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SALALAH INTEGRATED STUDY

LAND RESOURCES REPORT

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This field document is one of a series of reports prepared during the course of the Salalah integrated study. The conclusions and recommendations given are those considered appropriate at the time of its preparation.

The material produced by the study is comprised of 29 colour maps, also available in digital format, computer databases on soil and crop water requirements, a computerized land evaluation system and 6 inter-related reports:

- The first report, which is the "Summary of Conclusions and Recommendations" is meant for decision makers.*
- The second report is titled " Land Resources Report" and describes the soil and water resources. The land evaluation chapter of this report contains information on crops, including potential yields and profits that can be achieved under improved management. This chapter is also the basis of cropping pattern recommendations.*
- The third report titled "Land Use Report" gives detailed statistics on land use and land cover. A very detailed analysis highlights the influence of farm size and water salinity on current cropping patterns. This information is used by most other reports.*
- The fourth report is the "Irrigation Report" which analyses current irrigation practices and proposes alternatives for improved water management. Detailed specifications as well as well as costing are included.*
- The fifth report is titled " Plant Production Report, Special Investigations". It contains analyses and recommendations on plant protection and weed control practices in Salalah. Similar information on micronutrients is also included. The last section of this report contains an analysis of the livestock sector by staff of the Directorate General of Agricultural Research. Monographs on the major crops of the area were also produced and published separately.*
- The sixth report is the "Farming Systems Report" which contains a detailed analysis of the socio-economic constraints on the farm households. Marketing and credit are also dealt with in this report.*

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1. ENVIRONMENTAL SETTING

1.1 Location of the study area (Figure 1)

Salalah is the capital of the Governorate of Dhofar in the southern region and the second largest town in the Sultanate of Oman. It is located in an outwash alluvial plain roughly triangular in shape with a coastal margin some 60 km in length and 15 km maximum width running from Taqah in the east to Raysut in the west.

The cultivated area is scattered in several blocs within urban areas. Because of this scattering, the survey area had to include about 4200 ha in order to cover all the irrigated agricultural land except Taqah.

The study area stretches in latitude from $16^{\circ} 58'$ to $17^{\circ} 03'$ N and in longitude from $54^{\circ} 02'$ (North Awqadain) to $54^{\circ} 14'$ E (Razat Farm).

1.2 Climate

Salalah is protected from desert influence by the Dhofar plateau which culminate at some 2,000 m. The Dhofar region, to which Salalah plain belongs, is the only part of the Arabian peninsula that benefits from a regular summer monsoon. This monsoon lasts generally from mid June to end of August and is accompanied by fog and occasional rains.

Salalah airport and the royal Razat Farm were the two sources of climatic data used in this study.

The airport meteorological station has been collecting rainfall and temperature data since 1942. Bright sunshine data is available starting from 1978 whereas relative humidity is available from 1979 onwards and wind speed since 1981.

Table 1 gives the mean monthly climatic data of Salalah airport. More comprehensive data can be found in appendix 1.

1.2.1 Rainfall

Although monsoonal rains occur every year their intensity is quite variable from one year to another.

The average yearly rainfall is about 110 mm but in 1963 total yearly rainfall was 509 mm and in 1974 it was only 21 mm. There is always some rain in July and August whereas other months can be totally dry.

Figure 1. Location Map of Study Area

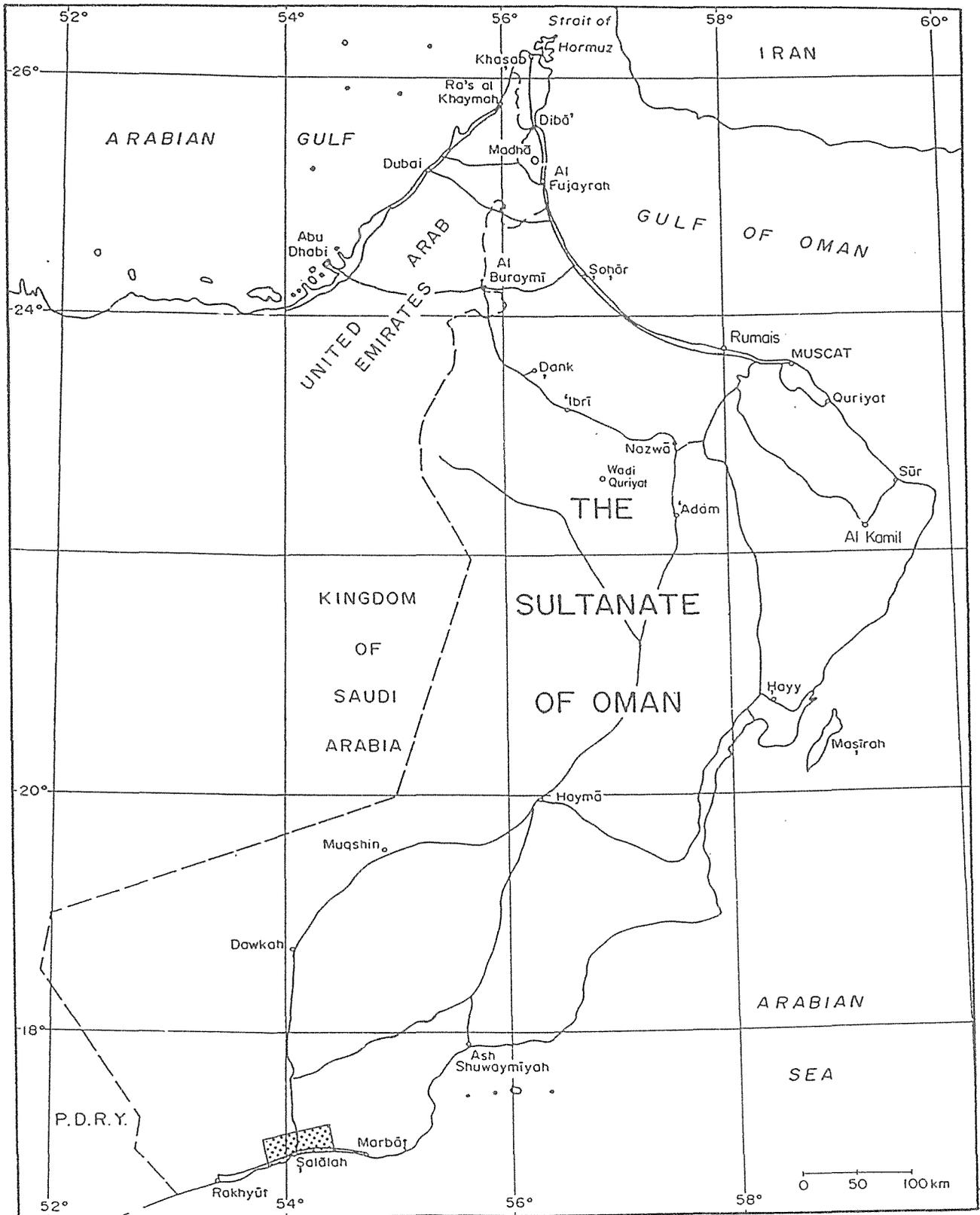


Table 1

MEAN MONTHLY CLIMATIC DATA
Salalah Airport

Climatic Data	Months												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
Average Air Temperature (Celcius degree)	22.8	23.5	25.4	27.3	28.8	29.0	26.2	25.1	26.2	26.0	25.6	23.8	25.8
Relative Air Humidity	50	58	62	68	75	80	89	90	81	67	54	51	69
Wind speed (km/day)	294	276	251	251	276	363	276	251	276	216	199	294	269
Sunshine (hours per day)	9.3	9.1	9.6	10.3	10.8	6.7	1.5	1.4	6.3	10.1	10.1	9.6	7.9
Rainfall (mm)	1	4	5	11	11	8	27	26	4	6	6	3	112

Rain usually falls as mists, drizzle and low intensity showers of relatively long duration on the plain. Cyclonic rainfall which is infrequent and of short duration associated with storms of extremely high intensity may occur during two periods of the year, May - June and October - November. They cause major run-off over the plain and floods in low lying areas by the sea. The third type of rainfall originates from short-lived synoptic conditions lasting up to one week.

1.2.2 Air Temperature

Temperature is remarkably stable throughout the year. The yearly average is 25.8 °C, January is the coolest month with an average of 22.8 °C and the hottest month is June with 29 °C. The absolute recorded minimum temperature was 10 °C in February 1957 and the maximum was 47.2 °C in June 1946.

1.2.3 Air Relative Humidity

Average humidity is about 69 percent but it is between 50 and 60 percent from November through February and more than 80 percent from June through September.

Absolute minimum air relative humidity is 5 percent and absolute maximum is 100 percent.

1.2.4 Winds

Winds blow mostly from the south west, the south and the west throughout the year. Northerly desert winds, locally called shamal, blow sometimes from December through February and can cause crop damage due to their drying effect and to the sand particles they carry.

1.2.5 Bright Sunshine

The number of bright sunshine hours is between 9 and 10 hours per day most of the year except from June through September due to cloudiness and fog during the monsoon. In July and August there are only about one and a half hour of bright sunshine on the average every day.

Although the data series of the airport are reasonably long, they cannot be applied as such to the small farms for the following reasons:

- Wind pattern and therefore heat and humidity transfers are different because the airport is located in an open area which offers little obstacle to wind circulation. On the contrary small farms with dense vegetation of varying heights offer maximum resistance to air flow.
- The irrigated soil resists heat transfer more than dry areas devoid of vegetation as found at the airport.

- The bulk of the small farms are closer to the sea than the airport.

The climatic data of the airport can however be more safely extrapolated to the large farms growing rhodes grass because they are also of the open landscape type.

Since the airport is the only source of long climatic records it was necessary to find a way to extrapolate it's data to the small scale farming areas. Three years of reliable and complete climatic records were found in Razat Royal Farm (1983, 84, 85).

The meteorological station of Razat farm is more representative of small farms situation because it is located in a vegetated area closer to the sea. A correlation of mean monthly data was made for wind speed and air humidity for the years 1983-1984 and 1985.

Table 2 gives the mean monthly climatic data of Razat farm.

A correlation on a monthly basis was made for 1983, 1984 and 1985 between airport data and Razat farm data. The results are shown in table 3.

This table shows clearly that if temperature and bright sunshine hours are reasonably close to the airport data, there are considerable differences in wind speed and to a lesser degree in air relative humidity.

To be on the safe side it was decided to take a ratio of 50 percent for wind speed instead of the average 39 percent found in the correlation. The correlation results were closely followed for air humidity.

Table 4 gives the extrapolated climatic data for small scale farming areas.

Table 2

MEAN MONTHLY CLIMATIC DATA
 Royal Razat Farm
 For years 1983/84/85

Climatic Data	Months												
	1	2	3	4	5	6	7	8	9	10	11	12	Year
Average Air Temperature (Celcius degree)	22.8	22.5	24.0	26.4	28.0	28.8	26.7	25.4	25.4	24.6	24.5	23.4	25.2
Relative Air Humidity	59	61	63	77	81	86	91	91	87	76	70	67	76
Wind speed (km/day)	121	121	112	95	138	147	86	86	95	104	112	147	114
Sunshine (hours per day)	9.13	9.28	9.59	10.02	9.91	4.96	1.37	1.95	5.41	10.15	10.07	9.42	7.61
Rainfall (mm)	3.5	33.9	0.0	37.4	23.4	1.2	8.4	32.7	4.5	0.0	0.0	0.0	145.0

Table 3

COMPARISON OF SELECTED MEAN MONTHLY CLIMATIC DATA
 Airport Versus Royal Razat Farm
 For years 1983/84/85

Climatic Data	Months												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
Mean Air Temperature													
Airport	23.2	23.1	25.7	27.7	28.9	29.0	26.3	25.4	26.0	26.0	25.6	23.9	25.9
Razat	22.8	22.5	24.0	26.4	28.0	28.8	26.7	25.4	25.4	24.6	24.5	23.4	25.2
Razat/Airport	98%	97%	93%	95%	97%	99%	102%	100%	98%	95%	96%	98%	97%
Relative Air Humidity													
Airport	50	52	57	70	77	81	89	89	81	66	55	51	68
Razat	59	61	63	77	81	86	91	91	87	76	70	67	76
Razat/Airport	118%	117%	111%	110%	106%	106%	102%	102%	107%	115%	127%	131%	111%
Wind speed (km/day)													
Airport	281	296	252	267	311	415	311	281	296	252	207	326	291
Razat	121	121	112	95	138	147	86	86	95	104	112	147	114
Razat/Airport	43%	41%	45%	36%	44%	35%	28%	31%	32%	41%	54%	45%	39%
Mean Daily Sunshine													
Airport	9.2	9.2	9.8	10.1	10.5	6.2	1.3	1.6	5.9	10.1	10.2	9.7	7.8
Razat	9.1	9.3	9.6	10.0	9.9	5.0	1.45	2.0	5.4	10.1	10.1	9.4	7.6
Razat/Airport	99%	101%	98%	99%	94%	81%	108%	125%	92%	100%	99%	97%	97%

Table 4
ESTIMATED MEAN MONTHLY CLIMATIC DATA
Small Farms

Climatic Data	Months												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
Average Air Temperature (Celcius degree)	22.8	23.5	25.4	27.3	28.8	29.0	26.2	25.1	26.2	26.0	25.6	23.8	25.8
Relative Air Humidity	58	67	68	75	79	84	89	90	85	77	67	64	75
Wind speed (km/day)	147	138	121	130	138	181	138	121	138	112	95	147	134
Sunshine (hours per day)	9.3	9.1	9.6	10.3	10.8	6.7	1.5	1.4	6.3	10.1	10.1	9.6	7.9
Rainfall (mm)	1	4	5	11	11	8	27	26	4	6	6	3	110

1.2.6 Crop reference evapotranspiration

The data in table 1 and 4 were used to calculate crop reference evapotranspiration (ET_0). Our calculations were made with a specialized computer programme developed by the FAO to calculate crop water requirements (CROPWAT version 5.7, October 1991).

Table 5 gives the calculated reference evapotranspiration for large and small farms.

Table 5

Reference Evapotranspiration for Salalah Farms
(mm per year)

Months	Big Farms	Small Farms
January	5.1	3.8
February	5.0	4.0
March	5.4	4.6
April	5.8	5.2
May	5.9	5.5
June	4.9	4.4
July	2.8	2.8
August	2.6	2.6
September	4.0	3.7
October	5.0	4.4
November	4.9	3.9
December	5.1	3.8
Year Total	1713.3	1480.5
No rainfall-data considered, IRR.-Req. = ETcrop!		

The calculation is based on the Penman formula as modified by Monteith (FAO 1990-1991). The figures that we find are considerably less than those used by Dames and Moore International (2311 mm/year) in their Salalah water resources master plan study (1991). This difference is due to the fact that they have used the old Penman formula.

Given the importance of the reference evapotranspiration on the estimation of crop water requirements it is necessary to add some field evidence to the results of the calculations.

It was therefore decided to find out some reliable data on actual crop water consumptive use. Rhodes grass was chosen as a reference crop for 3 reasons:

- it is a perennial grass which covers well the soil all the year and therefore is close to the standard conditions for the measurement of ET^0 .
- it is irrigated on considerable areas under centre pivot or spray gun systems under which application rates can be easily measured.
- Modern farms growing rhodes grass in the above-mentioned conditions keep records of the water application and of their yields.

In October 1991, the following water application rates were measured:

- Razat farm, gun irrigation: 4.1 mm/day
- Dhofar cattle feed , Sahalnawt farm, centre pivot, 4.55 mm/day.
- Dhofar cattle feed, Robat farm, centre pivot 4.85 mm/day.

These figures compare well with our result of 5.08 mm for the month of October. It should be stressed that these farms are all making between 30 and 40 tons of rhodes grass hay per hectare per year, which under the level of fertilizer they are using is quite good. Therefore if there is a moisture stress, which could not be observed in the field, it must be minimal.

Definitive conclusions could not however be based on the results of one month and some yearly record were needed.

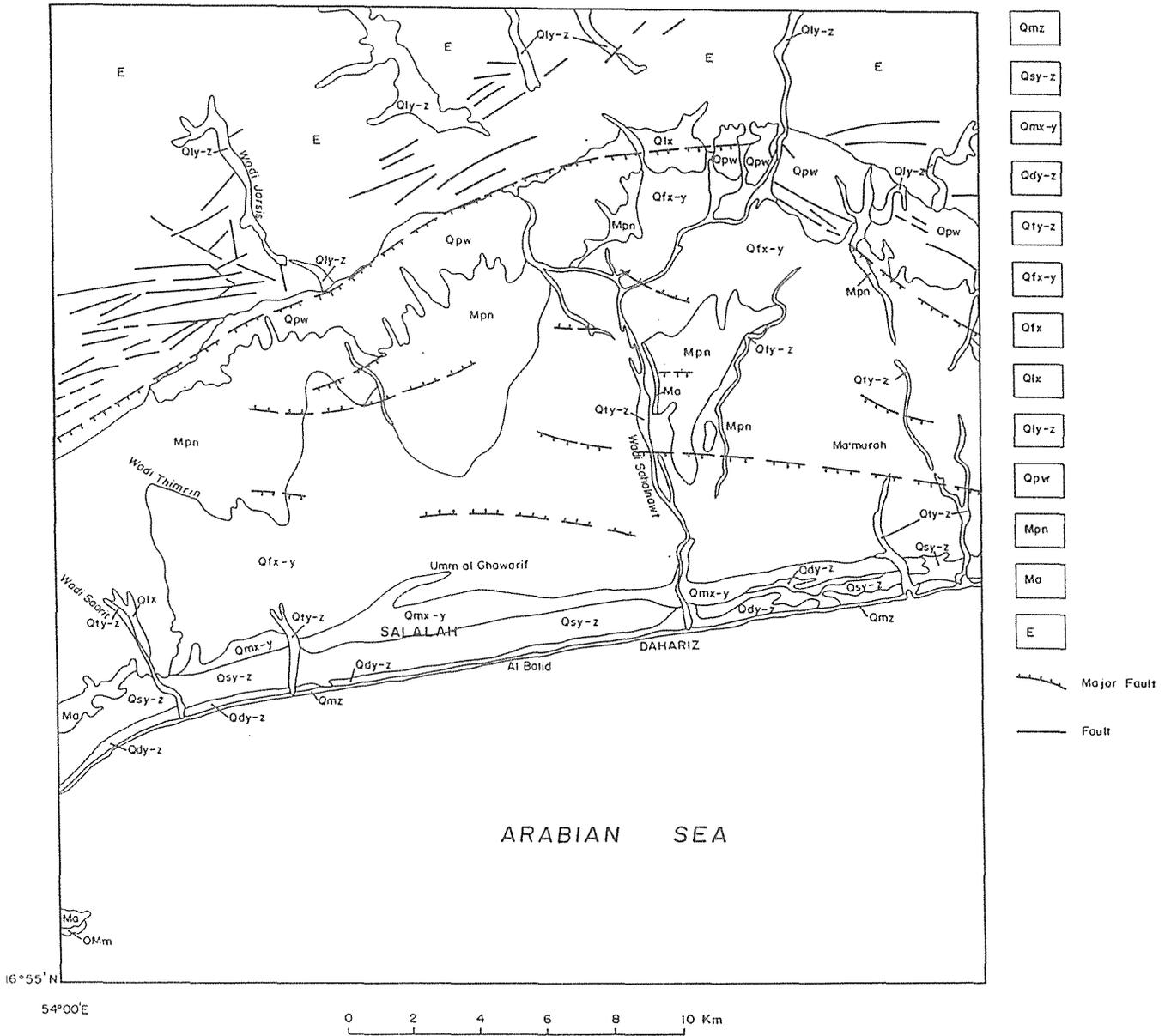
Fortunately the MAF Animal Research Directorate in Salalah, has a monthly record of the water consumption for each of the 3 centre pivots they are using to grow rhodes grass. The centre pivot CP2 has consumed 1305 mm of water for the 12 months period extending from October 1990 to September 1991. During this period the crop was already mature. This figure compares well with the calculations.

Given the above, it was decided to use the ET^0 as shown in table 5 for all crop water requirements.

1.3 Geomorphology and geology

Figure 2 is a simplified geological map of the study area derived from the 1/100,000 scale draft geological map prepared by the Ministry of Petroleum and Minerals, complemented by observations made by project staff.

Figure 2 . GEOLOGIC MAP OF SALALAH STUDY AREA



Starting from the arabian sea, the first formation is beach sands (Qmz) followed by a cordon of coastal sand dunes (Qdy-z). These dunes prevent part of runoff water from reaching the sea and cause the formation of sabkha and khubra deposits (Qsy-z). This formation of fine and medium textured young alluvium is the parent material of much of the best irrigated soils of Salalah plain.

Further inland there is a shelf of beach rock (Qmx-y) which is comprised of indurated calcareous marine sands corresponding to an old coast-line. This beach rock is locally covered by thin alluvium and also underlies the sabkha and khubra deposits described in the precedent paragraph.

Subrecent alluvial fans (Qfx-y), generally very gravelly, highly calcareous and locally gypsiferous, cover most of the plain. This formation has a dense network of shallow wadis, gullies and rills draining to the sea.

Pliocene old alluvial fans (Mpn) formed of red conglomerates with red silty clay occupy most of the western side and a small part of the centre of the plain. These fans have a broken topography with numerous deep gullies.

At the foot of the Dhofar plateau and running parallel to it there is a formation of old travertine and weakly cemented conglomerate (Qpw) which are the oldest pleistocene formations of the area.

The Dhofar plateau itself is mostly comprised of Eocene Tertiary deposits (E).

1.4 Water resources

1.4.1 Surface Hydrology

Considerable runoff occur on the steep slopes of the Dhofar plateau and concentrate in numerous wadis, gullies and rills crossing the plain towards the sea.

Starting from the west, wadi Saarit, wadi Sumr, wadi Garziz, wadi Sahalnawt and wadi Razat are the main wadis draining the plain. All these wadis reach the sea through lagoons, locally known as Khawr. Even out of the monsoon these lagoons discharge sweet water to the sea, probably due to wadi underflow. Some farms use lagoon brackish water for the production of rhodes grass as is the case in the MAF Balid experimental farm.

There are some major springs that provide surface water to the survey area. They are namely Ayn Garziz, Ayn Sahalnawt, Ayn Razat and Ayn Hamran. They are conducted into lined canals or pipes to support agricultural development in some large farms in the plain. The water is collected into reservoirs where it is sometimes mixed with groundwater to decrease its salinity before irrigation. This practice is currently adopted at Sahalnawt and the Royal Razat farm as well as the livestock research station.

1.4.2 Groundwater

This section is directly extracted from a special report prepared by the Directorate General of Irrigation Affairs of The MAF.

In the north, in the higher parts of the jebel (Dhofar plateau), water is very deep as shown by the boreholes drilled for cattle watering, up to 400 m below ground. The water is in limestones.

At the jebel front, at the limit of the plain many springs represent overflows from the mountain limestone aquifer. The three most important springs, Ain Garziz, Ain Sahalnawt and Ain Razat are just north of Salalah. Their average annual flow is 8.5 MCM. The Ministry of Water Resources drilled many wells all along the limit of the mountain with good discharges. Well hydrographs, show recharge by the monsoon. The wells drilled in the central area near the main springs yield the freshest water.

In the coastal area water is found in a shallow karstic aquifer with fresh water only in central part towards Salalah town and more saline water on both sides. The fresh water aquifer represents the outflow from the aquifer in the mountain and at the jebel front. It is heavily pumped for town water supply, 8 MCM/yr partly semifiltrating to the water table, and for agriculture. Total agricultural consumption is about 35 MCM/yr.

The preparation of the coastal area groundwater balance is difficult as the main inflow is the underground flow from the mountain for the evaluation of which no calculation is possible. Recently two water balances were calibrated using groundwater models :

- in 1990 Mott MacDonald working for the Ministry of Agriculture & Fisheries concluded that there was an equilibrium between the flow to the aquifer from the mountain and the net abstraction for agriculture,
- in 1991 Dames and Moore International concluded that, considering also the pumping for potable supply, there is deficit of 8 MCM/yr in the aquifer.

The Water and Wastewater Masterplan prepared by Dames and Moore Consultant working for the Dhofar municipality reached the conclusion that the long term production for potable supply is 25 MCM/yr. Considering that the priority being for town water supply the Master Plan proposes :

- to abandon the large fodder farms which might be shifted to Nejd,
- to inject the treated waste water in the aquifer,
- to irrigate the coconut farm planned by the Ministry of Agriculture and Fisheries using treated water.

1.4.3 Irrigation water quality

In order to be able to give specific cropping pattern recommendations to each farmer an irrigation water quality survey was carried out in all farms in the study area. It is important to note that the objective of the survey was to determine what water quality is used in each farm and not to map the aquifer. Many farms have no well and use wells of neighbouring farms.

Nevertheless the geographic distribution of water quality in the plain as shown in the maps prepared in this study is very useful in understanding certain aspects of the aquifer.

In all 796 wells were visited. A number was assigned to each well and depth to the watertable, water salinity, total dissolved solids and water temperature were recorded. This information was entered in a computerized database then used to plot salinity maps, at farm level, at the scale of 1/10,000 with a geographic information system (GIS).

The data were also sorted into salinity classes as follows:

class 1 :	less than 2	dS/m
class 2 :	2 to 3	dS/m
class 3 :	3 to 5	dS/m
class 4 :	5 to 7	dS/m
class 5 :	7 to 10	dS/m
class 6 :	more than 10	dS/m
class 7 :	water of more than one salinity class	

The choice of these classes was based on resistance to salinity of the main crops grown in the study area.

Table 6 shows the irrigation water distribution of salinity in each extension district in Salalah plain. This table shows that about one third of the area uses brackish water of electrical conductivity varying from 3 to 15 dS/m. In Awqadain district all the cultivated area is cultivated with brackish water generally more than 5 dS/m. In Salalah district nearly 90 percent of the cultivated area is irrigated with water between 3 and 7 dS/m. Dahariz district has all kind of salinity class whereas Hafa-Qarad district has almost 80 percent of its' cultivated area irrigated with good water less than 2 dS/m.

Table 6
Total Cultivated Area By Water Salinity Class
In Each Extension District Salalah 1991

Extension District	Total Area (feddan)	Irrigation Water Salinity (dS/m)						
		Less 2	2 to 3	3 to 5	5 to 7	7 to 10	More 10	Mixed Classes
HAFA-QARAD	2900.8	2272.2	278.3	307.7	16.5			26.5
Al Hafa	41.0%	78.3%	9.6%	10.6%	0.6%			0.9%
Al Qarad	495.8	160.6	122.0	208.7	4.5			
	7.0%	32.4%	24.6%	42.1%	0.9%			
	2405.0	2111.6	156.3	98.6	12.0			26.5
	34.0%	87.8%	6.5%	4.1%	0.5%			1.1%
AWQADAIN	479.9			68.4	212.1	89.5	94.5	15.4
	6.8%			14.3%	44.2%	18.6%	19.7%	3.2%
Awqadain East	174.8			34.3	87.7	28.5	24.3	
	2.5%			19.6%	50.2%	16.3%	13.9%	
Awqadain North	72.0			0.9	0.9		70.2	
	1.0%			1.2%	1.3%		97.5%	
Awqadain West	175.0			19.4	85.8	54.4		15.4
	2.5%			11.1%	49.0%	31.1%		8.8%
North Hospital	58.1			13.9	37.6	6.6		
	0.8%			23.9%	64.8%	11.3%		
DAHARIZ	2858.8	268.8	167.9	366.6	245.4	164.0	26.9	1619.3
	40.4%	9.4%	5.9%	12.8%	8.6%	5.7%	0.9%	56.6%
Dahariz North	845.2	268.8	119.7	190.0	145.9	5.2		115.7
	12.0%	31.8%	14.2%	22.5%	17.3%	0.6%		13.7%
Dahariz South	451.0		44.4	170.0	80.5	103.4	26.9	25.7
	6.4%		9.9%	37.7%	17.9%	22.9%	6.0%	5.7%
Sahalnawt	778.3		3.8	6.7	18.9	55.3		693.6
	11.0%		0.5%	0.9%	2.4%	7.1%		89.1%
Razat	784.3							784.3
	11.1%							100.0%
SALALAH	829.2		5.3	468.2	254.3	62.9		38.6
	11.7%		0.6%	56.5%	30.7%	7.6%		4.7%
Salalah Centre	78.3		4.6	65.3	8.4			
	1.1%		5.9%	83.4%	10.7%			
Salalah East	166.4		0.7	129.3	36.4			
	2.4%		0.4%	77.7%	21.9%			
Salalah West	402.1			217.9	132.7	22.9		28.5
	5.7%			54.2%	33.0%	5.7%		7.1%
Al Wadi	182.4			55.6	76.8	39.9		10.0
	2.6%			30.5%	42.1%	21.9%		5.5%
Total Area (fed)	7068.7	2541.0	452.1	1211.1	728.5	316.0	121.5	1699.7
In %	100.0%	35.9%	6.4%	17.1%	10.3%	4.5%	1.7%	24.0%

It should however be noted that in Hafa-Qarad and Dahariz there are some very large farms growing rhodes grass using water of good quality. This means that the situation of small farmers in these two districts is less good than the global figures show. Table 7 gives the water salinity distribution by farm-size class.

