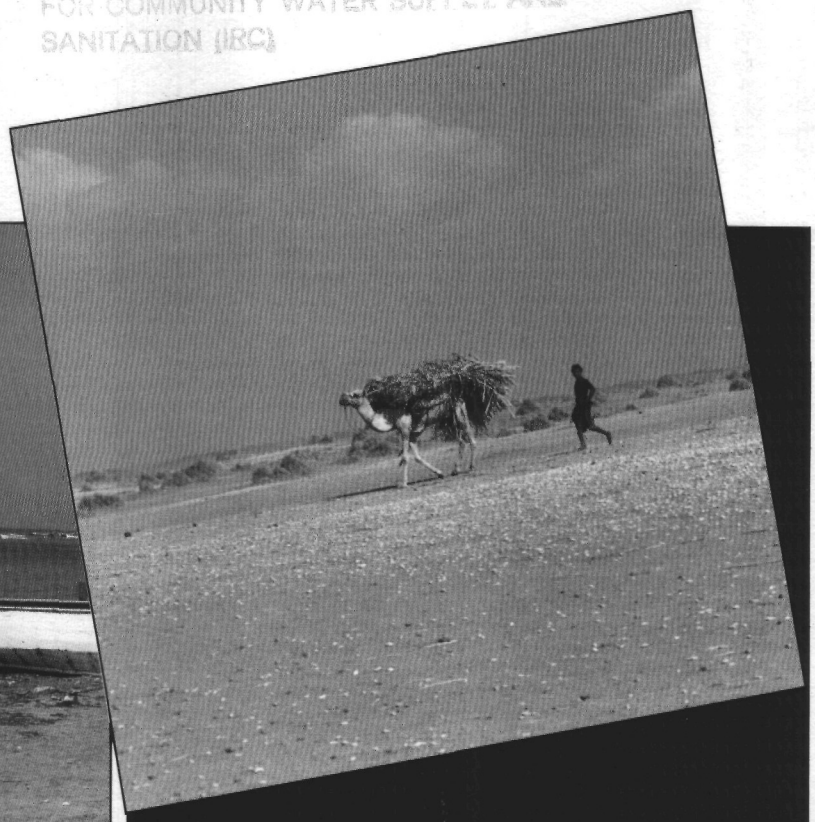
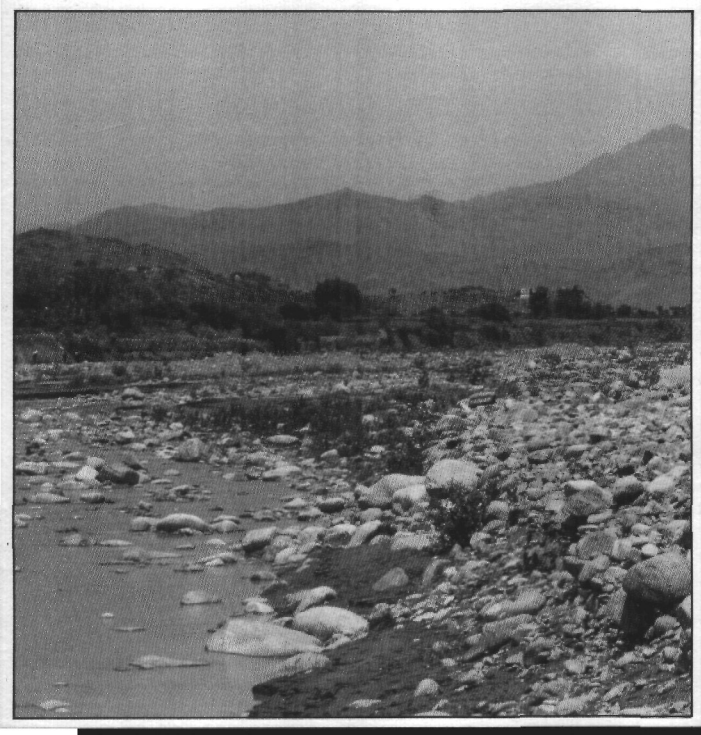
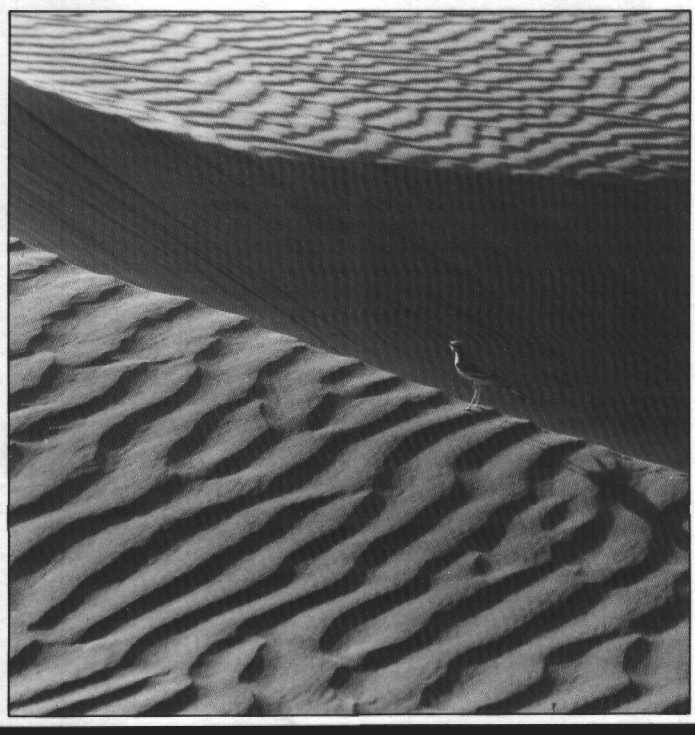
Environmental Profile Tihama



Yemen Arab Republic





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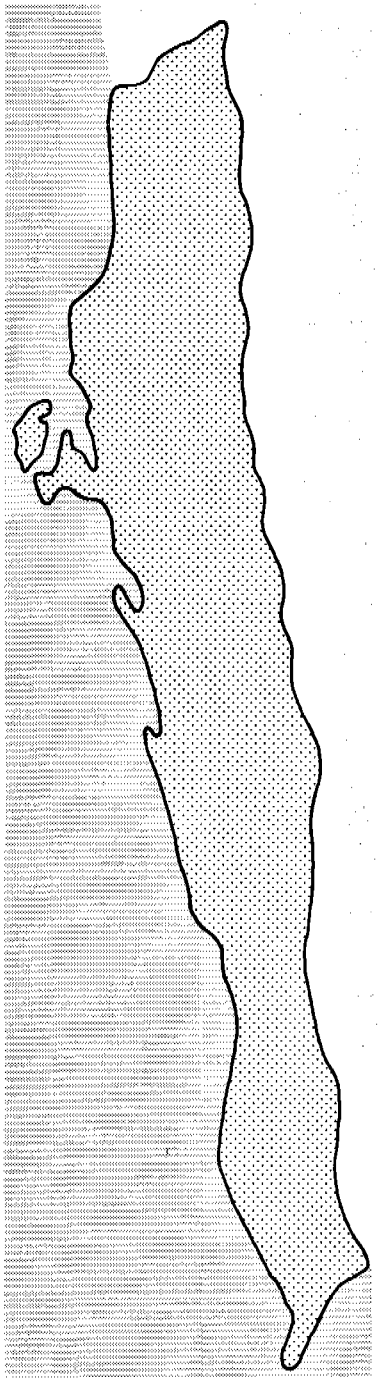
and Municipalities



Evironmental Profile Tihama

Yemen Arab Republic

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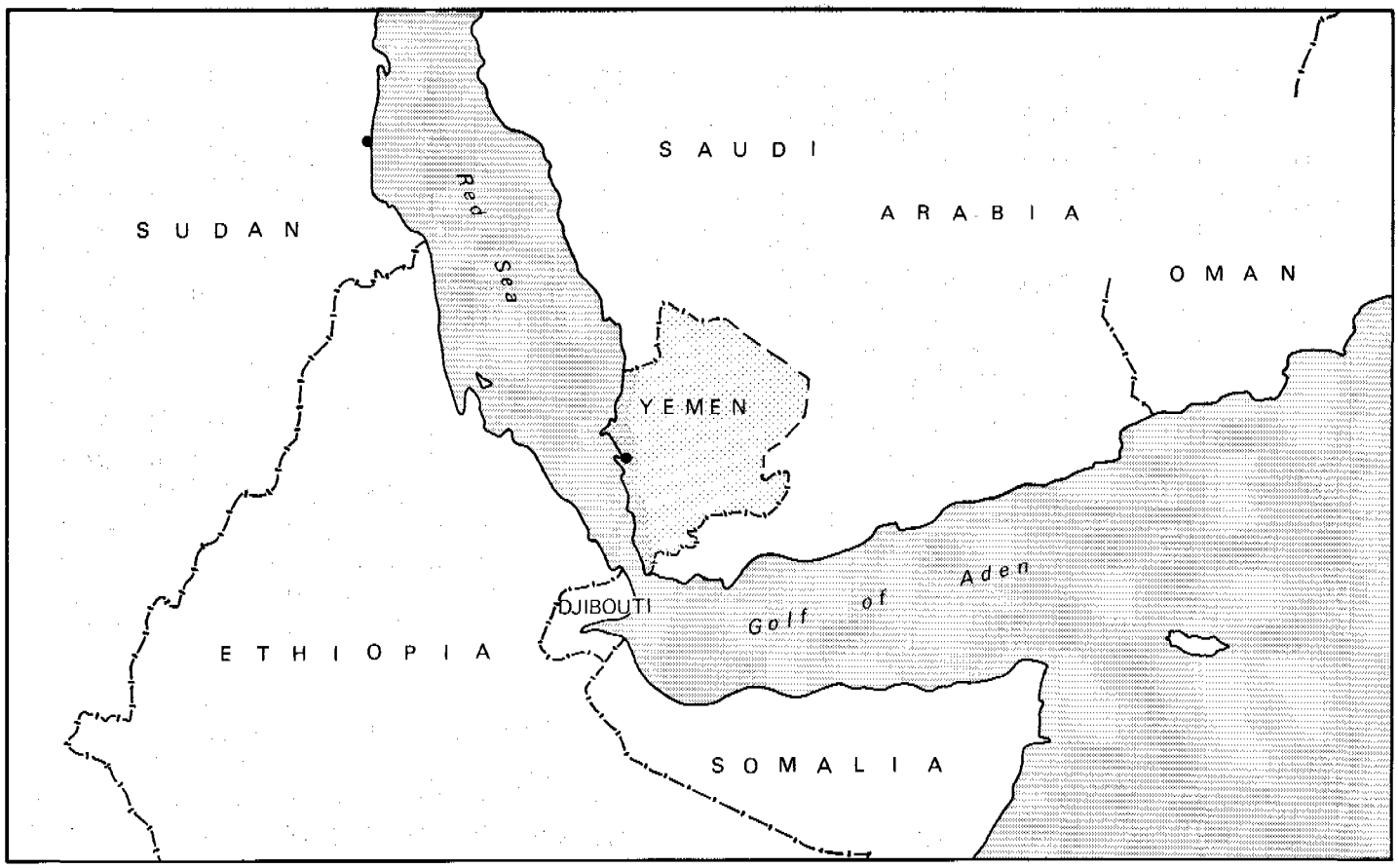


The Tihama in the Yemen Arab Republic in the Middle East

Tihama kadi on his farm

Doum palms on the Red Sea shore

1. Introduction

1.1 Scope/Objective

This Environmental Profile describes the environment of the coastal plain, the Tihama, of 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 the Tihama 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 the Tihama 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 Tihama.

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 Tihama 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 and authorities, both modern 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 for studying the vast area that the Tihama covers, was satellite imagery.

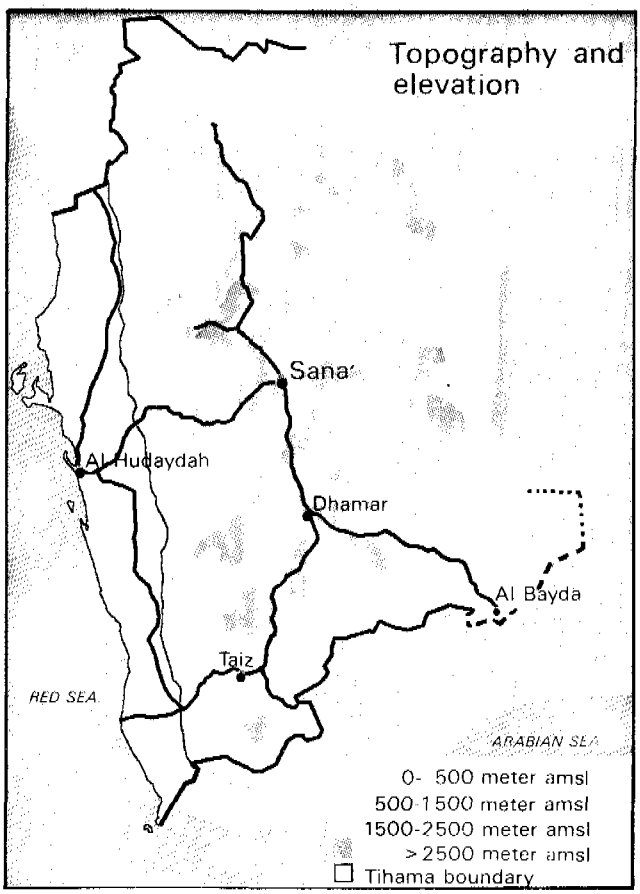
Due to the limited availability and reliability of environmental information, and the very little time available for the preparation of the Profile, many shortcomings may be apparent when reading it. This should lead to the conclusion that more attention to the subject is necessary in future.

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 provided the framework in which these activities were carried out. They were carrried out by specialists from the University of Sana', the Agricultural Research Authority in Yemen, the Research Institute for Nature Management, the TNO Institute of Applied Geoscience and DHV Consultants from the Netherlands.

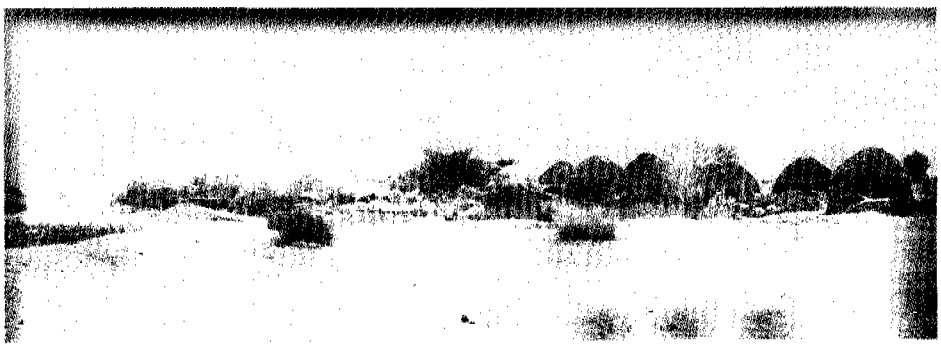
During the study, a seminar was held in Sana' at which team members held a presentation in front of the authorities concerned. A number of statements were presented and discussed on this occasion, which are reflected in the concluding chapter of this Profile

1.3 One of a series

This Environmental Profile is one of a series of three. The other Volumes of this series discuss the environment and environmental problems in, respectively, Dhamar Governorate and Al Bayda Governorate. 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 in which the country can be divided. These zones have a north-south orientation. The zones 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.



Luhayya mosque



Tihama village with round huts

2. Setting

2.1 History

The Tihama is an area of great historical importance to the Yemen. It was visited by many medieval scientists, especially during the Yemen Golden Age, in the reign of the Rasulid Sultans (13th to 16th century). This long period of Rasulid control of the Tihama and southern Yemen, lasting more than two centuries, was without doubt the most brilliant in the early and medieval history of the Yemen. The town of Zabid was one of the great intellectual centres of the world in that period and many religious, astronomical, mathematical and other subjects were studied. In this town, the basis for modern Algebra was developed. Attention was also paid in this period to the study of agriculture and nature, though it was not a subject of major interest.

The Tihama played a role in many earlier civilisations as well. The sea trade between Egypt and India was already visiting ports in the Tihama as early as 100 A.D., during the reign of the Himyarite kings. Following the opening of this and other sea routes, much of the impetus behind the caravan routes and the famous civilizations (such as Saba' with its Queen of Sheba and Qataban) along the border of the Eastern Desert (based on caravan routes and the incense trade) was transferred to the Tihama. In the 16th century, the Ottoman occupation of Yemen started in the Tihama. Some years after the assumption of power by Imam Yahya in 1904, the Turks had to accept a division of power and the Imamate gained complete control over the territory of the Yemen Arab Republic by 1918.

Even the Dutch have an historical connection with the Tihama. The old port of Al Mukhah, in the south of the Tihama, is nowadays a very quiet place, but during the seventeenth century it used to be the principal port for South Arabia. The Netherlands East Indies Company established a "factorij" in Al Mukhah in 1621. The Company, which was extremely powerful at that time, traded in Al Mukhah between 1614 and 1716. However,the trade focused on coffee and was not very profitable. The Dutch word for coffee, "mokka", comes from this harbour.

During the Imamate, Yemen remained isolated while the world changed rapidly. The isolation ended with the proclamation of the Yemen Arab Republic on September 26, 1962. This heralded a period of change in the Yemen which is quite unmatched elsewhere in the world: From a country which, in the 1960s, had virtually no cars or even tracks suitable for cars, to one having a network of tarmac and secondary roads and many thousands of cars. No industries developed in Yemen until after the Revolution, and no modern medicine was practiced. Now there is an infrastructure of hospitals and dispensaries. No modern legal framework existed at the time of the Revolution. It was developed since then.

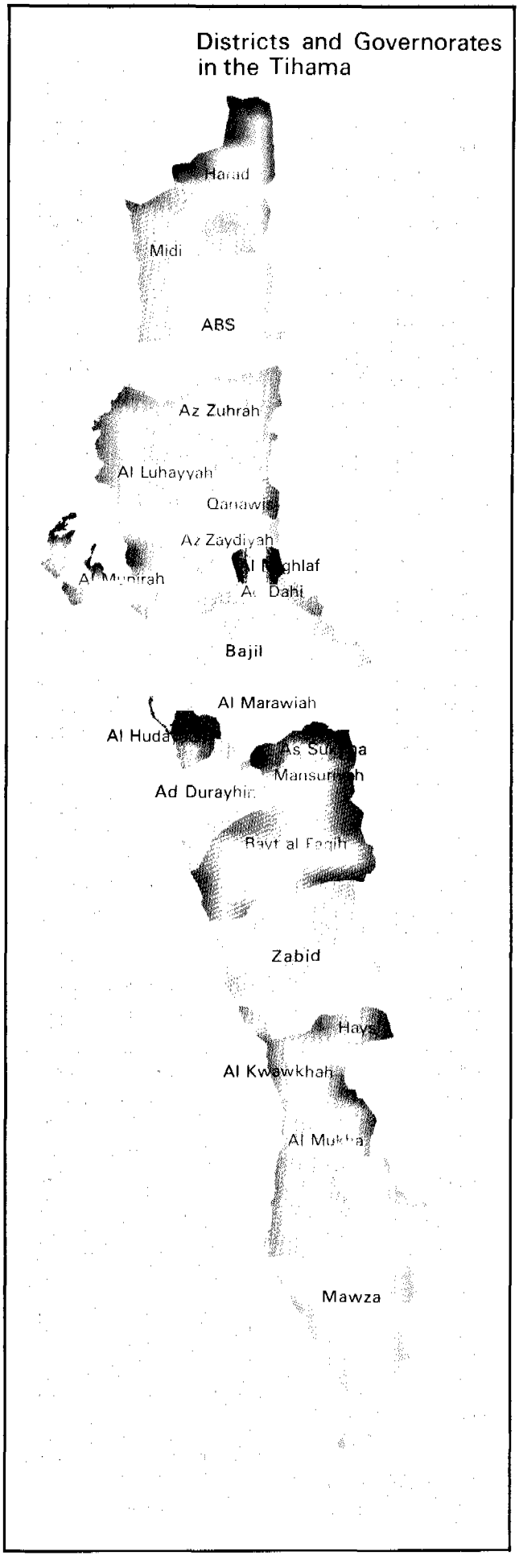
These changes have also had an impact on the environment, although rather less than one would expect, given the pace of modernization. The reason for this is that the human occupation of the Tihama as well as Yemen in general, has been rather intensive since times immemorial, which is quite different from the situation in, for example many African countries. Most long term impacts of human occupation on the environment took place centuries ago. Agricultural land had been developed since medieval times on quite a large scale and there has been intensive use of forest resources and wildlife for centuries. What happens to the actual agricultural, hydrological and other resources and the remainder of tree and wildlife resources is the subject of this Profile.

