control of groundwater abstraction rates and optimization of the spatial abstraction pattern, with the objective to stop the ongoing over-exploitation of the main aquifers. Serious problems will arise unless the abstractions are controlled in due time,
- conjunctive management of groundwater and surface water resources,
- rational allocation of the scarce resources among the water users (including the planning for long term domestic water supply)
- protection of the aquifers against pollution, since many are highly vulnerable for contamination.

The experience gained by the studies carried out in the last decades has greatly contributed to the development of thinking on the role of water in Al Bayda Governorate development and how to deal with it. Among others, it

has revealed the importance of an integrated approach to water resources, including non-technical aspects as well as technical ones, and it has highlighted the need for sufficient and reliable basic information on all relevant aspects.

Lack of an overall water resources management strategy prevents that the water resources problems as indicated above are systematically taken care of. Preparing a regional master plan for water resources development and management may be of great help to promote proper use of the area's water resources and to avoid excessive problems in the future.

Al Bayda Governorate is an area with potential for nature conservation.



The comparison between the negative impact of the use of man on soils on the communally owned lands and groundwater resources is of course not too lightly made. However, the process of degradation of groundwater resources in such a comparison is very rapid and serious on the short term, while soil conservation on the communally owned lands is important on the long term.

9.4 Implementation of environmental policies

Legislative aspects

Coherent laws and regulations, their implementation and particularly their enforcement are absent 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 environment as in the past. At a local scale, however, 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 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 central and provincial government controlled activities,**
- **use of existing traditional administrative structures at the local level.**

- **the responsibilities for environmental management have to be made clear at all levels of administration. Each ministry has to recognize its own responsibilities towards their activities that have or may have consequences for the environment.**

Conflicting objectives

There is of course a conflict between short term commercial opportunities and sustainable use of the environment. The government is the only body who 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 on 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 acuminated 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 Constraints for Urban environment

The rapid increase of urban populations and the introduction of modern technologies, combined with a lack in 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, provided 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 exhaust 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 cause 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 should be available 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 supply the missing information. This should result in a suitable monitoring system.**

A better insight is needed in 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.

Research on the possibilities for nature conservation should be looked into urgently.

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 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.

The population in Al Bayda Governorate is growing rapidly. If the population continues to grow at the present rate the Governorate will contain near 500,000 inhabitants by the year 2000, instead of the 296,000 registered in 1986.

Al Bayda Governorate is largely located on a highland plateau, consisting of not very steep mountains and dissected by wadis. Most of these wadis drain their water to outside the Governorate. Rainfall is relatively little compared to other parts of the country and only in the highest southwestern parts rained cultivation is possible. In all other aricultural areas use is made of wadi water, run-off water and groundwater for cultivation. The groundwater under the Rada' Plains and along the border in the southeast has permitted the recent development of well-irrigated cultivation. The groundwater is used so intensively now that this deve-

lopment may not be sustainable in view of the already quickly lowering groundwater tables.

The remote zones of the Governorate still serve as firewood production areas. The firewood trade is also a very important source of income for many of the impoverished Bedu and others in these areas. The natural regrowth of the firewood trees is slow and not in any balance with the speed of firewood cutting. If the process continues at the current rate, Al Bayda will have lost its wood resources completely.

Al Bayda has a high potential for game reserves, etc. given the low population density, the remoteness of many areas and the still existing natural habitats. Wildlife existed in the Governorate much longer than it did elsewhere in the Yemen. However, the population as yet does not support conservation measures. Environmental education is very important in this respect as well as with respect to other problems of modern life.

Within few years from now, there will not be enough firewood left in the Governorate to maintain these last of the caravans.



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12. Colophon

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