From this table it appears that about 36 percent of the area operated in farms 10 feddans or less is irrigated with good water (less than 3 dS/m) whereas 35 percent use brackish water 3 to 5 dS/m and about 28 percent use strongly saline (more than 7 dS/m).

In farms larger than 10 feddans 47 percent of the area are irrigated with water less than 3 dS/m and 40 percent are irrigated with mixed water.

The water salinity maps show clearly that the central part of the plain has good water whereas the eastern and western parts have brackish water. Razat farm is an exception because falaj water is used on most crops except coconut.

Water salinity in Awqadain is not a new phenomenon and old Dhofaris say that it has always been there.

It is noteworthy that there is a large man-made runoff drainage collector protecting the airport. This structure may have played a role, by preventing local sweet water recharge, in the fact that Salalah extension district has more saline groundwater.

17 representative wells were sampled for chemical analysis and the results are shown in table 8.

The samples were arranged in an increasing salinity order to highlight any correlation existing between total electrical conductivity and the concentration of any anion or cation. Several conclusions can be drawn:

- The sodium adsorption ratio (SAR) is not too high and does not represent a big limitation.
- Below 3 dS/m water is relatively good and no toxicity problems are expected with most crops grown in the study area.
- From 3 to 5 dS/m chloride and sodium concentration become too high for sensitive crops.
- From 5 to 7 dS/m chloride and sodium concentration will cause reduction in yield of most crops. Ca/Mg ratio becomes less than 1 and may cause nutritional imbalance. Boron concentration reaches a concentration at which it can cause damage to sensitive crops like sweet potato.
- Beyond 7 dS/m the water samples show toxic levels in sodium, chloride, boron and a strong imbalance between magnesium and calcium.
- Carbonate and bicarbonate levels are high and will necessitate a good maintenance of drip irrigation systems.

Table 7

Total Cultivated Area By water Salinity Class
And By Farm-size Class
Salalah 1991

Water salinity Class	Total Area (feddan)	Farm Size In Feddan				
		Less 3	3 to 6	6 to 10	10 or less	More than 10
< 2 dS/m	2541.0 35.9%	77.1 18.5%	260.9 20.3%	353.1 29.9%	691.1 23.9%	1850.0 44.2%
2-3 dS/m	451.5 6.4%	103.4 24.7%	135.4 10.5%	107.2 9.1%	346.0 12.0%	105.5 2.5%
3-5 dS/m	1210.5 17.1%	152.7 36.5%	467.2 36.3%	390.0 33.0%	1009.9 35.0%	200.6 4.8%
5-7 dS/m	728.2 10.3%	52.6 12.6%	222.5 17.3%	195.8 16.6%	470.8 16.3%	257.4 6.2%
7-10 dS/m	316.3 4.5%	21.7 5.2%	116.5 9.1%	92.6 7.8%	230.9 8.0%	85.5 2.0%
>10 dS/m	121.4 1.7%	7.9 1.9%	71.3 5.5%	30.5 2.6%	109.6 3.8%	11.8 0.3%
Mixed	1699.7 24.0%	2.6 0.6%	12.8 1.0%	13.5 1.1%	28.8 1.0%	1670.9 40.0%
Total Area	7068.7 100.0%	417.9 100.0%	1286.6 100.0%	1182.6 100.0%	2887.1 100.0%	4181.5 100.0%

Table 8

Water Analysis Of Representative Wells
Salalah Plain

WELL Nbr	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	SAR	E.C. ds/m	pH	B (ppm)
	----- meq/l -----												
1000	4.41	3.30	3.78	0.08	0.68	4.68	2.34	4.28	0.81	1.93	1.12	7.70	0.37
315	4.15	2.69	4.96	0.08	0.50	4.85	3.64	3.45	0.47	2.68	1.21	7.80	0.22
813	5.12	6.16	6.26	0.10	1.00	4.42	4.32	8.38	1.02	2.64	1.70	7.83	0.15
738	7.31	4.26	7.00	0.15	0.60	3.95	6.72	8.90	1.10	2.91	1.83	7.54	0.37
759	6.04	4.34	7.22	0.10	0.60	3.85	6.03	8.20	1.19	3.17	1.86	7.67	0.22
525	7.89	7.47	10.61	0.26	0.60	3.80	10.35	12.80	1.10	3.83	3.15	7.63	0.10
477	8.03	7.68	12.70	0.44	0.80	5.45	14.55	8.21	0.94	4.53	3.71	7.72	0.20
750	10.83	9.36	12.65	0.23	0.80	5.65	11.52	15.67	0.47	3.98	3.96	7.16	0.27
173	9.67	8.68	25.22	0.46	0.70	3.90	24.63	15.71	0.94	8.33	4.64	7.86	0.30
630	10.29	14.24	31.13	0.51	0.70	6.45	28.14	22.70	0.94	8.89	5.34	7.58	0.45
821	13.71	14.99	34.04	0.67	0.68	4.16	31.69	26.83	1.74	8.99	6.36	7.71	0.70
807	11.24	12.42	37.17	0.82	1.00	5.48	34.52	21.36	1.38	10.81	6.45	7.26	0.77
801	14.60	14.75	37.70	0.92	0.80	4.90	33.21	29.03	1.10	9.84	6.88	7.50	0.55
711	20.11	18.82	40.87	0.82	0.80	4.20	38.41	37.14	1.74	9.26	8.15	7.53	1.00
448	11.00	17.80	48.09	1.36	0.60	4.95	48.12	26.64	0.94	12.67	9.00	7.96	0.80
397	19.08	22.62	56.09	1.69	0.60	3.35	52.40	43.12	1.10	12.28	11.83	7.84	61.30
341	15.39	28.40	74.61	2.41	0.50	2.95	85.32	31.20	1.49	15.95	17.00	7.97	1.35

2. THE SOILS OF THE STUDY AREA

2.1 Methodology

The soil survey started in December 1990 and was completed in July 1991. It covered an area of about 4,200 hectares out of which about 3,544 ha are enclosed.

A preliminary reconnaissance survey was carried out first followed by stereoscopic examination of the colour aerial photographs. The sites of field observations were then marked on the photographs overlays.

Field mapping was done at scale 1/5,000 then reduced to 1/10,000. About 1004 profiles were described, and 380 samples collected from representative profiles for general chemical and physical analysis. An additional 22 soil samples and 64 plant samples were collected in order to determine micro-nutrient deficiencies.

All the observation were described on a special format according to the draft Soil Survey Manual (SCS-USDA; 1984). The analytical analyses were made in the Soils Laboratory of the Directorate General of Agricultural Research of the MAF, by project and local staff.

17 infiltration and permeability tests were made using double rings infiltrometers, generally each in duplicate or triplicate.

38 soil types (phases of series) were defined in the study area and were classified in both the American and the FAO soil classification systems. They were also given local series names.

Soil data was compiled at farm level and the draft soil maps were digitized and soil information was stored in computerized databases in a geographic information system (GIS). Colour maps were published with the GIS at scale 1/10,000 (8 sheets). Similarly a generalized soil map in one single sheet was prepared at 1/25,000.

2.2 General soil information

This section aims at providing the reader with an overview of the most salient features of the soils of the study area. More detailed information is included in other sections of this report. The terminology used is explained in the glossary.

2.2.1 Physical properties

Table 9 shows that deep to very deep soils cover about 85 percent of the study area whereas moderately deep cover about 9 percent and shallow and very shallow soils 4 percent.

As shown in table 10, topsoil is generally coarse loamy (loam or sandy loam) in about 60 percent of the study area and fine loamy (heavy loam or sandy clay loam) in about 7 percent. Gravelly topsoil, mostly gravelly sandy loam, occur in about 29 percent of the area. Sandy texture occur in less than 1 percent of the area.

Table 9

Salalah detailed Soil Survey
Total area of soil depth phases

	Ha	Percentages
DEEP TO VERY DEEP SOILS	3024.04	85.34
MODERATELY DEEP SOILS	334.59	9.44
SHALLOW	135.57	3.83
VERY SHALLOW	7.45	0.21
MICELLANEOUS	41.90	1.18
TOTAL	3543.55	100.00

Table 10

Salalah detailed soil survey
Total area of texture of surface layers

	Ha	Percentages
SANDY CLAY LOAM	99.62	2.81
HEAVY LOAM	155.07	4.38
LOAM	1042.31	29.41
SANDY LOAM	1081.77	30.53
LOAMY SAND	9.83	0.28
GRAVELLY LOAM	68.88	1.94
GRAVELLY SANDY LOAM	1003.11	28.31
GRAVELLY LOAMY SAND	15.21	0.43
VERY GRAVELLY SANDY LOAM	18.40	0.52
MICELLANEOUS	49.35	1.39
TOTAL	3543.55	100.00

Fine loamy subsoils are dominant (about 40 percent) in the area followed by coarse loamy subsoils (about 26 percent) and loamy skeletal subsoils (about 26 percent). Sandy and sandy skeletal subsoils represent only about 7 percent of the total area.

Available water holding capacity is high or moderate in about 56 percent of the area, whereas it is low in about 33 percent and very low in about 9 percent.

Infiltration rate is generally low to moderately low (about 71 percent of the area), moderate in about 13 percent and moderately high to very high in about 14 percent.

2.2.2 Chemical and biological properties

The average topsoil calcium carbonate content is 62 percent with a minimum of 45 and a maximum of about 90 percent. Gypsum content is less than 15 percent and occur only in Gypsiorthids and Salorthids which cover only about 3 percent of the area.

The soil pH is generally mildly to moderately alkaline. **Table 11** shows that most soils are non to slightly saline (83 percent of study area), about 14 percent are moderately saline and only about 2.5 percent are strongly saline.

The average topsoil cations exchange capacity (CEC) is low at about 6 meq/100 g. Calcium followed by magnesium are the main cations saturating the soil exchange complex. Although several identified soil types have very high exchangeable sodium, they are of limited extent. Exchangeable potassium content is moderate with an average of about 0.6 meq/100 g.

Organic matter is higher than in other areas in the Sultanate but remains low by international standards. The average organic carbon content in the topsoil is about 0.6 percent. Most soils have moderate to high available phosphorus (Olsen extraction method) and the average was found to be about 9.6 ppm.

Salalah soils have a very high calcium carbonate and therefore micro-nutrient deficiencies are quite common. Iron, manganese, zinc and copper are the most common micro-nutrients which are in short supply. Severe deficiency symptoms were observed on most crops.

Table 11

Salalah detailed soil survey
Total area of soil salinity phases

	Ha	Percentages
EXTREMELY SALINE	47.42	1.34
STRONGLY SALINE	39.20	1.11
MODERATELY SALINE	480.32	13.55
SLIGHTLY SALINE	1080.83	30.50
NON/TO VERY SLIGHTLY SALINE	1846.43	52.11
MICELLANEOUS	49.35	1.39
TOTAL	3543.55	100.00

2.3 Soil formation and classification

2.3.1 Soil forming factors

Soils develop under the influence of forming factors which are: parent material, climate, living organisms, relief and time. For areas like Salalah anthropic influence is also an important soil forming factor.

2.3.1.1 Parent material

The soils of the study developed mostly from alluvium derived from the Dhofar mountains limestone. This origin together with the weak leaching power of the climate, explain the very high calcium carbonate content of the soils of Salalah plain. This alluvium consists of very gravelly loamy material in the older alluvial fans and of much less gravelly loamy, occasionally sandy, material in the fan aprons and in depressions that occur behind littoral sand dunes.

Few soils developed on residuum derived from beach rock. This beach rock is made of consolidated highly calcareous marine sands. These soils are generally shallow.

2.3.1.2 Climate

Climate in Salalah is marked by monsoonal influence from June to September. During the monsoon there is high air humidity, fog and relatively cool temperatures. Occasionally, heavy rain showers can occur but they are rather erratic. Most rain falls as fine drizzle and therefore has very little leaching power and little influence on soil development.

From October to May the climate is relatively dry and hot. Differences between day and night temperatures as are minimal.

The climate of the study area is not conducive to rapid soil development.

2.3.1.3 Living organisms

These are plants and animals. Plant roots loosen the parent material hence facilitating the penetration of air and water. Plants also exchange water, mineral and organic substances with the soil. Ultimately, upon their decay, plants enrich the soil with organic and mineral compounds. Since the study area comprises mostly cultivated soils, vegetation is very dense its contribution to soil formation is very important.

Animals, particularly worms, insects and small mammals play an important role in mixing the soil and in enriching it with their dropping. Although little is known on soil fauna in Salalah, field evidence suggests that there is an important soil fauna benefiting from the moisture provided by irrigation and the addition of manure by the farmers.

2.3.1.4 Relief

The slope of the land influences surface runoff hence largely controlling the amount of water that penetrates the soil. In Salalah however most soils have been leveled and a complex system of terraces was built by man hence reducing the importance of slopes as a soil forming factor.

2.3.1.5 Time

Soils evolve with time under the combined action of the soil forming factors. Most soils in the study area are relatively young and many of them are even man-made. Some soils on gravelly alluvial fans have developed over a longer period of time probably some 15,000 to 30,000 years. These soils usually have a Calcic and/ or a Gypsic horizon.

2.3.1.6 Man

Man's influence is a major factor of soil development in cultivated areas. In Salalah, farmers influence soil development in at least three different ways:

Irrigation changes favorably the natural soil moisture regime hence creating a soil environment which is more conducive to biological activity. Irrigation, especially ineffective surface irrigation, changes the soil salts balance either by excessive leaching or by addition of soluble salts.

Man has also strongly modified the soils by adding large quantities of earth, locally called "sahub" which is brought from flooded areas. This is current practice in Salalah, mostly among banana growers.

Massive additions of farm yard manure by the farmers has substantially improved the organic matter status of cultivated soils in Salalah.

2.3.2 Soil forming processes

On the older alluvial fans most soils have undergone some limited leaching of lime and/or gypsum. However the vast majority of cultivated soils in Salalah plain are young soils where soluble salts leaching or addition through irrigation are the dominant soil forming processes.

Soil mixing by roots as well as cultivation practices prevents the differentiation of pedogenic horizons.

In some soils impeded drainage has created a shallow watertable which is responsible for the development of gley horizons. The typical grey colour of these horizons is due to the reduction of ferric oxides into ferrous compounds in anaerobic conditions.

2.3.3 Soil Classification

2.3.3.1 Introduction

Soils were classified according to Soil Taxonomy, the soil classification system of the United States of America (USDA- SCS, 1975). This decision was made in order to allow for exchange of soil information between the Sultanate of Oman and neighbouring countries who are using Soil Taxonomy.

However, the typical pedons were also classified according to the Revised Legend of the Soil Map of the World (Unesco-FAO -ISRIC, 1988).

Both soil classification systems use the concept of diagnostic horizons. These are horizons, or layers in the soil that have a particular significance with regard to its formation or its behaviour.

Some diagnostic horizons are surface horizons or epipedons. Others are normally encountered below the surface horizons; they are subsurface diagnostic horizons.

Six diagnostic horizons were recognized during this soil survey:

1. Ochric epipedon: It is a light coloured horizon that is generally low in organic matter.
2. Calcic horizon: It is a subsurface horizon of accumulation of calcium carbonate or of calcium and magnesium carbonates. It is encountered in Calciorthids, in some Gypsiorthids and in Eutropepts.
3. Cambic horizon: It is a subsurface horizon that is weakly developed. Rock structure is largely obliterated and the horizon has redder or greyer colours, or has lost part of its carbonates through leaching. It was mostly encountered in Eutropepts.
4. Gypsic horizon: It is a subsurface horizon of accumulation of calcium sulfates (gypsum) that is not strongly cemented.
5. Salic horizon: It is a subsurface horizon of accumulation of salts more soluble in water than gypsum. Sodium chloride are the dominant highly soluble salts in most saline soils in the study area. Nitrates were also found in most Salalah soils. Salic horizons are encountered in many types of soils but are only diagnostic in Salorthids.

2.3.3.2 Categories of Soil Taxonomy

Soil Taxonomy is organized hierarchically in 6 categories. At the highest level of the system is the order which subdivides successively into suborders, great groups, subgroups, families and finally into series. Given the fact that this survey was carried out at detailed level the soil series were further subdivided into phases.

Out of the 11 orders that are defined by Soil Taxonomy, only 3 exist in Salalah and Oman in general. These are the Entisols, Inceptisols and Aridisols.

Entisols are soils that have little or no evidence of development. They have no other diagnostic horizon than the ochric epipedon. In the study area Entisols are found in young alluvial deposits and aeolian sands. Psamments, Orthents and Fluvents are the 3 great groups of Entisols present in Salalah plain.

In the study area Psamments formed in coastal sandy aeolian deposits or in young sandy alluvium. The psamments of Salalah are Torripsamments because they have a torric moisture regime as defined by Soil Taxonomy. They are mostly strongly saline, strongly calcareous, deep to moderately deep soils.

Fluvents are Entisols that formed in young alluvial deposits that are subject to flooding. In the study area they have mostly loamy textures but some are sandy. They always include at least one loamy or finer layer. They are the dominant soils in Salalah plain.

In Salalah plain, Orthents are Entisols that formed in very gravelly sandy alluvial deposits. Torriorthents are Orthents that have a torric moisture regime as defined by Soil Taxonomy.

Inceptisols are soils that show limited evidence of soil development. In Salalah they have a Cambic and sometimes a Calcic diagnostic horizons and a Ustic moisture regime as defined by Soil Taxonomy.

Eutropepts are Inceptisols that have a high saturation in exchangeable bases and have a warm temperature regime. They occur in low lying areas with a high watertable. They are slightly to moderately saline soils.

Aridisols are soils that do not have water available to mesophytic plants for long periods of time. They have at least one subsurface diagnostic horizon and an aridic moisture regime as defined by Soil Taxonomy. However, the Salorthids may have aquic moisture regime. Orthids are the only Aridisols suborder encountered in Oman. Orthids are subdivided in several great groups among which only Salorthids, Gypsiorthids and Calciorthids were encountered in Salalah plain.

Calciorthids are Orthids that have a Calcic diagnostic horizon and do not have a Gypsic horizon. These soils were mostly found in the old gravelly alluvial fans. They are generally strongly calcareous, non-saline to strongly saline, gravelly and deep to moderately deep.

Gypsiorthids are Orthids that have a Gypsic horizon. Gypsiorthids were mostly encountered in old alluvial fans. They contain only modest amounts of gypsum, are slightly to strongly saline, strongly calcareous and very gravelly.

Salorthids are very saline soils that form in wet depressions where capillary rise and evaporation concentrate highly soluble salts in a salic diagnostic horizon. Salorthids were generally encountered in depression behind coastal dunes.

From table 12 appears that Torrifuvents occupy about 52 percent of the area, followed by Calciorthids (about 30 percent) and Eutropepts (about 13 percent).

Table 12

Salalah detailed soil survey
Total area of soil subgroups

	Ha	Percentages
TYPIC SALORTHIDS	47.42	1.34
CALCIC GYPSIORTHIDS	34.34	0.97
CAMBIC GYPSIORTHIDS	22.71	0.64
TYPIC CALCIORTHIDS	1056.91	29.83
AQUIC EUTROPEPTS	466.53	13.17
TYPIC TORRIPSAMMENTS	22.29	0.63
TYPIC TORRIFLUVENTS	1745.72	49.26
THAPTO CALCIORTHIDIC TORRIFLUVENTS	98.28	2.77
MICELLANEOUS	49.35	1.39
TOTAL	3543.55	100.00

2.4 Description of map units

Map units are the soil types shown in the map legend. In this detailed survey map units are consociations of phases of soil series. As specified by the National Soils Handbook of the United States (USDA-SCS, 1983) in each map unit, the phase after which it is named or similar soils make at least 75 percent of the area. Dissimilar soils do not exceed about 25 percent and limiting inclusions do not exceed 15 percent.

Table 13 gives the extent of each map unit. Most units are very small but they were defined because maximum detail is needed at farm level and most farms are very small.

Some soil series have only one phase whereas others have up to 3. Each soil series and its phases are described below. A typical pedon as well as range of characteristics are included in each description.

Analytical results can be found in appendix 2.

All the technical terms used in this section, or elsewhere in this publication, are defined in Soil Taxonomy, In the National Soils Handbook or in the draft Soil Survey Manual (USDA-SCS, 1983)

Table 13

Salalah detailed soil survey
Total area of soil map unit

Name	Number	Ha	Percentages
AWQADAIN	1	47.42	1.34
RAWRI	2	21.49	0.61
SAHALNAWT	3	11.79	0.33
MAMURAH	4	1.06	0.03
NAHIZ	5	3.46	0.10
ETIN	6	2.34	0.07
HUMRAN	7	16.91	0.48
DHOFAR 01	8	155.07	4.38
DHOFAR 02	9	79.40	2.24
SALAM	10	0.97	0.03
GARZIZ	11	8.17	0.23
SAADA	12	776.80	21.92
GHADO	13	19.16	0.54
HAGAIF	14	17.34	0.49
MOUTAZA	15	286.49	8.08
MANSHAHT	16	2.27	0.06
RAYSUT	17	32.02	0.90
QURUM	18	76.91	2.17
MAHIS	19	68.84	1.94
BALID	10	7.08	0.20
MAGHSAYL	21	15.21	0.43
SALALAH 01	22	267.39	7.55
SALALAH 02	23	423.22	11.94
NEW SALALAH	24	52.20	1.47
QOAF 01	25	207.63	5.86
QOAF 02	26	178.14	5.03
QOAF 03	27	71.60	2.02
GHAWARIF	28	205.77	5.81
RAZAT	29	130.47	3.68
ROBAT	30	22.42	0.63
LUB 01	31	9.26	0.26
LUB 02	32	2.35	0.07
HASEELAH 01	33	36.97	1.04
HASEELAH 02	34	9.12	0.26
JEHED	35	2.75	0.08
DAHARIZ	36	126.43	3.57
HAFI	37	54.98	1.55
HISIN	38	43.30	1.22
ROCK	39	7.45	0.21
EXCAVATIONS	40	1.87	0.05
CEMETERY	41	31.54	0.89
DATA NOT AVAILABLE	0	8.49	0.24
TOTAL		3543.55	100.00

AWQADAIN SERIES
(Unit 1)

The Awqadain series consists of very deep, very poorly drained extremely saline soils with moderately slow permeability. They formed in highly calcareous alluvial and marine deposits on the lowest lying areas in the Salalah coastal plain.

Gleyed horizons occur mainly below a depth of 50 cm and a shallow watertable occur slightly below 150 cm but occasionally rises up to 90 cm.

Slopes range from 0 to 1 percent and runoff is slow.

Typical Pedon: SCQ838

UNIT 1

Awqadain sandy clay loam on 0 to 1% straight slope in an uncultivated field.

Sheet: 8580

Coordinates (U.T.M.): X = 186345.5E
Y = 1881734.0N

Photo: 37

Location: AWQADAIN EAST

Date of description: 09/04/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Gleyic Solonchaks

ST: Typic Salorthid, clayey, carbonatic, very deep.

Phase: sandy clay loam

Soil Climate: aquic isohyperthermic

Topography: flat

Element/Position: fluvio-marine terrace

Land Use: fallow

Land form: coastal plain

Slope: 0 - 1% straight

Sealing/Crusting: salt crust

Vegetation: halophytic small shrubs (5-10% total cover)

Parent Material: fluvio-marine deposits derived from sedimentary
rock

Internal drainage: very poor

External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: > 150 cm

Surface features: salt efflorescences and pseudosands

Az1 0-4 cm dark brown 10 YR 4/3 (moist) sandy clay loam, weak medium platy structure; friable (moist), slightly sticky (wet), common fine roots, many salts crystals; strongly effervescent; abrupt smooth boundary.

Az2 4-28 cm dark brown 10 YR 4/3 (moist) clay, moderate medium subangular blocky structure; firm (moist), sticky (wet), very plastic (wet), common very fine tubular pores; common fine roots, few salts crystals; violently effervescent; clear smooth boundary.

C1 28-60 cm brown 10 YR 5/3 (moist) sandy clay loam; weak fine subangular blocky structure; friable (moist), slightly sticky (wet), plastic (wet), many very fine tubular pores; few medium roots, strongly effervescent; clear smooth boundary.

Ckg2 60-95 cm light gray 2.5 Y 7/2 (moist) clay; structureless massive structure; firm (moist), sticky (wet), very plastic (wet), abundant very fine tubular pores; very few fine roots, 6% fine gravel, common calcareous concretions; strongly effervescent; abrupt smooth boundary.

Cg3 95-150 cm grayish brown 10 YR 5/2 (moist) clay; structureless massive structure; firm (moist), sticky (wet), very plastic (wet), few very fine tubular pores; very few very fine roots, slightly effervescent.

Remarks: common shell fragments in the 5th layer.

Range in characteristics:

The salic horizon which contains a high secondary enrichment of salts has an average thickness of 20 cm. Salinity ranges from 60 to more than 200 dS/m.

The A horizon has hue of 10 YR, value of 3 to 5 moist and chroma of 3 or 4 moist. It commonly is sandy clay loam and less commonly heavy loam, fine sandy loam or loam. Salt crystals accumulation is clearly visible. The A horizon is mildly alkaline to moderately alkaline.

The upper part of the control section is rarely gleyed and has hue of 10 YR, value of 4 or 5 and chroma 3 or 4 moist. Texture is commonly sandy clay loam or heavy loam and less commonly clay loam or clay. It is moderately alkaline.

The lower part of the control section is gleyed and has hue of hue of 2,5 Y or less frequently 10 YR, value of 6 and chroma of 2. Texture is commonly sandy clay loam, clay loam and less commonly clay. It has few to common calcium carbonate concretions. It is mildly alkaline.

The substratum does not differ from the lower part of the control section. It has common to many calcium carbonate concretions. It is mildly alkaline.

Geographic Setting:

Awqadain soils are on low lying areas in the Salalah coastal plain.

Drainage and Permeability:

Awqadain soils commonly are very poorly and less commonly poorly drained soils. Infiltration rate is moderately low and permeability is moderately slow.

Cultivated Crops:

Short grass is the main crop followed by coconut, vegetables and banana. All these crops are very strongly affected by salinity.

Distribution and Extent:

Awqadain soils are mainly located in the Awqadain agricultural extension center. Their extent is 47.42 Ha which is 1.34% of the area.

Remarks:

The average depth to the upper boundary of the gleyed layers is 60 cm. Occasionally gleyed horizons start from about 20 cm in depth.

RAWRI AND NAHIZ SERIES
(Unit 2 and 5)

The Rawri and the Nahiz series consist of very deep, well drained, slightly saline soils with moderately slow permeability.

They formed in slightly gypsiferous and very strongly calcareous alluvial deposits on alluvial fan terraces. Both series have a gravelly loam top soil, a fine loamy particle size class, a diagnostic gypsic horizon and evidence of secondary calcium carbonate accumulation.

In Rawri soils a diagnostic calcic horizon overlying the gypsic horizon is recognized.

In Nahiz soils calcium carbonate and gypsum accumulations are interlaced and form a single composite layer.

In both series slopes range from 0 to 3 percent and runoff is slow.

Typical Pedon: SCK257

UNIT 2

Rawri gravelly loam on 0 to 1% straight slope in a cultivated field.

Sheet: 9585

Coordinates (U.T.M.): X = 197964.1E
Y = 1885410.0N

Photo: 31

Location: DAHARIZ NORTH

Date of description: 03/03/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Calcic Gypsisols

ST: Calcic Gypsiorthid, fine loamy, carbonatic, very deep

Phase: gravelly loam, slightly saline

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial fan terrace

Land Use: cultivated

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium/derived from sedimentary rock

Internal drainage: good
External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: > 150 cm

Ap	0-15 cm	dark yellowish brown 10 YR 4/4 (moist) loam; structureless massive structure; friable, slightly sticky, plastic; many very fine roots; violently effervescent; clear smooth boundary.
C	15-32 cm	yellowish brown 10 YR 5/4 (moist) very gravelly loam; structureless massive structure; friable, slightly sticky, plastic; many very fine tubular pores; many very fine roots; 15% fine, 15% medium and 20% coarse gravel; violently effervescent; clear smooth boundary.
Ck	32-55 cm	yellowish brown 10 YR 5/5 (moist) very gravelly coarse sandy loam; structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pores; common very fine roots; 15% fine, 15% medium and 15% coarse gravel and 10% cobbles; common calcareous soft aggregates, few calcareous pendants; violently effervescent; clear smooth boundary.
Cky1	55-100 cm	yellowish brown 10 YR 5/4 (moist) heavy loam; structureless massive structure; friable, sticky, plastic; many very fine tubular pores; common very fine roots; common calcareous soft aggregates; common gypsum crystals; strongly effervescent; gradual smooth boundary.
Cky2	100-150 cm	yellowish brown 10 YR 5/4 (moist) heavy loam; structureless massive structure; friable, sticky, plastic; many very fine tubular pores; common calcareous soft aggregates; few gypsum crystals; strongly effervescent.