2.2 Topography and landscape

Some say that the African Sahel ends at the foothills of the Yemen mountain belt. Of course, both in terms of culture and resources the situation is quite different, though in some respects, there are similarities. The flat expanse of the dry rangelands of the Tihama is dissected by wadis along which agricultural lands and villages are situated. Many of these villages consist of round grass-roofed huts.

The Tihama is bordered on the west by the Red Sea. In the east, the natural border consists of the foothills of the Mountain Belt. This mountain belt rises to 3660 meters above sea level within a distance of 50 km from the beginning of the foothills (at roughly 400 meters above sea level). Very large wadis flow into the Tihama from the mountains. These wadis channel most of the water for agriculture in the Tihama, in the form of ground water or by surface flow. A wadi is a stream bed, which is dry for most of the time, but through which, sometimes, very large floods are drained. These wadis hardly ever reach the sea. Important agricultural areas in the Tihama are found in or near these wadi beds. Between the wadis, there are vast rangelands with sand or silt dunes or sometimes stony surfaces. When rainfall is sufficient, the dunes are also used for cultivation. This occurs in the eastern part of the Tihama which also has a denser tree cover. In seventeenth century travel descriptions, these trees are even described as rather dense forests.

The landscape itself is relatively young and is formed by the continuous flow of sediments from the mountains. Along the coast, Red Sea currents deposit material at some locations and erode the coast at others.



In a west to east cross-section of the Tihama the overall slope of the terrain increases from 0% near the coast to about 2 % over the eastern part.

The main port of Yemen is Al Hudaydah, which is also the capital of the Al Hudaydah Governorate that covers the largest part of the Tihama. There is substantial industrial activity in the town. Al Hudaydah is, together with Sana' and Taiz, one of the three large towns in the Yemen Arab Republic. There are many secondary towns in the Tihama, among which Bayt al Faqih is the largest, with a very important market for agricultural products from which they are distributed over the whole of Yemen. The other towns and the small port towns are connected by tarmac and good gravel roads. The smaller villages can almost always be rea-

Also in the Tihama the population grows rapidly and consists of a high percentage of young people.

ched by car these days using hard tracks. This relatively good accessibility is a very recent and important development in the Tihama and is certainly unique with respect to rural areas in the mountains and in the east of the country, where accessibility is often extremely poor, just as it used to be in the Tihama.

In 1962,a start was made on the large scale development of wadi irrigated agriculture, managed by the Tihama Development Authority. Since then, large irrigation schemes with an infrastructure of roads, canals, etc. have been implemented along Wadi Mawr, Wadi Surdud, Wadi Zabid and Wadi Rima. Possibilities to develop Wadi Siham in a similar way are currently under study.

2.3 Population

Before 1975, the estimated population of Yemen made by different bodies and varied, at between 4 and 5 million. Since the censuses of 1975 and 1986, the Yemeni population is known more accurately. The population of the Yemen Arab Republic in 1986 is estimated at 9.2 million, of which 1.13 million live in the Tihama.

During the first census in 1975 only 0.65 million inhabitants were registered. The annual growth rate that follows from these numbers is 4.9 %. However, given the absence of reliable data on birth, death and migration this figure cannot be confirmed. While the death rate in the Tihama has probably decreased with the introduction of modern medicine during the last twenty years, it is known that child mortality is still very high. It may be assumed that the real growth rate is very high though perhaps not as high as the calculated growth rate. It may also be assumed that the improved accessibility since 1975 resulted in a more complete census in 1986.

The total population of the Tihama forms about 12 % of the total population of the Yemen Arab Republic, but, in contrast, the region takes up only 10% of the land area of the Yemen. The Tihama consists of 22 administrative districts, of which 17 belong to Al Hudaydah Governorate, three districts belong to Hajjah Governorate and two districts to Taiz Governorate. At this district level, population data are available.

Most people in the Tihama are, like the majority of the Yemeni, involved in agriculture. Population concentrations are found in the urban centres and in the areas with the highest agricultural potential, around Wadi Zabid and other wadis. Other small groups are the bedouin, living from their livestock and fishermen living in small villages along the coast, but distributing their produce over the whole Tihama and further inland.

The urban population forms about one quarter of the total Tihama population. It is concentrated mainly in Al Hudaydah, but also in the secondary and smaller towns (i.e. in urban centres with over 5000 inhabitants). Jobs in Al Hudaydah are found in trade, industry and the informal sector, and in the administration and services sectors.
There are slightly more men than women in the Tihama. This is more pronounced in the urban centres. This is due to migration for labour. In 1975 in Al Hudaydah the sex ratio was much more uneven than it is now. This is explained by the fact that the family follows the man after a certain time when he is able to generate a more or less permanent income, and the family can benefit from a better access to medicine and education.

The available figures also indicate that of the Yemeni working force a relatively high percentage is working in the Tihama, nowadays. This is astonishing given the fact that the Tihama used to be considered as a relatively backward area in the Yemen. It is clear that the situation has changed.

Temporal or even permanent emigration abroad is also important in the Tihama. There is one emigrant in every third household in Al Hudaydah town. The remittances these emigrants send to their families amount to large sums. For example, in the year 1980, over the whole country these sums amounted to more than six billion Yemen Ryal. Al Hudaydah district alone received about 10 % of this amount.

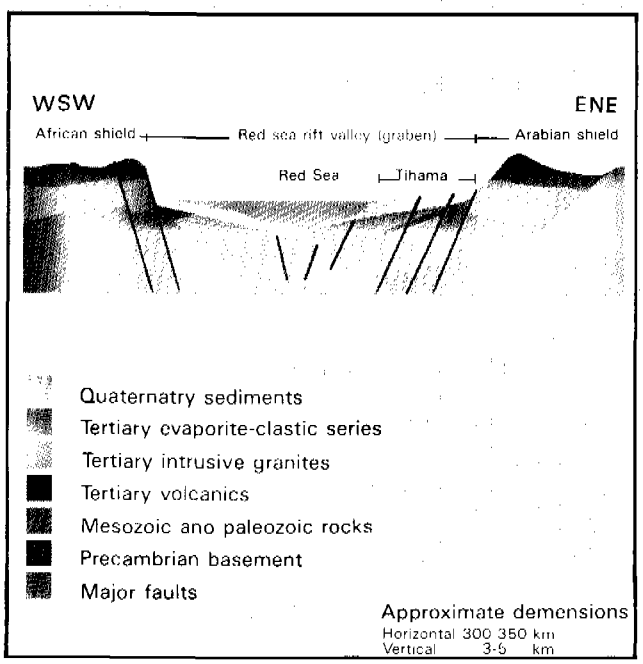
Population in the Tihama in numbers

Total population and density in Tihama.

District	Total 1986	Total 1975	Density 1986 inhab./km2
Al Hudaydah	155110	82723	646
Al Marawiah	70297	48064	97
Al Luhayyah	53816	39206	45
Az Zuhrah	66319	45174	76
Az Zaydiyah	46222	39395	62
Al Qanawis	34558	20676	89
Al Mighlaf	20432	15358	112
Ad Dahi	24524	17901	101
Al Munirah	18679	15474	24
Bajil	77381	49129	50
Zabid	167549	11462	89
Hays	27266	18420	104
Al Khawkhah	18594	16582	38
Bayt Al Faqih	121677	81110	73
Ad Durayhimi	28918	18726	46
Al Mansuriyah	29686	30016	98
As Sukhna	31254	8921	118
Al Mukhah(Taiz)	37963	22011	26
Mouza(Taiz)	22001	20329	9
Midi(Hajjah)	5919	7585	7
Harad(Hajjah)	28585	18063	27
Abs(Hajjah)	40830	26438	26
Totals	**112758**		
	0	**652713**	**57**

Districtwise distribution of sexes in 1986.

District	Males 1986	Females 1986	Sexratio 1986
Al Hudaydah	85605	69505	.23
Al Marawiah	35166	35131	1.00
Al Luhayyah	26659	27157	.98
Az Zuhrah	32778	33541	.98
Az Zaydiyah	22854	23368	.98
Al Qanawis	16558	18000	.92
Al Mighlaf	10024	10408	.96
Ad Dahi	12055	12469	.97
Al Munirah	8733	9946	.88
Bajil	38232	39149	.98
Zabid	82481	85068	.97
Hays	13460	13806	.97
Al Khawkhah	9234	9360	.99
Bayt Al Faqih	60600	61077	.99
Ad Durayhimi	14378	14540	.99
Al Mansuriyah	14590	15096	.97
As Sukhna	14975	16279	.92
Al Mukhah(Taiz)	19922	18041	1.10
Mouza(Taiz)	11299	10702	1.06
Midi(Hajjah)	3094	2825	1.10
Harad(Hajjah)	14637	13948	1.05
Abs(Hajjah)	20612	20218	1.02
Totals	**567946**	**559634**	**1.01**

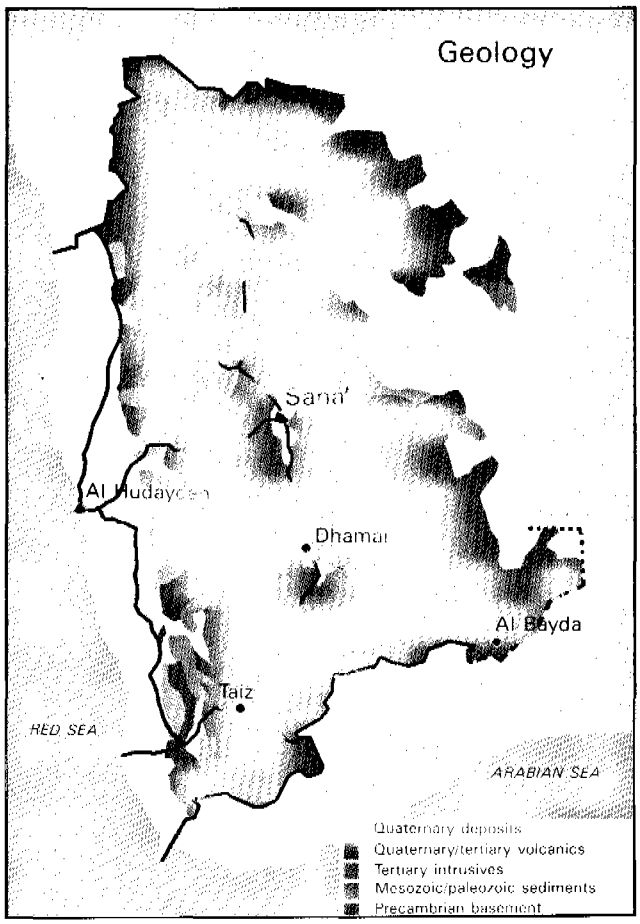


Schematic diagram of geological cross-section across the Red Sea rift valley.

2.4 Geology

The topography of the country is linked to the geological processes that took place in the past, some of them continuing up to the present day.

Most of the country lies on a block that has been strongly uplifted, tilted slightly eastward, and faulted into numerous small blocks. These tectonic processes started during the Tertiary, simultaneously with the formation of the Red Sea graben. They were accompanied by widespread volcanic activity: the Paleozoic and Mesozoic sediments that outcrop widely in the northern part of the Yemen Highlands, have been buried under thick layers of lavas and tuffs in the central and southern part of the country. Elsewhere, in particular along the eastern edge of the Yemen Highlands, these sedimentary layers have been removed by erosion and Precambrian basement rocks are visible. Quartenary sediments cover the Tihama, various intermontane



plains and the Eastern Desert lands; on a more local scale, they are present in the beds of numerous wadis all over the country.

The Tihama is situated within the Red Sea graben. At the surface Quaternary alluvial and aeolian deposits are predominant. These deposits are only thin in the eastern part of the Tihama, but thicken westwards, attaining 300 meters in the extreme western part. They are underlain by Tertiary sediments in the western zone, but more to the east they rest upon Tertiary volcanic rocks or older formations. Locally, the Quaternary cover is interrupted by outcrops of pre-Quaternary rocks.

2.5 Climate

The climate in the Yemen is relatively favourable compared to the remainder of the Arabian Peninsula: rainfall is more abundant than elsewhere and temperatures are moderate over large areas because of altitude. As far as rainfall is concerned, a strong east-west trend is evident in the Tihama, from virtually nil along the coast to quantities permitting rainfed cultivation in the eastern part. The rains fall in spring (Rabi), late summer and autumn (Sayf and Kharif). The Sayf and Kharif rains are more reliable and most rain falls in this period.

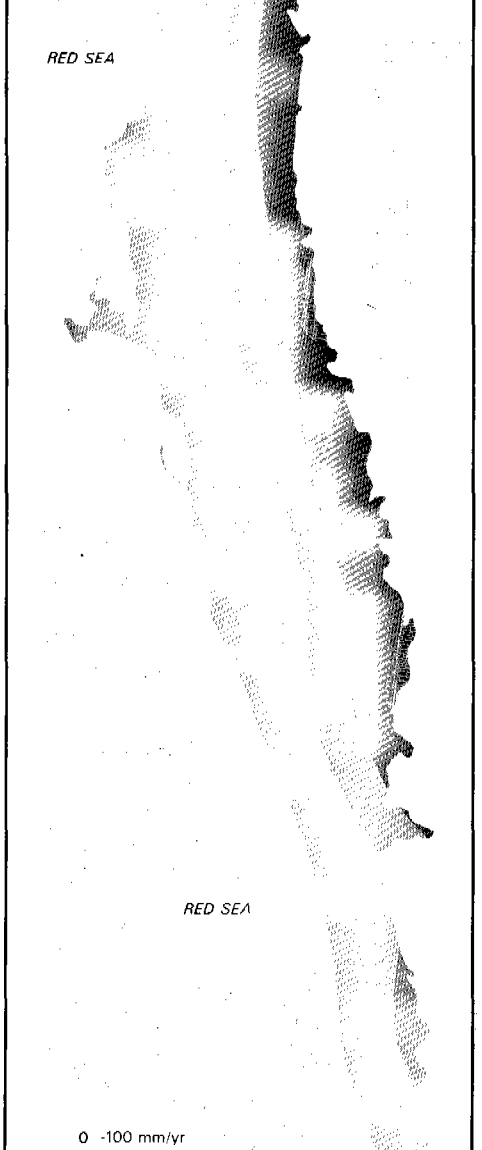
Differences in temperature are only modest, which can be explained by the limited variation in topographic elevation. The average annual temperature is around 30 degrees Celsius. Rather high relative air humidity (averages over 60%) keeps the diurnal variation much smaller than in the mountainous zones of Yemen.

Aridity is evident since much more water potentially evaporates than is generated by the rains.

2.6 Drainage

Even though rainfall is not abundant in the Yemen, rain storms often produce more water, than the upper soil layers can absorb immediately. Hence, surface water runs off downslope towards the wadis. The catchment areas of these wadis may be grouped into larger basins. In the Yemen Arab Republic we may distinguish between the areas draining towards the Red Sea, towards the Gulf of Aden, towards the Arabian Sea and towards the great inland desert of the Southern part of the Arabian peninsula (Rub al Khali Basin).

The Tihama is situated entirely within the Red Sea Basin. It constitutes the lower part of the basin, which is a favourable position from



the point of view of water resources. All excess water draining from the neighbouring west-facing mountain catchment enters the Tihama.

2.7 Legislative framework

Within the framework of rules that together regulate the life of man in the Yemen, a distinction can be made between the laws that originate from Shari'a, the Qoranic law and the customary law, which is usually in line with the foundations of Islam. The customary law, however, may vary from location to location, and in case of water rights, for example, many local particularities and regulations can be found.

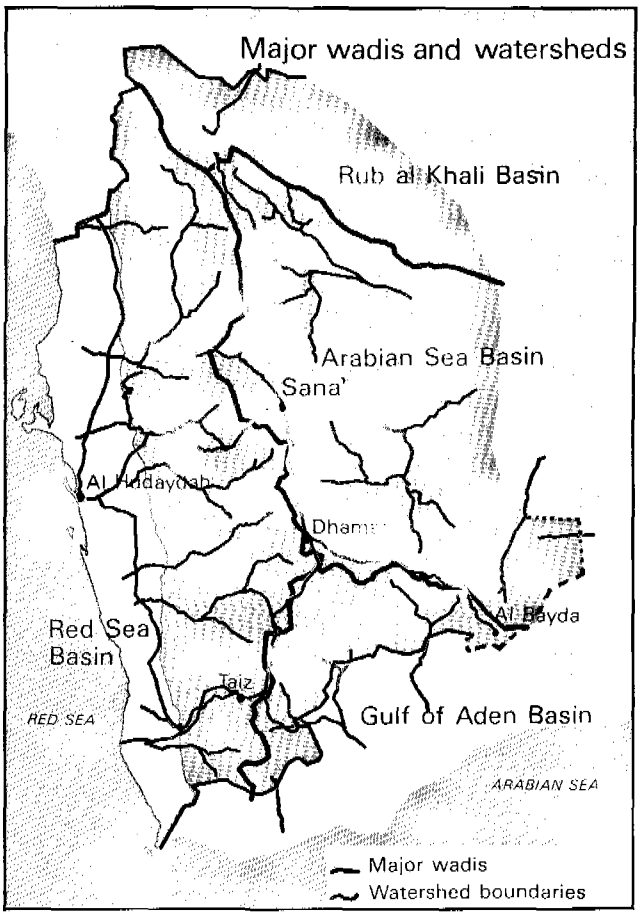
Modern law, enforcing proper management of the environment is still virtually non-existing. This is not surprising, given the fact that the problems arising from modern life have only begun to be felt recently. During the Imamate no attention was paid to legislation in this and many other fields. It 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 the management of water resources.

2.8 Why water is given priority

It is evident that all human activities are made possible by the presence of water. First to drink and wash, secondly to water livestock and crops and thirdly for industrial use. In the Yemen, 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 one location to another, This availability is the first important factor that determines and has determined the use of the land. For this reason, water availability is a frequently recurring topic of this Profile.

The availability of water determines the way of life in the Tihama



3. Water and land

3.1 Types of land

The landscape of the Tihama as a whole is rather monotonous. It consists of alluvial material deposited by the wadis and sometimes locally transported by the winds. However, when looked upon in detail a great variation in environments is found. On the scale of this Profile only a few can be visualized and discussed. Nine main so-called land units are distinguished with regard to their physical characteristics but also in respect of their potential for human occupation.

From west to east certain types of land can be distinguished. They are crossed by the wadis, their floodplains, etc.