Typical Pedon: SBG619

UNIT 5

Nahiz gravelly heavy loam on a 0 to 1 percent straight slope in a cultivated field.

Sheet: 9585

Coordinates (U.T.M.): X = 195438.8E
Y = 1887149.0N

Photo: 17

Location: QARAD

Date of description: 30/04/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Haplic Gypsisols

ST: Cambic Gypsiorthid, fine loamy, carbonatic,

Phase: gravelly heavy loam, slightly saline

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: irrigated rhodes grass

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Total fragment cover: few

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: > 150 cm

Ap 0 - 7 cm dark yellowish brown 10 YR 3/4 (moist) loam; moderate medium platy structure; very friable (moist), slightly sticky (wet), plastic (wet), many very fine tubular pores; abundant very fine roots, 20% fine gravel, 10% medium gravel, few worn cast; violently effervescent; clear smooth boundary.

C1 7 -29 cm dark yellowish brown 10 YR 4/4 (moist) heavy loam; moderate fine subangular blocky structure; friable (moist), non sticky (wet), plastic (wet), common very fine tubular pores; many very fine roots, 10% fine gravel, 15%

- medium gravel, few worn cast; violently effervescent; clear smooth boundary.
- C2 29-45 cm dark brown 7.5 YR 4/4 (moist) sandy loam; weak fine subangular blocky structure; very friable (moist), slightly sticky (wet), plastic (wet), common very fine tubular pores; many very fine roots, 15% fine gravel, 15% medium gravel, few worn cast; violently effervescent; clear smooth boundary.
- Cy3 45-70 cm dark yellowish brown 10 YR 4/4 (moist) heavy sandy loam; weak fine and medium subangular blocky structure; friable (moist, non sticky (wet), slightly plastic (wet), many very fine tubular pores; many very fine roots, 10% fine gravel, 10% medium gravel, common gypsiferous soft aggregates and few calcareous soft aggregates; very few worn cast; violently effervescent; clear smooth boundary.
- Cyk4 70-115 cm yellowish brown 10 YR 5/4 (moist) sandy clay loam; weak medium subangular blocky structure; friable (moist), sticky (wet), plastic (wet), abundant very fine tubular pores; many very fine roots, 6% fine gravel, 8% medium gravel, many gypsiferous soft aggregates and many calcareous soft aggregates; very few worn cast; violently effervescent; clear smooth boundary.
- Cyk5 115-150 cm yellowish brown 10 YR 5/4 (moist) sandy clay loam; structureless massive structure; friable (moist), sticky (wet), very plastic (wet), abundant very fine tubular pores; many very fine roots, 15% fine gravel, 25% medium gravel, 15% coarse gravel, common gypsiferous soft aggregates and many calcareous soft aggregates; very few worn cast; violently effervescent.

Range in Characteristics:

In both series the A horizon has hue of 10 YR, value of 3 or 4 and chroma of 4 moist. It commonly is gravelly sandy loam or loam and less commonly gravelly sandy clay loam or heavy loam. It is mildly to moderately alkaline.

In Rawri soils:

* the calcic horizon has a hue of 7,5 YR or less commonly 10 YR, value of 4 or 5, and chroma of 4 to 6 moist. Texture commonly is heavy loam, less commonly gravelly to very gravelly loam or coarse sandy loam. Calcium carbonates accumulates mainly as soft aggregates but coatings are perceptible on fragments.

The average thickness is about 40 cm. It is mildly to moderately alkaline.

* the gypsic horizon has a hue of 10 YR or less commonly 7,5 YR, value of 4 to 5, chroma of 4 to 6 moist. Texture commonly is clay loam and less commonly sandy clay loam or heavy loam. Gypsum content is 10 to 20% and it accumulates as crystals. It is mildly alkaline.

In Nahiz soils:

* the upper part of the control section has hue of 7,5 YR, value of 4 or 5 and chroma of 4 to 6 moist. Texture commonly is gravelly heavy sandy loam or loam less commonly gravelly to very gravelly sandy loam. It is mildly to moderately alkaline.

* the gypsic horizon has an average thickness of 65 cm. It has commonly hue of 10 YR less commonly 7,5 YR, value of 4 or 5, and chroma of 3 to 6 moist. Texture commonly is sandy clay loam or heavy sandy loam less commonly gravelly clay loam or heavy loam. Gypsum content is 15 to 30% and it accumulates as crystals. Some calcium carbonate accumulates as soft aggregates. It is mildly alkaline.

In both series the substratum has hue of 10 YR, less commonly 7,5 YR, value of 4 or 5 and chroma of 4 or 5 moist. Texture commonly is loam less commonly sandy clay loam and occasionally gravelly or very gravelly clay loam. It has gypsum and calcium carbonates accumulations. It is mildly alkaline.

Geographic Setting:

Rawri as well as Nahiz soils are on alluvial fan terraces. The slope gradient commonly range from 0 to 1 percent but complete range is from 0 to 3 percent.

Drainage and Permeability:

Rawri and Nahiz are well drained soils. Infiltration rate is low and permeability is moderately slow.

Cultivated Crops:

In both series short grass is the main crop. Banana and coconut are of small extent in Nahiz soil series only.

Distribution and Extent:

Rawri soils are mainly in Dahariz North. Nahiz soils are in Sahalnawt and in Al Qarad. Their extent is 21.5 Ha for Rawri and 3.5 Ha for Nahiz which are respectively 0.6% and 0.1 percent of the area.

Remarks:

Nahiz series includes, and is actually based on, as many as 7 field observations. At the final stage only about 3.5 Ha are legibly drawn on the soil map.

SAHALNAWT AND ETIN SERIES
(Unit 3 and 6)

The Sahalnawt and the Etin series consist of very deep and deep, well drained, moderately permeable soils.

They formed in slightly gypsiferous and very strongly calcareous alluvial deposits on fan terraces.

Both series have a gravelly sandy loam top soil, a loamy skeletal particle size class, a gypsic horizon and evidence of secondary calcium carbonate accumulation.

In Sahalnawt soils a calcic horizon overlying the gypsic horizon is recognized.

In Etin soils the calcic and gypsic horizons which are diagnostic features form a single composite layer where the calcium carbonate and the gypsum accumulations occur in the same layers.

In both series slopes range from 0 to 3 percent and runoff is slow.

Typical Pedon: SBK108

UNIT 3

Sahalnawt gravelly sandy clay loam on a 0 to 1% straight slope in a cultivated field.

Sheet: 0085

Coordinates (U.T.M.): X = 201371.4E
Y = 1887329.0N

Photo: 21

Location: SAHALNAWT

Date of description: 28/04/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Calcic Gypsisols

ST: Calcic Gypsiorthid, loamy skeletal, carbonatic

Phase: gravelly sandy clay loam, moderately saline

Soil Climate: aridic isohyperthermic

Topography: almost flat

Land Use: irrigated rhodes grass

Land form: alluvial plain

Slope: 1 - 2% convex

Parent Material: alluvium derived from sedimentary rock

Internal drainage: good
External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: > 150 cm

- Ap 0-10 cm dark yellowish brown 10 YR 4/4 (moist) heavy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine roots, 5% fine gravel, 5% medium gravel, 10% coarse gravel, violently effervescent; clear smooth boundary.
- C1 10-25 cm dark yellowish brown 10 YR 4/5 (moist) heavy sandy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine roots, 5% fine gravel, 10% medium gravel, 10% coarse gravel, 5% cobbles, violently effervescent; clear smooth boundary.
- Ck2 25-50 cm strong brown 7.5 YR 4/6 (moist) heavy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine roots, 5% distinct carbonate on rock fragments; 5% fine gravel, 5% medium gravel, 20% coarse gravel, 10% cobbles, very few soft calcareous soft aggregates; violently effervescent; clear smooth boundary.
- Ck3 50-80 cm brown 7.5 YR 5/5 (moist) heavy silt loam; structureless massive structure; friable (moist), sticky (wet), plastic (wet), common very fine roots, 5% fine gravel, 5% medium gravel, 30% coarse gravel, 10% cobbles, common calcareous soft aggregates and few calcareous pendants; violently effervescent; clear smooth boundary.
- Cky4 80-110 cm strong brown 7.5 YR 5/6 (moist) clay loam; structureless massive structure; friable (moist), sticky (wet), plastic (wet), < 5% distinct carbonate on rock fragments; 10% fine gravel, 10% medium gravel, 30% coarse gravel, 10% cobbles, many gypsiferous crystals and few calcareous soft aggregates and few gypsiferous pendants; strongly effervescent; clear smooth boundary.
- Cky5 110-150 cm strong brown 7.5 YR 5/6 (moist) heavy clay loam; structureless massive structure; friable (moist), sticky (wet), plastic (wet), < 5% distinct carbonate on rock fragments; 5% fine gravel, 10% medium gravel, 20% coarse gravel,

20% cobbles, 10% stones, many gypsiferous crystals and few calcareous soft aggregates and few gypsiferous pendants; strongly effervescent.

Typical Pedon: SCS891

UNIT 6

Etin sandy loam on a 0 to 1 percent straight slope in a cultivated field

Sheet: 8080

Coordinates (U.T.M.): X = 183216.4E

Photo: 39

Y = 1881666.0N

Location: AWQADAIN NORTH

Date of description: 29/04/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Haplic Gypsisols

ST: Cambic Gypsiorthid, loamy skeletal, carbonatic

Phase: sandy clay loam, moderately saline

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: young coconut

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: > 150 cm

Surface features: pseudosands

Ay 0-21 cm yellowish brown 10 YR 5/6 (moist) sandy loam; structureless massive structure; very friable (moist), non sticky (wet), slightly plastic (wet), few very fine tubular pores; few very fine roots, common gypsiferous soft aggregates; very few worm cast; violently effervescent; abrupt smooth boundary.

- C1 21-29 cm dark yellowish brown 10 YR 4/6 (moist) sandy loam; structureless massive structure; very friable (moist), non sticky (wet), slightly plastic (wet), common very fine tubular pores; few very fine roots, 8% fine gravel, 5% medium gravel, very few worn cast; violently effervescent; clear smooth boundary.
- Ck2 29-64 cm dark yellowish brown 10 YR 4/4 (moist) coarse sandy loam weak fine subangular blocky structure; very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; common very fine roots, < 5% carbonate on rock fragments; 10 % fine gravel, 10% medium gravel, 20% coarse gravel, 5% cobbles, few calcareous pendants; very few worn cast; violently effervescent; abrupt smooth boundary.
- Ck3 64-85 cm strong brown 7.5 YR 5/6 (moist) sandy clay loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), few very fine roots, < 5% carbonate on rock fragments; 10% fine gravel, 15% medium gravel, 35% coarse gravel, 10% cobbles, common calcareous pendants; violently effervescent; clear smooth boundary.
- Ck4 85-150 cm strong brown 7.5 YR 5/6 (moist) loamy coarse sand; structureless massive structure; very friable (moist), non sticky (wet), non plastic (wet), < 5% carbonate on rock fragments; 10% fine gravel, 20% medium gravel, 30% coarse gravel, 5% cobbles, common calcareous pendants; violently effervescent.

Range in Characteristics:

In both series the A horizon has hue of 10 YR or occasionally 7,5 YR, value and chroma of 4 or 5 moist. It commonly is gravelly to very gravelly sandy loam or loam and less commonly gravelly to very gravelly sandy clay loam. It is mildly to moderately alkaline.

In Sahalnawt soils:

* the calcic horizon has hue of 7,5 YR less commonly 10 YR, value of 4 or 5 and chroma of 4 to 6 moist. Texture commonly is very gravelly sandy clay loam or heavy loam and less commonly very gravelly sandy loam. Calcium carbonate accumulates mainly as soft aggregates and accessorially as pendants and coatings. It is mildly to moderately alkaline.

* the gypsic horizon has hue of 7,5 YR less commonly 10 YR, value and chroma of 4 to 6 moist. Texture commonly is very gravelly to extremely gravelly sandy clay loam and less commonly

very to extremely gravelly sandy loam. Gypsum content is 5 to 15% and it accumulates mainly as crystals and less commonly as pendants. Calcium carbonate accumulation is still perceptible. It is mildly alkaline.

In Etin soils:

* the upper part of the control section has commonly hue of 10 YR less commonly 7,5 YR, value of 4 or 5 and chroma of 4 to 6 moist. Texture commonly is very gravelly sandy loam or heavy sandy loam and less commonly loam. It is mildly alkaline.

* the gypsic horizon has an average thickness of 60 cm. It has hue of 10 YR, value of 5 and chroma of 5 to 6 moist. Texture commonly is very to extremely gravelly sandy clay loam less commonly extremely gravelly coarse sandy loam. Gypsum content is 5 to 20% and it accumulates as crystals. Calcium carbonate accumulates as soft aggregates and concretions. It is mildly alkaline.

In both series the substratum has a lower content of gypsum and calcium carbonate, a higher content of coarse fragments otherwise is like the gypsic horizon.

Geographic Setting:

Sahalnawt as well as Etin soils are on alluvial fan terraces. The slope gradient commonly range from 0 to 1 percent but complete range is from 0 to 3 percent.

Drainage and Permeability:

Sahalnawt and Etin are well drained soils. Infiltration rate is low and permeability is moderate.

Cultivated Crops:

In Sahalnawt short grass is the main crop followed by banana and vegetables.

In Etin coconut is the dominant crop followed by short grass and banana.

Distribution and Extent:

Sahalnawt soils are mainly in Sahalnawt. Their extent is about 12 Ha which is 0.33% of the area.

Etin soils are in Al Qarad and in Awqadain North. Their extent is about 2.5 Ha which is 0.07% of the area.

Remarks:

Etin series includes, and is actually based on, as many as 5 field observations. At the final stage only 2.5 Ha are legibly drawn on the soil map.

The depth to bedrock is restricted to 125 in some Etin soils.

MAMURAH AND HUMRAN SERIES
(Unit 4 and 7)

The Mamurah and the Humran series consist of very deep, well drained soils with very rapid permeability.

They formed in slightly gypsiferous and very strongly calcareous alluvial fan terraces.

Both series have a sandy skeletal particle size class and a gypsic horizon.

In Mamurah soil series the top soil is very gravelly sandy loam and there is a calcic horizon overlying the gypsic horizon.

Humran soils have a gravelly sandy loam top soil and lack the secondary calcium carbonate accumulation.

In both series slopes range from 0 to 3 percent and runoff is slow.

Typical Pedon: 257

UNIT 4

Mamurah very gravelly sandy loam on 0 to 1% straight slope in an uncultivated field.

Sheet: 9585

Coordinates (U.T.M.):

X = 198002.4E

Y = 1887150.0N

Photo: 19

Location: DAHARIZ

Date of description: 07/03/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Calcic Gypsisols

ST: Calcic Gypsiorthid, sandy skeletal, carbonatic, very deep

Phase: very gravelly sandy loam, slightly saline

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: virgin land, not fenced

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium/derived from sedimentary rock

Internal drainage: good
External drainage: slow

Moisture condition: dry 0-150 cm

Effective soil depth: > 150 cm

Ak	0-20 cm	dark yellowish brown 10 YR 4/4 (moist) very gravelly sandy loam, structureless massive structure; slightly hard, friable, slightly sticky, slightly plastic; 15% fine, 20% medium and 10% coarse gravel; 15% calcareous soft aggregates, violently effervescent; clear smooth boundary.
Ck	20-60 cm	strong brown 7.5 YR 4/6 (moist) extremely gravelly loamy sand, structureless massive structure; slightly hard, very friable, non sticky, non plastic; 15% fine, 20% medium and 20% coarse gravel and 10% cobbles; 10% calcareous soft aggregates, very few calcium carbonate coating on rock fragments; violently effervescent, clear smooth boundary.
Cy	60-150 cm	brownish yellow 10 YR 6/6 extremely gravelly coarse sand, structureless single grain structure; loose, non sticky, non plastic; 15% fine, 15% medium and 25% coarse gravel and 15% cobbles; 10% gypsum crystals, few gypsum pendants on rock fragments; strong effervescent.

Typical Pedon: SCK277

UNIT 7

Humran gravelly sandy loam on a 0 to 2 percent convex slope in a cultivated field.

Sheet: 9585

Coordinates (U.T.M.): X = 197127.7E
Y = 1885261.0N

Photo: 31

Location: DAHARIZ NORTH

Date of description: 10/04/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Haplic Gypsisols

ST: Cambic Gypsiorthid, sandy skeletal, mixed

Phase: gravelly sandy loam, strongly saline

Soil Climate: aridic isohyperthermic

Topography: almost flat

Land Use: banana and young coconut

Land form: alluvial plain

Slope: 1 - 2% convex

Parent Material: alluvium derived from sedimentary rock

Surface stoniness: many

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-160 cm

Effective soil depth: > 150 cm

Ap 0-20 cm yellowish brown 10 YR 5/4 (moist) and pale brown 10 YR 6/3 (dry) coarse sandy loam; structureless massive structure; soft (dry), very friable (moist), non sticky (wet), non plastic (wet), 20% fine gravel, 10% medium gravel, 15% coarse gravel, violently effervescent; gradual smooth boundary.

Cy1 20-45 cm brownish yellow 10 YR 6/6 (moist) and yellow 10 YR 7/6 (dry) loamy coarse sand; structureless single grain structure; loose (dry), loose (moist), non sticky (wet), non plastic (wet), 20% fine gravel, 5% medium gravel, 5% coarse gravel, common irregular gypsiferous crystals and common gypsiferous

pendants; strongly effervescent; clear wavy boundary.

- Cy2 45-65 cm yellowish brown 10 YR 6/6 (moist) and yellow 10 YR 8/6 (dry) coarse sandy loam; structureless massive structure; loose (dry), loose (moist), non sticky (wet), non plastic (wet), 20% fine gravel, 20% medium gravel, 10% coarse gravel, common gypsiferous pendants; strongly effervescent; clear smooth boundary.
- Cy3 65-90 cm brownish yellow 10 YR 6/6 (moist) and 10 YR 7/6 (dry) loamy coarse sand; structureless single grain structure; loose (dry), loose (moist), non sticky (wet), non plastic (wet), 15% fine gravel, 15% medium gravel, 20% coarse gravel, 20% cobbles, common gypsiferous pendants; strongly effervescent; gradual smooth boundary.
- Cy4 90-110 cm brownish yellow 10 YR 6/6 (moist) and yellow 10 YR 7/6 (dry) loamy coarse sand; structureless single grain structure; loose (dry), loose (moist), non sticky (wet), non plastic (wet), 20% fine gravel, 20% medium gravel, 10% coarse gravel, common gypsiferous pendants; strongly effervescent; clear smooth boundary.
- Cy5 110-160 cm brownish yellow 10 YR 6/6 (moist) and yellow 10 YR 8/6 (dry) loamy coarse sand; structureless single grain structure; loose (dry), loose (moist), non sticky (wet), non plastic (wet), 15% fine gravel, 20% medium gravel, 30% coarse gravel, common gypsiferous pendants; strongly effervescent.

Range in Characteristics:

In both series the A horizon has hue of 10 YR, value and chroma of 4 or 5 moist. It commonly is gravelly to very gravelly sandy loam and less commonly gravelly loam or loamy sand. It is mildly alkaline.

In Mamurah soils the calcic horizon has an average thickness of 40 cm. It has commonly hue of 10 YR less commonly 7,5 YR, value of 4 or 5, chroma of 4 to 6 moist. Texture commonly is very gravelly to extremely gravelly loamy coarse sand or loamy sand and less commonly very to extremely gravelly sandy loam. Calcium carbonate accumulates mainly as soft aggregates and accessorially as pendants and coatings. It is mildly to moderately alkaline.

In both series the gypsic horizon has an average thickness of 50 cm. It has hue of 10 YR, value and chroma of 4 to 6 moist. Texture is very gravelly to extremely gravelly loamy coarse sand

or coarse sand. It is occasionally stratified with gravelly sandy loam. Gypsum content ranges from 10 to 20% and it accumulates as crystals and pendants. It is mildly alkaline.

In Mamurah soils the calcium carbonate accumulation extends into the underlying gypsic horizon.

In both series the substratum has a lower gypsum content and is otherwise like the gypsic horizon.

Geographic Setting:

Mamurah and Humran soils are on alluvial fan terraces.

The slope gradient commonly ranges from 0 to 1 percent but the complete range is 0 to 3 percent.

Drainage and Permeability:

Mamurah and Humran are well drained soils. Infiltration rate is low and permeability is very rapid.

Cultivated Crops:

Almost all areas of Mamurah are uncultivated. In Humran soils banana, miscellaneous fruit trees, short and tall grasses are the main crops.

Distribution and Extent:

Humran as well as Mamurah soils are in Dahariz North.

The extent is 1.06 Ha for Mamurah and 16.91 Ha for Humran which represent respectively 0.06 and 0.48% of the area.

Remarks:

Mamurah soils includes, and is actually based on, as many as 5 field observations. At the final stage only about 1 Ha is legibly drawn on the soil map.

DHOFAR SERIES
(Unit 8 and 9)

The Dhofar series consists of very deep and deep well drained soils with moderately slow permeability.

They formed in highly calcareous alluvial deposits on fan terraces.

Dhofar soils have a fine loamy particle size class and a calcic subsurface diagnostic horizon.

Dhofar **phase 1** has a heavy loam top soil and a sandy substratum whereas Dhofar **phase 2** has a sandy clay loam topsoil and a very gravelly loamy substratum contrasting with the material above.

Slopes range from 0 to 1 percent and runoff is slow.

Typical Pedon: SCG050

UNIT 8

Dhofar heavy loam, 0 to 1% slope in a cultivated field.

Sheet: 0080

Coordinates (U.T.M.): X = 202057.6E
Y = 1884851.0N

Photo: 27

Location: RAZAT FARM

Date of description: 30/04/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Haplic Calcisols

ST: Typic calciorthid, fine loamy, carbonatic, very deep

Phase : sandy substratum

Soil Climate: aridic isohyperthermic

Topography: flat

Land Use: irrigated Rhodes grass

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: good

External drainage: slow

Moisture condition: dry 0-10 cm, slightly moist 10-56 cm, moist
56- 110 cm

Effective soil depth: > 150 cm

- Ap 0-10 cm dark yellowish brown 10 YR 4/4 (moist) and pale brown 10 YR 6/3 (dry) sandy loam; structureless massive structure; slightly hard (dry), very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine and fine tubular pores; common very fine and fine roots, common termite channels; violently effervescent; clear smooth boundary.
- C1 10-40 cm dark yellowish brown 10 YR 4/4 (moist) and yellowish brown 10 YR 5/4 (dry) heavy sandy loam; structureless massive structure; soft (dry), very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine and fine tubular pores; common very fine roots, violently effervescent; clear smooth boundary.
- Ck2 40-56 cm dark yellowish brown 10 YR 4/4 (moist) and light yellowish brown 10 YR 6/4 (dry) sandy clay loam; structureless massive structure; slightly hard (dry), firm (moist), sticky (wet), plastic (wet), many very fine tubular pores; common very fine roots, few fine calcareous soft aggregates; violently effervescent; clear smooth boundary.
- Ck3 56-90 cm strong brown 7.5 YR 4/6 (moist) and strong brown 7.5 YR 4/6 (dry) heavy clay loam; structureless massive structure; slightly hard (dry), firm (moist), sticky (wet), plastic (wet), many very fine and fine tubular pores; few very fine roots, common shell fragments, many calcareous soft aggregates; violently effervescent; clear smooth boundary.
- Ck4 90-110 cm strong brown 7.5 YR 4/6 (moist) and brown 7.5 YR 5/5 (dry) clay loam; structureless massive structure; soft (dry), firm (moist), sticky (wet), plastic (wet), many very fine tubular pores; very few very fine roots, common shell fragments, many calcareous soft aggregates; violently effervescent; clear smooth boundary.
- Ck5 110-132 cm reddish yellow 7.5 YR 6/6 (moist) loamy sand, structureless massive structure; soft (dry), very friable (moist), slightly sticky (wet), slightly plastic (wet), common very fine tubular pores; very few very fine roots, common shell fragments, many calcareous soft aggregates; violently effervescent; clear smooth boundary.
- C6 132-150 cm brownish yellow 10 YR 6/6 (moist) loamy sand, structureless massive structure; soft (dry), very friable (moist), slightly sticky (wet),

slightly plastic (wet), few shell fragments,
violently effervescent.

Typical Pedon: SBG648

UNIT 9

Dhofar very gravelly heavy substratum loam on 0 - 1%
straight slope in a cultivated field.

Sheet: 9085

Coordinates (U.T.M.): X = 194504.8E
Y = 1886255.0N

Photo: 17

Location: QARAD

Date of description: 09/04/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Haplic Calcisols

ST: Typic Calciorthid, fine loamy, carbonatic

Phase 02: very gravelly heavy loam substratum

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: irrigated rhodes grass

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: > 150 cm

Ap1 0-8 cm dark yellowish brown 10 YR 4/4 (moist) heavy
loam; moderate fine subangular blocky
structure; very friable (moist), non sticky
(wet), slightly plastic (wet), common very
fine tubular pores; abundant very fine roots,
6% fine gravel, 6% medium gravel, few worm
cast; violently effervescent; clear smooth
boundary.

Ap2 8-30 cm dark yellowish brown 10 YR 4/4 (moist) heavy
loam; moderate medium subangular blocky

- structure; friable (moist), slightly sticky (wet), plastic (wet) common very fine tubular pores; many very fine roots, 8% fine gravel, 4% medium gravel, few worm cast; strongly effervescent; clear smooth boundary.
- Bk1 30-46 cm yellowish brown 10 YR 5/4 (moist) heavy loam; weak fine subangular blocky structure; friable (moist), slightly sticky (wet), plastic (wet), plastic (wet), many very fine tubular pores; common very fine roots, 5% fine gravel, 5% medium gravel, few worm cast; violently effervescent; clear smooth boundary.
- Bk2 46-60 cm yellowish brown 10 YR 5/6 (moist) clay loam; weak fine subangular blocky structure; friable (moist), sticky (wet), plastic (wet), many very fine tubular pores, common calcareous soft aggregates; few worm cast; violently effervescent; clear smooth boundary.
- Bk3 60-85 cm strong brown 7.5 YR 5/6 (moist) clay loam; weak fine subangular blocky structure; friable (moist), sticky (wet), very plastic (wet), many very fine tubular pores; common very fine roots, 10% fine gravel, 10% coarse gravel, common calcareous soft aggregates and gradual smooth boundary.
- Ck 85-150 cm dark yellowish brown 10 YR 4/4 (moist) clay loam; weak medium subangular blocky structure; friable (moist), sticky (wet), very plastic (wet), many very fine tubular pores; few very fine roots, 15% fine gravel, 25% medium gravel, 19% coarse gravel, common calcareous soft aggregates and common iron-manganese concretions; very few worm cast; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value and chroma of 3 or 4 moist. It commonly is sandy clay loam or heavy loam, less commonly loam or heavy sandy loam and occasionally gravelly sandy loam or loam. It is mildly to moderately alkaline.

The upper part of the control section has hue of 10 YR, value and chroma of 4 or 5 moist. Texture commonly is heavy loam or sandy clay loam, less commonly sandy loam or loam and occasionally gravelly sandy clay loam or clay loam. It is moderately alkaline.

The calcic horizon has an average thickness of 60 and the calcium carbonate accumulates as soft aggregates. It has commonly a hue of 7,5 YR less commonly 10 YR, value and chroma

of 4 to 6 moist. Texture commonly is sandy clay loam or clay loam less commonly heavy loam or sandy loam and occasionally gravelly sandy clay loam or clay loam. It is moderately alkaline.

Substratum has commonly hue of 10 YR less commonly 7,5 YR, value of 4 to 7 and chroma of 4 to 6 moist. It is moderately alkaline. Texture commonly is sandy loam or loamy sand and less commonly sandy clay loam. The Dhofar phase 2 texture commonly is very gravelly sandy clay loam or clay loam and less commonly gravelly sandy clay loam or clay loam.