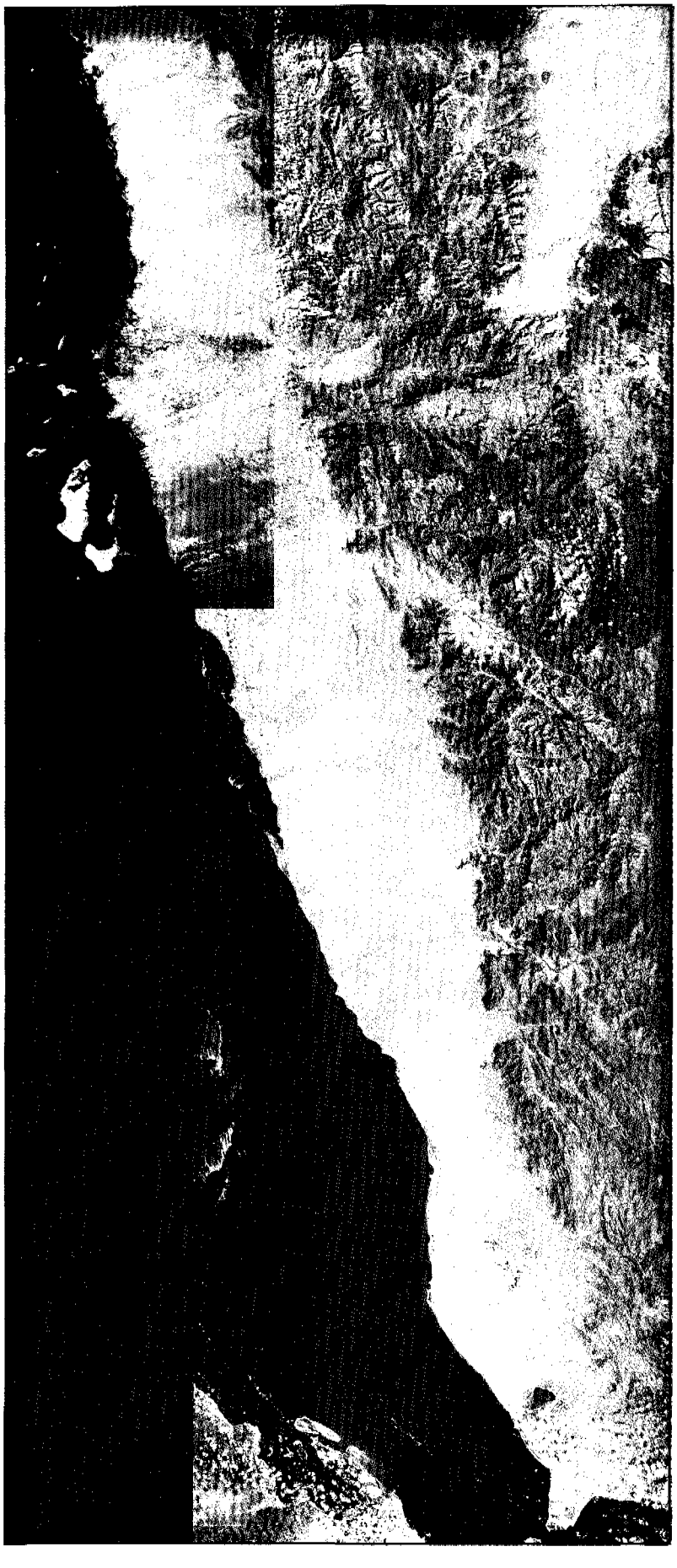
A mangrove zone is present along the muddy parts of the coast. Where the coast is not muddy, coral reefs are present at some distance from the coast. Mangroves can still be found along the northern Tihama.

A zone with beaches, bare and vegetated sebkhas and coastal dunes extends along the coast and is only interrupted by zones where fresh surface or ground water reaches the coast. Sebkhas are areas where usually brackish ground water evaporates. They are therefore very saline.

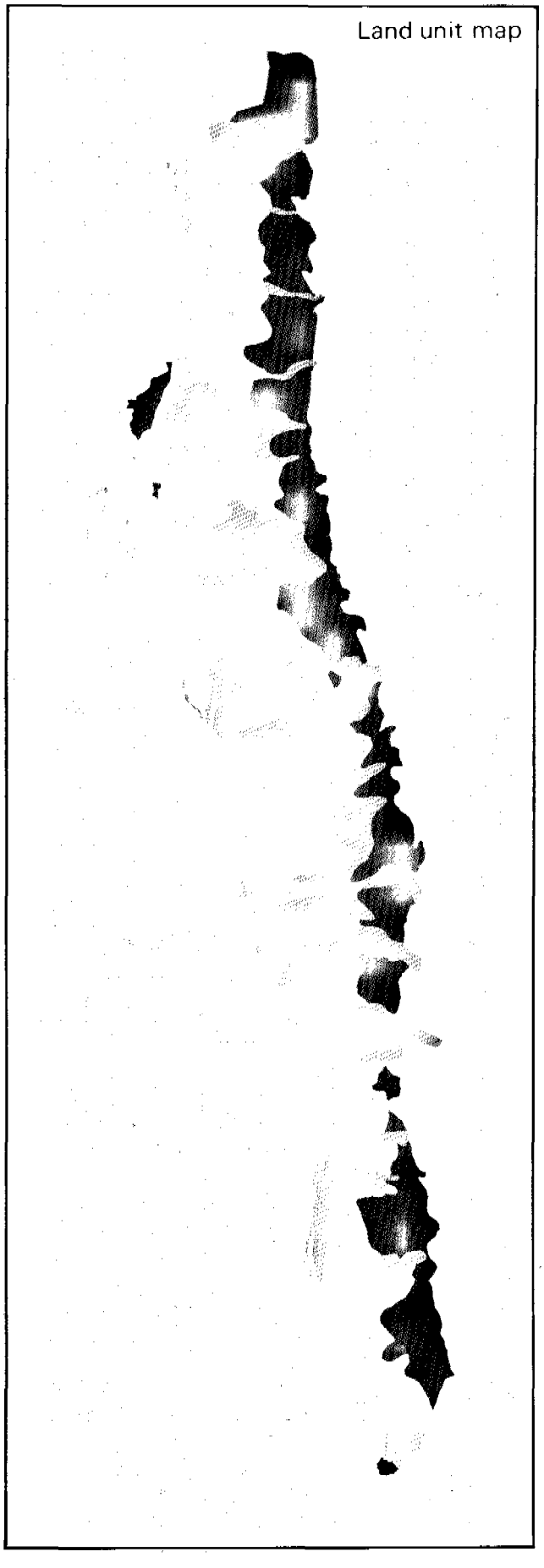
East of the coastal zone vast flat rangelands are found, in the west without shrub or trees and in the east, where more rain falls, an open shrubland has developed. In the area near Al Mansuriyah large longitudinal dunes (erg) were formed thousand years ago from the very fine sands that cover the whole zone.

In the east, the Tihama is bordered by the foothills. The material that is deposited here comes from the mountains and is called "pediment". Except when cultivated, the pediment is covered by a desert pavement (hammada). The soil

Mosaic of satellite of Tihama and mountains (landsat MSS of April 1985 and January 1986).



Land unit map of Tihama
A land unit is an area with a relatively similar landscape and use.



material between the stones erodes away and a pavement remains that protects the underlying soil.

The wadis enter the Tihama usually through a narrow passage, cut into bedrock. In these so-called gorges some permanent base flow usually exists. The floods transport enormous amounts of sediments and water and then disappear rapidly. Many of the silts are deposited in the areas that are now in use for wadi irrigation. Somewhat finer material is deposited in the wadi terminal areas, where well irrigated agriculture flourishes these days.

At the downstream end of the wadi terminal areas, close to the sea, ground water may be found at very shallow depths. These are the areas with the date and doum palm groves.

	Name	Physiography	Water	Vegetation	Soil
M	Mangroves	tidal swamp	inundated by tides	mangrove trees	clayey sands
B	Coastal zone	beaches, sebkhas, coastal dunes	sprayed, brackish or fresh groundwater	no trees, saltbush, grassland	sands and sandy clays
S	Sandy plains and dunes *non-cultivable*	flat plains, undulating *longitudinal* dunes	deep groundwater < 250 mm. rain	shrub and grassland	fine sands
C	Dunes and sandy plains cultivable	undulating longitudinal dunes and flat plains	deep groundwater < 250 mm. rain	discontinuous shrub- and grassland	fine sands
T	Terminus of wadis	very flat plains with hummocks	shallow fresh groundwater	palm groves and vegetated hummocks	loamy sands
F	Floodplains of wadis	flat plains	irrigated by surface or groundwater	wadi bound shrub thickets	silts
P	Pediment *partially* cultivable	sloping *areas* with and without terraces	rain and *run-off* > 300 mm.	discontinuous *open* woodland	gravelly *silts and* loams
N	Non-cultivable pediment	sloping areas without terraces	rain and run-off < 300 mm.	open woodland	gravelly silts and loams
O	Rock outcrop	outcropping rock	generates run-off	almost bare, some succulents	no soil

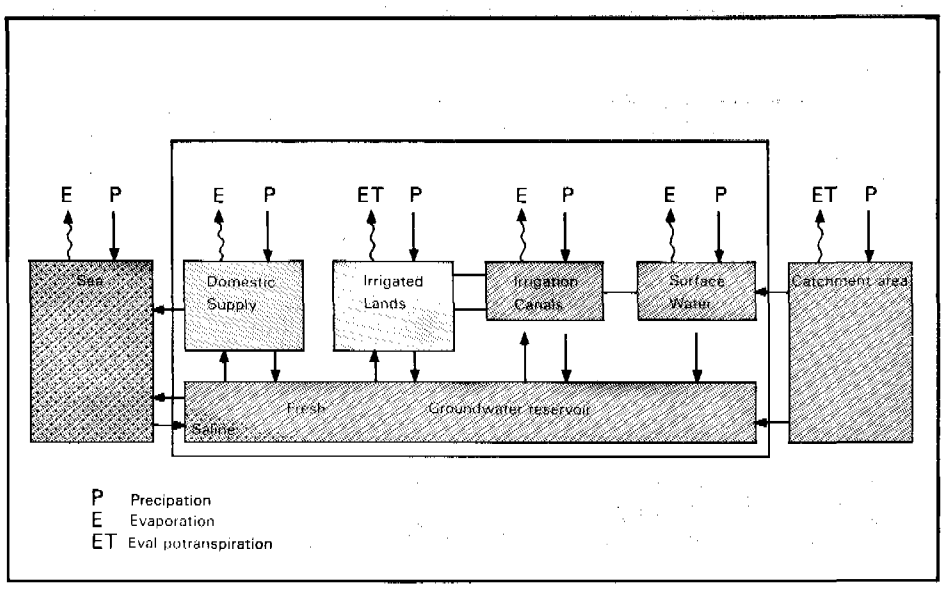
3.2 Surface water systems

Seven major streams and a number of minor ones descend from the mountain belt and enter the Tihama. They bring all excess water from the adjoining, relatively wet, mountain catchment areas to the Tihama, on average an estimated 500 to 1000 millions of cubic metres per year.

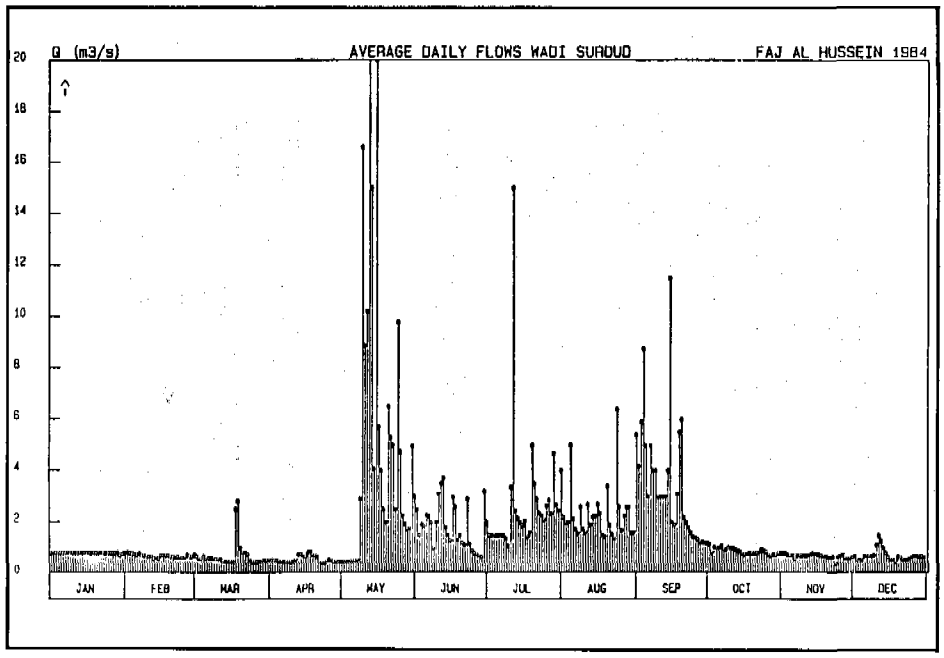
The regime of these streams is extremely flashy. Instantaneous hydrographs show a much higher range of flows than the average daily figures reveal: within 24 hours the discharge in the major wadis may increase from less than 1 m3/second to as much as 500 or 1000 m3/second.

The floods (peak flows) may be very destructive and carry much sediment. Permanent or almost permanent flow (base flow) occurs only in some stretches of the wadi channel. They are most reliable in the zone immediately upstream of the Tihama, where they constitute a significant portion of the total annual discharge.

The mountain streams degenerate quickly on arrival in the relatively flat Tihama zone: the stream beds widen and divert, and lose the water they convey through infiltration, diversion and evaporation. Little local run-off originates in the Tihama, especially in the eastern part, because the lands are flat and permeable and rainfall is limited. Consequently, local drainage networks are poorly developed and hardly any surface run-off reaches the Red Sea.



Principal water flows in the Tihama.



Average daily flows in Wadi Surdud in 1984 as an example of the regime of streams entering the Tihama.

3.3 Occurrence and characteristics of ground water

Aquifer systems

Fresh ground water resources in the Tihama are found almost exclusively within the Quaternary sedimentary layers.

Basically, the Quaternary sediments in the Tihama constitute one large regional ground water reservoir, up to 300 meters in depth. The underlying Tertiary layers form the base of the reservoir. In the east these layers are impermeable consolidated rocks, whereas to the west the Tertiary sediments are of low to moderate permeability and contain immobile saline water.

The Quaternary aquifer system is not homogeneous: close examination reveals that it is composed of a number of semiindependent "ground water flow domains". These domains are typically fan-shaped and reflect preferential zones for ground water flow. This can be explained by the observed sedimentation patterns (the sediments inside these zones are in general more permeable than those outside), the spatial distribution of the major sources of ground water recharge (wadis) and the regional drainage basin (Red Sea), within which the major part of the ground water flow in the Tihama is concentrated.

Ground water recharge, storage and discharge

The natural pattern of ground water recharge and discharge in the Tihama is conceptually very simple. Ground water recharge

takes place mainly along the eastern edge of the Tihama, natural discharge exclusively at or near the Red Sea coast; hence, ground water flows from east to west. Ground water recharge is produced dominantly by the wadis entering the Tihama and to a lesser extent by direct infiltration of local rainfall, by return flows from irrigation and by underflow from the consolidated rock units bordering to the east.

Ground water discharge takes place by submarine outflow into the Red Sea, by evaporation along the shore (in the sebkhas) and by ground water abstraction. Under natural conditions there is as much recharge as discharge. This balance has been disturbed during the last twenty years, by a significant increase in ground water extraction for irrigation. The latter mechanism has become significant only recently, but is at present the dominant discharge mechanism.
The pore volume of the Quaternary aquifer constitutes an enormous ground water reservoir. It contains currently some 250 - 500 billion cubic metres of fresh ground water in storage, which exceeds the average annual discharge by approximately three orders of magnitude. This enormous quantity means that a systematic exhaustion of the reservoir only becomes noticeable at a stage when the reservoir is already seriously depleted. The average annual ground water discharge is currently exceeding the average recharge; consequently, storage depletion of fresh ground water occurs.

Ground water quality

Fresh to slightly brackish water prevails in the shallow parts of the Quaternary aquifer. In general, there is a tendency of increasing ground water mineralization occurring in a down-flow direction; furthermore, mineralization is more pronounced in the ''stagnant'' zones outside the active flow domains.

Brackish and saline ground water at shallow depths is common near the Red Sea coast, except where appreciable submarine ground water outflow occurs. This mineralized ground water is, in some zones, genetically distinct from the circulating fresh ground water (e.g. it may be of seawater origin); elsewhere it is produced by evaporation in zones of near-surface water tables (sebkhas).

Wadi Zabid is among the larger wadis entering the Tihama.

4. The human factor

In the previous chapter, details of the physical environment were presented. In this chapter the human occupation is projected over this physical environment: how are the Tihami using their natural resources?

4.1 Agriculture

The Tihama was under cultivation thousands of years before the birth of Christ. This cultivation started, presumably, along the wadi beds in which seeds were planted after the floods had passed. Later, wadi water was diverted onto land adjacent to the wadis by a system of guide bunds. The bunds increase the local water level in a flood, and this water is diverted onto the farmland. This system became more and more sophisticated and continues up to the present day along all major wadis.

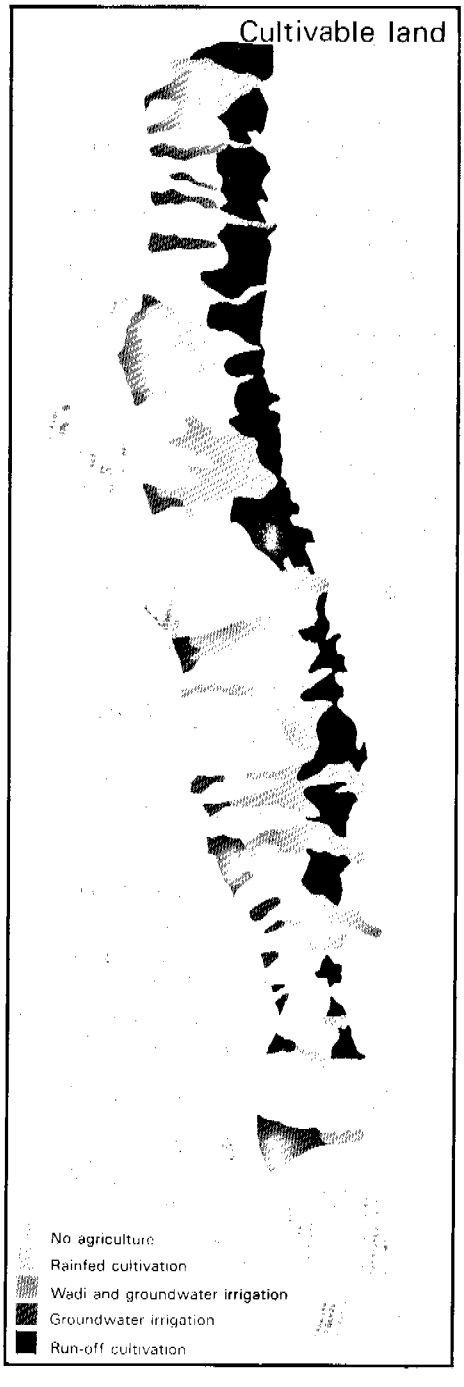
Agriculture in the Tihama is practised in different systems. These systems can be differentiated according to the access to water that a farmer has for his crops. This physical factor is still the single most important factor in shaping a farming system in the Tihama, but market conditions and the economics of input agriculture (diesel, fertilizer, pesticides, etc.) are becomming much more important than in the past.

The following agricultural systems can be distinguished:

- Wadi irrigated cultivation
- Deep ground water irrigated cultivation
- Shallow ground water irrigated cultivation
- Rainfed cultivation
- Run-off cultivation

Acreages of arable land

Cultivation type	Dry year(ha)	Wet year(ha)	Normal year(ha)	Crops
Wadi irrigation	30,000	40,000	38,000	sorghum, alfalfa
Deep groundwater irrigation	66,200	66,200	66,200	fruits, vegetables
Shallow groundwater irrigation	3,500	3,500	3,500	dates, alfalfa, sorghum
rainfed cultivation	0	300,000	194.000	millet, cowpea
run-off cultivation	5,000	8,000	7,000	sorghum, alfalfa
Totals	104,700	417,700	308,700	



Wadi irrigated cultivation

Wadi irrigated cultivation takes place traditionally by diverting flood

Sorghum crop and irrigation canals inside the Wadi Rima irrigation system. Some years ago many two-wheel drive vehicles could not traverse the area, nowadays they can.