Geographic Setting:

Dhofar soils are on broad alluvial fan terraces.

Drainage and Permeability:

Dhofar soils are well drained. Infiltration rate is low and permeability is moderately slow.

Cultivated Crops:

Short grass is the main crop in Dhofar soils followed by vegetables and coconut.

Distribution and Extent:

Dhofar phase 1 soils are in Razat Farm. Their extent is 155.07 Ha which is 4.38% of the area. Dhofar phase 2 soils are in Sahalnawt Dhofar Cattle Feed Farm and in Al Qarad. Their extent is 79.4 Ha which is 2.24% of the area.

		plastic (wet), few very fine and fine roots, violently effervescent, clear smooth boundary.
C1	13-25 cm	dark yellowish brown 10 YR 4/4 (moist) heavy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), common very fine and fine roots, violently effervescent; clear smooth boundary.
Ck2	25-37 cm	strong brown 7.5 YR 4/6 (moist) sandy clay loam; weak medium and coarse subangular blocky structure; friable (moist), slightly sticky (wet), plastic (wet), many very fine and fine tubular pores; many very fine and fine roots, few rounded soft calcareous soft aggregates; violently effervescent; clear wavy boundary. (35-40 cm).
Ck3	37-62 cm	dark brown 7.5 YR 4/4 (moist) clay loam; moderate fine and medium subangular blocky structure; friable (moist), sticky (wet), plastic (wet), many very fine and fine tubular pores; many rounded soft calcareous soft aggregates; violently effervescent; abrupt wavy boundary.
R	62 cm +	calcareous beachrock

Range in Characteristics:

The A horizon has hue of 10 YR, value of 4 and chroma of 3 or 4 moist. It commonly is loam and less commonly fine sandy loam. It is mildly alkaline.

The subsoil has hue of 7,5 YR, value of 4 or 5 and chroma 4 to 6 moist. Texture commonly is clay loam or sandy clay loam and less commonly or gravelly sandy clay loam. It is moderately alkaline.

The calcic horizon has an average thickness of 40 cm. The calcium carbonate accumulates as soft aggregates.

Geographic Setting:

Salam soils are on alluvial terraces.

Drainage and Permeability:

Salam soils are well drained soils. Infiltration rate is low and permeability is moderately slow.

Cultivated Crops:

Short grasses are the main crop.

Distribution and Extent:

Salam soils are mainly in Dahariz Agricultural Extension Center. Their extent is about 1.0 Ha which is 0.03% of the area.

Remarks:

The depth to bedrock typically is 70 cm but the complete range includes 50 to 100 cm.

Salam series includes and, is actually based on, as many as 8 field observations. At the final stage only about 1.0 Ha is legibly drawn on the soil map.

- very fine roots, common termite channels; violently effervescent; clear smooth boundary.
- C1 14-29 cm dark yellowish brown 10 YR 4/4 (moist) loam, structureless massive structure; friable, slightly sticky, slightly plastic, many very fine tubular pores, many very fine roots, common termite channels; violently effervescent; clear smooth boundary.
- C2 29-45 cm brown 7.5 YR 5/4 (moist) loam, structureless massive structure; friable, slightly sticky, slightly plastic, many very fine tubular pores; common very fine roots; violently effervescent; clear smooth boundary.
- 2Ck1 45-70 cm brown 7.5 YR 5/4 (moist) loam, structureless massive structure; slightly sticky, slightly plastic, many very fine tubular pores; few very fine roots; 10% fine, 8% medium and 2% coarse shell fragments; 10% fine and medium rounded calcareous soft aggregates, violently effervescent; clear smooth boundary.
- 2Ck2 70-100 cm strong brown 7.5 YR 5/6 (moist) sandy clay loam, weak medium and coarse subangular blocky structure firm, sticky, plastic; many very fine tubular pores; very few very fine roots; 7% fine, 5% medium and 2% coarse shell fragments; 20% fine and medium, rounded calcareous soft aggregates; violently effervescent; clear smooth boundary.
- 2C 100-150 cm light yellowish brown 10 YR 6/4 (moist) sand, structureless single grain structure; loose, non sticky, non plastic; 15% fine, 5% medium shell fragments; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value and chroma of 4 moist. Texture is sandy loam or fine sandy loam. It is moderately alkaline.

The upper part of the control section commonly has hue of 10 YR, less commonly 7,5 YR, value and chroma of 4 or 5 moist. Texture commonly is sandy loam or loam and occasionally loamy sand. It is moderately alkaline.

The calcic horizon has an average thickness of 50 cm. The calcium carbonate accumulates as soft aggregates. It has hue of 7,5 YR, value and chroma of 4 to 6 moist. Texture commonly is sandy loam or loam, less commonly gravelly sandy loam or loam and occasionally loamy sand or sandy clay loam. It is moderately alkaline.

The substratum has hue of 10 YR, value of 5 to 7 and chroma of 4 to 6 moist. Texture commonly is loamy sand or sand, less commonly gravelly sand or heavy sandy loam and occasionally sandy clay loam. It is moderately alkaline.

Geographic Setting:

Garziz soils are on alluvial fan terraces.

Drainage and Permeability:

Garziz are well drained soils. Infiltration rate is low and permeability is moderate.

Cultivated Crops:

Banana followed by short grass are the main crops.

Distribution and Extent:

Garziz soils are mainly located in Razat farm. The extent is 8.17 Ha which is 0.23% of the mapped area.

Remarks:

The typical pedon presented above is not sampled because of the small extent of these soils.

- 15% fine gravel, 5% medium gravel, violently effervescent; clear smooth boundary.
- C1 12-45 cm dark yellowish brown 10 YR 4/4 (moist) heavy sandy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine and fine roots; 15% fine gravel, 10% medium gravel, violently effervescent; clear smooth boundary.
- Ck2 45-70 cm yellowish brown 10 YR 5/4 (moist) sandy clay loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), common very fine roots, < 5% distinct carbonate on rock fragments and all faces; 20% fine gravel, 20% medium gravel, 10% coarse gravel, few fine calcareous soft aggregates; violently effervescent; clear smooth boundary.
- Ck3 70-110 cm yellowish brown 10 YR 5/4 (moist) sandy clay loam; structureless massive structure; friable (moist), sticky (wet), plastic (wet), common very fine roots, < 5% distinct carbonate on rock fragments; 10% fine gravel, 10% medium gravel, 20% coarse gravel, 10% cobbles, common fine calcareous soft aggregates and few calcareous pendants; violently effervescent; clear smooth boundary.
- Ck4 110-150 cm dark yellowish brown 10 YR 4/4 (moist) sandy clay loam; structureless massive structure; friable (moist), sticky (wet), plastic (wet), common very fine roots, < 5% distinct carbonate on rock fragments; 10% fine gravel, 10% medium gravel, 25% coarse gravel, 5% cobbles, many fine calcareous soft aggregates and few calcareous pendants; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 4 or 5 and chroma of 3 to 6 moist. Texture commonly is gravelly to very gravelly sandy loam or sandy clay loam, less commonly loam or heavy loam. It is mildly to moderately alkaline.

The upper part of the control section has commonly hue of 7,5 YR and less commonly 10 YR, value of 4 or 5 and chroma of 4 to 6 moist. It commonly is gravelly to very gravelly sandy loam or loam, less commonly gravelly to very gravelly sandy clay loam, heavy sandy loam or loam and occasionally sandy loam or loam. It is mildly to moderately alkaline.

The lower part of the control section has commonly hue of 7,5 YR and less commonly 10 YR, value of 4 to 6 and chroma of 3 to 6 moist. It commonly is very gravelly to extremely gravelly sandy clay loam, heavy sandy loam, loam or clay loam, less commonly very gravelly to extremely gravelly sandy loam or loam and occasionally gravelly sandy clay, heavy sandy loam, loam or clay loam. Calcium carbonates accumulate mainly as soft aggregates and accessory as pendants and coatings on rock fragments. It is mildly to moderately alkaline.

The substratum has commonly hue of 7,5 YR and less commonly 10 YR, value of 4 to 6 and chroma 3 to 6 moist. It commonly is very gravelly to extremely gravelly sandy clay loam, heavy sandy loam, loam or clay loam less commonly very gravelly to extremely gravelly sandy loam or loam and occasionally extremely gravelly loamy coarse sand or coarse sand. Calcium carbonates accumulate as soft aggregates, pendants and coatings on rock fragments. It is mildly to moderately alkaline.

Geographic Setting:

Saada soils are on alluvial terraces in the upper part of the Salalah plain. The slope gradient commonly ranges from 0 to 1 percent, but the complete range is 0 to 3 percent.

Drainage and Permeability:

Saada are well drained soils. Infiltration rate is low and permeability is moderate.

Cultivated Crops:

Short grass is the main crop. Banana, coconut, alfalfa, millet, papaya and vegetables are of small extent.

Distribution and Extent:

Saada soils are in Al Qarad and Dahariz extension centers. Their extent is 776.80 Ha which is 21.92 of the mapped area.

GHADO SERIES
(Unit 13)

The Ghado series consist of moderately deep, well drained, moderately saline soils with moderate permeability. They formed in very gravelly to cobbly residuum with admixture of gravelly alluvial deposits.

The secondary calcium carbonate accumulates as soft aggregates mainly below 30 cm and the requirements for the calcic horizon are matched.

Slopes range from 0 to 1 percent and runoff is slow.

Typical Pedon: SCQ803

UNIT 13

Ghado loam on 0 to 1 percent straight slope in a cultivated field.

Sheet: 8580

Coordinates (U.T.M.): X = 186544.9E
Y = 1883198.0N

Photo: 37

Location: NORTH HOSPITAL

Date of description: 11/04/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Haplic Calcisols

ST: Typic Calciorthid, loamy skeletal, carbonatic moderately deep

Phase: gravelly loam, moderately saline

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: irrigated coconut and millet

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium over residuum derived from sedimentary
rock

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-53 cm

Effective soil depth: 53 cm

Surface features: pseudosands

- Ap 0-17 cm dark yellowish brown 10 YR 4/4 (moist) loam; weak medium subangular blocky structure; friable (moist), non sticky (wet), slightly plastic (wet), many very fine tubular pores; many very fine roots, few worm cast; strongly effervescent; abrupt smooth boundary
- Bk1 17-36 cm yellowish brown 10 YR 5/4 (moist) heavy loam; weak fine subangular blocky structure; friable (moist), slightly sticky (wet), plastic (wet), many very fine tubular pores; common very fine roots, 5% fine gravel, 20% medium gravel, 25% coarse gravel, common calcareous soft aggregates; common worm cast; violently effervescent; abrupt smooth boundary.
- Bk2 36-53 cm pink 7.5 YR 7/4 (moist) clay loam; structureless massive structure; firm (moist), slightly sticky (wet), very plastic (wet), common very fine roots, 5% fine gravel, 15% medium gravel, 30% coarse gravel, many calcareous soft aggregates; violently effervescent; very abrupt broken boundary.
- R 53 cm + limestone

Range in Characteristics:

The A horizon has hue of 10 YR, value and chroma of 3 or 4 moist. It commonly is gravelly loam less commonly gravelly sandy loam. It is mildly alkaline.

The subsoil has a hue of 7,5 YR, value of 4 to 7 and chroma of 4 to 6 moist. Texture commonly is very gravelly sandy clay loam or heavy loam and less commonly very gravelly sandy loam. It is mildly alkaline.

Geographic Setting:

Ghado soils are on alluvial terraces.

Drainage and Permeability:

Ghado are well drained soils. Infiltration rate is low and permeability is moderate.

Cultivated Crops:

Short grass and coconut are the main crops. Banana, tall grass and vegetables are of small extent.

Distribution and Extent:

Ghado soils are mainly in the North Hospital area. Their extent is 19.16 Ha which is 0.54% of the area.

Remarks:

The depth to bedrock ranges from 53 cm to 95 cm. The calcic horizon has an average thickness of 35 cm.

HAGAIF SERIES
(Unit 14)

The Hagaif series consists of very deep, well drained, slightly saline soils having a rapid permeability.

They formed in very gravelly alluvial deposits on low terraces or in channels. The secondary calcium carbonate accumulates as soft aggregates or pendants in a calcic horizon.

Slopes range from 0 to 3 percent and runoff is slow.

Typical Pedon: 188

UNIT 14

Hagaif very gravelly sandy loam on 0 to 1% straight slope in a cultivated field.

Sheet: 9585

Coordinates (U.T.M.): X = 198237.3E
Y = 1885939.0N

Photo: 29

Location: DAHARIZ NORTH

Date of description: 05/03/91

Author (s): MAHMOUD KHAIRY

Classification

FAO: Haplic Calcisols

ST: Typic Calciorthid, sandy skeletal, carbonatic, very deep

Phase: very gravelly sandy loam, slightly saline

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: irrigated banana, coconut and papaya

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Surface stoniness: 40% fine to coarse gravel

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: > 150 cm

- Ap 0-14 cm Dark yellowish brown 10 YR 4/4 (moist) very gravelly sandy loam; structureless massive structure; friable, non sticky, slightly plastic, common very fine roots; 10% fine, 15% medium and 15% coarse gravel, violently effervescent; clear smooth boundary.
- C1 14-40 cm dark brown to brown 10 YR 4/3 (moist) gravelly sandy loam; structureless massive structure; friable, non sticky, slightly plastic, common very fine tubular pores; common very fine roots; 20% fine, 5% medium and 5% coarse gravel, violently effervescent; clear smooth boundary.
- 2Ck1 40-60 cm strong brown 7.5 YR 4/6 (moist) extremely gravelly loamy sand; structureless massive structure; very friable, non sticky, non plastic; common very fine tubular pores; few very fine roots; 20% fine, 20% medium and 25% coarse gravel; 10% calcareous soft aggregates, few pendants, very few calcareous coatings on rock fragments; violently effervescent; clear smooth boundary.
- 2Ck2 60-150 cm brown to strong brown 7.5 YR 5/5 (moist) extremely gravelly loamy coarse sand; structureless massive structure; very friable, non sticky, non plastic; very few very fine roots; 15% fine, 20% medium and 20% coarse gravel and 10% cobbles; 5% calcareous soft aggregates, few pendants, very few calcareous coatings on rock fragments; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 4 or 5 and chroma of 4 moist. It commonly is gravelly to very gravelly sandy loam and less commonly gravelly loamy sand. It is moderately alkaline.

The upper part of the control section has hue of 10 YR, less commonly 7.5 YR, value of 4 or 5 and chroma of 3 to 6 moist. Texture commonly is very gravelly loamy sand and less commonly very gravelly sandy loam. It is mildly to moderately alkaline.

The lower part of the control section and the substratum have hue of 10 YR, less commonly 7.5 YR, value of 4 or 5 and chroma of 4 to 6 moist. Texture is very gravelly loamy coarse sand in the control section while in the substratum it is extremely gravelly loamy coarse sand or coarse sand. Both layers are mildly to moderately alkaline.

Geographic Setting:

Hagaif soils are on low alluvial terraces and in broad channels.

Drainage and Permeability:

Hagaif soils are well drained soils. Infiltration rate is low and permeability is rapid.

Cultivated Crops:

Short grass is the main crop followed by banana, coconut and vegetables.

Distribution and Extent:

Hagaif soils are mainly in Dahariz extension center. Their extent is 17.34 Ha which is 0.49% of the area.

Remarks:

The calcic horizon has an average thickness of 30 cm and is commonly in the upper part of the control section. It may occur at a greater depth in some pedons.

* The typical pedon presented above is not sampled because of the small extent of these soils.

MOUTAZA AND QURUM SERIES
(Unit 15 and 18)

The Moutaza and Qurum series consist of very deep and deep poorly drained soils with moderately rapid permeability. Both formed in highly calcareous alluvium in low lying areas in the Salalah plain.

Moutaza soils are fine loamy and moderately saline whereas Qurum soils are coarse loamy and slightly saline.

In both series there is evidence of alteration in the subsoil and the requirements for a cambic horizon are met.

Moutaza and Qurum soils have gleyed horizons at a depth of between 50 cm and 100 cm and are poorly drained soils.

In both series slopes range from 0 to 1 percent and runoff is slow.

Typical Pedon: SC0733

UNIT 15

Moutaza sandy loam on 0 to 1 percent straight slope in a cultivated field.

Sheet: 8580

Coordinates (U.T.M.): X = 188347.8E
Y = 1881741.0N

Photo: 35

Location: SALALAH WEST

Date of description: 27/04/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Gleyic Cambisols

ST: Aquic Eutropept, fine loamy, carbonatic, very deep

Phase: loam, moderately saline

Soil Climate: aquic isohyperthermic

Topography: flat

Element/Position: low lying area

Land Use: irrigated banana, coconut and millet

Land form: coastal plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: poor

External drainage: slow

Moisture condition: moist 0-125 cm, wet 125-150 cm

Effective soil depth: > 150 cm

Surface features: pseudosands

Remarks: water table at a depth of 150 cm.

- Ap1 0-5 cm yellowish brown 10 YR 5/4 (moist) sandy clay loam; weak fine subangular blocky structure; very friable (moist), non sticky (wet), slightly plastic (wet), many very fine tubular pores; many fine roots, few worm cast; violently effervescent; clear smooth boundary.
- Ap2 5-25 cm dark yellowish brown 10 YR 4/4 (moist) sandy clay loam; weak medium subangular blocky structure; very friable (moist), non sticky (wet), slightly plastic (wet), many very fine tubular pores; many very fine roots, few worm cast; violently effervescent; gradual smooth boundary.
- B1 25-48 cm dark yellowish brown 10 YR 4/4 (moist) heavy loam; structureless massive structure; friable (moist), slightly sticky (wet), plastic (wet), abundant very fine tubular pores; many very fine roots, very few worm cast; strongly effervescent; clear smooth boundary.
- Bk2 48-70 cm dark yellowish brown 10 YR 4/6 (moist) loam; weak fine subangular blocky structure; friable (moist), sticky (wet), very plastic (wet), many very fine tubular pores; many very fine roots, common calcareous soft aggregates; few worm cast; strongly effervescent; abrupt smooth boundary.
- Ck3 70-88 cm brown 10 YR 5/3 (moist) silty clay loam; structureless massive structure; friable (moist), slightly sticky (wet), plastic (wet), many very fine tubular pores; many very fine roots, common calcareous soft aggregates; strongly effervescent; clear smooth boundary.
- Ckg4 88-125 cm light gray 2.5 Y 7/2 (moist) heavy silt loam; structureless massive structure; friable (moist), sticky (wet), plastic (wet), abundant very fine tubular pores; 15% fine gravel, 15% medium gravel, 10% coarse gravel, 15% cobbles, abundant calcareous concretions; violently effervescent; abrupt smooth boundary.

Cg5 125-150 cm brown 10 YR 5/3 (moist) loamy coarse sand;
structureless single grain structure; non
sticky (wet), non plastic (wet), violently
effervescent

Remarks: discontinuous thin silt lamellae in the 5th
layer

Typical Pedon: 340

UNIT 18

Qurum sandy loam on 0 to 1% straight slope in a cultivated
field.

Sheet: 9580

Coordinates (U.T.M.): X = 196891.0E
Y = 1883115.0N

Photo: 31

Location: DAHARIZ SOUTH

Date of description: 02/01/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Gleyic Cambisols

ST: Aquic Eutropept, coarse loamy, carbonatic, very deep

Phase: sandy loam, slightly saline

Soil Climate: aquic isohyperthermic

Topography: flat

Element/Position: depression

Land Use: fallow

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: poor

External drainage: slow

Moisture condition: dry 0-7 cm, slightly moist 7-16 cm,
moist 16-120 cm, slightly wet 120-150 cm

Effective soil depth: > 150 cm

- Ap 0-7 cm brown 10 YR 5/3 sandy loam and dark brown to brown 10 YR 4/3 (moist); structureless massive structure; slightly hard, friable, non sticky, slightly plastic; common very fine roots; violently effervescent; clear smooth boundary.
- C1 7-23 cm dark brown to brown 10 YR 4/3 (moist) sandy loam; structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pores; common very fine roots; violently effervescent; clear smooth boundary.
- C2 23-46 cm brown 10 YR 5/3 (moist) sandy loam; structureless massive structure; friable non sticky, slightly plastic; many very fine tubular pores; common very fine roots; violently effervescent; clear smooth boundary.
- C3 46-90 cm brown 10 YR 5/3 (moist) sandy loam; weak medium and coarse subangular blocky structure; friable, non sticky, slightly plastic; many very fine tubular pores; few very fine roots; strongly effervescent; clear smooth boundary.
- Ckg1 90-120 cm light gray 10 YR 7/2 (moist) sandy clay loam, moderate medium and coarse subangular blocky structure; firm, sticky, plastic; many very fine tubular pores; very few very fine roots; many fine and medium calcareous soft aggregates; violently effervescent; clear smooth boundary.
- Ckg2 120-150 cm light gray 10 YR 7/2 (moist) clay loam; common medium distinct very dark gray 2.5 Y 3/0 spot-like mottles, moderate medium and coarse subangular blocky structure; firm, sticky, plastic; many very fine tubular pores; many medium and coarse calcareous concretions; common fine and medium calcareous soft aggregates; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 3 or 4 and chroma of 3 moist in Moutaza soils and 4 and 5 in Qurum soils. It commonly is sandy loam or loam and less commonly sandy clay loam. It is mildly to moderately alkaline.

The upper part of the control section in both series has hue of 10 YR and less commonly 7,5 YR, value of 4 to 6 and chroma of 3 to 6 moist. In Moutaza series texture is commonly heavy sandy loam, heavy loam or sandy clay loam and occasionally sandy loam or loam. In Qurum series the texture is sandy loam or loam

and less commonly gravelly sandy clay loam. It is moderately alkaline.

In both series the lower part of the control section has hue of 10 YR or 2,5 Y, value of 5 to 7 and chroma of 1 to 3 moist. In Moutaza series texture commonly is sandy clay loam less commonly clay loam, silty clay loam or clay and occasionally gravelly to very gravelly clay loam or silty clay loam. In Qurum series it is commonly sandy loam or loam and less commonly gravelly sandy clay loam. It is moderately alkaline.

The substratum has commonly hue of 2,5 Y or 5 Y and less commonly 10 YR, value of 4 to 8 and chroma of 2 to 4 moist. It commonly is sandy clay loam and less commonly gravelly sandy clay loam, clay or clay loam. It is mildly to moderately alkaline.

Geographic Setting:

Moutaza and Qurum soils are in low lying areas.

Drainage and Permeability:

Both series have a moderately high infiltration rate and a moderately rapid permeability.

Moutaza and Qurum soils are poorly drained.

Cultivated Crops:

In both series Coconut is the main crop followed by short grass, banana and vegetables.

Distribution and Extent:

Moutaza and Qurum soils occur in the lower part of the Salalah plain.

The extent is 286.5 Ha for Moutaza soils and 76.9 Ha for Qurum soils which are respectively 8.08 % and 2.17 % of the area.

Remarks:

In Moutaza the depth to bedrock typically is more than 150 cm but the range includes 120 cm to 150 cm in a few pedons.

In both series calcium carbonate concretions or soft aggregates are common in the lower part of the control section or in the substratum.

MANSHAHT SERIES
(Unit 16)

The Manshaht series consist of very deep and deep, moderately saline soils with moderately rapid permeability.

Manshaht soils formed in highly calcareous fine loamy or clayey alluvium in low lying areas in the Salalah plain.

There is evidence of alteration in the subsoil and the requirements for a cambic horizon are met.

Manshaht have gleyed horizons at a depth of between 25 cm and 50 cm and are very poorly drained soils.

Slopes range from 0 to 1 percent and runoff is slow.

Typical Pedon: SCM589

UNIT 16

Manshaht gravelly heavy loam on 0 to 1% straight in a cultivated field.

Sheet: 9080

Coordinates (U.T.M.): X = 191487.5E
Y = 1882673.0N

Photo: 33

Location: SALALAH EAST

Date of description: 08/05/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Gleyic Cambisols

ST: Aquic Eutropept, clayey, carbonatic

Phase: gravelly heavy loam, very strongly saline

Soil Climate: aquic isohyperthermic

Topography: flat

Element/Position: depression

Land Use: irrigated old coconut

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: very poor

External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: > 150 cm

Surface features: pseudosands

- Ap1 0-2 cm dark brown 10 YR 4/3 (moist) loam; weak fine platy structure; very friable (moist), non sticky (wet), slightly plastic (wet), few very fine tubular pores; common fine roots, very few worm cast; strongly effervescent; abrupt smooth boundary
- Ap2 2-4 cm dark yellowish brown 10 YR 4/4 (moist) heavy loam; weak fine platy structure; very friable (moist), slightly sticky (wet), plastic (wet), common very fine tubular pores; common fine roots, few worm cast; violently effervescent; clear smooth boundary.
- Ck1 4-13 cm brown 10 YR 5/3 (moist) sandy clay loam; structureless massive structure; very friable (moist), sticky (wet), plastic (wet), many very fine tubular pores; common medium roots, 10% fine gravel, 10% medium gravel, many calcareous concretions and few calcareous soft aggregates; few worm cast; violently effervescent; clear smooth boundary.
- Ckg2 13 cm + light gray 10 YR 7/2 (moist) silty clay; structureless massive structure; very friable (moist), sticky (wet), plastic (wet), abundant very fine and fine tubular pores; many coarse roots, 15% fine gravel, 10% medium gravel, many calcareous concretions and few calcareous soft aggregates; few worm cast; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 3 or 4 and chroma of 3 moist. It commonly is loam or sandy loam less commonly sandy clay loam. It is mildly to moderately alkaline.

The upper part of the control section has hue of 10 YR or 2,5 YR, value of 3 to 6 and chroma of 1 or 2 moist. Texture commonly is heavy sandy loam, heavy loam or sandy clay loam and occasionally sandy loam or loam. It is moderately alkaline.

The lower part of the control section has hue of 10 YR or 2,5 Y, value of 5 to 7 and chroma of 2 moist. Texture commonly is sandy clay loam less commonly clay loam, silty clay loam or clay and occasionally gravelly to very gravelly clay loam or silty clay loam. It is moderately alkaline.

The substratum has commonly hue of 2,5 Y or 5 Y and less commonly 10 YR, value of 4 to 8 and chroma of 2 or 3 moist. It

commonly is sandy clay loam and less commonly gravelly sandy clay loam, clay or clay loam. It is mildly to moderately alkaline.

Geographic Setting:

Manshaht soils are in low lying areas.

Drainage and Permeability:

Manshaht soils have a moderately high infiltration rate and a moderately rapid permeability. They are very poorly drained.

Cultivated Crops:

Banana and vegetables are the main crops followed by coconut and short grasses.

Distribution and Extent:

Manshaht soils occur in the lower part of Dahariz Extension Center.

Manshaht soils extent is 2.27 Ha which is 0.06% of the area.

Remarks:

Calcium carbonate concretions or soft aggregates are common in the lower part of the control section or in the substratum.

Manshaht series includes and is actually based on as many as 10 field observations. At the final stage only about 2.3 Ha are legibly drawn on the soil map.

RAYSUT SERIES
(Unit 17)

The Raysut series consists of moderately deep, poorly drained moderately saline soils with moderately rapid permeability. They formed in highly calcareous fine loamy alluvium. Though moderately deep there is no evidence of admixture with residual material. Raysut soils have gleyed horizons at a depth of between 40 and the underlying bedrock.

There is in the subsoil evidence of alteration and the requirements for a cambic horizon are met.

Slopes range from 0 to 3 percent and runoff is slow.

Typical Pedon: 706

UNIT 17

Raysut sandy loam on 0 to 1% straight slope in a cultivated field.

Sheet: 8580

Coordinates (U.T.M.): X = 189216.2
Y = 1882569.0N

Photo: 35

Location: SALALAH WEST

Date of description: 27/12/90

Author (s): HACHEM DAWOUD, ABDELLALI LOUAH, MAHMOUD KHAIRY

Classification:

FAO: Gleyic Cambisols

ST: Aquic Eutropept, fine loamy, carbonatic, moderately deep

Phase: sandy loam, moderately saline

Soil Climate: aquic isohyperthermic

Topography: flat

Element/Position: low lying area

Land Use: irrigated coconut, rhodes grass, alfalfa and vegetables

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: poor

External drainage: slow

Moisture condition: slightly moist 0-8 cm, moist 8-90 cm

Effective soil depth: 90 cm

Surface features: pseudosands

- Ap 0-8 cm dark brown to brown 10 YR 4/3 (moist) sandy loam; structureless massive structure; friable, non sticky, slightly plastic; common very fine roots; strongly effervescent; clear smooth boundary.
- C1 8-20 cm dark yellowish brown 10 YR 4/4 (moist) sandy loam; structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pores; common very fine roots; strongly effervescent; clear smooth boundary.
- C2 20-50 cm yellowish brown 10 YR 5/4 (moist) heavy sandy loam; structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pore; common very fine roots; strongly effervescent; clear smooth boundary.
- 2Ckg1 50-70 cm gray 10 YR 5/1 (moist) sandy clay loam, weak medium and coarse subangular block structure; friable, sticky, plastic, many very fine tubular pores; few very fine roots; many fine to coarse calcareous concretions; violently effervescent; clear smooth boundary.
- 2Ckg2 70-90 cm grayish brown 10 YR 5/2 (moist) sandy clay loam; weak medium and coarse subangular blocky structure; friable, sticky, plastic; many very fine tubular pores; very few very fine roots; abundant fine to coarse calcareous concretions; violently effervescent; abrupt smooth boundary.
- R 90 cm + calcareous sandstone bedrock.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 3 or 4 and chroma of 3 moist. It commonly is sandy loam and less commonly heavy loam or clay loam. It is mildly to moderately alkaline.

The upper part of the control section has hue of 10 YR, value of 4 or 5 and chroma of 3 or 4 moist. Texture commonly is heavy sandy loam and less commonly heavy loam. It is moderately alkaline.

The lower part of the control section above the lithic contact is gleyed and has hue of 10 YR, 2,5 Y or 5 Y, value of 6 or 7 and chroma of 2 moist. It commonly is sandy clay loam and less commonly clay loam. It is moderately alkaline.

Geographic Setting:

Raysut soils are in low lying areas.

Drainage and Permeability:

Raysut are poorly drained soils. Infiltration rate is moderately high and permeability is moderately rapid.

Cultivated Crops:

Short grass is the main crop followed by banana, coconut and tall grass.

Distribution and Extent:

Raysut soils are mainly in Dahariz extension center. Their extent is 32.02 Ha which is 0.90% of the mapped area.

Remarks:

The depth to bedrock commonly is more than 75 cm but the complete range is 50 to 100 cm. Raysut soils commonly have calcium carbonate concretions.

The typical pedon presented above is not sampled because of the small extent of these soils.

Effective soil depth: > 150 cm

- Az 0-7 cm dark yellowish brown 10 YR 4/4 (moist) slightly gravelly sandy loam; structureless massive structure; friable, non sticky, slightly plastic; common very fine and fine roots; 5% fine, 4% medium and 1% coarse gravel; very few salt crystals; violently effervescent; clear smooth boundary.
- C1 7-27 cm dark yellowish brown 10 YR 4/4 (moist) slightly gravelly sandy loam; structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pores; many very fine and fine roots; 4% fine, 4% medium and 2% coarse gravel; violently effervescent; clear smooth boundary.
- C2 27-40 cm dark brown to brown 10 YR 4/3 (moist) gravelly sandy loam; structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pores; many fine and medium roots; 4% fine, 5% medium and 7% coarse gravel; violently effervescent; clear smooth boundary.
- Ckg1 40-80 cm light yellowish brown 2.5 Y 6/4 (moist) very gravelly heavy sandy loam, weak medium and coarse subangular blocky structure; friable, slightly sticky, plastic; many very fine tubular pores; common medium and coarse roots; 10% fine, 10% medium, 25% coarse gravel and 5% cobbles; few fine and medium rounded calcareous soft aggregates; common calcareous coatings and few calcareous pendants on rock fragments; strongly effervescent; clear smooth boundary.
- Ckg2 80-110 cm olive yellow 2.5 YR 6/6 (moist) gravelly heavy sandy loam, common medium distinct yellowish brown 10 YR 5/4 spot-like mottles; weak medium and coarse subangular blocky structure; friable, slightly sticky, plastic; many very fine tubular pores; common medium and coarse roots; 4% fine, 6% medium and 6% coarse gravel; common fine and medium rounded calcareous soft aggregates, few calcareous coatings and few pendants on rock fragments; strongly effervescent; clear smooth boundary.
- Ckg3 110-150 cm light yellowish brown 2.5 Y 6/4 (moist) very gravelly sandy clay loam; moderate medium and coarse subangular blocky structure; firm, sticky, plastic; many very fine tubular pores; few medium and coarse roots; 15% fine, 10% medium, 20% coarse gravel and 5% cobbles;

common fine and medium rounded calcareous soft aggregates, common calcareous coatings and few pendants on rock fragments; strongly effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 4 and chroma of 3 or 4 moist. It commonly is sandy loam or loam less commonly gravelly to very gravelly sandy loam or loam. It is mildly to moderately alkaline.

The upper part of the control section commonly has hue of 10 YR less commonly 7,5 YR, value of 4 or 5 and chroma of 4 to 6 moist. Texture commonly is very gravelly sandy loam or loam less commonly sandy loam or loam and occasionally very gravelly heavy sandy loam or sandy clay loam. It is moderately alkaline.

The lower part of the control section has hue of 2,5 Y, value of 5 or 6 and chroma of 2 to 6 moist. Texture commonly is very gravelly sandy clay loam, clay loam or heavy sandy loam less commonly very gravelly coarse sandy loam or loam.

The substratum commonly has hue of 2,5 Y less commonly 10 YR, value of 6 or 7 and chroma of 2 to 6 moist. It commonly is very gravelly sandy clay loam or heavy sandy loam less commonly gravelly sandy clay loam or clay loam and occasionally extremely gravelly coarse sandy loam.

Geographic Setting:

Mahis soils are in depressions and low lying areas.

Drainage and Permeability:

Mahis are poorly drained soils. Infiltration rate is moderately high and permeability is moderately rapid.

Cultivated Crops:

Coconut and short grass are the main crops. Citrus and other fruit trees are minor crops.

Distribution and Extent:

Mahis soils are mainly in Dahariz extension center. The extent is 68.84 Ha which is 1.94% of the area.

Remarks:

The depth to bedrock typically is more than 150 cm but the range includes 115 to 150 cm in a few pedons.

Mahis soils commonly have calcium carbonate as soft aggregates, coatings and pendants in the lower part of the control section and substratum.

* The typical pedon presented above is not sampled because of the small extent of these soils.

structure; soft (dry), very friable (moist), non sticky (wet), non plastic (wet), few very fine tubular pores; common medium roots, violently effervescent; abrupt smooth boundary.

- C1 18- 40 cm yellow 10 YR 7/6 (moist) coarse sand; structureless single grain structure; loose (moist), non sticky (wet), non plastic (wet), no pores; many coarse roots, violently effervescent; clear smooth boundary.
- C2 40-180 cm very pale brown 10 YR 7/4 (moist) sand; structureless single grain structure; loose (moist), non sticky (wet), non plastic (wet), no pores; many coarse roots, violently effervescent; abrupt smooth boundary.
- C3 180 cm + strongly cemented sand (paralithic contact).

Remarks: common shell fragments in the Ap horizon

Range in Characteristics:

The A horizon has hue of 10 YR, value of 4 or 5 and chroma of 3 or 4 moist.

Texture commonly is loamy sand and occasionally sandy loam. It is mildly alkaline.

The control section has hue of 10 YR, value of 4 to 8 and chroma of 3 to 6 moist. Texture commonly is sand and less commonly loamy sand. It is moderately alkaline.

The substratum has hue of 10 YR, value of 4 to 8 and chroma of 3 to 4 moist. It commonly is sand and less commonly loamy sand. It is moderately alkaline.

Geographic Setting:

Balid soils are in low lying areas along the seaside.

Drainage and Permeability:

Balid are well drained soils. Infiltration rate is very high and permeability is very rapid.

Cultivated Crops

Coconut is the main crop followed by short grasses.

Distribution and Extent:

Balid soils are in the Hafa-Qarad extension center. The extent is 7.08 Ha which is 0.20% of the area.

Remarks:

In the Balid series, the depth to indurated layers typically is more than 150 cm, but the range includes 110 to 150 cm in a few pedons.

- C2 8-40 cm pale brown 10 YR 6/3 (moist) and very pale brown 10 YR 7/3 (dry) loamy sand; structureless single grain structure; loose (dry), loose (moist), non sticky (wet), non plastic (wet), 5% fine gravel, 5% medium gravel, 15% coarse gravel, 5% cobbles, violently effervescent; clear smooth boundary.
- C3 40-55 cm light yellowish brown 10 YR 6/4 (moist) and very pale brown 10 YR 7/4 (dry) sand; structureless single grain structure; loose (dry), loose (moist), non sticky (wet), non plastic (wet), violently effervescent; clear irregular boundary.
- R 55 + calcareous beach rock

Range in Characteristics:

The A horizon has hue of 10 YR, value of 4 or 5 and chroma of 3 or 4 moist. Texture commonly is gravelly loamy sand and less commonly slightly gravelly loamy sand or sand. It is mildly alkaline.

Subsoil has hue of 10 YR, value of 5 to 7 and chroma of 3 to 6 moist. Texture commonly is sand and less commonly loamy sand. It is moderately alkaline.

Geographic Setting:

Maghsayl soils are in low lying areas along the seaside.

Drainage and Permeability:

Maghsayl are well drained soils. Infiltration rate is very high and permeability is very rapid.

Cultivated Crops:

Coconut is the main crop. Short grass is frequent and banana is a minor crop.

Distribution and Extent:

Maghsayl soils are mostly in the Dahariz extension center. Their extent is 15.21 Ha which is 0.43% of the area.

- Ap 0-14 cm dark yellowish brown 10 YR 4/4 (moist) fine sandy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), few very fine and fine roots, strongly effervescent; clear smooth boundary.
- C1 14-40 cm yellowish brown 10 YR 5/4 (moist) sandy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine and fine tubular pores; few very fine and fine roots, few worm cast; strongly effervescent; clear smooth boundary.
- C2 40-65 cm yellowish brown 10 YR 5/4 (moist) sandy clay loam; structureless massive structure; friable (moist), sticky (wet), plastic (wet), abundant very fine and fine tubular pores; common very fine and fine roots, strongly effervescent; clear smooth boundary.
- C3 65-84 cm yellowish brown 10 YR 5/4 (moist) clay loam structureless massive structure; friable (moist), sticky (wet), plastic (wet), many very fine and fine tubular pores; few fine and medium roots, strongly effervescent; clear smooth boundary.
- C4 87-120 cm yellowish brown 10 YR 5/4 (moist) clay loam; structureless massive structure; friable (moist), sticky (wet), plastic (wet), many very fine and fine tubular pores; very few fine and medium roots, strongly effervescent; clear smooth boundary.
- C5 120-150 cm strong brown 7.5 YR 5/6 (moist) sandy clay loam; structureless massive structure; friable (moist), sticky (wet), common very fine tubular pores; strongly effervescent.

Typical Pedon: SCM538

UNIT 23

Sheet: 9080

Coordinates (U.T.M.): X = 193076.3E
Y = 1882729.0N

Photo: 33

Location: HAFA

Date of description: 24/02/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Cambic Fluvisols

ST: Typic Torrifuvent, fine loamy, carbonatic
Phase 02: gleyed heavy loam substratum

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: irrigated banana

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium/derived from sedimentary rock

Internal drainage: moderately good

External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: > 150 cm

Ap	0-9 cm	yellow 10 YR (moist) loam; weak coarse platy structure; very friable (moist), non sticky (wet), slightly plastic (wet), common very fine tubular pores; common coarse roots, common worm cast; strongly effervescent; clear smooth boundary.
C1	9-29 cm	dark brown 10 YR 4/3 (moist) sandy loam; moderate medium subangular blocky structure; very friable (moist), non sticky (wet), slightly plastic (wet), common very fine tubular pores; common coarse roots, few worm cast; strongly effervescent; clear smooth boundary.
C2	29-45 cm	yellowish brown 10 YR 5/4 (moist) sandy loam; weak fine subangular blocky structure; very friable (moist), non sticky (wet), slightly plastic (wet), common very fine tubular pores; common coarse roots, violently effervescent; clear smooth boundary.
C3	45-84 cm	dark yellowish brown 10 YR 4/4 (moist) clay loam; weak fine subangular blocky structure; very friable (moist), slightly sticky (wet), plastic (wet), common very fine tubular pores; common coarse roots, violently effervescent; gradual smooth boundary.
C4	84-105 cm	dark yellowish brown 10 YR 4/6 (moist) clay loam; weak very fine subangular blocky structure; very friable (moist), slightly

sticky (wet), plastic (wet), abundant very fine tubular pores; no roots, violently effervescent; clear smooth boundary.

Ck5 105-122 cm dark yellowish 10 YR 4/4 (moist) heavy clay loam; < 2% fine spots very dark grayish brown mottles; moderate very fine subangular blocky structure; very friable (moist), slightly sticky (wet), plastic (wet), many very fine tubular pores; 10% fine gravel, very few very fine iron-manganese concretions and many calcareous soft aggregates and few calcareous concretions; violently effervescent; abrupt smooth boundary.

Ckg6 122-150 cm white 10 YR 8/2 (moist) heavy clay loam; structureless massive structure; very friable (moist), sticky (wet), plastic (wet), many very fine tubular pores; 15% fine gravel, 20% medium gravel, 35% coarse gravel, common calcareous soft aggregates and many calcareous concretions; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 3 to 5 and chroma of 2 to 4 moist. Texture commonly is loam or sandy loam, less commonly heavy sandy loam or loam and occasionally sandy clay loam. It is moderately alkaline.

The control section commonly has hue of 10 YR, less commonly 7, 5 YR, value of 3 to 5 and chroma of 3 to 6 moist.

Texture commonly is sandy clay loam, heavy sandy loam, less commonly heavy loam or clay loam stratified with sandy loam or loam. It is moderately alkaline.

The substratum in the first phase typically has hue of 10 YR and occasionally 7, 5 YR. It has value of 4 to 6 and chroma of 3 to 6 moist. Texture commonly is sandy clay loam or heavy sandy loam and occasionally sandy loam or loam.

The substratum in the second phase commonly has hue of 10 YR less commonly 2, 5 Y, value of 4 to 7 and chroma of 1 to 4 moist. It commonly is sandy clay loam or heavy sandy loam less commonly clay loam or heavy loam and occasionally silty clay loam or heavy silt loam.

Both phases have a moderately alkaline substratum.

Geographic Setting:

Salalah soils are on terraces in the lower part of the surveyed area in the Salalah plain.

Drainage and Permeability:

Salalah phase 1 are well drained soils while Salalah phase 2 are moderately well drained soils.

In both phases the infiltration rate is moderately low and the permeability is moderate.

Cultivated Crops:

In Salalah phase 1 soils short grass is the main crop followed by banana. Tall grass, vegetables and coconut are of smaller extent.

In Salalah phase 2 soils banana is the main crop. Coconut, vegetables and short grass are frequent. Tall grass and papaya are minor crops.

Distribution and Extent:

Salalah phase 1 and phase 2 soils are extensive in Salalah extension center as well as in Hafa- Qarad. Their respective extent is about 267 and 423 Ha which is 7.55 and 11.94 percent of the area.

Remarks:

The depth to bedrock typically is more than 150 cm but the range includes 115 to 150 cm in a few pedons.

NEW SALALAH AND GHAWARIF SERIES
(Unit 24 and 28)

The New Salalah and Ghawarif series consist of moderately deep, well drained soils with moderate permeability.

They formed in highly calcareous alluvium and have no diagnostic subsurface horizon.

Residual material influence is very limited although soils are moderately deep to bedrock.

New Salalah soils have a fine loamy particle size class and a moderate permeability.

Ghawarif soils are in the coarse loamy family and have a moderately rapid permeability.

Slopes range from 0 to 1% and runoff is slow.

Typical Pedon: SCG063

UNIT 24

Sheet: 0085

Coordinates (U.T.M.): X = 202362.3E
Y = 1885919.0N

Photo: 27

Location: RAZAT FARM

Date of description: 29/04/91

Author (s): MAHMOUD KHAIRY

Classification

FAO: Calcaric Fluvisols

ST: Typic Torrifuvent, fine loamy, carbonatic, moderately deep

Phase: sandy clay loam,

Soil Climate: aridic isohyperthermic

Topography: flat

Land Use: irrigated grapes

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium over residuum derived from sedimentary
rock

Internal drainage: good

External drainage: slow

Moisture condition: dry 0-15 cm, slightly moist 15-30 cm, moist
30-75 cm

Effective soil depth: 75 cm

- Ap 0-15 cm dark yellowish brown 10 YR 4/4 (moist) and light yellowish brown 10 YR 6/4 (dry) heavy sandy loam; structureless massive structure; soft (dry), very friable (moist), slightly sticky (wet), slightly plastic (wet), 7% fine gravel, 4% medium gravel, 3% cobbles, violently effervescent; clear smooth boundary.
- C1 15-30 cm dark yellowish brown 10 YR 4/4 (moist) and light yellowish brown 10 YR 6/4 (dry) sandy clay loam; structureless massive structure; soft (dry), very friable (moist), slightly sticky (wet), slightly plastic (wet), few fine tubular pores; very few very fine and fine roots, 5% fine gravel, 4% medium gravel, 1% coarse gravel, violently effervescent; clear smooth boundary.
- C2 30-55 cm dark yellowish brown 10 YR 4/4 (moist) sandy clay loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), common very fine tubular pores; few fine and medium roots, 10% fine gravel, 8% medium gravel, 2% coarse gravel, strongly effervescent; clear smooth boundary.
- C3 55-75 cm dark yellowish brown 10 YR 4/4 (moist) sandy clay loam; structureless massive structure; friable (moist), sticky (wet), plastic (wet), many very fine tubular pores; very few fine and medium roots, 15% fine gravel, 13% medium gravel, 2% coarse gravel, strongly effervescent; abrupt irregular boundary.
- R 75 cm + calcareous beach rock

Typical Pedon: 327

UNIT 28

Ghawarif sandy loam on a 0 to 1 percent straight slope in a cultivated field.

Sheet: 9580

Coordinates (U.T.M.): X = 197204.5E
Y = 1883774.0N

Photo: 31

Location: DAHARIZ NORTH

Date of description: 05/01/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Calcaric Fluvisols

ST: Typic Torrifuvent, coarse loamy, carbonatic, moderately deep

Phase: sandy loam

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: irrigated rhodes-grass and millet

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-56 cm

Effective soil depth: 56 cm

Ap	0-15 cm	dark brown to brown 10 YR 4/3 (moist) sandy loam, structureless massive structure; friable, non sticky, slightly plastic; common very fine roots; violently effervescent; clear smooth boundary.
C1	15-32 cm	dark yellowish brown 10 YR 4/4 (moist) sandy loam, structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pores; many very fine roots; violently effervescent; clear smooth boundary.
C2	32-56 cm	dark yellowish brown 10 YR 4/4 (moist) sandy loam, structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pores; common very fine roots; violently effervescent; abrupt smooth boundary.
R	56 cm +	bedrock.

Range in Characteristics:

In both series the A horizon has hue of 10 YR, value of 3 to 5 and chroma of 3 to 6 moist. It is moderately alkaline.

In New Salalah soils topsoil texture commonly is sandy clay loam and less commonly sandy loam, heavy loam or loam.

In Ghawarif soils topsoil texture commonly is sandy loam and less commonly heavy sandy loam, sandy clay loam or loam.

In both series subsoil has commonly hue of 10 YR, less commonly 7,5 YR, value of 4 to 5, and chroma of 3 to 6 moist. It is moderately alkaline.

In New Salalah soils subsoil texture commonly is sandy clay loam and less commonly heavy loam or clay loam.

In Ghawarif subsoil subsoil texture commonly is sandy loam less commonly sandy loam stratified with loam, loamy sand or gravelly loamy sand.

Geographic Setting:

New Salalah and Ghawarif soils are on terraces.

Drainage and Permeability:

New Salalah and Ghawarif are well drained soils. Infiltration rate is moderately low. Permeability is moderate in New Salalah soils and moderately rapid in Ghawarif soils.

Cultivated Crops:

In New Salalah soils banana is the main crop while short grass, coconut and vegetables are of smaller extent.

In Ghawarif soils short grass is the main crop while coconut, banana, other fruit trees and vegetables are of smaller extent.

Distribution and Extent:

New Salalah soils are mainly in Al Qarad extension center. Their extent is 52.2 Ha which is 1.47 percent of the area.

Ghawarif soils are mainly in Dahariz and in Al Qarad extension centers. Their extent is about 206 Ha which is 5.81 percent of the area.

QOAF SERIES
(Unit 25,26 and 27)

The Qoaf series consists of very deep and deep soils with moderately rapid permeability.

They formed in highly calcareous alluvial deposits on terraces.

Qoaf soils have a sandy loam top soil and a coarse loamy particle size class in the subsoil. They have no diagnostic subsurface horizon.

Qoaf **phase 01** soils are well drained soils and have a coarse loamy substratum. Qoaf **phase 02** soils are also well drained but have a very gravelly substratum. Qoaf **phase 03** soils have a gleyed heavy loam substratum, are moderately well drained and slightly saline at least in the top soil.

Slopes range from 0 to 1 percent and runoff is slow.

Typical Pedon: SCM566

UNIT 25

Sheet: 9080

Coordinates (U.T.M.): X = 192573.5E
Y = 1882182.0N

Photo: 33

Location: HAFA

Date of description: 23/04/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Calcaric Fluvisols

ST: Typic Torrifuvent, coarse loamy, carbonatic

Phase 01: sandy loam

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: Alluvial terrace

Land Use: irrigated coconut

Land form: coastal plain

Slope: 0 - 1% straight

Parent Material: alluvium

Internal drainage: good

External drainage: slow

Moisture condition: dry 0-20 cm, moist 20-180 cm

Effective soil depth: > 150 cm

- Ap 0-20 cm dark brown 10 YR 4/3 (moist) and brown 10 YR 5/3 (dry) sandy loam; moderate medium subangular blocky structure; slightly hard (dry), very friable (moist), non sticky (wet), slightly plastic (wet), common fine tubular pores; many very fine roots, few worm cast; violently effervescent; abrupt smooth boundary.
- C1 20-54 cm dark yellowish brown 10 YR 4/4 (moist) sandy clay loam; weak fine subangular blocky structure; very friable (moist), non sticky (wet), slightly plastic (wet), many very fine tubular pores; common very fine and common coarse roots, few worm cast; violently effervescent; clear smooth boundary.
- C2 54-95 cm dark yellowish brown 10 YR 4/6 (moist) sandy loam; weak fine subangular blocky structure; very friable (moist), non sticky (wet), slightly plastic (wet), common very fine tubular pores; common coarse roots, very few worm cast; violently effervescent; clear smooth boundary.
- C3 95-110 cm yellowish brown 10 YR 5/6 (moist) sandy loam; structureless massive structure; very friable (moist), non sticky (wet), slightly plastic (wet), no pores; common coarse roots, strongly effervescent; abrupt smooth boundary.
- C4 110-180 cm very pale brown 10 YR 7/4 (moist) sand; structureless single grain structure; loose (moist), non sticky (wet), non plastic (wet), violently effervescent.

Typical Pedon: SCM523

UNIT 26

Sheet: 9080

Coordinates (U.T.M.): X = 193119.5E
Y = 1883716.0N

Photo: 33

Location: HAFA

Date of description: 02/05/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Calcaric Fluvisols

ST: Typic Torrifuvent, coarse loamy, carbonatic

Phase 02: very gravelly substratum

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: irrigated banana

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-105 cm

Effective soil depth: 104 cm

Surface features: pseudosands

Ap	0-13 cm	dark brown 10 YR 3/3 (moist) sandy loam; weak fine subangular blocky structure; very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; many very fine roots, common worm cast; violently effervescent; clear smooth boundary.
C1	13-27 cm	dark yellowish brown 10 YR 3/2 (moist) sandy loam; weak very fine subangular blocky structure; very friable (moist), non sticky (wet), slightly plastic (wet), many very fine tubular pores; many very fine roots, 6% fine gravel, 6% medium gravel, few worm cast; violently effervescent; clear smooth boundary.
C2	27-64 cm	yellowish brown 10 YR 5/6 (moist) sandy loam; structureless massive structure; very friable (moist), non sticky (wet), slightly plastic (wet), common very fine tubular pores; common very fine roots, 5% fine gravel, 4% medium gravel, very few worm cast; violently effervescent; clear smooth boundary.
C3	64-94 cm	dark yellowish brown 10 YR 4/6 (moist) fine sandy loam; structureless massive structure; very friable (moist), non sticky (wet), slightly plastic (wet), many very fine tubular pores; few very fine roots, very few worm cast; violently effervescent; abrupt smooth boundary.
C4	94-105 cm	dark yellowish brown 10 YR 4/4 (moist) heavy loam; structureless massive structure; very

friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; 15% fine gravel, 20% medium gravel, 10% coarse gravel, violently effervescent; very abrupt broken boundary.

Cr 104 cm + partly consolidated weathered rock (paralithic contact)

Typical Pedon: SCQ778

UNIT 27

Sheet: 8580

Coordinates (U.T.M.): X = 187406.3E
Y = 1883291.0N

Photo: 37

Location: AL WADI

Date of description: 04/05/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Calcaric Fluvisols

ST: Typic Torrifuvents, coarse loamy, carbonatic

Phase 03: gleyed heavy loam substratum, slightly saline

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: irrigated vegetables

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Total fragment cover: common

Surface rock fragments: fine and medium gravel

Internal drainage: moderately good

External drainage: slow

Moisture condition: dry 0-63 cm, moist 63-170 cm

Effective soil depth: > 150 cm

Surface features: few salt efflorescences

Ap 0-26 cm dark brown 10 YR 4/3 (moist) sandy loam; weak fine subangular blocky structure; soft (dry),

- very friable (moist), non sticky (wet), slightly plastic (wet), common very fine tubular pores; abundant very fine roots, 10% fine gravel, 12% medium gravel, 3% coarse gravel, few worm cast; violently effervescent; abrupt smooth boundary.
- C1 26-45 cm dark yellowish brown 10 YR 4/4 (moist) loamy coarse and; structureless single grain structure; loose (dry), loose (moist), non sticky (wet), non plastic (wet), many very fine tubular pores; common very fine roots, 25% fine gravel, 35% medium gravel, 10% coarse gravel, violently effervescent; abrupt smooth boundary.
- C2 45-64 cm dark yellowish brown 10 YR 4/4 (moist) loam; moderate medium subangular blocky structure; strongly cemented (dry), very friable (moist), slightly sticky (wet), slightly plastic (wet), abundant very fine tubular pores; common very fine roots, violently effervescent; clear smooth boundary.
- C3 63-90 cm dark yellowish brown 10 YR 4/4 (moist) loam; structureless massive structure; very friable (moist), slightly sticky (wet), slightly plastic (wet), abundant very fine tubular pores; common very fine roots, violently effervescent; clear smooth boundary.
- C4 90-106 cm dark yellowish brown 10 YR 4/4 (moist) loam; structureless massive structure; very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; abundant very fine roots, few calcareous soft aggregates; violently effervescent; clear smooth boundary.
- Ckg5 106-133 cm grayish brown 10 YR 5/2 (moist) loam; structureless massive structure; very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; common very fine roots, 5% fine gravel, 5% medium gravel, common calcareous concretions and abundant calcareous soft aggregates; violently effervescent; clear smooth boundary.
- Ckg6 133-170 cm grayish brown 10 YR 5/2 (moist) sandy clay loam; structureless massive structure; very friable (moist), sticky (wet), plastic (wet), many very fine tubular pores; 10% fine gravel, 20% medium gravel, 10% coarse gravel, common calcareous concretions and abundant calcareous soft aggregates; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 3 to 5 and chroma of 2 to 6 moist. Texture commonly is sandy loam or loam less commonly loamy sand and occasionally heavy sandy loam or loam. The topsoil is moderately alkaline.

In the control section Qoaf sandy loam (QOF 01) has commonly hue of 10 YR less commonly 7,5 YR, value and chroma of 3 to 6 moist. Qoaf very gravelly substratum (QOF 02) has commonly hue of 10 YR less commonly 7,5 YR value and chroma of 3 to 6 moist. Qoaf gleyed heavy loam substratum (QOF 03) has hue of 10 YR, value of 3 to 5 and chroma of 3 to 6 moist.

Texture in the control section typically is sandy loam or loam stratified with gravelly to very gravelly sandy loam or loam occasionally with heavy loam or sandy loamy sand. The subsoil is moderately alkaline.

In the substratum Qoaf sandy loam (QOF 01) commonly has hue of 10 YR less commonly 7, 5 YR, value of 4 to 7 and chroma of 3 to 6 moist. It commonly is sandy loam or loam less commonly sandy clay loam or heavy loam occasionally loamy sand, sand and gravelly sandy clay loam or loam.