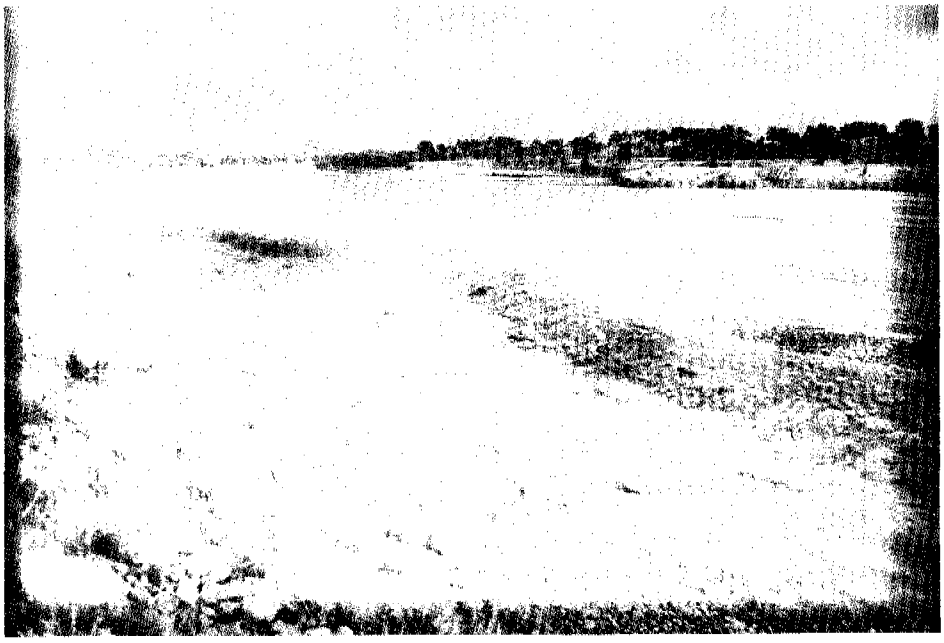
water and fertile sediments with it onto the fields. This method of irrigation still takes place on quite a large scale. However, modern irrigation schemes have taken away the need for erecting diversion structures in the wadis on an increasing number of farms, although the traditional structures are still in evidence. Many are constructed with the help of tractors and some by animal traction. When a large flood passes the structures are always washed away, but not before a satisfactory amount of water to start cultivation has been received. When the next crop watering is required a new structure is built. A sorghum crop needs three floodings to produce a good yield.

In Wadi Mawr, Wadi Rima and Wadi Zabid modern irrigation systems have been implemented, aimed at making more efficient use of the water. The degree of success varies from place to place and problems do occur with respect to the inequity of water distribution and poor on-farm irrigation practices. Other problems are, on the one hand, due to poor maintenance of the systems and, on the other, to poor design criteria. The large floods, in combination on with the smal base flow and the tremendous amounts of sediment, pose a technically very complicated problem for the functioning of irrigation structures. In the short period of development, much has been achieved in this field, but it should be realized that traditional irrigated agriculture was a balanced system developed over thousands of years. Modernized irrigated agriculture, of course, cannot achieve the same efficiency within 20 years.

A fundamental difference between traditional and modernized irrigation is that much less sediment arrives on the fields in the modernized system, thus creating the need for mineral fertilizers, which are still hardly applied nor available in the Tihama.

The crops grown in wadi irrigated areas are mainly cereals (sorghum and some maize) and fodder (alfalfa and ratoon of sorghum). In areas near the wadi gorges where a permanent base flow exists, farmers started to grow bananas some years ago, while other perennial crops and legumes have also become more prominent. The introduction of ground water irrigation is also evident in the formerly only wadi irrigated areas in order to secure the water supply for the crops and especially for the cultivation of fruits. The wadi irrigated surface varies, of course, from season to season. The main rainy season starts in July/August and continues to October. The shorter rainy season starts in March/April and continues until June.

Wadi Zabid, with in the foreground a traditional intake canal for flood water for irrigation.



Deep ground water irrigated cultivation

The irrigation of crops with diesel pumps was introduced in the Tihama some 20 years ago. During the seventies and eighties a tremendous growth was witnessed. Formerly marginal agricultural areas were transformed into important cash crop producing areas, e.g. the Mahat area at the terminus of Wadi Rima. Pump irrigated farms were also established within the wadi irrigated areas, especially where water availability was insecure. The development of this deep ground water irrigation from zero to over 9000 pumps in 1989 affected the water balance of the Tihama considerably, resulting in a lowering of ground water tables near concentrations of pumps, especially in the central part of the Tihama.

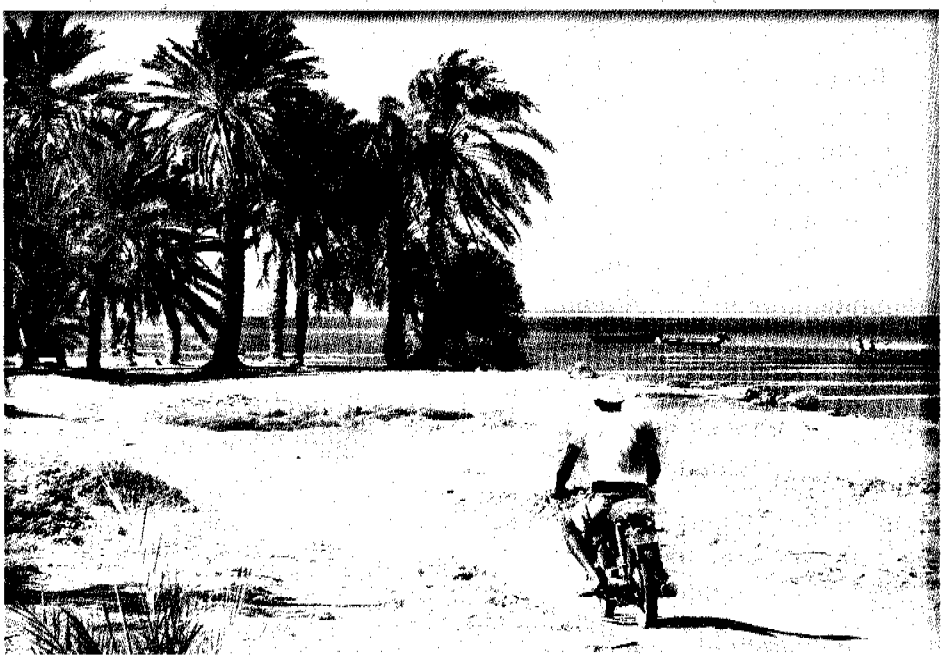
Perennial fruit tree cultivation (papaya, banana, mango, and many others) is the most rewarding crop in the deep ground water irrigated areas while legumes such as okra, tomatoes, water melon, peppers, cucumber, tropical spinach , sweet melons and sweet peppers are also produced. Other crops include sesame, cotton and jasmine (perfume).

Shallow ground water irrigated cultivation

The shallow ground water irrigated cultivation is a traditional type of cultivation, centred around the production of dates near the coast. It is practised nowadays with modern means and the cultivated area has expanded. Near the coast, ground water is much more shallow than in the central part of the Tihama. It almost reaches the surface on the beaches in the wadi terminal areas. Date palm cultivation may extend in these areas continue almost onto the beach. Storms have some-

times destroyed large date palm stands e.g. near Al Mukha, a town famous for its dates in the seventeenth and eighteenth century. Dates were a much appreciated export product from the Tihama in those days.

Date palms are intercropped with annual crops such as sorghum, alfalfa and legumes on a minor scale. Millet is also grown in an opportunistic fashion beyond the date palm holdings, during the Kharif. Deep ground water exploration has also led to lowering ground water tables in the upper reaches of date palm cultivation. These date palms can no longer be supported without irrigation from motor pumps as well.

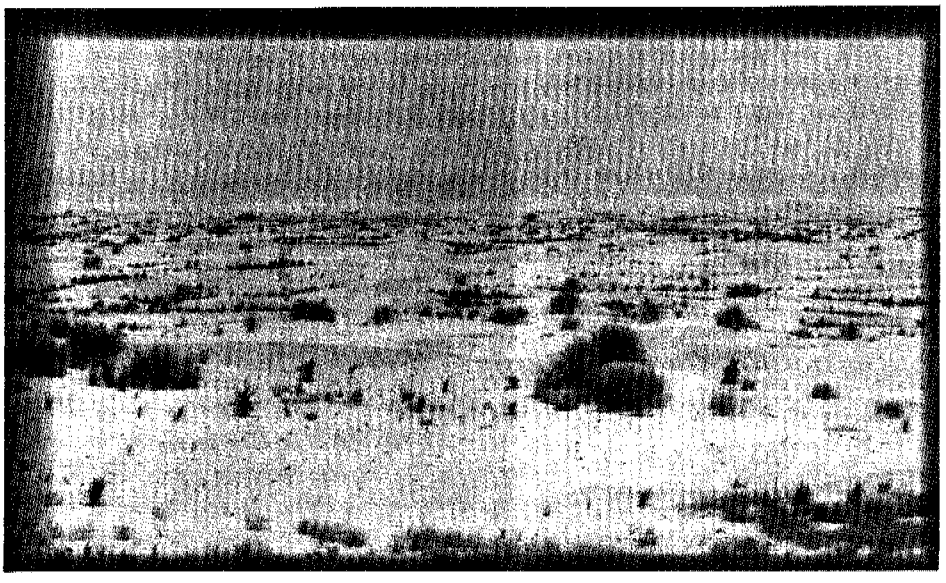


Date palm cultivation may continue up to the sea front at locations where fresh groundwater discharges underground into the sea.

Rainfed cultivation

Rainfed cultivation takes place rather opportunistically on the sandy plains and dunes. The herbaceous layer is removed for cultivation but usually a tree may be left here and there. This type of cultivation is important especially in the area around Al Mansuriyah and in the sandy plains between Al Marawiah, Ad Dahi and Bajil, both in the eastern part of the Tihama, where rainfall is relatively favourable. However, near almost every village, some areas may be used for rainfed cultivation if the farmers judge there is a chance to have a successful crop yield in a certain year.

In a year of good summer and autumn rains, enormous areas in the Tihama may be seeded especially with millet and to a lesser extent with cowpea. In years of mediocre rainfall, the cultivated area may be very small. Virtually no areas yielded a successful rainfed crop in the extremely dry year 1984. Both in 1988 and 1989 the cultivated area may have amounted to as much as 300,000 hectares. The long term estimate for the rainfed cultivable surface is about 190,000 hectares, which is more than twice the surface of the sum of the more intensively cultivated areas. The yield per hectare is much smaller since the seeds are planted far apart.



An extreme form of rainfed millet cultivation on dunes near Al Mansuriyah.

Run-off cultivation

A special form of rainfed cultivation is found in the eastern part of the central and northern Tihama, where bunded lands are found that receive run-off water from either nearby mountain slopes or from the slightly sloping area above the bund. Sorghum is the main crop on these lands and is cultivated in late summer and autumn.

A "run-off" farmer has a much larger chance of a successful crop than a "rainfed" farmer. This has implications for differences in the respective farming systems. Technically speaking, however, the contribution of run-off water to a "runoff" crop is usually smaller than the contribution of the rains, that fall directly on the field.

Mechanization

The use of tractors has also increased tremendously in recent years. Despite the often small plot size, mechanization is rapidly introduced. However, animal traction has not been completely abandoned by most farmers.

4.2 Livestock production

Livestock production in the Tihama is an essential part of the activities of virtually all rural people as it is in other parts of the Yemen, and the Tihama is a livestock exporting region. The Yemen, as a whole, imports livestock from Somalia, Djibouti and Ethiopia in increasing numbers. These imports take place especially through the ports of Al Mukha, Dhubab and Mousa. The situation for the Tihama is also different because far more rangelands are available for animals than elsewhere. However, even in the Tihama as much as 40% of the diet of livestock may consist of fodder crops and crop residues, consisting of alfalfa, sorghum leaves and stalks. In the varieties of sorghum cultivated in the Tihama (e.g. Kayra), both grain and fodder producing characteristics are important. The quantity of produced sorghum forage is enormous. This is sometimes exported to areas as far away as Al Bayda, along the eastern border of the country.

On the one hand, livestock provides the family with milk, but it is also a source of income and always a form of investment. The importance of livestock varies with the water availability and security of income from crop production. The more risky agriculture is, e.g. in case of rainfed farming, the more important livestock is to the farmer, not only for income but also as a financial buffer. When crop production gives a reliable income, a smaller part of a farmer's income is generated by livestock. Cows are kept in the vicinity of the house and herds of sheep and goats either graze on the stubble of the fields or on the rangelands surrounding the villages.

Livestock raising is still a way of life in the western part of the Tihama, but the nomadic way of life of many bedouin is dwindling and many families are trying to gain access to land resources for cultivation and are trying to build up an income through labour, etc. other than by livestock rearing. Especially along the coast in the northern Tihama, large herds of camels can still be found, together with relatively prosperous bedouin families.

4.3 Firewood collection and timber

In the Tihama, as in the rest of Yemen, food is prepared largely with firewood. In the urban centres increasing use is made of gas for cooking, but firewood remains important. The town of Zabid is largely built from bricks, an activity that has almost stopped completely due to the increasing prices of firewood. Currently, the Tihama is still an exporter region of firewood

Camel raising is still a way of life in the western part of the Tihama.

in the Yemen, but, nevertheless, firewood is getting more and more scarce. Charcoal in Yemen comes almost exclusively from the Tihama. Doum palms still provide an important part of the wood for huts of many Tihami in the western and central parts. In urban areas all timber is imported nowadays.

4.4 Fishery

The villages and towns along the coast all harbour a population of fishermen, whose way of life has changed the least compared with that of other Tihami. Fishing still takes place from small boats and rafts on the Red Sea. Part of the produce is consumed and the remainder is sold. The catch is landed at night and is transported by motorbike to all parts of the Tihama. Fish from the Red Sea is sold in Sana' and other upland towns, especially the catches of fishermen from Al Hudaydah, who have access to means of transport. In smokin fish, large quantities of firewood are used.

Sebkha areas along the coast are sometimes used for salt production. A system of canals loads sea water into ponds where it is allowed to evaporate

Since the cultivation of cash crops has become more important to most farmers, the use of agro-chemicals is increasing, despite their scarce supply on the markets. Their use is an important factor in agricultural extension.

One method of conservation for fish: Ice is transported to the fishing boats. The ambient temperature is 35 degrees Celsius.

Another method of conservation for fish: in smoking fish copius quantities of firewood are used

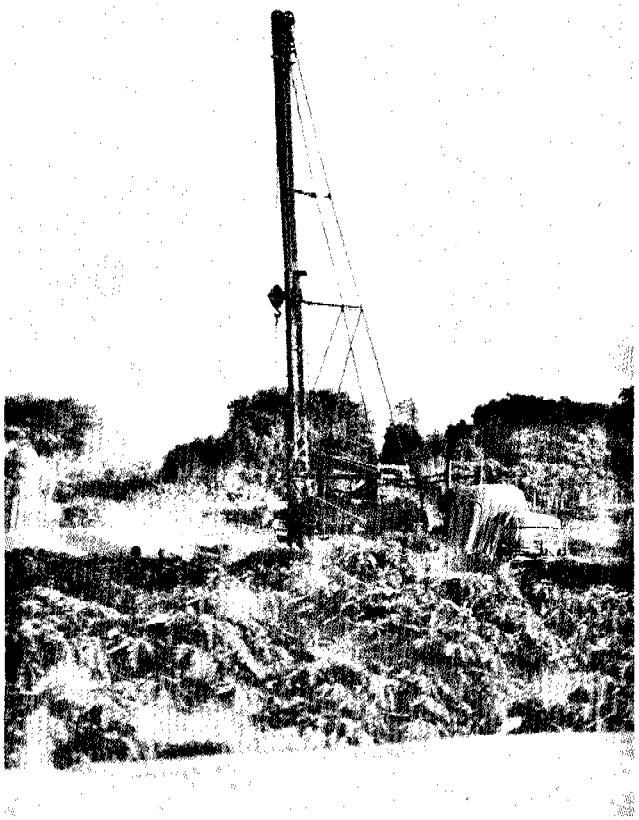
Absolute and relative number and areas of farm holdings under one type of land tenure in Al Hudaydah Governorate alone.

Holdings	Owned	Sharecrop	Rented waqf	Rented individuals	Total
number	46415	4010	403	0	50828
% of total	79.4	6.9	0.7	0	86.4
area (ha)	271341	10419	446	0	283206
% of total	81.4	3.1	0.7	0	84.9
average holding size	5.85	2.6	3.59		5.57

Absolute and relative number and areas of farm holdings under two or more types of land tenure in Al Hudaydah Governorate alone.

Holdings	Owned land 50% or more of total area	Owned land less than 50% of total area	No owned land in holding	Total
number	3892	3262	549	7703
% of total	6.6	5.6	0.9	13.1
area (ha)	26233	228211	1347	50401
% of total	2.9	6.8	0.4	15.1

Wells to irrigate from groundwater are drilled on the initiative of individual farmers.



Tihama goats and sheep.

5. Land and water use ecology

Nature provides the natural resources that allow mankind to grow food, raise livestock, collect fuelwood, catch fish, etc. Man uses the resources and tries to maximize their output. In this sense, every farmer and fisherman is managing natural resources.

Everyone has his own way of surviving and obtaining economic results, by implementing different land use activities. Yet at a macro level a limited number of sets of activities or farming systems can be distinguished in the Tihama. Land tenure and rights and access to water resources are factors of great importance in this respect. In this chapter the situation with respect to the driving forces behind the use of the resources and their management is assessed.

The poultry industry underwent a tremendous growth at the beginning of the eighties. Now the industry is well over the peak.

5.1 Land tenure

The way in which land and water resources are managed by the people who use the resources is to a large extent determined by whether people have had the rights to use these resources for many generations, or, whether 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.

In Islamic law, land can be owned or used ('Amir) 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''.

Forms of land tenureship include privately owned land (melek), state owned (miri), endowment (waqf), and leased (sharak) land. Land tenure includes the legal right of the holder to operate the land. The holder can be the owner, tenant or share cropper.

The Tihama contains more than 70,000 farm holdings of which 80 % are privately owned. Some 7 % of the holdings are fully share cropped and less than 1 % is rented waqf land. Another 6 % of the holdings is owned for more than 50% and the remainder 6 % is owned for less than 50%. However, ownership does not exclude share cropping arrangements with labourers, who are, for example, newcomers to Tihama.

The share cropping system in the Tihama is quite unique. Various arrangements are made under different conditions, particularly with respect to the source of irrigation water. Under spate irrigation or rainfed conditions the owner's and the tenant's share is 50 % each. Costs are incurred by the tenant. On ground water irrigated farms, variable arrangements are made depending on whether or not the landlord owns the well. The arrangements are as follows:

- The owner of the land and well gets 75 % and the tenant 25 % of the total produce. All costs of water, seeds, ploughing, etc. are born by the landowner. Zakat (tax) and harvesting costs are deducted before the shares are split.
- The landlord receives 25 %, the pump and well owner 50 % and the tenant 25 %. Water costs are born by the pump and well owner and other costs are deducted before distributing shares.

Share cropping arrangements often occur on irrigated land and rarely on rainfed lands. Under these arrangements, share croppers lack the means and the incentive to undertake improvements to increase the productivity of the land.

The statements above apply especially to agricultural land. Rangelands and tree resources may also be communally owned. Whether this form of land tenure is still functioning and protecting 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 life wood exist in a great variety on the communally owned lands. Resources

which have no claims from private persons, communities or the state, are very rare in the Tihama. For this reason the movements of bedouin livestock are confined to the western Tihama, especially to the relatively sparsely populated areas in the extreme north and south.

5.2 Water rights

The system of water rights in the Tihama 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 for 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 exceptions to the rule, such as the local customary laws in Wadi Zabid. Such practices conform to the Islamic law in theory, but in practice it does not guarantee equity within the secondary distribution system.

According to custom and Islamic law, every landowner is entitled to dig a well on 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 is carried out privately, and there is no control over its exploitation neither from the national government nor 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 been promulgated.