QOF 02 commonly has hue of 10 YR less commonly 7,5 YR, value of 4 to 6 and chroma of 3 to 6 moist. Texture commonly is very gravelly heavy sandy loam or sandy clay loam less commonly very gravelly sandy loam, occasionally very gravelly loamy coarse sand.

QOF 03 commonly has hue of 10 YR less commonly 2, 5 Y, value of 5 to 8 and chroma of 1 to 3 moist. Texture commonly is sandy clay loam or heavy sandy loam less commonly heavy loam or clay loam and occasionally sandy loam or loam.

All substrata are moderately alkaline.

Geographic Setting:

Almost all Qoaf soils are either on terraces in the central and lower part of the Salalah plain or in low lying areas (QOF 02) in the northernmost parts of the Al Qarad region.

Drainage and Permeability:

Qoaf phases 01 and 02 are well drained soils and have a moderate infiltration rate. Qoaf phase 03 are moderately well drained soils and have a moderately low infiltration rate.

All Qoaf soils have a moderately rapid permeability.

Cultivated Crops:

Short grasses are the main crop followed by banana, coconut and tall grasses.

Distribution and Extent:

Qoaf soils are mainly in the Hafa- Qarad and Dahariz extension centers.

The extent is 207.63 Ha for Qoaf 01, 178.14 Ha for Qoaf 02 and 71.6 Ha for Qoaf 03 which are respectively 5.86, 5.03 and 2.02 percent of the area.

Remarks:

The depth to bedrock typically is more than 150 cm but the range includes 105 to 150 cm in a few pedons. Qoaf **phase 03** soils have calcium carbonate concretions at a depth of between 100 and 150 cm.

RAZAT SERIES
(Unit 29)

The Razat series consists of shallow, well drained soils with moderately rapid permeability.

The depth to bedrock ranges from 25 to 50 cm.

Razat soils formed in slightly gravelly residuum with admixture of alluvial materials.

They have no diagnostic horizon.

Slopes range from 0 to 1 percent and runoff is slow.

Typical Pedon: SCG022

UNIT 29

Razat sandy loam on a 0 to 1 percent straight slope in a fallow land.

Sheet: 0085

Coordinates (U.T.M.): X = 203617.8E
Y = 1885298.0N

Photo: 27

Location: RAZAT FARM

Date of description: 30/04/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Calcaric Fluvisols

ST: Typic Torrifuvent, loamy, carbonatic, shallow

Phase: sandy loam,

Soil Climate: aridic isohyperthermic

Topography: flat

Land Use: fallow

Land form: alluvial plain

Slope: straight

Parent Material: alluvium over residuum derived from sedimentary
rock

Internal drainage: good

External drainage: slow

Moisture condition: dry 0-10 cm, slightly moist 10-40 cm

Effective soil depth: 40 cm

Ap	0-10 cm	dark yellowish brown 10 YR 4/4 (moist) and very pale brown 10 YR 7/3 (dry) sandy loam; structureless massive structure; slightly hard (dry), very friable (moist), slightly sticky (wet), slightly plastic (wet), violently effervescent; clear smooth boundary.
C1	10-27 cm	dark yellowish brown 10 YR 4/4 (moist) and yellowish brown 10 YR 5/4 (dry) sandy loam; structureless massive structure; slightly hard (dry), very friable (moist), slightly sticky (wet), slightly plastic (wet), common very fine and fine tubular pores; violently effervescent; clear smooth boundary.
C2	27-40 cm	dark yellowish brown 10 YR 4/4 (moist) and yellowish brown 10 YR 5/4 (dry) sandy clay loam; structureless massive structure; soft (dry), very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; violently effervescent; abrupt wavy boundary.
R	40 +	calcareous beach rock.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 4 or 5 and chroma of 3 or 4 moist. It commonly is sandy loam and less commonly loam. It is mildly to moderately alkaline.

The subsoil overlying bedrock has hue of 10 YR, value of 4 and chroma of 3 to 6 moist. Texture commonly is sandy loam or loam and occasionally gravelly sandy loam, sandy clay loam or heavy loam. It is mildly to moderately alkaline.

Geographic Setting:

Razat soils are on alluvial terraces.

Drainage and Permeability:

Razat are well drained soils. Infiltration rate is low and permeability is moderately rapid.

Cultivated Crops:

Coconut and short grass are the main crops followed by banana, papaya and vegetables.

Distribution and Extent:

Most Razat soils occur in the Razat farm. Others are scattered in the central part of the Salalah plain. Their extent is 130.47 Ha which is 3.68% of the area.

Ap	0-9 cm	dark yellowish brown 10 YR 4/4 (moist) gravelly loam; structureless massive structure; friable, non sticky, slightly plastic; common very fine roots; 20% fine and 10% medium gravel; violently effervescent; clear smooth boundary.
C1	9-33 cm	dark yellowish brown 10 YR 4/4 (moist) slightly gravelly loam; structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pores, many very fine roots; 5% fine and 2% medium gravel; violently effervescent; clear smooth boundary.
C2	33-80 cm	light yellowish brown 10 YR 6/4 (moist) very gravelly heavy sandy loam; structureless massive structure; friable, slightly sticky, plastic; common very fine tubular pores, common very fine roots; 28% fine, 15% medium and 2% coarse gravel; violently effervescent; clear smooth boundary.
C3	80-105 cm	light yellowish brown 10 YR 6/4 (moist) very gravelly sandy clay loam; structureless massive structure; firm, sticky, plastic; common very fine tubular pores, few very fine roots; 25% fine, 13% medium and 7% coarse gravel; 3% calcareous soft aggregates; violently effervescent; clear smooth boundary.
C4	105-150 cm	light yellowish brown 10 YR 6/4 (moist) very gravelly loamy coarse sand, structureless single grain structure; loose, non sticky, non plastic; 44% fine, 10% medium and 5% coarse gravel; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 3 to 5 and chroma of 3 to 6 moist. Texture commonly is gravelly loam or sandy loam less commonly gravelly to very gravelly loam and occasionally loamy sand. It is mildly alkaline.

The control section has commonly hue of 10 YR, less commonly 7, 5 YR, value of 4 to 6 and chroma of 3 to 6 moist. Texture commonly is very gravelly to extremely gravelly heavy sandy loam or sandy clay loam less commonly very gravelly to extremely gravelly sandy loam or loam and occasionally sandy loam or loam. It is mildly to moderately alkaline.

The substratum has commonly hue of 7, 5 YR less commonly 10 YR, value of 4 to 7 and chroma of 3 to 6 moist. It commonly is very gravelly to extremely gravelly loamy coarse sand less commonly very gravelly to extremely gravelly sandy clay loam and occasionally very gravelly coarse sandy loam. It is moderately alkaline.

Geographic Setting:

Robat soils are in channels or on fan terraces.

Drainage and Permeability:

Robat are well drained soils. Infiltration rate is low and permeability is moderately rapid.

Cultivated Crops:

Coconut and short grass are the main crops followed by banana and vegetables as minor crops.

Distribution and Extent:

Robat soils are scattered in the Salalah plain. Their extent is 22.5 Ha which is 0.63% of the area.

Remarks:

The typical pedon presented above is not sampled because of the small extent of this mapunit.

LUB SERIES
(Units 31 and 32)

The Lub series consists of moderately saline, well drained soils with moderately rapid permeability.

They formed in very gravelly, highly calcareous alluvium on terraces.

They have a loamy skeletal particle size and no diagnostic subsurface horizon is recognized.

Lub phase 01 soils are moderately deep either to bedrock or to indurated layers and have a slightly gravelly loamy top soil.

In Lub phase 02 the depth to bedrock ranges from 20 to 50 cm (shallow soils) and the top soil is gravelly loam.

Slopes range from 0 to 3 percent and runoff is slow.

Typical Pedon: 892

UNIT 31

Lub 01 loam on 1 to 2% convex slope in a cultivated field.

Sheet: 8080

Coordinates (U.T.M.): X = 183103.8E

Y = 1881688.0N

Photo: 39

Location: AWQADAIN NORTH

Date of description: 23/03/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Calcaric Fluvisols

ST: Typic Torrifluvent, loamy skeletal, carbonatic, moderately deep Phase: loam, moderately saline

Soil Climate: aridic isohyperthermic

Topography: very gently undulating

Element/Position: alluvial terrace

Land Use: irrigated coconut

Land form: alluvial plain

Slope: 1 - 2% convex

Parent Material: alluvium derived from sedimentary rock

Surface stoniness: 50% fine to coarse gravel

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-75 cm

Effective soil depth: 75 cm

Surface features: pseudosands

Az 0-10 cm dark yellowish brown 10 YR 4/4 (moist) gravelly heavy loam, structureless massive structure; friable, slightly sticky, plastic; 10% fine, 15% medium and 5% coarse gravel; 20% salt crystals; violently effervescent; clear smooth boundary.

C1 10-40 cm dark yellowish brown 10 YR 4/4 (moist) loam, structureless massive structure; friable, non sticky, slightly plastic; many very fine tubular pores; common very fine roots; violently effervescent; clear smooth boundary.

C2 40-75 cm dark yellowish brown 10 YR 4/4 (moist) very gravelly heavy loam, structureless massive structure; friable, slightly sticky, plastic; common very fine tubular pores; common very fine roots; 20% fine, 15% medium and 10% coarse gravel; violently effervescent; clear smooth boundary.

Cm 75 cm + strongly cemented gravel.

Typical Pedon: 902

UNIT 32

Lub 02 gravelly loam on 1 to 2% convex slope in a cultivated field.

Sheet: Coordinates (U.T.M.): X = 182602.5
Y = 1881640.0N

Photo: 39

Location: Awqadain

Date of description: 23/03/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Calcaric Fluvisols

ST: Typic Torrifuvent, loamy skeletal, carbonatic, shallow

Phase: gravelly loam, moderately saline

Soil Climate: aridic isohyperthermic

Topography: very gently undulating

Element/Position: alluvial terrace

Land Use: fallow

Land form: alluvial plain

Slope: 1 - 2% convex

Human influence: ploughing

Parent Material: alluvium over residuum derived from sedimentary
rock

Surface stoniness: 50% fine to coarse gravel

Internal drainage: good

External drainage: slow

Moisture condition: dry 0-40 cm

Effective soil depth: > 40 cm

Surface features: pseudosands

Az 0-22 cm dark yellowish brown 10 YR 4/4 (moist)
gravelly loam, structureless massive
structure; slightly hard, friable, slightly
sticky, slightly plastic; common very fine
tubular pores; few very fine roots; 10% fine
and 10% medium gravel, 2% salt crystals;
violently effervescent; clear smooth boundary.

CR 22-40 cm dark yellowish brown 10 YR 4/4 (moist) very
gravelly silty clay loam, structureless
massive structure; hard, firm, slightly
sticky, plastic; common very fine tubular
pores; common very fine roots; 10% fine, 25%
medium and 20% coarse angular gravel; 3%
calcareous soft aggregates, violently
effervescent; clear smooth boundary.

R 40 cm + limestone bedrock

Range in Characteristics:

The A horizon has hue of 10 YR, value and chroma of 3 to 4 moist. Texture commonly is loam (Lub Phase 01) or gravelly loam (Lub phase 02) and less commonly slightly gravelly to gravelly sandy loam or heavy loam.

The subsoil has hue of 10 YR value of 4 to 7 and chroma of 3 to 4 moist. It commonly is extremely gravelly heavy loam and less commonly extremely gravelly silty clay loam or gravelly sandy loam.

Geographic Setting:

Lub soils are on terraces or in low lying areas.

Drainage and Permeability:

Lub are well drained soils. Infiltration rate is low and permeability is moderately rapid.

Cultivated Crops:

Fallow lands are of large extent in the Lub phase 01 soils while coconut is the main crop in Lub phase 02 soils.

Distribution and Extent:

Lub phase 01 are mainly in the northern part of Qarad extension center. Their extent is 9.26 Ha which is 0.26 percent of the area.

Lub phase 02 are in the Awqadain extension center. Their extent is 2.35 Ha which is 0.07 percent of the area.

Remarks:

No profile was sampled because of the small extent of these soils.

HASEELAH SERIES
(Unit 33 and 34)

The Haseelah series consists of very deep and deep soils with rapid permeability.

They formed in highly calcareous alluvial deposits on terraces.

Haseelah soils have a sandy loam top soil and the subsoil particle size class is sandy.

They have no diagnostic subsurface horizon. Haseelah phase 1 are well drained soils. Haseelah phase 2 soils differ in that they have a gleyed heavy loam substratum, are moderately well drained and are slightly saline.

Slopes range from 0 to 1 per cent and runoff is slow.

Typical Pedon: SCK336

UNIT 33

Sheet: 9580

Coordinates (U.T.M.): X = 196853.7E
Y = 1883625.0N

Photo: 31

Location: DAHARIZ NORTH

Date of description: 11/04/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Calcaric Fluvisols

ST: Typic Torrifuvent, sandy, carbonatic

Phase 01: sandy loam

Soil Climate: aridic isohyperthermic

Topography: flat

Land Use: irrigated coconut, banana, papaya and rhodes grass

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium over residuum derived from sedimentary rock

Internal drainage: good

External drainage: slow

Moisture condition: moist 0-150 cm

Effective soil depth: 150 cm

Ap	0-15 cm	dark brown 10 YR 4/3 (moist) sandy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine and fine tubular pores; abundant very fine and fine roots, strongly effervescent; clear smooth boundary.
C1	15-32 cm	dark brown 10 YR 4/3 (moist) sandy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine and fine tubular pores; many very fine roots, strongly effervescent; clear smooth boundary.
C2	32-54 cm	yellowish brown 10 YR 5/4 (moist) loamy sand to sandy loam; structureless massive structure; very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; common very fine roots, strongly effervescent; clear smooth boundary.
C3	54-77 cm	brown 7.5 YR 5/5 (moist) loamy sand; structureless massive structure; very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; common very fine and fine roots, strongly effervescent; gradual wavy boundary. (74-80 cm).
C4	77-105 cm	dark brown 10 YR 4/3 (moist) loamy sand; structureless massive structure; very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; common very fine roots, strongly effervescent; clear smooth boundary.
Ck5	105-150 cm	brown 10 YR 5/3 (moist) sandy loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; few very fine roots, few medium irregular calcareous concretions; strongly effervescent.
R	150 cm +	beach rock

Range in Characteristics

The A horizon has hue of 10 YR value and chroma of 3 or 4 moist. Texture commonly is sandy loam or loam and less commonly loamy sand. It is moderately alkaline.

The control section commonly has hue of 10 YR and less commonly 7.5 YR, value of 4 to 6 and chroma of 3 to 6 moist. Texture commonly is loamy sand or sand stratified with sandy loam, fine sandy loam or loam. It is moderately alkaline.

In the substratum:

* Haseelah phase 1 commonly has hue of 10 YR less commonly 7,5 YR, value of 4 to 7, chroma of 3 to 6 moist. It commonly is sand or loamy sand and less commonly sandy loam. It is moderately alkaline.

* Haseelah phase 02 has hue of 10 YR, value of 5 or 6 and chroma of 2 or 3 moist. it commonly is heavy sandy loam or loam and less commonly clay loam. It is moderately alkaline.

Geographic Setting:

Haseelah soils are on alluvial terraces.

Drainage and Permeability:

Haseelah phase 01 are well drained soils while Haseelah phase 02 are moderately well drained soils. All Haseelah soils have moderate infiltration rates and rapid permeability.

Cultivated Crops:

In Haseelah phase 01 banana is the main crop followed by short grass, vegetables and coconut. Tall grass and citrus are minor crops.

In Haseelah phase 02 short grass is the main crop followed by alfalfa. Coconut and vegetables are minor crops.

Distribution and Extent:

Haseelah soils are mainly in Dahariz extension center. Their extent is about 37 Ha for Haseelah phase 01 and about 10 Ha for Haseelah phase 02 which is respectively 1.04 and 0.26 percent of the area.

Remarks:

The depth to bedrock typically is more than 150 cm but the range includes 110 to 150 cm in a few pedons.

Ap	0-10 cm	dark yellowish brown 10 YR 4/4 (moist) sandy loam; structureless massive structure; very friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine and fine tubular pores; common very fine and fine roots, very few worm cast; violently effervescent; gradual smooth boundary.
C1	10-30 cm	brown 7.5 YR 5/5 (moist) loamy sand; structureless massive structure; loose (moist), non sticky (wet), non plastic (wet), many very fine and fine tubular pores; few medium and coarse roots, violently effervescent; very abrupt irregular boundary.
R	32 cm +	calcareous sandstone bedrock

Range in Characteristics:

The A horizon has hue of 10 YR, value of 4 or 5 and chroma of 3 to 5 moist. Texture commonly is loamy sand and less commonly sandy loam.

It is moderately alkaline.

The subsoil has hue of 10 YR, value of 4 to 6 and chroma of 3 to 5 moist. It is loamy sand stratified with sandy loam or very gravelly sandy loam. It is moderately alkaline.

Geographic Setting:

Jehed soils are on alluvial terraces where they often occur in association with the Ghawarif soils.

Drainage and Permeability:

Jehed are well drained soils. Infiltration rate is high and permeability is rapid.

Cultivated Crops:

Banana is the main crop. Citrus, vegetables, short grass and papaya are minor crops.

Distribution and Extent:

Jehed soils are mostly located in Dahariz extension center. Their extent is 2.75 Ha which is 0.08% of the area.

DAHARIZ SERIES
(Unit 36)

The Dahariz series consists of very deep and deep, well drained, moderately saline soils with very rapid permeability.

Dahariz soils formed in very gravelly to cobbly sand stratified with coarse loamy alluvial materials in alluvial fans. They have no diagnostic horizon.

Slopes range from 0 to 1 percent and runoff is slow.

Typical Pedon: SCM481

UNIT 36

Dahariz gravelly sandy loam on a 0 to 1 percent slope in a fallow land.

Sheet: 9085

Coordinates (U.T.M.): X = 192777.8E
Y = 1885634.0N

Photo: 33

Location: AL QARAD

Date of description: 30/04/91

Author (s): ABDELLALI LOUAH

Classification:

FAO: Calcaric Fluvisols

ST: Typic Torrifluvent, sandy skeletal, carbonatic, very deep

Phase: gravelly sandy loam, moderately saline

Soil Climate: aridic isohyperthermic

Topography: flat

Element/Position: alluvial terrace

Land Use: fallow

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium derived from sedimentary rock

Internal drainage: good

External drainage: slow

Moisture condition: dry 0-83 cm, moist 83-160 cm

Effective soil depth: > 150 cm

Ap 0-10/15 cm yellowish brown 10 YR 5/8 (moist) and yellow
10 YR 7/6 (dry) coarse sandy loam;

structureless massive structure; soft (dry), very friable (moist), non sticky (wet), non plastic (wet), many very fine tubular pores; many very fine roots, 10% fine gravel, 25% medium gravel, 5% coarse gravel, violently effervescent; clear wavy boundary. (10-15 cm).

- C1 10/15-34 cm yellowish brown 10 YR 5/8 (moist) and yellow 10 YR 7/6 (dry) loamy coarse sand; structureless single grain structure; loose (dry), loose (moist), non sticky (wet), non plastic (wet); common very fine roots, 25% fine gravel, 35% medium gravel, 10% coarse gravel, few worm cast; violently effervescent; abrupt smooth boundary.
- C2 34-66 cm yellowish brown 10 YR 5/8 (moist) and yellow 10 YR 7/6 (dry) loamy sand; structureless massive structure; soft (dry), very friable (moist), non sticky (wet), non plastic (wet), few very fine tubular pores; common very fine roots, 15% fine gravel, 20% medium gravel, 5% coarse gravel, violently effervescent; abrupt smooth boundary.
- C3 66-83 cm yellowish brown 10 YR 5/6 (moist) and yellow 10 YR 7/6 (dry) loamy coarse sand; structureless massive structure; soft (dry), very friable (moist), non sticky (wet), non plastic (wet), few very fine tubular pores; few very fine roots, 5% fine gravel, 5% medium gravel, violently effervescent; abrupt smooth boundary.
- C4 83-102 cm dark yellowish brown 10 YR 4/6 (moist) sandy loam; structureless massive structure; friable (moist), many very fine tubular pores; few very fine roots, 15% fine gravel, 13% medium gravel, 2% coarse gravel, few calcareous soft aggregates, violently effervescent; clear smooth boundary.
- Ck5 102-160 cm yellowish brown 10 YR 5/6 (moist) heavy loam; 2-20% medium spots brownish yellow mottles; structureless massive structure; very friable (moist), abundant very fine tubular pores; 10% fine gravel, 5% medium gravel, 5% coarse gravel, few gypsiferous crystals and many calcareous soft aggregates; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value of 3 to 5 and chroma of 3 to 6 moist. Texture commonly is gravelly and less commonly very gravelly sandy loam or loam. It is moderately alkaline.

The control section has commonly hue of 10 YR less commonly 7.5 YR, value of 4 to 6 and chroma of 3 to 6 moist. It is very gravelly to extremely gravelly loamy coarse sand or coarse sand stratified with very gravelly to extremely gravelly sandy loam occasionally sandy loam, loam or loamy sand. It is mildly to moderately alkaline.

Substratum commonly has hue of 10 YR less commonly 7.5 YR, value and chroma of 4 to 6 moist. Texture commonly is very gravelly to extremely gravelly coarse sand or loamy coarse sand less commonly very gravelly to extremely gravelly sandy loam and occasionally sandy loam or gravelly clay loam. It is mildly to moderately alkaline.

Geographic Setting:

Dahariz soils are in broad channels in alluvial fans, mainly in the upper part of the Salalah plain.

Drainage and Permeability:

Dahariz soils are well drained. Infiltration rate is low and permeability is very rapid.

Cultivated Crops:

Short grass and coconut are the main crops. Banana and vegetables are minor crops.

Distribution and Extent:

Most Dahariz soils are located in Hafa-Qarad extension center. Their extent is 126.43 Ha which is 3.57% of the area.

Remarks:

Dahariz series depth to bedrock typically is more than 150 cm but the range includes 100 to 150 cm in very few pedons.

Hafa Series
(Unit 37)

The Hafa series consists of very deep and deep well drained soils with slow permeability.

They formed in highly calcareous fine loamy alluvial material in low lying areas.

They have buried calcium carbonate accumulations (calcic horizon) at a depth of between 50 and 100 cm.

Slopes range from 0 to 1 percent and runoff is slow.

Typical Pedon: SCK295

UNIT 37

Hafa sandy clay loam on a 0 to 1 percent slope in a cultivated field.

Sheet: 9580

Coordinates (U.T.M.): X = 196397.9E

Y = 1884768.0N

Photo: 31

Location: DAHARIZ NORTH

Date of description: 10/04/91

Author (s): MAHMOUD KHAIRY

Classification:

FAO: Fluvi-Haplic Calcisols

ST: Thapto-calciorthidic Torrifuvent, fine loamy,
carbonatic, deep.

Phase: sandy clay loam

Soil Climate: aridic isohyperthermic

Topography: flat

Land Use: fallow

Land form: alluvial plain

Slope: 0 - 1% straight

Parent Material: alluvium over residuum derived from sedimentary
rock

Internal drainage: good

External drainage: slow

Moisture condition: dry 0-20 cm, moist 20-75 cm, slightly moist
75-110 cm

Effective soil depth: 110 cm

- Ap 0-20 cm yellowish brown 10 YR 5/4 (moist) and very pale brown 10 YR 7/3 (dry) sandy clay loam; weak medium and coarse subangular blocky parting into weak fine and medium granular structure; soft (dry), friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine and fine roots, violently effervescent; clear wavy boundary.
- C1 20-33 cm yellowish brown 10 YR 5/4 (moist) sandy clay loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; common very fine roots, strongly effervescent; clear smooth boundary.
- C2 33-55/60 cm yellowish brown 10 YR 5/4 (moist) sandy clay loam; structureless massive structure; friable (moist), slightly sticky (wet), slightly plastic (wet), many very fine tubular pores; few very fine roots, 8% fine gravel, 2% medium gravel, strongly effervescent; clear wavy boundary. (55-60 cm).
- 2Ckg3 55/60-75 cm light yellowish brown 10 YR 6/4 (moist) sandy clay loam; weak fine and medium subangular blocky structure; friable (moist), sticky (wet), plastic (wet), many very fine tubular pores; few very fine roots, < 5% distinct carbonate on rock fragments; 10% fine gravel, 4% medium gravel, common fine calcareous soft aggregates and very few calcareous pendants; violently effervescent; clear smooth boundary.
- 2Ckg4 75-110 cm very pale brown 10 YR 7/4 (moist) coarse sandy loam; structureless massive structure; very friable (moist), non sticky (wet), non plastic (wet), < 5% distinct carbonate on rock fragments; 10% fine gravel, 5% coarse gravel, 5% cobbles, few very fine calcareous soft aggregates; strongly effervescent; abrupt smooth boundary.
- R 110 cm + calcareous beach rock

Range in Characteristics:

The A horizon has hue of 10 YR, value and chroma of 3 to 4 moist. Texture commonly is sandy clay loam or sandy loam and less commonly loam or heavy loam. It is moderately alkaline.

The upper part of the control section has commonly hue of 10 YR less commonly 7,5 YR, value of 4 or 5 and chroma of 3 to 6 moist. It commonly is heavy loam, sandy loam or sandy clay loam less commonly sandy loam or loam and occasionally gravelly loam or sandy loam. It is moderately alkaline.

The lower part of the control section includes the calcic horizon and commonly has hue of 10 YR less commonly 7,5 YR, value of 4 to 7 and chroma of 3 to 6 moist. Texture commonly is sandy clay loam, clay loam or silty clay loam less commonly gravelly clay loam or gravelly sandy clay loam and occasionally very gravelly clay loam or very gravelly sandy clay loam. The calcium carbonate accumulates as soft aggregates and concretions. It is moderately alkaline.

The substratum commonly has hue of 10 YR less commonly 7,5 YR and occasionally 2,5 Y, value of 5 to 7 and chroma of 1 to 6 moist. It commonly is sandy clay loam or clay loam less commonly very gravelly clay loam or very gravelly sandy clay loam and occasionally loamy sand. It has calcium carbonate soft aggregates and concretions. It is moderately alkaline.

Geographic Setting:

Hafa soils are in depressions or in low lying areas.

Drainage and Permeability:

Commonly well drained soils. However the drainage is slightly reduced at a depth of between 100 and 150 cm in some pedons. Infiltration rate is moderately low and permeability is moderately slow.

Cultivated Crops:

The main cultivated crops are banana, papaya, coconut and vegetables.

Distribution and Extent:

Hafa soils are located mainly in the Hafa-Qarad extension center. Their extent is about 55 Ha which is 1.55 percent of the mapped area.

Remarks:

The Hafa series's depth to bedrock typically is more than 150 cm but some pedons range from 105 to 150 cm. Because no other sampled profile was available, the typical pedon presented above is among the shallowest pedons of this series.

Ap	0-13 cm	dark yellowish brown 10 YR 4/6 (moist) fine sandy loam; structureless massive structure; friable, non sticky, slightly plastic, common very fine roots, strongly effervescent; clear smooth boundary.
C1	13-40 cm	dark yellowish brown 10 YR 4/4 (moist) heavy fine sandy loam; structureless massive structure; friable, slightly sticky, slightly plastic, many very fine tubular pores; many very fine roots, strongly effervescent; clear smooth boundary.
C2	40-90 cm	dark yellowish brown 10 YR 4/4 (moist) loam; structureless massive structure; friable, non sticky, slightly plastic, many very fine tubular pores; common very fine roots, strongly effervescent; clear smooth boundary.
2Ck	90-120 cm	brown 7.5 YR 5/4 (moist) heavy silt loam; structureless massive structure; friable, slightly sticky, plastic, many very fine tubular pores; few very fine roots, 10% calcareous soft aggregates, 5% calcareous concretions; violently effervescent; clear smooth boundary.
2Ckg	120-150 cm	pinkish gray 7.5 YR 6/2 (moist) silty clay loam; structureless massive structure; firm, slightly sticky, plastic, many very fine tubular pores; 15% calcareous soft aggregates, 25% calcareous concretions; violently effervescent.

Range in Characteristics:

The A horizon has hue of 10 YR, value and chroma of 3 or 4 moist. Texture commonly is sandy loam or sandy clay loam and less commonly loam. It is moderately alkaline.

The upper part of the control section has commonly of 10 YR less commonly 7,5 YR, value of 4 or 5 and chroma of 3 to 6 moist. Texture commonly is sandy loam or loam less commonly gravely sandy loam or loam and occasionally loamy sand. It is moderately alkaline.

The lower part of the control section includes the calcic horizon and commonly has hue of 10 YR less commonly 7,5 YR, value of 4 to 6 and chroma of 3 to 6 moist. It commonly is sandy clay loam or clay loam less commonly gravelly sandy clay loam or clay loam and occasionally very gravelly heavy sandy loam or sandy clay loam. The calcium carbonates accumulates as soft aggregates and concretions. It is moderately alkaline.

The substratum commonly has hue of 10 YR occasionally 2,5 Y, value of 5 to 8 and chroma of 2 to 6 moist. It commonly is

gravelly to very gravelly sandy clay loam or clay loam less commonly clay loam or heavy loam and occasionally gravelly to very gravelly sandy loam. It has calcium carbonate soft aggregates and concretions. It is moderately alkaline.

Geographic Setting:

Hisin soils are in low lying areas.

Drainage and Permeability:

Commonly well drained soils. However drainage is slightly reduced at a depth of between 100 and 150 cm in some pedons. Infiltration rate and permeability are moderate.

Cultivated Crops:

Short grass is the main crop. Citrus, banana and other fruit trees are minor crops.

Distribution and Extent:

Hisin soils are located mainly in Dahariz and Awqadain extension centers. The extent is 43.30 Ha which is 1.22% of the mapped area.

Remarks:

The depth to bedrock typically is more than 150 cm but the range includes 110 to 150 cm in a few pedons.

The typical pedon described above is not sampled. because of the small extent of these soils.

3. LAND EVALUATION

3.1 Introduction

Land use planning aims at guiding decisions on land use in such a way that the resources of the environment are put to the most beneficial use for man, whilst at the same time conserving those resources for the future. This planning must be based on an understanding of the resources, amongst which are soil and water.

Land evaluation as well as farming systems analysis are tools for land use planning. Land use planning, here restricted to agricultural land use planning aims at determining better uses of land resources that are socially desirable and acceptable while taking into account environmental opportunities and limitations.

Changes from present situation to the proposed improved situation must be achieved gradually with the participation of the target population. Therefore the land use planning exercise must not only identify alternative land uses but also determine what incentives and measures should be taken to foster the changes that will achieve the proposed land use improvements.

Farming systems analysis aims at diagnosing at farm level the present situation by describing and analyzing the farms and their components which are the household system and the plant and animal production systems. Linkages with external systems such as input supply and marketing ...etc are also described and analyzed.

Land evaluation aims at identifying the potential of a given land for relevant alternative enterprises that may improve productivity, sustainability or both. In this process the evaluation of physical resources, mostly land and water play an important role. The socio-economic opportunities and constraints must also be taken into account.

Farming systems analysis and land evaluation complement each other. This is why the integrated study of Salalah plain makes use of both as components of a global agricultural land use planning exercise.

3.2 Methodology

Land evaluation is the process of assessing the suitability of the land for alternative land uses (FAO, 1990). This process involves three steps:

- identification and description of relevant land use types (LUTs) which are the alternative enterprises. This include determining their land requirements.

- map the land units present in the study area and describe them in terms of land characteristics that are relevant to the LUTs.
- Assess the suitability of each land unit for each LUT by matching the LUT requirements with the land properties.

Land suitability can be assessed either qualitatively or quantitatively.

Qualitative suitability classifications do not estimate achievable crop yields, level of inputs, costs or returns. This kind of suitability classification is suited for reconnaissance level such as the General Soil Map of Oman (Soil Atlas). All land evaluation work done till now in Oman, whatever the scale, has always been of this type.

The Salalah land evaluation is the first quantitative land evaluation ever done in Oman. Quantitative land evaluation is done first in physical terms and both achievable yields and inputs levels are quantified. This physical evaluation is normally followed by an economic classification in financial terms such as gross margin per unit area.

Since economic variables may change quickly with time, a physical evaluation must always be given together with the economic one.

The advent of "expert systems" computer programs that allow to calculate quickly either a physical or an economic evaluation or both make it possible to reflect changes in economic variables in a matter of a few hours.

These "expert systems" allow the land evaluator to build a living land evaluation model that can be frequently updated and continue to serve as opposed to a static one embodied in a simple report.

Not only such a system can constitute a flexible tool for planners, it can also serve to determine "fair prices" for farm produce by estimating the farmer's production cost. This can be very useful for organizations such as PAMAP.

The Automated Land Evaluation System (ALES) software developed by Cornell University (1989) based on the FAO land evaluation methodology is such an "expert system". It was set up and used by the project to carry out the land evaluation of the Salalah study area.

In the following sections we will first describe ALES. This will be followed by the description of the LUTs and their requirements. Another section will describe the proportional yield model used in setting up ALES. Lastly the results of the land evaluation and the recommendations will be presented.

3.3 ALES land evaluation programme

3.3.1 Introduction to ALES

The text which follows is largely extracted from the ALES user's manual to which the reader is referred for further information.

The Automated Land Evaluation System, or ALES, is a computer program that allows land evaluators to build expert systems to evaluate land according to the method presented in the Food and Agriculture Organization "Framework for Land Evaluation" (FAO 1976).

The entities evaluated by ALES are map units which are in this study phases of soil series. Since each model is built by a different evaluator to satisfy local needs, there is no fixed list of land use requirements by which land uses are evaluated, and no fixed list of land characteristics from which land qualities are inferred. Instead, these lists are determined by the evaluator to suit local conditions and objectives.

ALES has six components:

- 1) a framework for a knowledge base describing proposed land uses, in both physical and economic terms;
- 2) a framework for a database describing the land areas being evaluated;
- 3) an inference mechanism to relate these two, thereby computing the physical and economic suitability of a set of map units for a set of proposed land uses;
- 4) an explanation facility that enables model builders to understand and fine-tune their models;
- 5) a consultation mode that enables a casual user to query the system about one land use at a time, and
- 6) a report generator.

In order to understand the structure and the functioning of ALES it is useful to review the steps involved in a land evaluation and give a few definitions of the terms used.

In a land evaluation exercise, the land use planner matches land areas, termed land units (LU) with land uses, termed land utilization types (LUT), determining the relative suitability of each area for each use. Land utilization types are specified by a set of land-use requirements (LUR), which are 'the conditions of land necessary for the successful and sustained practice of [a given LUT]' (FAO 1984).

Land units are defined by the values of a set of land characteristics (LC), which are simple attributes of land that

can be measured or estimated. Land characteristic values are combined into levels of land qualities (LQ), which are complex attributes of land which influence the suitability of land in a semi-independent manner.

The actual evaluation of each land unit for each land utilization type is computed by:

- (1) determining the actual land characteristic values for the land unit;
- (2) combining these land characteristic values into land quality values;
- (3) matching the land quality values with land use requirements to obtain single land suitabilities
- (4) combining these single land suitabilities values into composite suitability classes

3.3.2 The structure of an ALES evaluation

In ALES, each evaluation consists of a set of land utilization types (LUT), i.e. proposed land uses, and a set of land map units (LMU), i.e. land areas being considered. Each map unit is evaluated for its suitability for each land utilization type, resulting in a suitability matrix. ALES can compute both physical and economic suitability.

3.3.2.1 Physical evaluation

A physical evaluation indicates the degree of suitability for a land use, without respect to economic conditions. A physical evaluation emphasizes the relatively permanent aspects of suitability, such as climate and edaphic conditions, rather than changeable ones, such as prices. It tends to concentrate on risks or hazards, e.g. to the environment, or absolute limitations, e.g. due to climate, of implementing a given land utilization type on a given land area. The idea is that if a use is too risky or physically impossible, no economic analysis can justify it. In ALES, if a land unit is rated physically unsuitable (in the highest-numbered physical suitability class), it will not be evaluated economically; it is automatically in FAO suitability class 'N2' (permanently unsuitable under the assumptions of the LUT).

For land that is not completely unsuitable, a physical evaluation can be used to divide the land into degrees of suitability, based purely on physical conditions.

The advantage is that physical suitability doesn't change quickly. The disadvantages are:

- (1) land use decisions are always based on economics, even if the economics may be distorted by institutional intervention;
- (2) it is unclear, in the absence of an economic scale, how to determine degrees of suitability;
- (3) it is unclear how to compare two land utilization types in strictly physical terms.

A physical evaluation can also be used to divide the land units into management groups.

3.3.2.2 Economic evaluation

ALES is intended to provide the land use planner with a realistic estimate of the economic suitability of each land unit for each proposed land use.

Economic suitability may be evaluated by several economic variables. The one adopted in this study is the predicted gross margin, (R.O per feddan-year, based on predicted costs and returns).

Land utilization types may have any number of outputs, with any number of crops of each output over the rotation cycle. Using the number of years in the rotation, ALES is able to normalize all economic calculations to currency per area-year for gross margin analysis. Thus ALES can analyze rotations, multiple cropping systems, and intercrops.

Cost may be related to land use requirements as follows ; an increasing level of limitation can result in an increased cost of production, a decreased yield, or both. Costs of production may be recurrent (annual) or one-time (in a specific year), and are expressed by listing the number of units of inputs that are required. Thus if the price of an input or product changes, the entire cost of production can be recomputed.

With the ease with which ALES computes yields and economic returns, the supposed disadvantage of economic evaluation, namely that economic conditions change quickly, evaporates. Within a few minutes, an ALES user can enter new economic parameters into a model, recompute an evaluation, and print the new results.

The way in which the ALES model builder reasons with classified data is to build decision trees. Decision trees are hierarchical multiway keys in which the leaves are results such as land quality ratings, and the interior nodes (branch points) of the tree are decision criteria such as land characteristic values.

These trees are constructed by the model builder, and traversed during the computation of an evaluation result, using actual land data. In ALES, decision trees are used to determine values of land qualities from values of land characteristics,

expected proportional yields of outputs from values of land qualities, physical suitability subclasses from values of land qualities, and, optionally, values of land characteristics from values of other land characteristics.

Decision trees have several advantages as a method of expressing inferences, in the context in which ALES is intended to be used. Most notably, the model builder and user both have an explicit representation of the process used to reach a decision. Trees may be traced by hand or with the aid of ALES' "why?" screens, thus affording insight into the model builder's logic.

3.3.2.3 Gross margin analysis

Gross margin analysis, on a per-feddan-year basis, is adequate for showing the major differences between land areas for proposed land uses. This analysis does not consider the time value of money, i.e. it assumes a discount rate of 0 %. Cash flows are normalized to a per-year basis. One-time ('capital') costs are represented only by 'carrying' their interest over the subsequent years. This may be a useful approximation if the source of finance is not a concern to the project.

3.3.2.4 Who uses ALES ?

Four classes of people interact with ALES. First, model builders construct and validate land evaluation models; second, model users enter land data and request that the program compute an evaluation; third, consumers, such as land use planners, use the printed evaluation results. A final class of user is the system administrator, who is responsible for the correct functioning of the ALES program itself. Sometimes all these operations are carried out by a single person, especially in the case of small evaluation projects. It must also be noted that the maintenance of the software is the responsibility of Cornell University. The following sections explain in more detail the role of these four classes of users.

3.3.2.4.1 Model builder

The model builder is the person who constructs the 'expert system', within the ALES framework, that can be used to compute land suitability. Often, the model builder is the person responsible for coordinating a land evaluation at the project level. Or, the model builder can be a specialist assigned to a land evaluation team. There is no requirement, or even desirability, of the model builder being a computer programmer, however, familiarity with the ideas behind systems analysis will certainly be helpful to this individual.

The model builder must serve as the collator and arbitrator of contributions from agronomists, soils specialists, hydrologists, climatologists, economists, etc.

3.3.2.4.2 Model user

Completed models can be turned over to clerical staff, who then enter definitions and data for the remaining land units in the evaluation area, using the data entry forms designed by the model builder. They then compute a final comprehensive evaluation. Reports can be printed showing land areas ranked by use, and vice versa, for use by planners.

Model users should invoke ALES with the DOS command evaluate. In this mode they will not be able to alter the model, only the database, as well as economic parameters such as prices and interest rates.

3.3.2.4.3 Evaluation consumer

This class of users includes land use planners and others who want to see evaluation results packaged as summary reports. They will not use the program itself, but will be presented printed reports by model users. The printed reports will be prepared by model users. In addition, evaluation consumers may want to understand the reasoning of the evaluation. To do this, they will receive a 'guided tour' by the model builder or model user through the evaluation matrix and 'Why?' screens, or perhaps a consultation session. In the 'consultation' mode the program prompts the user to select the correct values of land characteristics for a single land area, and computes its suitability for one use, following a forward chain through all relevant decision trees. This is primarily a teaching tool, but could be used for single-site evaluations or land valuation.

Users who wish only to consult ALES should invoke ALES with the DOS command consult. This will start ALES directly to consultation mode, bypassing the main menu. In this mode users are not able to alter the model or the database, except that they may preload land data from an existing map unit, and may store the land data entered during the consultation into a map unit definition.

3.3.2.4.4 System administrator

The 'System Administrator' is the person who can work with the operating system, do backups, add new hardware, and so forth. This person installs ALES, configures new printers and other hardware into the system, and is responsible for the integrity of the MUMPS database system and the ALES database.

3.3.3 Building an ALES model

First, the model builder will build a preliminary version of a land evaluation model. This involves :

- 1) selecting a few representative land utilization types;
- 2) expressing these in terms of their most important land use requirements;

- 3) determine which land characteristics are available to form the basis of evaluation;
- 4) constructing decision trees to relate land characteristics to land use requirements;
- 5) collecting economic parameters, such as prices;
- 6) selecting some representative or well understood map units;
- 7) collecting and entering land characteristics data for these map units.
- 8) validating the model

Design of the preliminary model will require close cooperation with the many specialists whose knowledge is necessary for successful land evaluation. The model builder will serve as the collator and arbitrator of contributions from agronomists, soils specialists, hydrologists, climatologists, economists, etc. The design must be based on the project objectives and available data sources.

Once a preliminary model is built, and data entered on a representative set of map units, an evaluation matrix may be computed. This matrix shows the rating of each map unit for each land utilization type including expected yields of crops and gross margin. The ratings may be compared against values computed by other methods, and rankings of map units may be reviewed. If there are actual yield data, they may be compared with expected yields.

Viewing this matrix should cause the evaluator to ask many questions. Some ratings will appear unreasonable, either in absolute terms (e.g, the model predicts total crop failure, but the map unit in question does provide a reliable, low yield), or in relative terms (e.g. two map units are predicted to have very different gross margins for a particular LUT, but farms on the two areas are not noticeably different in their economic status). ALES provides a way to query the model and data to determine the source of any discrepancies and correct them, thus allowing for iterative model building.

Typically, this step will be repeated many times, until the model builder is satisfied that the model successfully predicts suitability, to the desired accuracy. Once a satisfactory preliminary model is completed, the evaluator can then extend it to a wider set of land utilization types.

3.4 Land utilization types

3.4.1 Introduction

The definition of the LUTs and their requirements (see appendix 3 for standard ALES LUT descriptions) is an essential stage in developing a land evaluation model. As shown in the land use report a large number of crops is grown in the study area. It was therefore necessary to identify those that are of economic significance and determine their requirements.

Crops grown in the study area are dominantly fruits, fodder and vegetables. Information was collected on these crops by:

- reviewing and compiling all the research results that were obtained in the Salalah agricultural research station and discussing with the researchers.
- visiting the most advanced farmers in the area to analyze their experience. In this regard the records of the Royal Razat farm since 1982 were examined and numerous visits and discussions with the farm's staff were made. Information was also obtained on rhodes grass from Dhofar Cattle Feed Farms.
- A series of consultancies on special aspects of plant production were made. Plant protection, weed control and micronutrient were the main subjects of these consultancies.

Twelve vegetables, three grasses and six fruit trees were selected for detailed analysis. These were:

- Fruits: Banana, chico (sapota), coconut, grapevine, guava and papaya.
- Fodder: Rhodes grass, buffel grass and elephant grass (napier).
- Vegetables: Cabbage, carrot, cauliflower, cucumber, eggplant, green beans, hot pepper, okra, squash, sweet melon, sweet pepper, sweet potato, tomato and watermelon.

For these crops the following information was collected:

- for vegetables, crop calendars, recommended planting dates and varieties.
- crop water requirements were calculated for each crop, using FAO's specialized software CROPWAT. A database was prepared with all the crop coefficients and lengths of growing periods.
- fertilizer requirements were determined for each crop.

- pesticides requirements were also estimated for each crop with the help of the plant protection staff of the MAF.
- planting materials quantities and costs as well as labour requirements and tractor services were also determined.
- Achievable yields were estimated under each level of irrigation water salinity. It should be noted that all potential yields are yields that are actually already achieved in the study area and not theoretical yields.
- Cost information was collected on all necessary inputs and produce selling prices. Wherever an input is subsidized, the subsidized price was used.

Vegetables were evaluated under surface irrigation and drip irrigation separately. Banana, papaya and grapes were evaluated under drip and coconut, chico and guava under bubbler irrigation systems. Rhodes grass was considered under improved surface irrigation and alternatively under sprinkler irrigation.

The projects' irrigation engineers selected the irrigation systems and calculated their cost.

All the above mentioned information on LUTs is presented in tabular form for clarity and briefly commented in the following sections.

Once all the above activities were completed a computer yield model was built using specialized software and achievable yields and gross margins were calculated for each combination of soil and water in the plain.

3.4.2 Vegetables

3.4.2.1 Planting materials, crop calendars and achievable yields

Table 14 gives the recommended vegetable varieties, their calendar, recommended planting dates, recommended varieties and achievable yields in optimal conditions. As a rule yields under surface irrigation were considered 15 percent less than under drip although in many cases the difference is much bigger. This information was collected from trials of the MAF research station and Razat farm.

Table 15 gives the quantity of seeds needed for each vegetable and its cost.

3.4.2.2 Labour and land preparation

Table 16 gives labour and tractor services requirements under surface irrigation and drip. Labour requirements were determined as follow:

- For surface irrigation a meeting was done with all the extensionists and they were requested to estimate for each crop how many feddans can be handled by one labourer. For vegetables their estimates converged towards an average of one labourer can handle 1 feddan of vegetables using only about 75 percent of his time during the field occupation period.
- Similar information was obtained for drip irrigation from the horticulturist and foremen of the Royal Razat farm and result was that about 35 percent of a labourer time are needed per feddan. The information on tractor services was obtained from the extensionists of the MAF because they are the people providing these services to farmers.
- Tractor services were counted at 2 R.O per hour whereas labour was counted at R.O. 82 per month as obtained from the farming systems survey.

Table 14

VEGETABLE PRODUCTION IN SALALAH PLAIN
Indicative Crop Calendars and Corresponding Achievable Yields

Crop	Achievable Yields Tons/fecdan		Recommended planting periods	Days to Matu- ration	Days of Harvest	Total Field Occup- ation (days)	Some Recommended Varieties
	Drip Irrig	Surface Irrig					
Cabbage	13	11	July to August	70	20	90	Premium, Brunswick
Carrot	14	12	July to December	143		143	Chantenay, Kuroda
Cauliflower	12	10	July to December	65	90	155	Early Snowball, Snowflower
Cucumber	11	9	March, April	45	45	90	Poinsett, Ashley
Eggplant	18	15	March, April	70	140	210	Black Beauty, Viserba
Green beans	6	5	August to December	53	75	128	Early Harvester, Strike
Hot pepper	14	12	March to May	46	180	226	Anaheim, Kashmiri Long Red
Okra	6	5	March, April and August	50	90	140	Clemson Spinless, Pusa Sawani
Squash	13	11	March to May and August	40	45	85	Iskandrani
Sweet melon	8	7	February, March and August	60	50	110	Ananas, Hale's Best Jumbo
Sweet pepper	12	10	March to May	46	164	210	California Wonder
Sweet potato	12	10	August and September	150		150	Local red (the white one takes about 180 days)
Tomato	22	19	July to August	75	125	200	Pakmor, Pearson A1 Improved
Water melon	13	11	February and August	75	20	95	Garrisonian, Crimson Sweet

Table 15

VEGETABLE PRODUCTION IN SALALAH PLAIN
Planting Materials (subsidized prices)

Crop	Variety	Quantity Kg/feddan	Price R.O./kg	Total Cost R.O./Feddan
Cabbage	Brunswick	0.400	5.250	2.100
Carrot	Chantenay Red Cored	5.000	7.500	37.500
Cauliflower	Early Snowball	0.350	9.650	3.378
Cucumber	Gada	1.500	18.250	27.375
Eggplant	Viserba	0.200	7.950	1.590
Green beans	Early Harvester	30.000	1.275	38.250
Hot pepper	Anaheim	0.400	21.600	8.640
Okra	Pusa Sawani	9.000	2.350	21.150
Squash	Iskandrani	2.500	4.350	10.875
Sweet melon	Ananas	1.500	5.100	7.650
Sweet pepper	California Wonder	0.400	11.400	4.560
Sweet potato	Local red	-	-	-
Tomato	Pakmor	0.200	22.950	4.590
Water melon	Crimson Sweet	1.500	11.050	16.575

Table 16

VEGETABLE PRODUCTION IN SALALAH PLAIN
Tractor Services and Labor Requirements

Crop	Total Field Occupation (days)	Surface Irrigation				Modern Irrigation			
		Labor		Tractor services		Labor		Tractor services	
		Quantity (m/m)	Cost (R.O.)	Quantity (Hours)	Cost (R.O.)	Quantity (m/m)	Cost (R.O.)	Quantity (Hours)	Cost (R.O.)
Cabbage	90	2.3	185	12	24	1.1	86	7	14
Carrot	143	3.6	293	10	20	1.7	137	7	14
Cauliflower	155	3.9	318	12	24	1.8	148	7	14
Cucumber	90	2.3	185	11	22	1.1	86	7	14
Eggplant	210	5.3	431	12	24	2.5	201	7	14
Green beans	128	3.2	262	12	24	1.5	122	7	14
Hot pepper	226	5.7	463	12	24	2.6	216	7	14
Okra	140	3.5	287	12	24	1.6	134	7	14
Squash	85	2.1	174	11	22	1.0	81	7	14
Sweet melon	110	2.8	226	11	22	1.3	105	7	14
Sweet pepper	210	5.3	431	12	24	2.5	201	7	14
Sweet potato	150	3.8	308	10	20	1.8	144	7	14
Tomato	200	5.0	410	11	22	2.3	191	7	14
Water melon	95	2.4	195	11	22	1.1	91	7	14
Monthly laborer cost: 82 R.O. Hourly tractor cost: 2 R.O.									

3.4.2.3 Fertilizers

Table 17, 18 and 19 give the fertilizers requirements. These were mostly compiled from research trials, consultant advice and broad comparison with nutrient levels in the soils. It has to be stressed that in the absence of soil testing trials only general recommendations can be given. They are however sufficiently precise to be used safely until further research is done. For vegetable as well as for all other crops, nitrogen is given as urea through an injector in pressurized irrigation systems and ammonium sulphate in surface irrigation. The reason is that at 20⁰ C the water solubility of ammonium sulfate is only 73 kg in 100 liters whereas it is 103.3 kg per 100 liters for urea. Therefore urea is more suited for use with pressurized irrigation systems (fertigation) whereas with surface irrigation it is better to use ammonium sulfate to avoid heavy fertilizer losses by leaching. of for urea. Another advantage of ammonium sulphate for use in highly calcareous soils is its' higher equivalent acidity. Many farmers complain that urea is too concentrated and causes burns on the plants. Indeed higher solubility means also higher osmotic pressure in the soil solution and therefore more difficulty for the plants to extract water. Urea however is a cheaper source of nitrogen.

3.4.2.4 Plant protection

Although recommendations were made by project's consultants on crop protection, the chemicals that they recommended have not been tested in local conditions and therefore cannot be recommended for direct use by farmers. Instead it was decided to base the land evaluation on the most successful existing treatments that are presently in use in the study area. If proper research is carried out in the future along the lines proposed by the consultants it is most likely that plant protection cost will diminish.

Tables 20 and 21 give the average quantities and number of insecticide and fungicide treatments that are needed.

Herbicides and nematicides were recommended according to soil drainage. This is due to the fact that poorly drained soils favour infestation by weeds and nematodes. Therefore the highest dosage recommended by the manufacturer was used for very poorly drained soils and the lowest for well drained soils. Tables 22 and 23 give information about herbicides and nematicides by drainage class.

Tables 24, 25, 26 and 27 give the total average cost of plant protection chemicals by crop and by drainage class.

Table 17

VEGETABLE PRODUCTION IN SALALAH PLAIN
Indicative Fertilizer Requirements

Crop	Nitrogen	Phosphorus	Potassium	Micronutrient Compound at about 10% Zn, Mn, Fe	Farm Yard Manure cu.m./Feddan
	<=====Kg per feddan=====>				
Cabbage	60	35	42	0.80	12
Carrot	60	46	65	0.70	12
Cauliflower	60	35	42	0.70	12
Cucumber	69	35	65	0.80	12
Eggplant	42	35	65	0.70	16
Green beans	42	46	65	0.80	12
Hot pepper	60	35	52	0.70	16
Okra	69	35	52	0.50	12
Squash	60	35	42	0.80	12
Sweet melon	60	35	42	0.50	12
Sweet pepper	60	35	52	0.70	16
Sweet potato	96	35	78	0.80	16
Tomato	96	46	65	1.00	16
Water melon	42	42	42	0.50	12

Table 18

VEGETABLE PRODUCTION IN SALALAH PLAIN
 Indicative Fertilizer Application Rates and Cost
 Drip Irrigation

Crop	Urea	Triple Superphos.	Potassium Sulphate	Micro-nutr. Compound (about 10%) Zn, Mn, Fe	Farm Yard Manure cu.m./feddan	Total Cost R.O./feddan
	<=====Kg per feddan =====>					
Cabbage	130	75	80	0.80	12	104
Carrot	130	100	125	0.70	12	110
Cauliflower	130	75	80	0.70	12	103
Cucumber	150	75	125	0.80	12	110
Eggplant	90	75	125	0.70	16	129
Green beans	90	100	125	0.80	12	109
Hot pepper	130	75	100	0.70	16	129
Okra	150	75	100	0.50	12	105
Squash	130	75	80	0.80	12	104
Sweet melon	130	75	80	0.50	12	101
Sweet pepper	130	75	100	0.70	16	129
Sweet potato	210	75	150	0.80	16	141
Tomato	210	100	125	1.00	16	143
Water melon	90	90	80	0.50	12	100

Urea : 3.330 R.O./50 kg subsidized price
 Tr. superphos.: 5.063 R.O./50 kg subsidized price
 Pot. sulphate : 5.138 R.O./50 kg subsidized price
 Fetrilon Combi: 9.500 R.O./kg
 Manure: 6.000 R.O./cu. m.

Farm yard manure with triple superphosphate as basal dressing
 Micronutrient in not more than 0.25 kg/feddan applications

Table 19

VEGETABLE PRODUCTION IN SALALAH PLAIN
Indicative Fertilizer Application Rates and Cost
Surface Irrigation

Crop	Ammonium Sulphate	Triple Superphos.	Potassium Sulphate	Micro-nutr. Compound (about 10%) Zn, Mn, Fe	Farm Yard Manure cu.m./feddan	Total Cost R.O./feddan
	<===== Kg per feddan=====>					
Cabbage	290	75	80	0.80	12	115
Carrot	290	100	125	0.70	12	121
Cauliflower	290	75	80	0.70	12	114
Cucumber	330	75	125	0.80	12	122
Eggplant	200	75	125	0.70	16	137
Green beans	200	100	125	0.80	12	116
Hot pepper	290	75	100	0.70	16	140
Okra	330	75	100	0.50	12	117
Squash	290	75	80	0.80	12	115
Sweet melon	290	75	80	0.50	12	112
Sweet pepper	290	75	100	0.70	16	140
Sweet potato	460	75	150	0.80	16	157
Tomato	460	100	125	1.00	16	159
Water melon	200	90	80	0.50	12	107

Ammonium sulph. : 3.160 R.O./50 kg subsidized price (1990)
Tr. superphos. : 5.063 R.O./50 kg subsidized price
Pot. sulphate : 5.138 R.O./50 kg subsidized price
Fetrilon Combi : 9.500 R.O./kg
Manure : 6.000 R.O./cu. m.