5.3 Incentives in agricultural production

Groundwater

Most of the agricultural land is privately owned and cropped. However, for the Tihama farmer, access to land is only one of the factors in cultivation. Access to water is another and most crucial factor. According to the rule "upstream first", farmers a long distance away from the source of the water, whether this comes from surface run-off or the wadi, are very uncertain of their yield or of any yield at all, until the end of the rainy season. Despite the fact that investments to make ground water more accessible may not be directly profitable, these investments offer a way out of the traditional water rights situation and provide much greater certainties of crop successes to farmers than before. The access to ground water increases the value of a holding very much. Individual farmers are very keen on possibilities for exploitation of ground water.

Transition from subsistence agriculture to market production

The cultivation of crops for urban communities is not new in the Tihama. Cities have existed for ages and there has been a demand for fruits and vegetables in towns since time immemorial, since they are an essential part of the Yemeni diet, whether rural or urban. However, with the improved accessibility of the Tihama and the expansion of the urban population, the demand for cash crops and the incentive for their production has increased tremendously. Many more farmers than before are involved in the production of cash crops

The increase in the use of agrochemicals, tractors, pumps and the growth of internal markets all illustrate the sudden shift in agriculture which until about twenty years ago was almost fully oriented towards subsistence, to the present day situation in which agriculture is almost fully monetarized. Most farmers finance the cultivation of crops for home consumption by the sale of cash crops. They are quite willing to continue in this way, given the very high value they attach to home-grown food:

"Produce from Yemen" as a synonym for quality

A large part of the agricultural production is used for home consumption. Yemeni in general attach a very high value to home-grown food. This applies to cereals, but also to milk, chicken, sheep, etc. In the same spirit, they are also very reluctant to use agro-chemicals (pesticides, fertilizers, etc.) on crops that are grown for consumption at home. Urban people would also be very reluctant to buy foodstuffs that have been treated with chemicals, if they knew. However, the use of agrochemicals is increasing despite their low availability. The high price that is paid for "produce from Yemen" provides a firm basis for agricultural development in the country.

Incentive for fruit production

In 1984 the import of fruits was prohibited by law. This import limitation has greatly enhanced the development of fruit tree cultivation. The price paid for the locally produced fruits is still very high and provides a good incentive for farmers to indulge in the cultivation of fruits.

5.4 Incentives in livestock production

The livestock that is kept around the house, chickens, sheep, goats, donkeys and 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 Yemen more often than not

contributes to the farmer's income. In the Tihama, livestock is traditionally an important commodity as well as being a savings account, but the production systems are in fact subsistence oriented.

The growth in poultry factories, that was so enormous in the Highlands, especially in the period '80 - '87, is well over its peak and 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.

Yemeni, especially in the towns, are consuming more meat than before. Livestock imports increase rapidly, while as yet there is no clear private or government initiative to enhance the national meat production. It seems that, as yet, there is not enough incentive or knowledge for individuals to initiate beef production, most likely due to the low price of imported meat.

5.5 Incentives in the management of wood and range resources

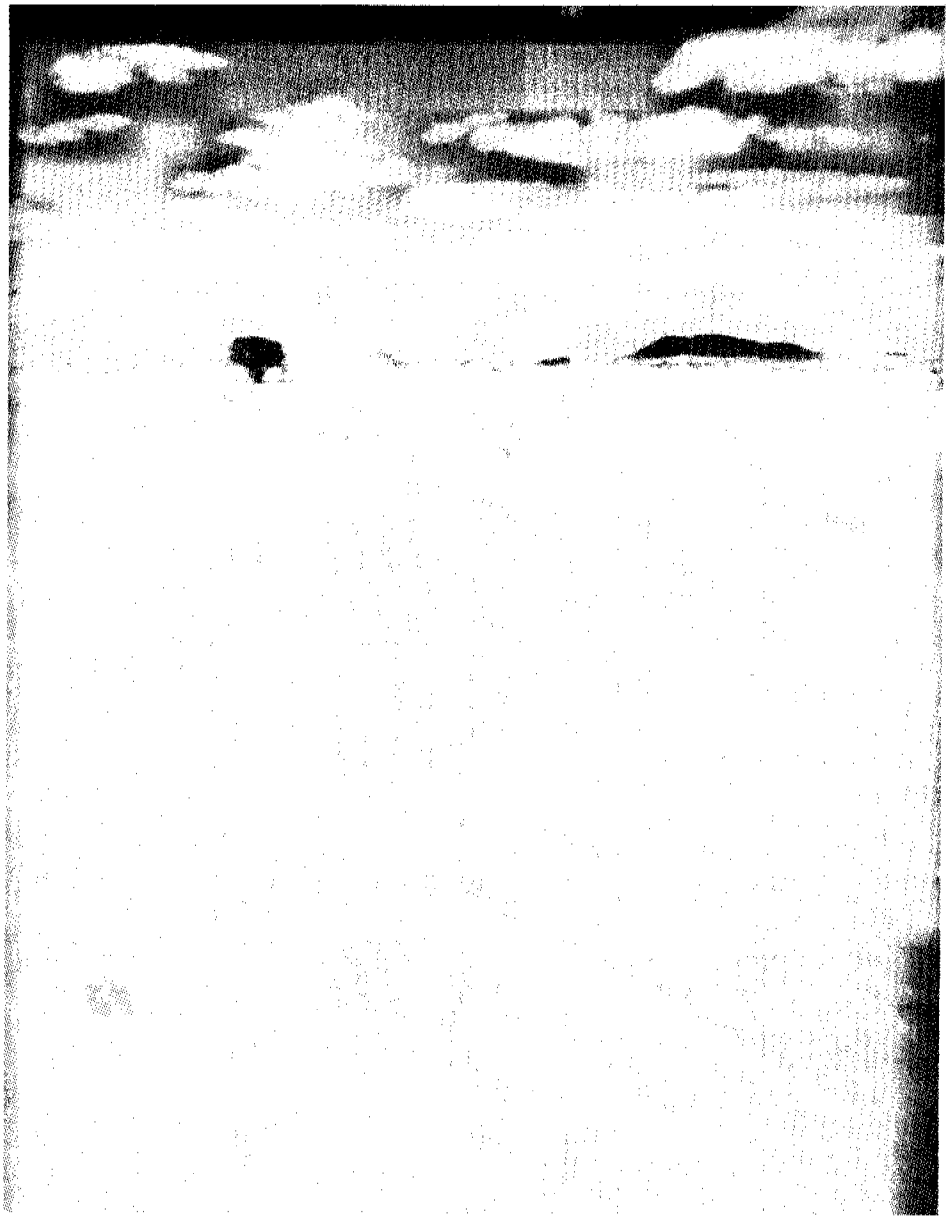
The firewood that is consumed by families in the rural areas is largely collected on the Tihama rangelands and to a limited extent from privately owned trees. It depends on the strength and degree of the organization of the local community whether incentives exist for the proper management of wood resources, but an incentive for proper managament certainly arises if it can be seen that the community will profit in the future from a proper management of wood resources. The same applies to the management of range resources. However, the communal ownership of tree and range resources exists in the first place to protect these resources against use by outsiders. Communal ownership does not necessarily imply proper management, since there may be insufficient knowledge to carry it out.

Firewood collection is undertaken by the villagers themselves or by labourers hired by a merchant. Firewood is a much wanted commodity. This commercial aspect usually has a rather devastating impact on the remainder of the trees. Given the marginal subsistence of those who collect firewood for money, there is no long-term incentive to protect the firewood resources from degradation.

For example, for rainfed farmers who have access to only meagre agricultural resources, the diet of their livestock comes to a very large extent from the communally owned rangelands, which they use in competition with other villagers. In recent years, there have been many droughts, while migration to find work has had a strong impact on the social organization. Livestock production is essential to the villagers for survival. In this situation, overgrazing of the rangelands in the vicinity of the village does occur on a large scale.

A non-deniable advantage of nomadic grazing remains that because of the mobility of herds (and people) over-use of good rangelands can to some extent be avoided. Nomadic bedouin also have incentives not to overgraze, given the fact that they cannot survive without good rangelands in future.

A form of desertification: small scale formation of dunes



Incentives and impact in recource management

Incentives and impact for resource management are different for different groups of resource users. Groups of resource users can be distinguished on the basis of their activities and their incentives. The farmers can essentially be grouped according to their use of water and their control over water and land:

Upstream farmers
These farmers are usually relatively well-off farm owners. They have good access to surface water, usally smal livestock holdings (unless it is a good investment) and relatively low off-farm income.

Downstream farm owners
This is a small wealthy group with vast land holdings, well and pump ownerships and a lot of off-farm activities in trade, etc.

Downstream farm share croppers
Sayf farmers, not so well-off, with relatively small numbers of goats and sheep, and an increasing dependency on well irrigation. Off-farm income is becoming more important.

Rainfed farmers
Subsistence farmers with relatively many off-farm activities and sheep and goats as a financial buffer. The land holdings are not so valuable as elsewhere.

Run-off farmers
Farmers with small land holdings, who rarely have access to groundwater and who own relatively few cattle and sheep. There is, however, a rather secure income from the farm, compared to rainfed farmers.

Deep ground water farm owners
These farmers are permanently active on the farm (have relatively few off-farm activities), fruit tree crops take on increasing importance, while livestock holdings are maintained as an investment. Sales of livestock cover the running costs of pumps, etc.

Deep ground water share croppers
These farmers are also permanently active on the farm (have relatively few off-farm activities), cultivating especially sorghum (grain and fodder), with small livestock holdings. Land owners are reluctant to permit fruit tree cultivation.

Shallow ground water farmers
Relatively well off farmers, gaining their income from dates, very small livestock holdings

Camel raising bedouin
A group of both poor and relatively well off people, roaming the western Tihama in search of pasture and water. Cultivation is still hardly practised, but labour is a source of income.

Fishermen
Fishermen living from the Red Sea fishery, gaining income from fish sales and to some extent from trade with other coasts.

Urban population
Buyers of agricultural produce and fuelwood with money earned in non-rural activities.

Merchant farmers
Usually stemming from land owners, but essentially involved in agri business such as animal feed, trade in agricultural produce over the country, poultry factories, livestock imports and firewood trade. Opportunistic.

Privately owned agricultural land is relatively well managed. Farmers succeed in adding value to the farms. The management of communally owned resources depends on the strength and organization of local communities. The changing socio-economic climate leads to more marginal incentives for proper management and consequently to a decline of the state of the communally owned resources.

How negative this impact is depends on how the technological skills are used and the resistant nature is to them. But since technological skills are increasing rapidly the impact will only become more negative, unless the incentives for the resource managers change or the government does exerts its protective role more effectively.

Even when people have the incentives to adequately manage the natural resources at their disposal, they may cause damage to the resources due to the marginality of their subsistence: they are cannibalizing their means of production because there is nothing else. This is especially the case in rainfed farming.

As yet, there are no incentives in the Tihama to use ground water resources carefully. On the contrary, everybody is motivated to obtain as a large a share of it, as possible. Very few people realise that groundwater may be a terminable resource. Judging by the numerous areas which have not yet reached danger level situations, it is clear that many communities are still capable of protecting their communal firewood and range resources.

Incentives and impact on different resources

Groups of resource users	Natural Resources				
	Range land	Ground water	Agric. land	Wood Resources	Wildlife Resources
	INC/IMP	INC/IMP	INC/IMP	INC/IMP	INC/IMP
Upstream farmers	0/0	0/0	+/++	-/0	-/-
Downstream farm owners	0/-	-/--	+/+	-/-	-/-
Downstream sharecroppers	-/--	0/-	0/0	-/--	-/-
Rainfed farmers	-/--	0/0	0/-	-/--	-/-
Deep groundwater farm owners	-/-	-/--	+/++	-/-	-/-
Deep groundwater sharecroppers	-/-	-/-	0/0	-/-	-/-
Shallow groundwater farmers	0/0	-/--	+/++	-/0	-/-
Camel raising bedouin	0/0	0/0	0/0	-/--	-/-
Fishermen	0/0	0/0	+/+	-/--	-/-
Urban population	0/0	-/-	0/+	-/--	-/-
Merchant farmers	-/-	-/--	-/-	-/0	-/-

-- = very negative
- = negative
0 = neutral
+ = positive
++ = very positive

6. Present state of natural resources

6.1 Changing landscapes

The landscapes of the Tihama are different from those of the past and those of the future. The reasons behind these changes may be sought in climatic change and in change due to human occupation. The climatic data that are available for the Tihama do not allow for an analysis of climatic change, since the meteorological records are too scarce for this purpose. However, from analyses in nearby regions of Africa and the Middle East it seems to early to take climatic change into account as an important factor for changes in the environment in this time period. On the other hand, should future climatic changes cause a rise in sea level, this would have a tremendous impact on an area, such as the Tihama, where human activity near the shoreline is very important and where salt water intrusion in the ground water is already locally important.

In travel descriptions of the thirteenth and seventeenthcentury the Tihama is described as a densely forested area. However, the definition of forest by Arab travellers may be interpreted somewhat differently than the term forest in its modern sense. It is recognized however, that the expansion of cultivated lands over the centuries has occurred largely on those places, where forest used to grow, namely along the wadi, on the wadi floodplains and terminal areas, dune valleys and on the foothills.

Nowadays many bare areas are found near the villages and in areas surrounded by larger towns. Centuries ago, these bare lands were presumably much less extensive, when both rainfed cultivation and grazing by livestock were much less intensive.

6.2 Sustainability

In the discussion of the impact of these changes there are two aspects that should be looked into. The first aspect is related to the biological diversity of the Tihama, the second to its production potential. The second aspect currently deserves much more attention in the perspective of rural development than the first, and given the isolation of the area during the last century, this is may be rightly so.

The changes man caused in the Tihama had an impact on its biological diversity. On the one hand, the Tihama became richer in species and habitats than before, since man has introduced new landscapes in destroying the old natural vegetation cover (date and doum palm stands, and other cultivated lands with the birds, insects and plants that go with them). The pace of change over at least two thousand years has been slow enough to justify this conclusion. On the other hand the rapid change that is currently taking place is of course, just as devastating to all the wildlife and flora that the Tihama supported as it is in other parts of the world.

Sustainable use of resources is a use which can continue for generations, without causing damage to the production potential harboured by soil and water resources. For example, a farmer may transform the formerly forested floodplain of a wadi into agricultural land. He takes away all the wood on the land for this purpose, and he prepares his field. As the years go by, his farm increases in quality, because of the care he takes in managing his land. Despite the fact that the forest is removed, the new use to which the farmer puts the land is sustainable in itself.

Environmental problems are problems caused by careless use of resources by man. If the trees cut down by the farmer are the last trees in his environment, he has not been careful in his resource use in this respect.

Problems in wadi irrigation, with the example of Wadi Rima

In Wadi Rima irrigation has taken place similarly to the traditional wadi irrigation practiced elsewhere in the Tihama for millenia:
use is made of the occasional heavy floods of very short duration. The floods are diverted to the fields and one or, exceptionally, two waterings are sufficient to sustain a deep rooting crop. Agricultural yields are in general low and vary from year to year, depending on the size and frequency of the floods. Devastating floods damage and frequently destroy irrigation structures and agricultural lands. Yearly repair and maintenance are essential elements of the system.

Traditionally, once the most upstream field has been irrigated and not earlier than that, water is diverted to the fields of the farmer downstream. Thus, lands situated near the water-intake can be triple cropped. By contrast, on the more extensive lands further downstream even a single watering may be an uncertain prospect. Water distribution is managed by the canal master, one for each canal. He arranges the priority of the water rights to the various fields and farmers according to the historically developed water rights.

As in Wadi Zabid and Wadi Mawr a modernized irrigation system has now been constructed. The design of this Wadi Rima irrigation system is based on a radically different concept from the system in Wadi Zabid and somewhat different from that in Wadi Mawr. Here the traditional flood irrigation system, aiming to divert flood waters at maximum flow rates at many locations, is replaced by a system relying on the diversion of low flow rates at one location. The system was completed in 1983 and has been intensively monitored since. It consists of a diversion weir, a main supply canal, a division structure, an inverted syphon (transporting diverted water under the wadi bed to the other bank) and two canal systems on the left and right banks.

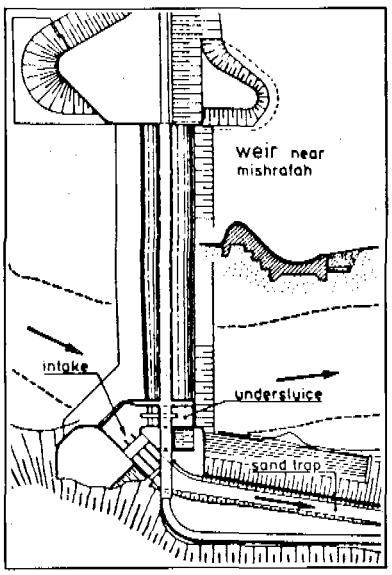
The different concepts of the main irrigation structures in Wadi Rima, Wadi Mawr and Wadi Zabid illustrate the technical difficulty of designs of structures that function well (better than the traditional ones!?) in the capricious wadis. The huge sediment loads are another technical problem for the structures and cause canal siltation. On the other hand the less sediment is let into the canals the less natural fertility is transported to the fields and the more mineral fertilizers are required. This trend in conjunction with others reduces the farmers capability for forage production since cash crops have to finance fertilizers, etc. A reduction of the livestock production capability inside the irrigation systems will increase the pressure on the grazing lands outside and thus further stimulate environmental degradation.

With the help of a computer an optimum gate operation schedule was formulated for the whole area, based on seven years of hydrologic data collection and on the lessons learned from the much older irrigation system in Wadi Zabid (1975-1979). However, the schedule had to be adjusted in view of an emerging dispute with regard to water rights, which at one time had become quite violent: In the new situation farmers with a very reliable access to flood water, received much less water, while farmers downstream received more; the computer did not take the historic water rights into account.

Research results indicate that higher agricultural yields can be obtained if the irrigation water is used more efficiently. There is scope for improvement in this respect. Moreover it is most urgent, given the fact that more intensive use of surface flow is being made. This wadi flow is at the same time the most important source for groundwater recharge, already a resource that is threatened by overuse.

The modernization of wadi irrigation in the Tihama is a good example of the environmental problems that are arising now as a result of economic development. The lesson from the past is that it is more economic to prevent the damage from being caused than to cure the problems afterwards.

Diversion structures in Wadi Rima



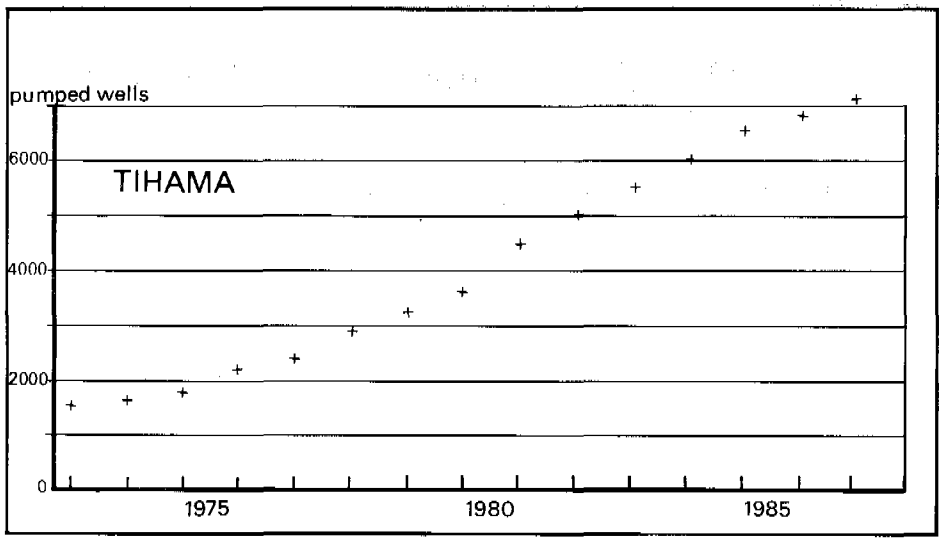
6.3 Use and misuse of resources

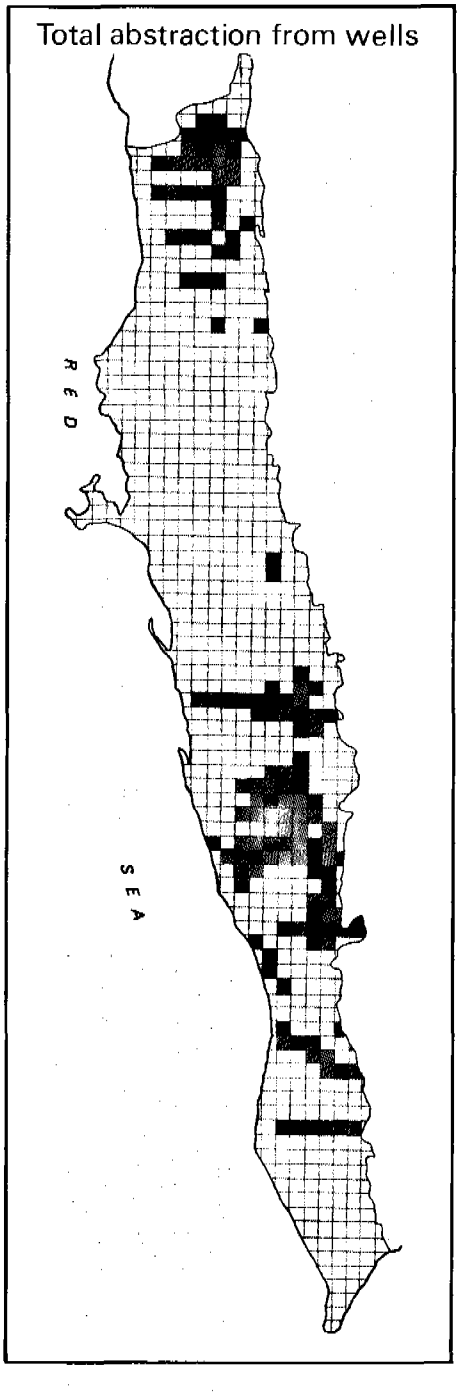
Farming
The sustainability of the use of agricultural land depends on the farming practices. these are different for the different farming systems, in which the dominant issue is again the farmer's access to water.

Wadi irrigated agriculture
The mere fact that wadi irrigation has existed for at least two thousand years in itself implies that the system is sustainable enough. The wadi water brings the nutrients onto the field in the form of fertile sediments. Low inputs are required other than labour. Modernized irrigation, though providing water only supplies a fraction of the sediments, and the use of mineral fertilizers is becoming urgent, since the natural soil fertility becomes exhausted rapidly.

A remarkable aspect of both traditional and modernized wadi irrigated farming is the integration of livestock in the farming system. Stubble, specially grown ratoon of sorghum and alfalfa provides animal feed.
The boundary between high potential irrigated cropland and adjacent low potential rangelands is much less sharp than it is elsewhere in the Tihama or in many other countries.

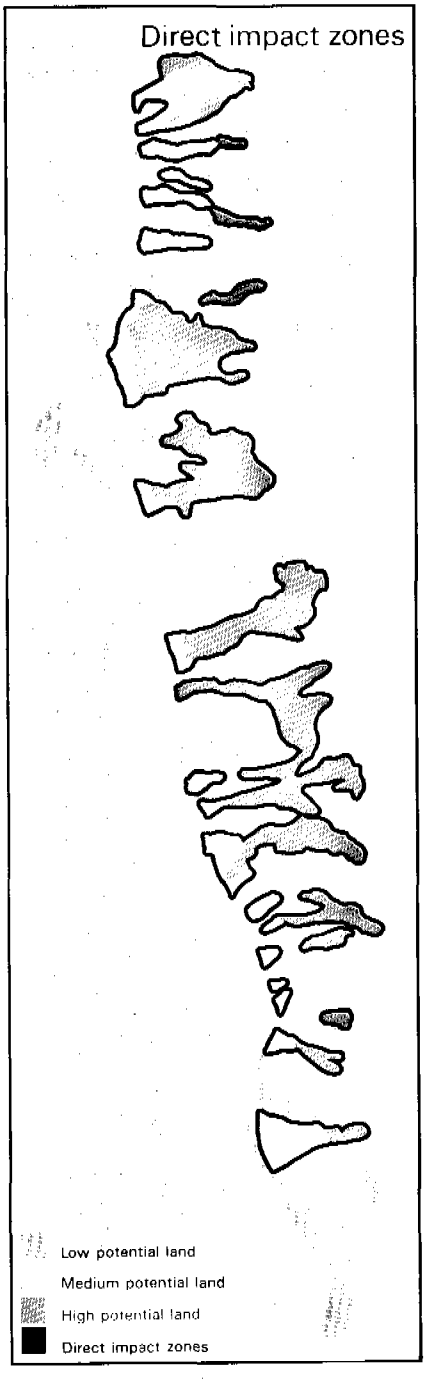
Deep ground water agriculture
The rangelands surrounding the deep ground water irrigated farms are usually much more overgrazed than in the case of the wadi irrigated agriculture. Another problem exists with respect to ground water. On a regional scale, the total abstraction exceeds by far the annual ground water recharge. The immediate consequences are that ground water level declines, on average by 0.5 meters per year, and there is a migration of saline (sea) ground water into the fresh water aquifer. The last feature is quite irreversible.





Animal traction is yet another aspect of low-input agriculture

The effect of high potential zones in otherwise low potential land



The productivity of any irrigated land in the Tihama is much higher than that of the adjacent rangeland or rainfed cropland in terms of, for example, tonnes of dry-matter production per hectare per year. The fact that farmers inside the irrigated areas have many animals is the basis for an environmental problem. The animals graze and browse for most of the time near the irrigated area, though outside the fields as long as there are crops. They graze and browse on the nearby lands more than elsewhere, if only on their way to or from pastures further away. The impact of this high grazing intensity in the low potential zone surrounding the high potential area is usually one of degradation of the rangelands in a circle around the irrigated areas. These circles may have radiuses of up to 20 or more km's in some semi-arid environments.

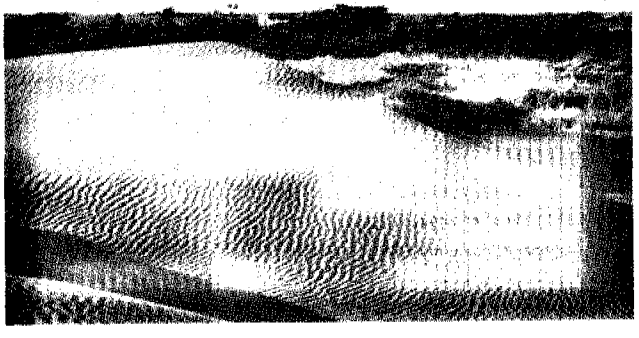
In the Tihama as in the rest of Yemen, animal production is a completely integrated part of traditional farming systems. This is quite different from almost any other known location. The mere fact that the animals are kept inside the farm at night and at least partly fed on farm-produced fodder has been effective in preventing degradation of the rangelands beyond a certain stage.

However, in some locations, the situation is different. This is the case especially when one or certainly when both of the following factors apply to an area:

- the degradation of rangeland occurs more rapidly when the productivity of the rangeland is lower. The lowest rangeland productivity occurs on the driest parts of the Tihama where no water is available to the pastures other than the periodic rain.
- the farming system is focused on the production of cash crops. This is especially the case in deep groundwater irrigated farms, where the costs of water cannot be offset by cultivating crops such as animal fodder. Usually the owner of the deep groundwater irrigated farm does not rely very much on animals for his income, but his share croppers, labourers and tenants certainly do.

In conclusion, it may be said that severely degraded areas, including the region near Zabid where reforestation efforts are concentrated, are situated in the central and western Tihama zone around areas of deep groundwater irrigation. This degradation has been caused by an inadequate integration of livestock and crop production on the farms. It is acknowledged that many of the farms where deep groundwater irrigation has been applied have been established recently and that a more balanced farming system may develop over time. This aspect deserves attention in the Tihama experimental farms.

Dune formation along the fringes of a deep groundwater irrigated area in the western part of the Tihama.



Shallow ground water agriculture
This much older type of cultivation, used especially for dates, has a negative impact on water resources nowadays. The production of dates on a larger scale combined with a lowering of the ground water tables due to the introduction of motorpumps has caused some wells in the areas used for date palm cultivation to become increasingly saline. Combined with this is the fact that a prudent use of ground water is needed, in any case, to sustain the production of dates.

Rainfed farming
Rainfed cultivation has always been described as being very variable in cultivated area. As a consequence of the sequence of dry years in the period from 1973 to 1987 and the population growth, much of the natural vegetation surrounding the villages of the rainfed farmers has been destroyed. This has given rise to dune formation in areas where the sand was formerly stable. The natural vegetation has not had much chance to regenerate in this period due to the heavy grazing that takes place in the dry years when the land cannot be cultivated. Of course, the high longitudinal dunes are not formed in this manner, but even in in these areas, dust storms are much more common than they used to be. The dependency on livestock, the limited access to land with a more secure water availability has resulted in a degraded and desert-like environment of the villages inside the Bajil, Al Marawi'ah and Ad Dahi triangle as well as in the villages on the tops of the longitudinal dunes near Al Mansuriyah.

The wind erosion is locally very strong in these areas. On the other hand, the current desert would disappear within a couple of years, if no man or animal touched the land. Of course, this is a rather unrealistic situation considering that people have to live at least partly from what this land may provide. Nevertheless, some reduction in the intensity of use would be beneficial to the village population in the long run. The process of desertification is quite reversible.

In the date palm groves too, increasing use is made of motor pumps.

Groundwater
It is estimated that roughly 20 % of the Tihama farmers had access to ground water in 1988, either by ownership of a well and pump or by hiring one of the two or by buying water. Already, this 20 % puts a tremendous demand on ground water and has given rise to lowering ground water tables and will presumably cause a great loss in capital in the form of wells which have become or will become dry. Groundwater is the most important and endangered resource for future development in the Tihama.

Grazing
The rangelands of the Tihama are intensively used by grazing and browsing livestock. The scope for an increase in livestock production based on improved range production is rather small in this respect. A possible increase in livestock production is more likely to be achieved by increasing fodder crop production for livestock feed. Near villages, in the rainfed agricultural areas and along the fringes of the well irrigated areas degradation of the rangelands takes place. The degradation is reversible if the intensity of grazing and firewood collection can be reduced. In the rainfed areas separation of lands for cultivation and grazing would be of great help in alleviating the desertification problem.

Most of the surface of the Tihama is covered by this open treeless rangeland, which is still in good condition.

Desertification in the Tihama

Desertification and carrying capacity.
Desertification is a form of degradation in which an ecosystem takes on the appearance of a desert. Desertification may occur without a change in climate. If the soil has not been eroded away by wind and water and there has not been any climatic change, the vegetation can regenerate, provided the regrowing trees and grasses are not immediately cut by man or grazed by animals. The fact that this last condition is practically never fulfilled is the true reason that desertified zones continue to exist in areas where it is not necessary.

The production capability of the environment is determined by its use. When grazing land is overgrazed, the number of animals it can support decreases. There is a certain number of animals per hectare which gives a sustainable maximum return in milk or meat. The determination of this carrying capacity is crucial in determining the sustainability of forms of land use.

Some reports claim that desertification is one of the greatest dangers to development in the Yemen and in particular to the Tihama.
According to this Profile, desertification is not a general feature in the Tihama but it occurs on a certain scale:

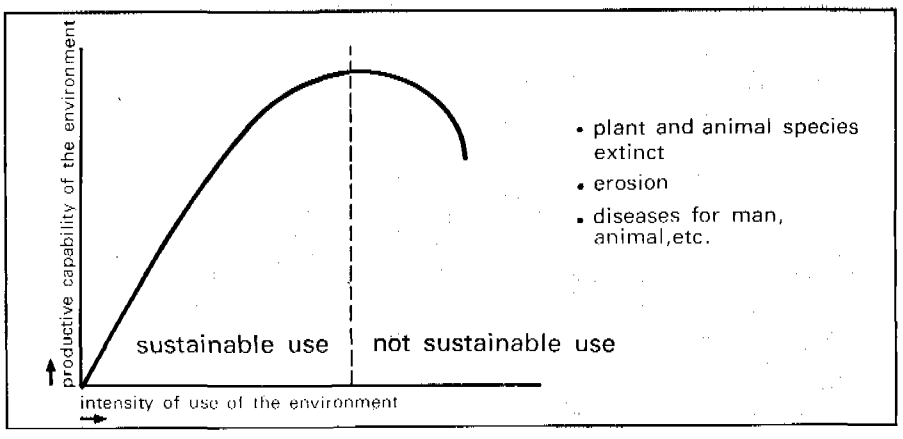
So far, the term degradation has been used to describe a reduction of the production capability of the environment. Desertification is a form of degradation in which an ecosystem takes on the appearance of a desert. Desertification may occur without a change in climate. In the Tihama certain areas have become desert-like:
- circular areas in the immediate vicinity of towns and villages, e.g where livestock concentrates to drink,
- zones around irrigated areas, where fuelwood is collected and goat and sheep feed on the rangeland nearest to the farm,
- zones of rainfed cultivation where the natural vegetation is removed, in order to cultivate millet and cowpea.

In some locations the sands and silts have started moving and the newly formed dunes threaten good farm land or villages. This is the case along the fringes of the well irrigated areas e.g. near Zabid and on the dunes near Al Mansuriyah. The latter location is the largest single desertified area in the Tihama, while other significant areas occur within the triangle formed by the towns of Bajil, Al Marawi'ah and Ad Dahi.

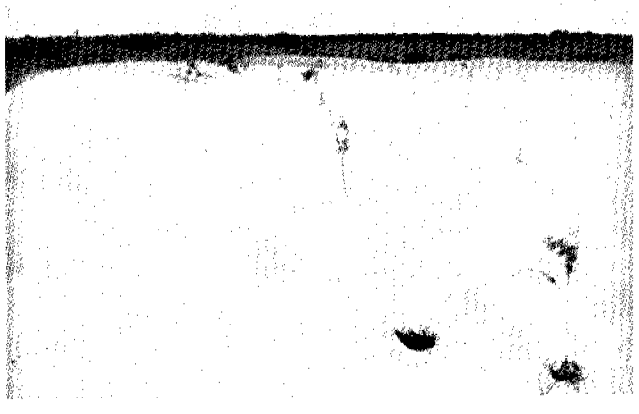
If the soil has not blown away completely as is the case in the Tihama and there has not been a climatic change, the vegetation can regenerate, provided the grasses and trees are not immediately cut by man or grazed by livestock.

In the case of the Tihama this means that desertification can be stopped quickly by stopping grazing and browsing by livestock and collecting fuelwood on the desertified lands.

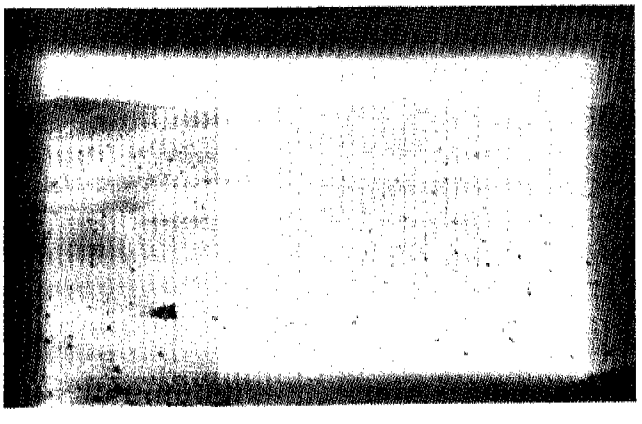
From a management point of view, the situation in the Tihama is rather favourable due to the fact that many of those who created the desertification are the same people who are now experiencing the trouble it causes. Obviously, these people must be very well motivated to stop the process of desertification in their environment. With help from specialists in sustainable land use management, good alternatives may be formulated and eventually trees or grasses may be planted, when the local community agrees with the formulated plan.



Reafforestation efforts near Zabid.



A desertified rainfed cultivation area where attempts to cultivate continue, although only a minimal yield will be obtained.

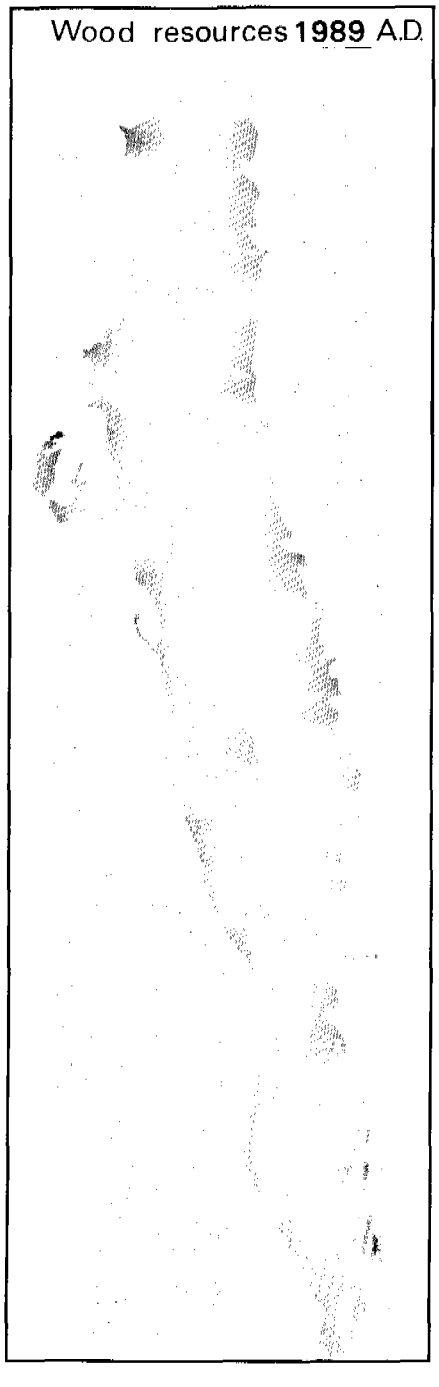


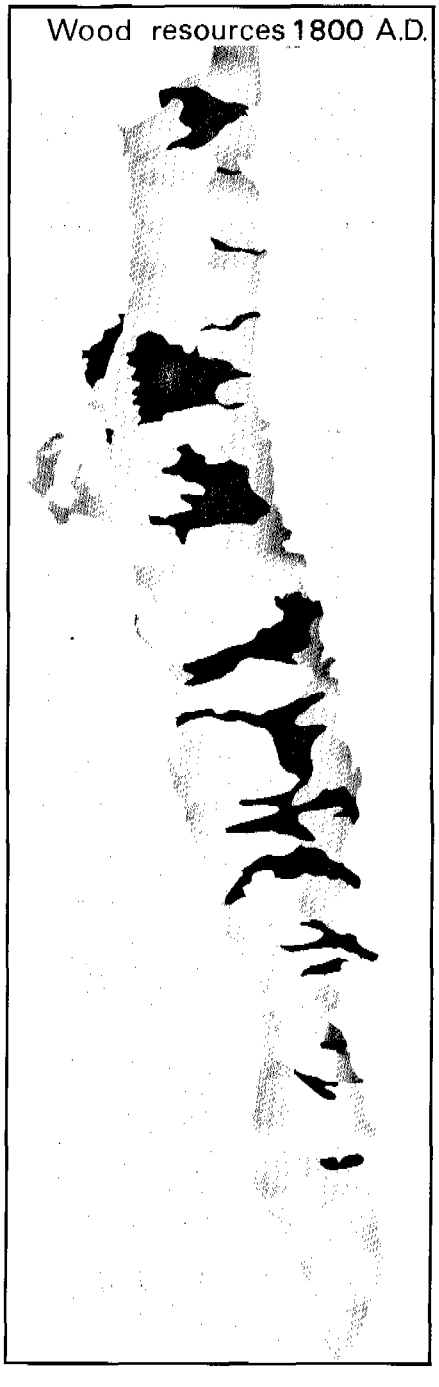
Wood resources
The enormous stand of firewood and timber that the Tihama represented in the seventeenth century has largely disappeared, and those trees that remain are now disappearing at increasingly rapid rates from some of the rangelands. Degradation takes place wherever more is consumed than produced, which is occurring more and more frequently. Source areas for relatively large scale firewood collection are still found in the southern Tihama between Hays and Wadi Mawza and in some relatively unpopulated areas in the northern Tihama, north of Az Zuhrah and in the Abs, Harad and Midi districts.

The Tihama used to have important mangrove stands at many locations from north to south. The straight poles the mangroves produce are in great demand for construction purposes. With the growth of especially the port towns, much of the mangrove stands were cut. For instance, the British cut down virtually all mangroves on Kamaran island and adjacent areas in the beginning of the twentieth century. The wood was used in Aden. The only remaining mangrove areas of importance are those near and north of Al Luhayyah. Most of the mangrove areas are only ten to twenty meters wide and are intensively browsed by camels.

Use of nature products
The great natural variety in plant and animal life in the Tihama and the bordering sea has provided man with many products. For instance, for many years, coral has been widely used in the construction of houses and mosques in the port towns, though on a relatively small scale. But in recent years, it has also been used for road construction. The large quantities used for this purpose have had a devastating impact on the reefs which are important areas in the sea for the reproduction and growth of fish.
The fishery as practised from the Tihama does not lead to overuse of the fish resources in the Red Sea, but this may not be true of the floating fishing factories that sometimes come ashore in Al Hudaydah. However, this subject is beyond the scope of this Profile.

Wildlife
Hardly any wildlife is left in the Yemen as a whole. Gazelle populations are still reported in the Northern Tihama. Wildlife as a resource for human use is not applicable anymore for the Yemen Arab Republic. The aspect of conservation is treated in Chapter 7.





Bare or cultivated land
Open shrubland
Grassland
Dense shrubland
Open woodland
Dense woodland

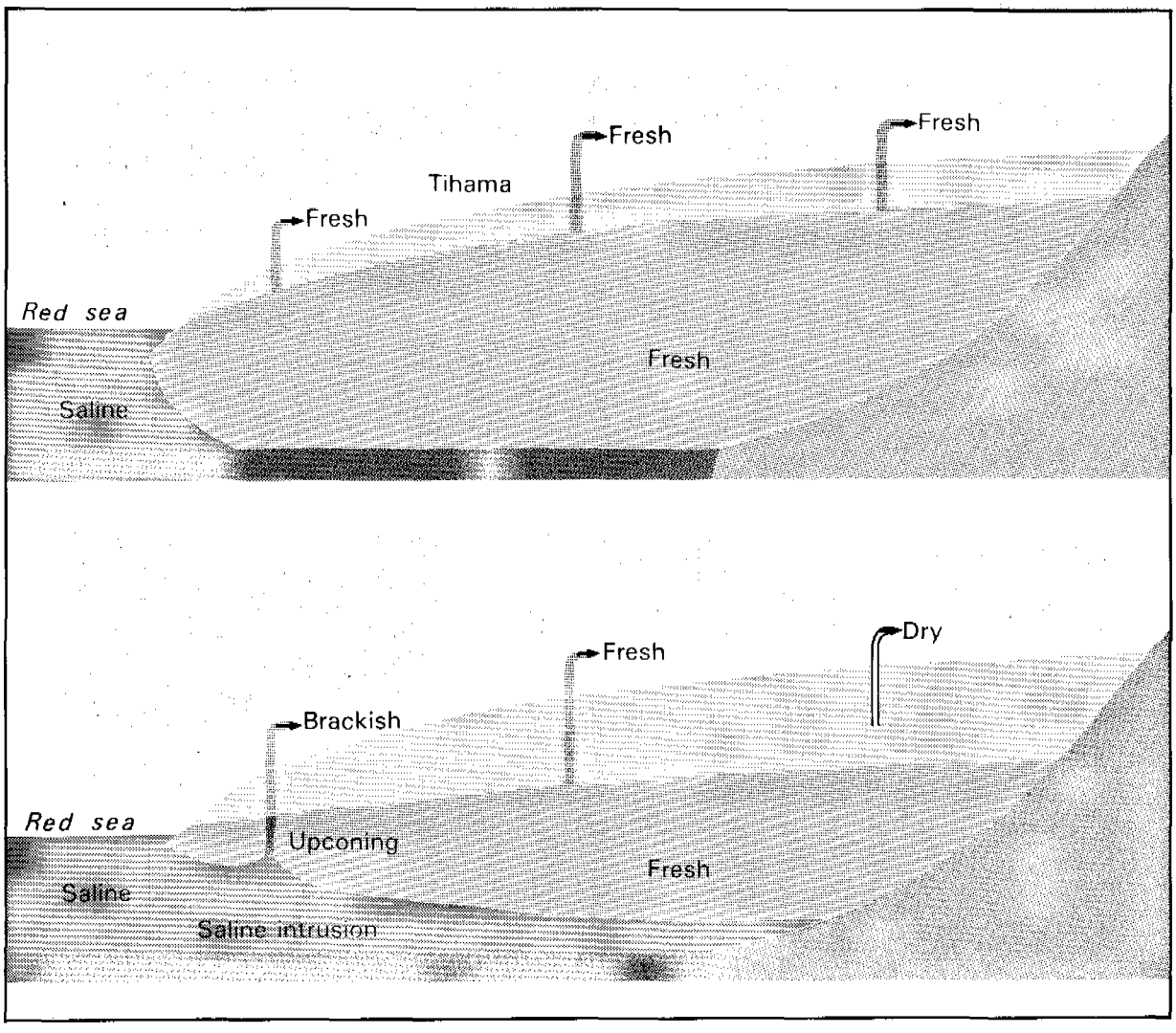
The use of ground water in the Tihama

Thihama ground water is a much wanted resource. However, as with all natural resources, it cannot be used without limitation. The ground water situation resembles that of the western half of the Netherlands, where a serious accident took place, such as may also occur in the Tihama.

Two facts which are a source of great hidden danger for the future of the Tihama have to do with its ground water. First, the Tihama contains an enormous fresh water reservoir, in which the annual fluctuations and the current overdraft is only noticeable in the long term. Second the Tihama ground water moves from east to west, flowing under the surface, into the sea. Since it is ground water, the movement is very slow. However, this movement and the mass of fresh ground water is enough to prevent the intrusion of salt water.

If this balance is seriously undermined by, for instance, lowering the ground water tables in the middle and upper reaches of the Tihama it can only be detected at the coast after many years, by which time significantly smaller amounts of fresh water will reach the sea. The danger when this situation is reached is that salt water will intrude very rapidly under the Tihama, as it did in the Netherlands. Whereas, in the Netherlands there happens to be a lot of fresh surface water and a surplus of rain, in the Tihama, there is a shortage of rain and very little fresh water.....

Diagram showing the long-term consequences of over-exploiting the Tihama Quaternary aquifer.



7. Conservation

In this Profile attention is paid separately to the natural resource of flora and fauna. It is evident that much of the wildlife which lived in Yemen in earlier centuries has completely disappeared. In this section the most important information is brought together on the natural vegetation and wild fauna of the Tihama as far as this is relevant for nature conservation purposes.
The Yemen Arab Republic is very rich in plant and animal species. Some 2000 plant species have already been identified as being present in the country, but the real figure may well be a few hundreds higher. A more systematic inventory of some animal groups was started only recently. The number of invertebrates (insects, etc.), but also vertebrates is continuously growing.

This great diversity of species, 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 is at a key position on migratory bird routes. The creation of distinct land use patterns by man and new surface water conditions, has not only resulted in local land resource (including plants and animals) degradation, but also to a further diversification of habitats in places and the introduction of new (exotic) species.

In the Yemen, the Holarctic and Paleotropic Regions meet. For different lifeforms the namegiving is different but for the Paleotropic Regions it is the Sudanian subregion that is widely represented in the Yemen flora and fauna. Generally speaking, it is the Sahora-Arabian and Sudanian species which predominate in the Tihama.

7.2 Flora and fauna

Vegetation and flora

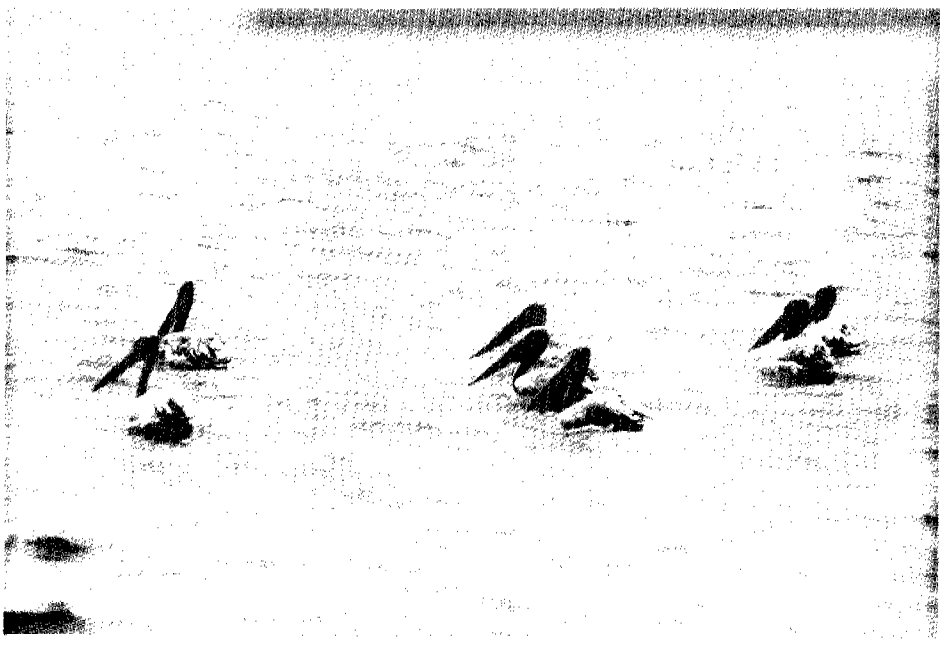
Many different vegetation types and plant species are found in the Tihama. For conservation, the remnants of mangrove swamps are of particular importance. Remnants of these swamps are found North of Kamaran Island and especially near Al Luhayya, the white mangrove being the dominant tree. Forest remnants in the Tihama foothills are important because they are the last pockets of natural vegetation in this area. The Jebel Bura valley forest is an outstanding example of a relic of the tropical forest, which once extended in large stretches below the foothills on the upper parts of the Tihama. The intensive clearing of Dober (Dobera glabra) on cultivated lands, has left only solitary and scattered trees of this species. The Commifora woodlands along the eastern fringe in the southern Tihama are under serious attack from land clearing and commercial fuelwood cutting.

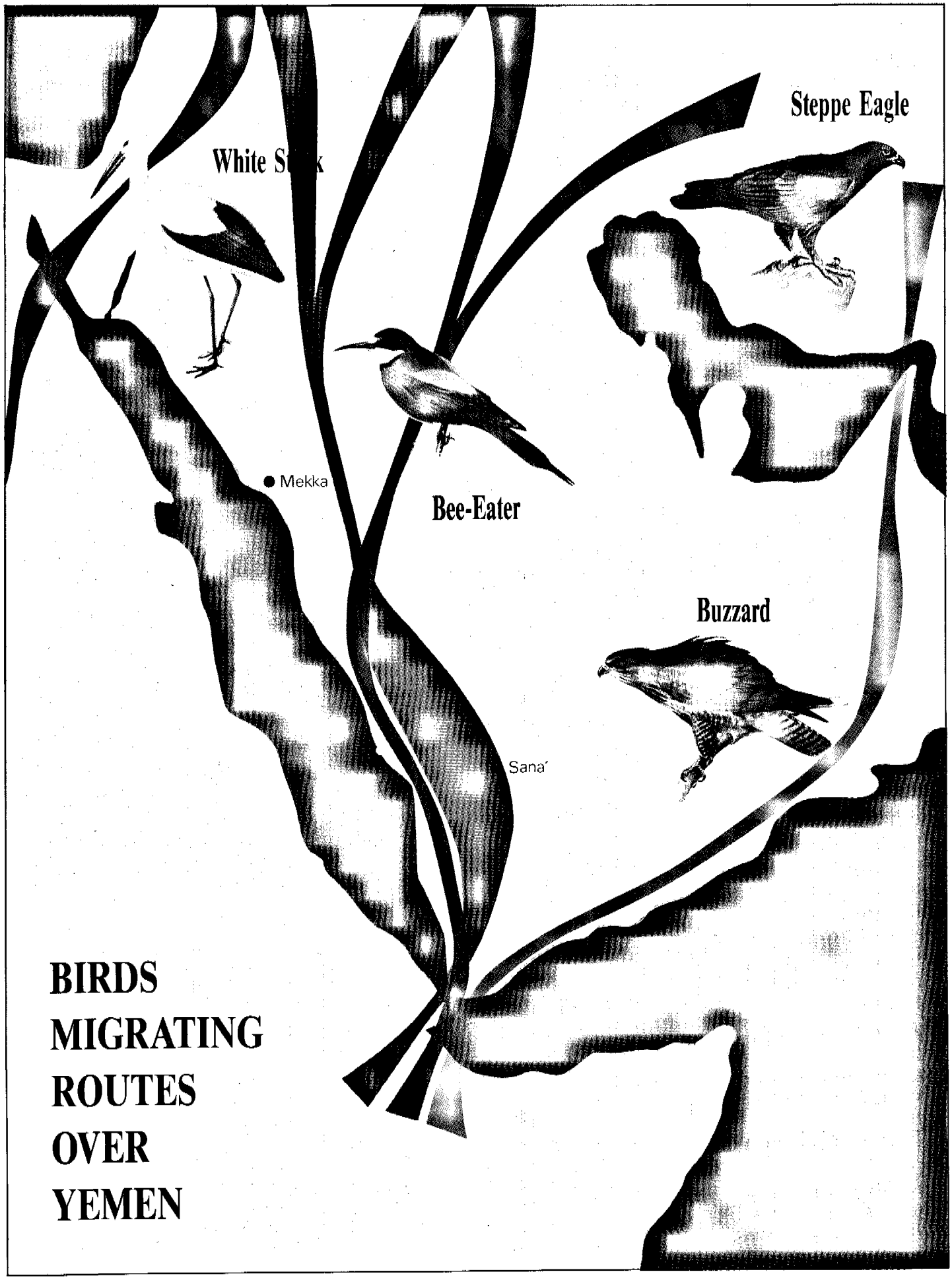
Fauna

Only a fragmented and incomplete picture can be presented in this section because very little information on the subject is available. Most of the information was collected during the Tihama expedition in 1982 (Stone, 1985). This and the ornithological expedition in 1985 of the Ornithological Society of the Middle East provided information almost exclusively on birds. The almost complete disappearance of the last remnants of larger mammals in even the relatively uninhabited areas of the Tihama indicate that the need for conservation of what is left is an urgent prority for this area. Birdlife concentrates along the shoreline. The mangrove and other wetlands are of particular importance in this respect.

In an area near Az Zuhrah, populations of Gazella gazella still appear to occur on the rangelands.

Pelicans in the Red Sea




Steppe Eagle
White S k
Mekka
Bee-Eater
Buzzard
Sana'
BIRDS
MIGRATING
ROUTES
OVER
YEMEN

7.3 Patterns of change

The vegetation and animal life as it is currently found in the Tihama is more endangered than 20 years ago, but even before this period, animal life and natural vegetation was dwindling in the Tihama, because the area has been in intensive use for a very long time.

In modern Yemeni society people are becoming more and more aware of the necessity to conservate flora and fauna. This necessity is felt even more strongly in the towns than among the rural population. It most certainly belongs to the tasks of the Environmental Protection Council to increase the awareness of the public in this direction.

7.4 Requirements for nature conservation

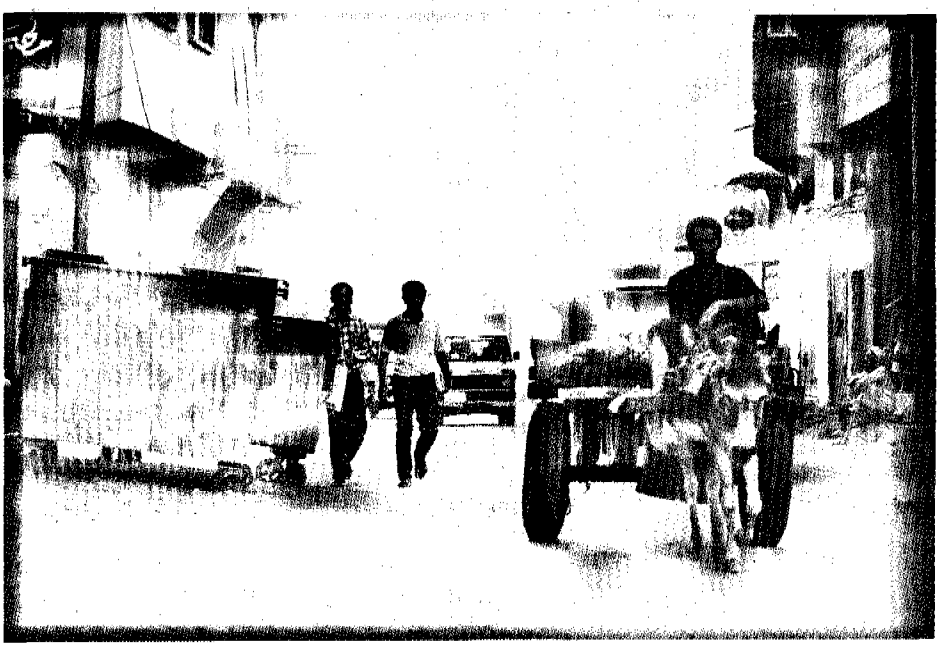
It has been clearly established that the Yemen is an important geographical area for many plant and animal species. Even the most basic information on distribution patterns, numbers, life histories and conservation requirements with respect to the action of man, is still lacking for most species. There is therefore an urgent need for more detailed information on the present status of plant and animal species and their habitat requirements. This information gathering could be taken up at university level and incorporated in the governmental institutions in the country, supported wherever necessary, by overseas expert assistance.

Mangroves near AL Luhayyah

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

- Organism protection. This requires amongst other things the establishment of laws and law enforcement on the hunting of animals and the gathering of plant species. It should also include rules for the control of trade.
- Habitat conservation. This should include area protection and monitoring. It might also include habitat- and wildlife management.
- Environmental education. This should aim at the technical training of professional staff and 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 understanding 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 the local population, particular species in areas where they have 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.



Waste collection in Al Hudaydah

Back streets of Bajil

Poster from the Al Hudaydah health education and sanitation campaigns

8. Urban environment and environmental health

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

8.1 Health situation

The general health situation is gradually improving. In urban centres, many people are exposed to infectious diseases related to poor sanitation. In the Tihama, where irrigated agriculture is widespread, the spread of water-borne and water-related diseases forms a serious health hazard unless preventive and prophylactic measures are effectively enforced. Malaria and schistosomiasis are commonly found. 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, suboptimal. 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 (birth12 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 Water supply

As in most parts of the world, an important factor in the location of early settlements and the development of early cultures was the availability of reliable, good quality water resources, both for human uses, transport and agricultural production. Also, sites were selected where natural waterrelated disasters were rare or absent. Ironically, in many urban centres of Yemen, water is now a limiting and threatening factor in modern development. Aquifers are seriously over-exploited and an alarming drop in groundwater tables imposes major constraints to water supply authorities, both in rural and urban areas. On the other hand, because of the impeded drainage of surface waters, parts of towns are flooded after heavy storms, damaging houses and buildings and affecting the health of many people, as puddles of polluted water are favourable breeding grounds for many disease vectors. Throughout the world, much attention has been given and appreciable progress has been made in the technical aspects of urban water management. However, it is not the size of pipes and channels, the capacity and location of water supply facilities and the construction of flood control structures which guarantee a sustainable exploitation of water resources. The planning and design of urban water supply are frequently attuned to available budgets rather than being based on considerations of optimal design and conservation and sustainability of the resource. Technical solutions are designed within the prescribed limits of short-term costbenefit analyses. Such an approach has the advantage of simplicity but may prove, in the long run, self-defeating. When disturbance in the sustainable use of natural water systems occurs, for instance, as a result of increased water demands and urban expansion, the correction of the disturbance may prove many times more expensive than the initial construction. The level of disturbance and the necessary corrections are strongly correlated: the greater the disturbance, the greater the correction required. Considering the rapid rate of urban development and the state of urban planning in Yemen, this issue deserves the utmost attention of the authorities concerned.

8.3 Urban Hydrology

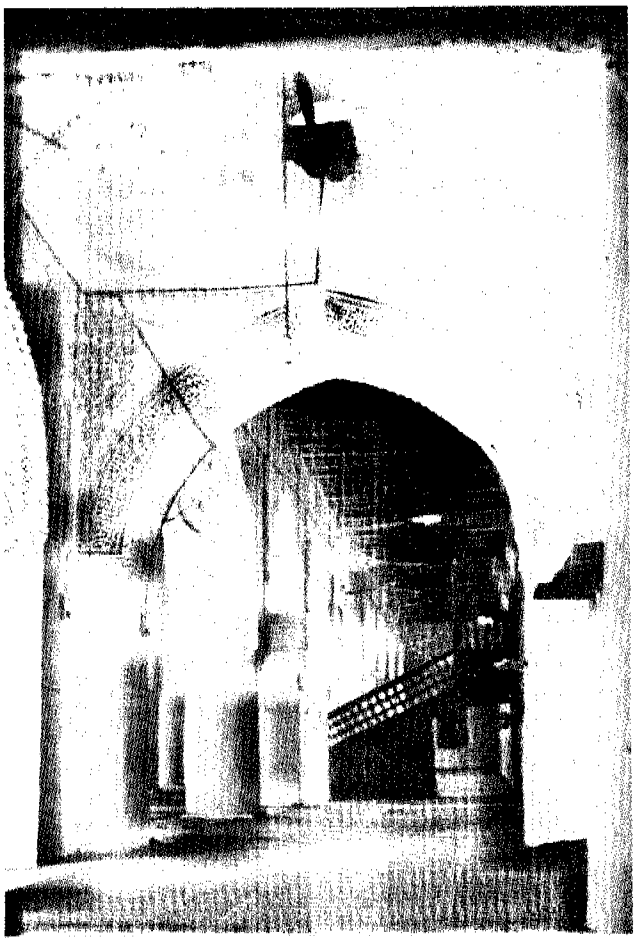
An essential element in the hydrological cycle for modern urban areas is that the natural drainage system is altered and impeded by constructions and sewerage. This results in flooding and pollution, problems which can be partly alleviated by technical solutions: storm sewers, detention ponds, septic 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 often

Preservation of cultural heritage

The town of Zabid is one of the oldest population centres in the Tihama, where outstanding examples of Yemeni cultural heritage can be found. Witnesses of the rich history of the region are the many old houses and buildings, city walls, gates, mosques and ruins. The state of preservation of many of these cultural monuments is precarious and many are damaged or on the verge of collapse.

There is no clear and unambiguous policy to preserve these cultural monuments. Moreover, enforcement of existing regulation seems weak, which has resulted in the removal of some buildings for new constructions. The preservation of remaining historical monuments should be institutionalised. First, an inventory should be made by specialists in local archeology and history. Second, legislation should be drafted allowing for the preservation of structures selected as National Monuments or Historic Sites. Third, a management plan for the restoration, preservation and maintenance of these monuments and sites should be prepared. The status of a National Cultural Preservation Authority should be enforced and institutionalised and its members should be involved in planning urban development projects. Staff should be trained for the implementation of the programme. Considering the urgency of the situation, it is likely that financial and technical support from abroad will be required for the implementation of such of a programme. Cooperation with the World Heritage Site programme of UNESCO could be considered.

Interior of the the great mosque in Zabid.



Decaying architectural heritage in Zabid.

extends beyond the urban area. 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.

These primary effects may all have secondary impacts on man and his environment. Moreover, some of these impacts spread rapidly because of high population density. For this reason, stringent water quantity and quality standards should be set for urban water supply systems.

8.4 Al Hudaydah's environmental problems

Al Hudaydah currently has a population of approximately 200,000. The population grows at the rate of 7 % per year. A health improvement and waste disposal project is currently being implemented.
About 100 to 120 tons of waste is being collected each day. The waste is dumped in trenches outside the town, which are covered with earth when full. Sometimes, waste is burned and when floods occur some waste is washed into the sea.
Because of the urgency of the waste problem, the project so far could not pay much attention to possibilities of recycling, selection of waste material, burning and composting of waste. For this reason, all types of waste are collected and disposed of together. This makes it unsuitable for composting because heavy metals and other substances toxic or harmful to humans, animals and crops may be included. Moreover, farmers in the area are not yet familiar with the use of compost.
Chemical waste in the area comes mainly from industrial waste water, but increasingly, industrial plants arrange the disposal of waste themselves and some treat their waste in the factory before disposal. No waste is directly dumped in the sea.

The Health Education programme is successful. Video tapes, cinema spots, posters etc. are being used to create people's awareness of the need to keep the urban environment clean and to improve hygiene. Various approaches have been tested to educate the public in aspects of environmental health. Target groups (women associations, school children) have been identified and information on environmental health has been attuned to local concepts. Video tapes on various subjects are shown in the streets, with appreciable results. Vector-borne diseases, such as malaria, hepatitis etc. are common. For this reason special attention is given to the control of mosquitos, flies, flees and rats.

Active participation of the population in waste collection is promoted through crash programmes organised by town-sector chiefs. The main aim of these programmes is to encourage people to join the project of cleaning up the city.

8.5 Zabid's environmental problems

Zabid is an old and quiet town with approximately 13,000 inhabitants. Solid waste pollution and flooding are serious problems in the old parts of the town. Streets in most parts are very narrow, making it impossible to use container trucks for waste collection. After five dry years, the 1988 rains were abundant and serious flooding of the unpaved streets occurred. The impeded drainage of stormwater was such that tank-lorries had to be used to suck the water from the streets. Clearly, these puddles of dirty water provide excellent breeding grounds for mosquitos and other disease vectors. In the lower parts of the town, a number of old buildings collapsed because flooding weakened the basements.
The existing drainage channel around the old town wall is blocked and silted up and some parts have been invaded by plants and shrubs.
No adequate sewerage system exists. The situation has worsened since the installation of modern water supply systems, i.e. water pipes, taps and water closets. This has led to a dramatic increase of water wastage, as compared to former times when people drew their water from wells near their homes.
Household and other waste is still being dumped in the streets. No containers are available for waste collection. Sweepers clean the streets and one truck and one small van are available for waste disposal. The waste is dumped in a valley a few kilometres outside town.

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 the Tihama is also manmade. It is the result of a combination of human activities in the area, particularly during the last twenty years. However, the impact of human use on the resources of the Tihama differs according to the resource, some impacts are reversible, others have caused permanent degradation or change over the centuries. The situation around groundwater resources may even be a time bomb under the agricultural development of the Tihama. The following statements indicate the conditions necessary for a more sustainable development of the Tihama.

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 the case of the Tihama, it means that man, in requiring an enduringly 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 a threat to the present one.

9.2. Socio-economic factors

Population growth and quality of life

The Tihama population is growing rapidly. It is expected that there will be well over 2 million people in the Tihama by the year 2000. The increasing needs of this growing population may accelerate the degradation of those environmental resources that are already under great 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, and one that the government should consider as one of its most urgent problems.

Urban development

The Tihama contains a number of the most dynamic and thriving towns in the country. The emphasis of the national government and foreign assistance is focused on Al Hudaydah. The town is a motor for the economy of the whole country and many problems, including environmental ones, have to be solved urgently. However, the planned development of secondary and tertiary towns in the Tihama is as important, and may provide a more sustainable infrastructure for development.

Services

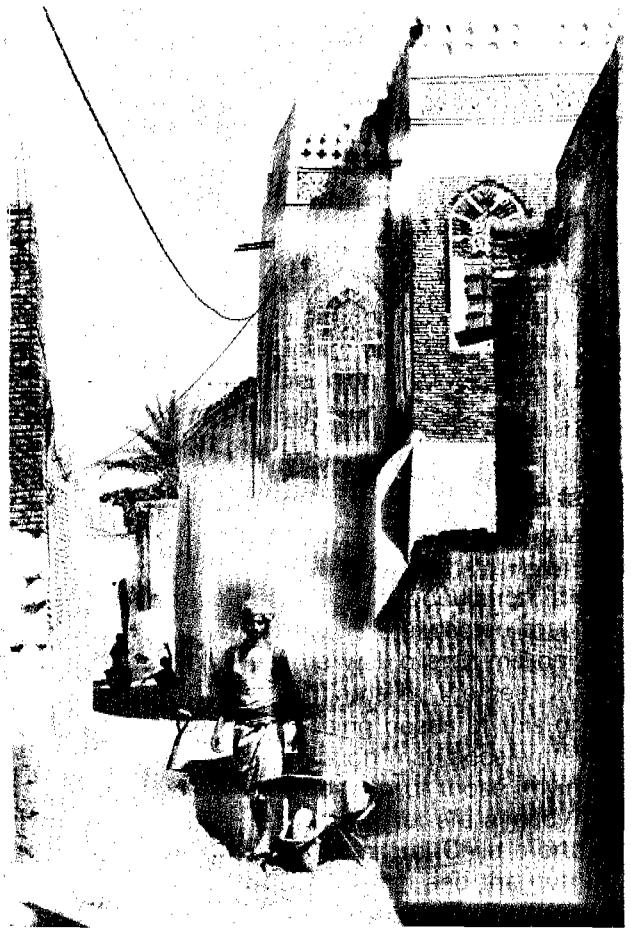
The present health and educational services do not yet meet the needs of the population. Improvement of the geographical distribution and level of services will strengthen the basis for more sustainable development

Environmental health

Child mortality is high and the nutritional status of children is rather poor. Health in the large, but especially in the smaller, towns is threatened by heaps of waste. Environmental health education is of great importance for improving the quality of live in the Tihama. Also advice to farmers in the wise use of pesticides is a point of major concern in this respect.

Diversification of economy

There are many indications that the economy of the Yemen Arab Republic, and in particular of the Tihama,is developing rapidly. Wage remittances and the internal economy are a driving force for agricultural development: money earned abroad or in sectors of the economy other than agriculture is



The old town of Zabid was entirely constructed with bricks. Nowadays, there is no longer firewood available to make bricks

used to buy agricultural products from the Tihama, though farmers may (or may not) invest their earnings in their farms in a way that leads to greater sustainability. It is crucial for the Tihama future that the government gives close guidance to agricultural development in this sense, more than is the case at the moment.

Urban development is only partly triggered by economic development. Many people go to the towns, hoping to build up a new life, but soon become disappointed, when they realize that there are hardly any jobs open to them. The presence of so many people who do not participate in the economic growth adds to the problems of the towns. However, these people left their rural environment because there were no jobs there either; there is no way back for 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

Rainfed farming
Traditional rainfed farming still provides the food for an important part of the Tihami. The current situation of rainfed farming in an often rather seriously degraded environment is partly due to the droughts of the period '73-'87 and for another part to the lack of consistent ideas and possibilities for the management of these areas. In fact, the management issue only became of importance when the population started to grow rapidly. The authorities need to give separate attention to this farming system by the authorities and local land management plans have to be formulated with the villagers involved.

Wadi irrigated farming
The Tihama Development Authority has built up much experience with the implementation and maintenance of new irrigation systems. It is recognized that many problems are related to these irrigation schemes. These problems are not only of a technical nature, such as the design and maintenance of canals and structures, but they are also related to environmental health, land tenancy, agricultural extension, fertilizers, etc.
For the future development of these and other systems, it is important to learn from experience. From an environmental point of view, the systems provide a sustainable basis for agricultural development when farmers' experience is combined with those of the irrigation engineers and adapted to local situations.

The increasing number of share croppers in the wadi irrigated and well irrigated areas may cause a future problem in land management. The dependency of share croppers on livestock grazing in the immediate surroundings and fuelwood collected from the same area increases the total pressure on those areas. Attention of the managers of the schemes and of the government in general, to integrate livestock production and wood production inside the agricultural areas is required. The fact that there is a good tradition in this respect is a great advantage.

Deep and shallow groundwater farming
Agricultural development of the Tihama depends to an important extent 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 the monitoring of groundwater resources.

Range management and livestock production
Livestock production is rather well integrated within agricultural production: grown fodder is an important animal feed. For the management of the rangelands it is crucial that this integration of livestock and crop production continues. There is a risk of further overgrazing if this integration is loosened by, for example, expanding the area cultivated with cash crops, at the cost of fodder production while, at the same time, maintaining livestock numbers.
In land use planning with respect to livestock production, the role of nomadic livestock is still of importance. The nomadic lifestyle offers the Tihama a versatile livestock production system, though in the long term, rangeland resources of the Tihama will be integrated within the other agricultural production systems and the nomadic lifestyle is bound to disappear. Planning of the use of rangeland resources and a stronger attachment of individuals or communities to certain rangelands is the only way in which incentives can be created for adequate use and management of the rangelands.

There is limited scope for an increase in animal production on the natural rangelands, but they are already under intensive use. However, livestock production, based on on-farm produced Yemeni cattle for meat, may be, or will become, attractive once the imports of cheap African livestock are restricted.

Tree resources
Fuelwood is already a scarce commodity in the Tihama, It will become more scarce in the future. Currently, the Tihama is still an exporting area of fuelwood and charcoal, but it is likely that the self-sufficiency of the Tihama will not continue for more than 5 years. Energy requirements of rural Tihami will increasingly be fulfilled by owned woodlots and urban population will increasingly make use of other fuel for cooking, such as gas and electricity. The government can assist in stimulating this shift in energy resources. From the point of view of nature conservation it is important to set areas aside where natural vegetation may regenerate and the classical Tihama forest can be admired by future generations. The same applies to the mangrove forests.

Wildlife resources
It is important to set aside areas for wildlife conservation, while there is still room for them in the Tihama. Possibilities for nature reserves in the Tihama foothills, near Jebel Bura, part of the northern Tihama, and the mangrove areas, need to be investigated.

Groundwater resources
The groundwater of the Tihama is the fundament for both agricultural, urban and industrial development this area. Issues for the management of Tihama groundwater are:
- reduction of water losses by improvement of the conveyance and farm irrigation efficiencies,
- control of groundwater abstraction rates and the optimization of the spatial abstraction pattern, with the objective of minimizing the losses due to coastal groundwater discharge, while at the same time keeping sea water intrusion, saline upconing and the groundwater level decline within acceptable limits,
- conjunctive management of groundwater and surface water resources,
- co-ordination between water resource development in the Tihama and in the catchment areas upstream,
- allocation of the scarce resources among the potential water users (including the planning for long term domestic water supply)
- protection of the aquifer against pollution.

The experience gained by the studies carried out in recent decades and by the, in the meantime, completed wadi irrigation improvement projects has greatly contributed to the development of thinking on the role of water in the Tihama's development and of 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.
It is expected that many ideas will gradually be incorporated into a well-defined water resources strategy for the area, which will beone of the cornerstones for regional development planning.

9.4 Implementation of environmental policies

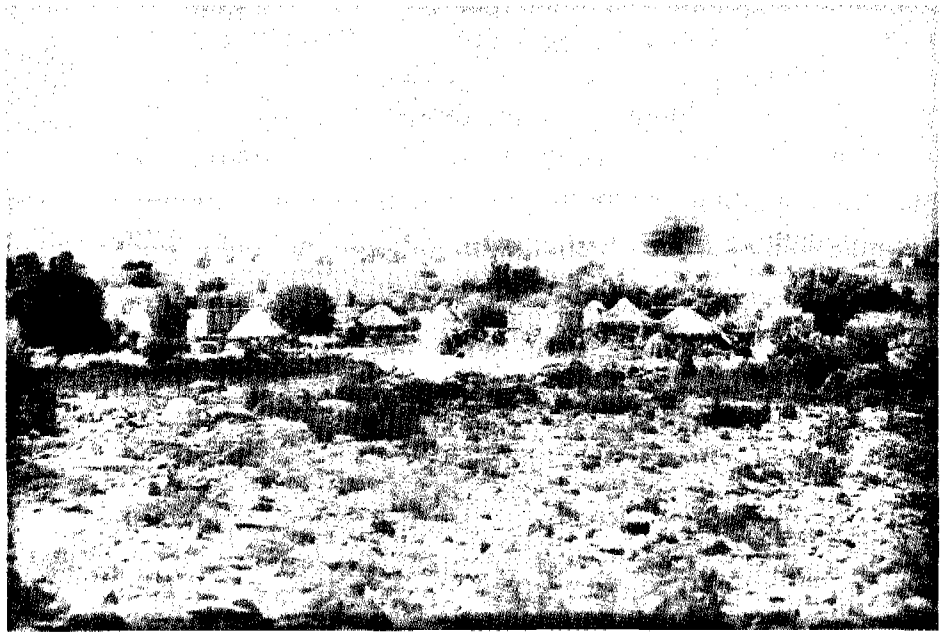
Legislative aspects
Coherent laws and regulations, their implementation and, in particular, their enforcement are either absent or not functioning. Considering the place of development in the Yemen Arab Republic and in the Tihama in particular, priority should be given to the formulation of a coherent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

Quiet streets when the Luhayya market is finished.

step. Especially with respect to the establishment of new industries or the enlargement of existing ones, environmental impact assessment procedures have to be developed and implemented.

Institutional aspects
The traditional institutional system is not capable of dealing with the problems of the environment of the Tihama as a whole. 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 such as:
- strengthening of the planning capabilities of the provincial government and the Local Coordinating Committees for Development with respect to the 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 both in the short term and the long term.



The upper Tihama used to be a parkland with these "Dobr" trees

Extension, raising awareness and environmental education
Private initiative in resource management is vital. Therefore it has to be stimulated and guided. This development of environmental awareness requires acuminate 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 Research

The environmental study has encountered limited data availability on every important issue. In order to establish sound natural resource management research existing information needs to be compiled and missing information supplied. This should result in a suitable monitoring system.

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

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

10. Summary

This Environmental Profile describes the environment of the Tihama, the coastal zone along the Red Sea 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 Tihami use and manage the available natural resources, and why do they do it the way they do?
By describing the motives, patterns and trends of use of natural resources in regard to their sustainability, the Environmental Profile creates a framework for decision making by the authorities.

The Environmental Profile introduces the ecological principles of the area as well as the most important demographic, socioeconomic, historic, cultural, legislative and institutional features and trends. If the population continues to grow at the current rate, the Tihama will contain 2.2 million people by the year 2000, instead of the 1.1 million registered in 1986.

Much attention is given to the balance between the use of the resources and the natural productivity. For this reason, land use in the Tihama 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 natural characteristics, predomonant 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 Tihama. The Profile concludes with a series of statements that affect sustainable use and management of the natural resources.

The Tihama is a flat area extending from the coast to the foothills of the mountain belt. From these mountains, large wadis drain excess water into the Tihama, thus creating an enormous ground water reservoir and, at the same time, creating the possibility for extensively practised wadi and groundwater irrigated agriculture. However, the cultivated area under rainfed cultivation is more than twice the size of the irrigated surface. Eighty percent of the Tihama surface is covered by rangelands, providing forage for livestock. The livestock that is also fed for 10 - 50 % on fodder grown for the purpose, depending on the farming system, uses these rangelands rather intensively. There is little scope for an increase in livestock production that feed from these rangelands.

The traditional wadi irrigation is a most sustainable form of agriculture in which livestock production is very well integrated. This will also apply to the modernized wadi irrigation schemes, if this integration is maintained and when mineral fertilizers can be financed by the individual farmer.

Modern well irrigation certainly creates the risk of an overexploitation of groundwater resources and of creating problems of desertification, caused by overgrazing by livestock owned by the farmers themselves.

Rainfed farming is under pressure due to population increases. Natural vegetation no longer gets the chance to regenerate and large scale desertification occurs, not in the least part due to the recurrent droughts in the period 1973 -1987.

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