Farm yard manure with triple superphosphate as basal dressing
Micronutrient in not more than 0.25 kg/feddan applications

Table 20

VEGETABLE PRODUCTION IN SALALAH PLAIN
Plant Protection Insecticides

Input	Unit	Unit Price	Quantity per Applic.	Cost per Applic.	Number of Applications per Season per Crop							
					Cabbage	Carrot	Cauliflower	Cucumber	Eggplant	Green bean	Hot pepper	
Insecticides												
Actellic	litre	2.450	0.4	0.980								
Decis	litre	4.000	0.4	1.600	2	1	2	4				2
Dimethoate	litre	1.800	0.5	0.900							3	4
Dipterex	kg	1.800	0.8	1.440	4		4	4	2		3	
Mineral oil	litre	1.000	0.2	0.200								4
Mitac	litre	2.500	0.6	1.500					2			2
Pirimor	kg	4.750	0.25	1.188	2		2	2	2			2
Cost per Crop (R.O./feddan)					11.3	1.6	11.3	18.1	11.9	7.0		13.0
Input	Unit	Unit Price	Quantity per Applic.	Cost per Applic.	Number of Applications per Season per Crop							
					Okra	Squash	Sweet melon	Sweet pepper	Sweet potato	Tomato	Water melon	
Insecticides												
Actellic	litre	2.450	0.4	0.980							4	
Decis	litre	4.000	0.4	1.600	4	4	4	2	2		4	4
Dimethoate	litre	1.800	0.5	0.900	4	4	4	4	2		4	4
Dipterex	kg	1.800	0.8	1.440	4	4	4		2		2	4
Mineral oil	litre	1.000	0.2	0.200				4				
Mitac	litre	2.500	0.6	1.500				2			2	
Pirimor	kg	4.750	0.25	1.188		2	2	2			1	2
Cost per Crop (R.O./feddan)					15.8	18.1	18.1	13.0	7.9	21.0		18.1

Table 21

VEGETABLE PRODUCTION IN SALALAH PLAIN
Plant Protection Fungicides

Input	Unit	Unit Price	Quantity per Applic.	Cost per Applic.	Number of Applications per Season per Crop							
					Cabbage	Carrot	Cauliflower	Cucumber	Eggplant	Green bean	Hot pepper	
Fungicides												
Mancozeb	kg	2.000	1.2	2.400	1		1	6	2	3	2	
Nimrod	litre	3.325	0.3	0.998		2		2				2
Ronilan	kg	4.300	0.6	2.580						3		
Rubigan	litre	5.000	0.2	1.000		2		2				
Cost per Crop (R.O./feddan)					2.4	4.0	2.4	18.4	4.8	14.9	6.8	
Input	Unit	Unit Price	Quantity per Applic.	Cost per Applic.	Number of Applications per Season per Crop							
					Okra	Squash	Sweet melon	Sweet pepper	Sweet potato	Tomato	Water melon	
Fungicides												
Mancozeb	kg	2.000	1.2	2.400	2	6	6	2		12	6	
Nimrod	litre	3.325	0.3	0.998		2	2	2		1	2	
Ronilan	kg	4.300	0.6	2.580								
Rubigan	litre	5.000	0.2	1.000		2	2					2
Cost per Crop (R.O./feddan)					4.8	18.4	18.4	6.8	0.0	29.8	18.4	

Table 22

VEGETABLE PRODUCTION IN SALALAH PLAIN
Plant Protection Herbicides

Input	Unit	Unit Price	Quantity Applied per Season per Crop						
			Cabbage	Carrot	Cauliflower	Cucumber	Eggplant	Green bean	Hot pepper
Herbicides									
-Fusilade	litre	5.150	1.7		1.7				1.7
-Roundup	litre	3.050							
Well drained			2	2	2	2	2	2	2
Mod. well dr.			3	3	3	3	3	3	3
Poorly drained			4	4	4	4	4	4	4
V. poorly dr.			5	5	5	5	5	5	5
-Sencor	kg	8.000		0.4					
Total Cost per Crop (R.O./feddan)									
Well drained			14.9	9.3	14.9	6.1	6.1	6.1	14.9
Mod. well drain.			17.9	12.4	17.9	9.2	9.2	9.2	17.9
Poorly drained			21.0	15.4	21.0	12.2	12.2	12.2	21.0
V. poorly drain.			24.0	18.5	24.0	15.3	15.3	15.3	24.0
Input	Unit	Unit Price	Quantity Applied per Season per Crop						
			Okra	Squash	Sweet melon	Sweet pepper	Sweet potato	Tomato	Water melon
Herbicides									
-Fusilade	litre	5.150				1.7		1.7	
-Roundup	litre	3.050							
Well drained			2	2	2	2	2	2	2
Mod. well drain.			3	3	3	3	3	3	3
Poorly drained			4	4	4	4	4	4	4
V. poorly drain.			5	5	5	5	5	5	5
-Sencor	kg	8.000						0.4	
Total Cost per Crop (R.O./feddan)									
Well drained			6.1	6.1	6.1	14.9	6.1	18.1	6.1
Mod. well drain.			9.2	9.2	9.2	17.9	9.2	21.1	9.2
Poorly drained			12.2	12.2	12.2	21.0	12.2	24.2	12.2
V. poorly drain.			15.3	15.3	15.3	24.0	15.3	27.2	15.3

Table 23

VEGETABLE PRODUCTION IN SALALAH PLAIN
Plant Protection Nematicides

Input	Unit	Unit Price	Quantity Applied per Season per Crop						
			Cabbage	Carrot	Caulifl	Cucumber	Eggplant	Green bean	Hot pepper
Nematicides									
-Furadan 5G	Kg	1.200							
Well drained				25		25	25		25
Mod. well drain.				35		35	35		35
Poorly drained				40		40	40		40
V. poorly drain.				45		45	45		45
Total Cost per Crop (R.O./feddan)									
Well drained			0.0	30.0	0.0	30.0	30.0	0.0	30.0
Mod. well drain.			0.0	42.0	0.0	42.0	42.0	0.0	42.0
Poorly drained			0.0	48.0	0.0	48.0	48.0	0.0	48.0
V. poorly drain.			0.0	54.0	0.0	54.0	54.0	0.0	54.0
Input	Unit	Unit Price	Quantity Applied per Season per Crop						
			Okra	Squash	Sweet melon	Sweet pepper	Sweet potato	Tomato	Water melon
Nematicides									
-Furadan 5G	Kg	1.200							
Well drained			25		25	25	25	25	25
Mod. well drain.			35		35	35	35	35	35
Poorly drained			40		40	40	40	40	40
V. poorly drain.			45		45	45	45	45	45
Total Cost per Crop (R.O./feddan)									
Well drained			30.0	0.0	30.0	30.0	30.0	30.0	30.0
Mod. well drain.			42.0	0.0	42.0	42.0	42.0	42.0	42.0
Poorly drained			48.0	0.0	48.0	48.0	48.0	48.0	48.0
V. poorly drain.			54.0	0.0	54.0	54.0	54.0	54.0	54.0

Table 24

VEGETABLE PRODUCTION IN SALALAH PLAIN
 Cost of Plant Protection
 Well Drained Soils

Inputs	Cabbage	Carrot	Cauliflower	Cucumber	Eggplant	Green bean	Hot pepper
Insecticides	11.3 40	1.6 4	11.3 40	18.1 25	11.9 23	7.0 25	13.0 20
Fungicides	2.4 8	4.0 9	2.4 8	18.4 25	4.8 9	14.9 53	6.8 11
Herbicides	14.9 52	9.3 21	14.9 52	6.1 8	6.1 12	6.1 22	14.9 23
Nematicides	0.0 0	30.0 67	0.0 0	30.0 41	30.0 57	0.0 0	30.0 46
Total	28.6	44.9	28.6	72.6	52.8	28.0	64.7
	Okra	Squash	Sweet melon	Sweet pepper	Sweet potato	Tomato	Water melon
Insecticides	15.8 28	18.1 42	18.1 25	13.0 20	7.9 18	21.0 21	18.1 25
Fungicides	4.8 8	18.4 43	18.4 25	6.8 11	0.0 0	29.8 30	18.4 25
Herbicides	6.1 11	6.1 14	6.1 8	14.9 23	6.1 14	18.1 18	6.1 8
Nematicides	30.0 53	0.0 0	30.0 41	30.0 46	30.0 68	30.0 30	30.0 41
Total	56.7	42.6	72.6	64.7	44.0	98.9	72.6

Upper figure cost in R.O.

Lower figure in % of total cost

Table 25

VEGETABLE PRODUCTION IN SALALAH PLAIN
 Cost of Plant Protection
 Moderately Well Drained Soils

Inputs	Cabbage	Carrot	Cauliflower	Cucumber	Eggplant	Green bean	Hot pepper
Insecticides	11.3 36	1.6 3	11.3 36	18.1 21	11.9 18	7.0 23	13.0 18
Fungicides	2.4 8	4.0 7	2.4 8	18.4 21	4.8 7	14.9 48	6.8 10
Herbicides	17.9 57	12.4 21	17.9 57	9.2 10	9.2 14	9.2 30	9.2 13
Nematicides	0.0 0	42.0 70	0.0 0	42.0 48	42.0 62	0.0 0	42.0 59
Total	31.6	60.0	31.6	87.7	67.9	31.1	71.0
	Okra	Squash	Sweet melon	Sweet pepper	Sweet potato	Tomato	Water melon
Insecticides	15.8 22	18.1 40	18.1 21	13.0 16	7.9 13	21.0 18	18.1 21
Fungicides	4.8 7	18.4 40	18.4 21	6.8 9	0.0 0	29.8 26	18.4 21
Herbicides	9.2 13	9.2 20	9.2 10	17.9 22	9.2 16	21.1 19	9.2 10
Nematicides	42.0 58	0.0 0	42.0 48	42.0 53	42.0 71	42.0 37	42.0 48
Total	71.8	45.7	87.7	79.7	59.1	113.9	87.7

Upper figure cost in R.O.

Lower figure in % of total cost

Table 26

VEGETABLE PRODUCTION IN SALALAH PLAIN
 Cost of Plant Protection
 Poorly Drained Soils

Inputs	Cabbage	Carrot	Cauliflower	Cucumber	Eggplant	Green bean	Hot pepper
Insecticides	11.3 33	1.6 2	11.3 33	18.1 19	11.9 15	7.0 21	13.0 15
Fungicides	2.4 7	4.0 6	2.4 7	18.4 19	4.8 6	14.9 44	6.8 8
Herbicides	21.0 61	15.4 22	21.0 61	12.2 13	12.2 16	12.2 36	21.0 24
Nematicides	0.0 0	48.0 70	0.0 0	48.0 50	48.0 62	0.0 0	48.0 54
Total	34.7	69.0	34.7	96.7	76.9	34.1	88.8
	Okra	Squash	Sweet melon	Sweet pepper	Sweet potato	Tomato	Water melon
Insecticides	15.8 20	18.1 37	18.1 19	13.0 15	7.9 12	21.0 17	18.1 19
Fungicides	4.8 6	18.4 38	18.4 19	6.8 8	0.0 0	29.8 24	18.4 19
Herbicides	12.2 15	12.2 25	12.2 13	21.0 24	12.2 18	24.2 20	12.2 13
Nematicides	48.0 59	0.0 0	48.0 50	48.0 54	48.0 70	48.0 39	48.0 50
Total	80.8	48.7	96.7	88.8	68.1	123.0	96.7

Upper figure cost in R.O.

Lower figure in % of total cost

Table 27

VEGETABLE PRODUCTION IN SALALAH PLAIN
Cost of Plant Protection

Very Poorly Drained Soils

Inputs	Cabbage	Carrot	Cauliflower	Cucumber	Eggplant	Green bean	Hot pepper
Insecticides	11.3 30	1.6 2	11.3 30	18.1 17	11.9 14	7.0 19	13.0 13
Fungicides	2.4 6	4.0 5	2.4 6	18.4 17	4.8 6	14.9 40	6.8 7
Herbicides	24.0 64	18.5 24	24.0 64	15.3 14	15.3 18	15.3 41	24.0 25
Nematicides	0.0 0	54.0 69	0.0 0	54.0 51	54.0 63	0.0 0	54.0 55
Total	37.7	78.1	37.7	105.8	86.0	37.2	97.8
	Okra	Squash	Sweet melon	Sweet pepper	Sweet potato	Tomato	Water melon
Insecticides	15.8 18	18.1 35	18.1 17	13.0 13	7.9 10	21.0 16	18.1 17
Fungicides	4.8 5	18.4 36	18.4 17	6.8 7	0.0 0	29.8 23	18.4 17
Herbicides	15.3 17	15.3 30	15.3 14	24.0 25	15.3 20	27.2 21	15.3 14
Nematicides	54.0 60	0.0 0	54.0 51	54.0 55	54.0 70	54.0 41	54.0 51
Total	89.9	51.8	105.8	97.8	77.2	132.0	105.8

Upper figure cost in R.O.

Lower figure in % of total cost

3.4.2.5 Required quantities of irrigation water

Table 28 shows the estimated quantity of water that needs to be pumped to produce each crop. Actually this quantity varies with the salinity level of the irrigation water as the leaching requirement changes. Since the cost of pumping is small the land evaluation calculations are generally based on the highest water requirements in the acceptable salinity range for the crop and on the highest ET_0 of the recommended planting period.

The price of the cubic metre of pumped water was taken as R.O. 0.004 for surface irrigation and R.O. 0.006 for pressurized irrigation systems. These prices are based on the farming systems survey findings and include pump and motor capital and depreciation costs.

3.4.3 Fruits

3.4.3.1 Planting materials and achievable yields

Table 29 gives the recommended planting distances as well as some recommended varieties, achievable yields in optimal conditions and quantities of seedlings that are needed and their cost (MAF nursery). The quantities of seedlings were calculated taking into account 30 percent replacement for coconut and 5 percent for other fruit trees. This information was collected from trials of the MAF research station, Razat and for banana also from good smallholder's farms.

3.4.3.2 Labour and land preparation

Table 30 gives labour, tractor and JCB services requirements for fruit trees. Annual or recurrent requirements are considered separately from orchard establishment requirements. under surface irrigation and drip. Labour requirements were determined with the MAF fruit researcher and extensionists and with the horticulturist and foremen of the Royal Razat farm. Tractor and JCB services were counted at 2 R.O per hour whereas labour was counted at R.O. 82 per month.

3.4.3.3 Fertilizers

Tables 31 and 32 give the fertilizers requirements. These were mostly compiled from research trials, consultant advice and broad comparison with nutrient levels in the soils. It has to be stressed that in the absence of soil testing trials, only general recommendations can be given. They are however sufficiently precise to be used safely until further research is done.

Table 28

VEGETABLE PRODUCTION IN SALALAH PLAIN
Gross Water Requirements
and Cost for Land Evaluation Purposes

Crop	Planting period	Surface Irrigation		Modern Irrigation	
		cu.m/feddan	Cost R.O./feddan	cu.m/feddan	Cost R.O./feddan
Cabbage	July, August	2800	11.2	1900	11.4
Carrot	July-December	5250	21.0	3500	21.0
Cauliflower	July-December	5800	23.2	3900	23.4
Cucumber	March-April	2800	11.2	1900	11.4
Eggplant	March-April	7200	28.8	4900	29.4
Green bean	August-December	4700	18.8	3200	19.2
Hot pepper	March-May	8300	33.2	5600	33.6
Okra	March, April and August	4800	19.2	3200	19.2
Squash	March to May and August	3200	12.8	2150	12.9
Sweet melon	February, March and August	3600	14.4	2400	14.4
Sweet pepper	March-May	7600	30.4	5000	30.0
Sweet potato	August-September	6400	25.6	4300	25.8
Tomato	July-August	7200	28.8	4800	28.8
Water melon	February and August	3400	13.6	2255	13.5

Table 29

FRUIT PRODUCTION IN SALALAH PLAIN
 Planting Materials Requirements and Cost
 MAF Nursery Prices (1991)

Crop	Some Recommended Varieties	Economic Lifetime (years)	Planting Distance (m)	Number of Trees per fed.	Planting Materials		
					Quantity per fed.	Unit Cost (R.O.)	Total Cost (R.O.)
Banana	Dwarf Cavendish	5	3 x 2.5	560	588	-	-
Chico (Sapota)	Cricketball	25	6 x 6	117	123	1.000	123
Coconut	King Coconut, Malayan Dwarf, Local	40	9 x 9	52	68	1.000	68
Grapes (cordons)	Shahi, Fakhri	15	3 x 3	467	490	0.250	123
Guava	Local red	25	6 x 6	117	123	0.250	31
Papaya	Local	3	3 x 2.5	560	588	0.100	59

Table 30

ANALYSIS OF FRUIT PRODUCTION
Tractor Services and Labor Requirements
Salalah Plain

Crop	Annual				Establishment					
	Permanent Labor		Seasonal Labor		Tractor Services		JCB Services		Labor	
	(m/m)	(RO)	(m/m)	(RO)	(Hours)	(RO)	(Hours)	(RO)	(m/m)	(RO)
Banana	4.80	394			7	14			0.40	33
Chico (Sapota)	2.40	197	1.00	82	7	14	20	40	0.25	21
Coconut	0.60	49			7	14	10	20	0.20	16
Grapes	2.40	197			7	14	39	78	0.75	62
Guava	2.40	197	1.25	103	7	14	20	40	0.25	21
Papaya	3.00	246			7	14			0.40	33
Monthly permanent laborer cost: 82 R.O. Monthly casual laborer cost: 82 R.O. Hourly tractor cost: 2 R.O. Hourly JCB cost: 2 R.O.										

Table 31

FRUIT PRODUCTION IN SALALAH PLAIN
 Indicative Fertilizer Application Rates
 Kg per Tree

Crop	At Planting			Yearly Requirement of Adult Trees				
	Triple Superphos.	Potassium Sulphate	Farm Yard Manure (cu. m.)	Urea	Ammonium Sulphate	Triple Superphos.	Potassium Sulphate	Farm Yard Manure (cu. m.)
Banana	-	-	0.050	1.370	-	0.400	0.800	0.030
Chico (Sapota)	2	1	0.250	-	1.900	0.550	0.900	0.030
Coconut	2	1	0.250	-	6.000	0.800	0.800	0.040
Grapes	1	0.5	0.050	0.874	-	0.200	0.300	0.030
Guava	2	1	0.250	-	1.900	0.500	0.800	0.030
Papaya	-	-	0.050	0.521	-	0.400	0.800	0.030

Table 32

FRUIT PRODUCTION IN SALALAH PLAIN
 Indicative Fertilizer Application Rates and Cost
 Kg per Feddan

Crop	At Planting				Urea	Yearly Requirement of Adult Trees					
	Triple Superphos	Potassium Sulphate	Farm Yard Manure (cu. m.)	Cost (R.O)		Ammonium Sulphate	Triple Superphos	Potassium Sulphate	Farm Yard Manure (cu. m.)	Micronutr. at 10% Zn, Mn, Fe	Cost (R.O)
Banana	-	-	28	168	767	-	224	448	17.0	2.5	246
Chico (Sapota)	234	117	29	210	-	222	64	105	3.5	1.7	68
Coconut	104	52	13	94	-	312	90	80	2.0	1.0	59
Grapes	467	233	23	209	408	-	93	140	14.0	1.1	145
Guava	234	117	29	210	-	222	59	94	3.5	0.9	59
Papaya	-	-	28	168	292		224	448	17.0	2.5	214

Urea: 3.330 R.O./50 kg subsidized price
 Ammonium sulph.: 3.160 R.O./50 kg subsidized price
 Tr. superphos.: 5.063 R.O./50 kg subsidized price
 Pot. sulphate: 5.138 R.O./50 kg subsidized price
 Fetrilon Combi: 9.500 R.O./kg
 Manure: 6.000 R.O./cu. m.

3.4.3.4 Plant protection

As for vegetables it was decided to make use of the most successful existing treatments that are presently in use in the study area. If proper research is carried out in the future along the lines proposed by the project's plant protection consultants it is most likely that plant protection cost will diminish.

Table 33 gives the average quantities and number of insecticide and fungicide treatments that are needed.

Herbicides and nematicides were recommended according to soil drainage. The highest dosage recommended by the manufacturer was used for very poorly drained soils and the lowest for well drained soils. **Table 34** gives information about herbicides, nematicides and raticides by drainage class.

Table 35 gives the total average cost of plant protection chemicals by crop and by drainage class.

3.4.3.5 Required quantities of irrigation water

Table 36 shows the estimated quantity of water that needs to be pumped to produce each crop. Actually this quantity varies with the salinity level of the irrigation water as the leaching requirement changes. Since the cost of pumping is small the land evaluation calculations are generally based on the highest water requirements in the acceptable salinity range for the crop.

3.4.4 Fodder

3.4.4.1 Introduction

As shown in the land use report fodder crops are quite extensive and occupy nearly 47 percent of the cultivated area. Short grasses alone occupy 42 percent of the cultivated area whereas tall grasses occupy about 4 percent and alfalfa a negligible 0.5 percent. The small extent of alfalfa is due to disease and pests.

Among short grasses rhodes grass is by far dominant although buffel grass is increasingly popular among smallholders for reasons elaborated below. Tall grasses are mostly elephant grass although some Guinea grass was also encountered.

Rhodes grass and buffel grass have very similar yields and input requirements but rhodes grass is more palatable. Many smallholders say however that although rhodes grass is more palatable than buffel grass they prefer the latter because yields decline is slower when long rotations are practiced. Since establishment cost is low this argument is not economically sound. Razat farm for instance is following a two and a half years rotation with rhodes grass.

Table 33

FRUIT PRODUCTION IN SALALAH PLAIN
 Recurrent Plant Protection Requirements and Their Cost
 Insecticides and Fungicides

Input	Unit	Unit Price	Quantity per Applic	Cost per Applic	Number of Applications per Year per Crop					
					Banana	Chico	Coconut	Grapes	Guava	Papaya
Insecticides										
Dimethoate	litre	1.800	0.5	0.900	2	2	3	3	3	
Dipterex	kg	1.800	0.8	1.440					3	
Mineral oil	litre	1.000	0.2	0.200	2		3		3	
Mitac	litre	2.500	0.6	1.500						2
Trimiltox Forte	kg	1.650	1.2	1.980			3			
Cost of Insecticides per Crop (R.O./feddan)					2.2	1.8	9.2	2.7	7.6	3.0
Fungicides										
Anti-fungal paste	litre	3.000	3	9.000				1		
Cuprasan (Cobox)	kg	1.800	0.6	1.080	2					
Mancozeb	kg	2.000	1.2	2.400	2			3	1	2
Ridomil	kg	4.300	2.4	10.320			2			
Rubigan	litre	5.000	0.2	1.000				2		
Cost of Fungicides per Crop (R.O./feddan)					7.0	0.0	20.6	18.2	2.4	4.8

Table 34

FRUIT PRODUCTION IN SALALAH PLAIN
 Recurrent Plant Protection Requirements and Their Cost
 Herbicides, Nematicides and Raticides

Input	Unit	Unit Price	Banana	Chico	Coconut	Grapes	Guava	Papaya
Quantity Applied per Year per Crop								
Herbicides								
-Fusilade	litre	5.150						
Well drained			1.7					1.7
Mod. well drain.			3.4					3.4
Poorly drained			5					5
V. poorly drain.			6.8					6.8
-Roundup	litre	3.050						
Well drained			3.4	3.4	3.4	3.4	3.4	3.4
Mod. well drain.			3.4	5	5	5	5	3.4
Poorly drained			3.4	6.8	6.8	6.8	6.8	3.4
V. poorly drain.			3.4	8.4	8.4	8.4	8.4	3.4
Total Cost of herbicides per Crop (R.O./feddan)								
Well drained			19.1	10.4	10.4	10.4	10.4	19.1
Mod. well drain.			27.9	15.3	15.3	15.3	15.3	27.9
Poorly drained			36.1	20.7	20.7	20.7	20.7	36.1
V. poorly drain.			45.4	25.6	25.6	25.6	25.6	45.4
Quantity Applied per Year per Crop								
Nematicides								
-Furadane	kg	1.200						
Well drained			25					25
Mod. well drain.			35					35
Poorly drained			70					40
V. poorly drain.			105					45
Total Cost of Nematicides per Crop (R.O./feddan)								
Well drained			30.0					30.0
Mod. well drain.			42.0					42.0
Poorly drained			84.0					48.0
V. poorly drain.			126.0					54.0
Raticides								
-Klerat	kg	1.590						
			Quantity Applied per Year per Crop					
					3.5			
Total Cost of Raticides per Crop (R.O./feddan)					5.6			

For all crops 4 litres of Roundup herbicides (12.2 R.O.) are used to clean the land before planting

Table 35

FRUIT PRODUCTION IN SALALAH PLAIN
Plant Protection

Inputs	Banana	Chico	Coconut	Grapes	Guava	Papaya
Well drained Soils						
Insecticides	2.2	9.2	1.8	2.7	7.6	3.0
Fungicides	7.0	20.6	0.0	18.2	2.4	4.8
Herbicides	19.1	10.4	10.4	10.4	10.4	19.1
Nematicides	30.0	0.0	0.0	0.0	0.0	30.0
Raticides	0.0	0.0	5.6	0.0	0.0	0.0
Total	58.3	40.2	17.8	31.3	20.4	56.9
Mod. well drained Soils						
Insecticides	2.2	9.2	1.8	2.7	7.6	3.0
Fungicides	7.0	20.6	0.0	18.2	2.4	4.8
Herbicides	27.9	15.3	15.3	15.3	15.3	27.9
Nematicides	42.0	0.0	0.0	0.0	0.0	42.0
Raticides	0.0	0.0	5.6	0.0	0.0	0.0
Total	79.1	45.1	22.7	36.2	25.3	77.0
Poorly drained Soils						
Insecticides	2.2	9.2	1.8	2.7	7.6	3.0
Fungicides	7.0	20.6	0.0	18.2	2.4	4.8
Herbicides	36.1	20.7	20.7	20.7	20.7	36.1
Nematicides	84.0	0.0	0.0	0.0	0.0	48.0
Raticides	0.0	0.0	5.6	0.0	0.0	0.0
Total	129.3	50.5	28.1	30.7	30.7	91.9
Very poorly drained Soils						
Insecticides	2.2	9.2	1.8	2.7	7.6	3.0
Fungicides	7.0	20.6	0.0	18.2	2.4	4.8
Herbicides	45.4	25.6	25.6	25.6	25.6	45.4
Nematicides	126.0	0.0	0.0	0.0	0.0	54.0
Raticides	0.0	0.0	5.6	0.0	0.0	0.0
Total	180.6	55.4	33.0	46.5	25.6	107.2

Table 36

FRUIT PRODUCTION IN SALALAH PLAIN
Gross Water Requirements and Cost
for Land Evaluation Purposes

Crop	Modern Irrigation cu.m/feddan	Cost R.O./feddan
Banana	8100	48.6
Chico	8000	48.0
Coconut	5500	33.0
Grapes	6700	40.2
Guava	8000	48.0
Papaya	8400	50.4

Elephant grass on the other hand gives very high green yields but its nutritive value is much lower. It is mostly grown by smallholders who raise cattle. This is because elephant grass is mixed with concentrated feed and its' role is mostly to provide roughage (volume). Elephant grass is rarely marketed and therefore it is difficult to make an economical analysis for it.

Considering the above it was decided to make the land evaluation only for rhodes grass in a three years rotation.

Rhodes grass was evaluated under sprinkler irrigation and under improved surface irrigation. In the latter hydrants are used to bring water to the irrigation basins.

In optimal conditions it is possible to produce the following yields:

- Rhodes grass under sprinkler: 65 tons of green fodder or 15 tons of hay per feddan.
- Rhodes grass under surface irrigation: 55 tons of green fodder or 12.8 tons of hay per feddan.
- Buffel grass under surface irrigation: 44 tons of green fodder or 11.1 tons of hay per feddan.
- Elephant grass under surface irrigation: 150 tons of green fodder or 22.8 tons of hay per feddan.

3.4.4.2 Establishment requirements and cost

Table 37 gives the establishment requirements and cost. 10 kg of seed are required per feddan and their cost is R.O. 55 (variety Callide, R.O. 5 per kg). Roundup herbicide is used to clear the field free of weeds before ploughing. In surface irrigation an additional 4 hours are required to achieve good levelling. Fertilizer is not counted at establishment because it is considered as a normal fertilization before the first cut.

3.4.4.3 Recurrent requirements and cost

Labour requirements were estimated with the extensionists as 4 man/month for surface irrigation and 1.2 man/month for sprinkler irrigation.

Table 38 gives the annual fertilizer requirements. Urea is used with sprinkler and ammonium sulphate with surface irrigation.

Table 37

FODDER PRODUCTION IN SALALAH PLAIN
Establishment Cost of Rhodes Grass

Input	Unit	Unit Price	Sprinkler Irrigation		Improved Surface Irrigation	
			Quantity	Cost	Quantity	Cost
Tractor Services	hour	2	7	14.0	11.0	22.0
Seeds	kg	5.500	10	55.0	10	55.0
Herbicides						
-Roundup	litre	3.050				
Well drained			3.4	10.4	10.4	10.4
Mod. well drain.			3.82	11.7	11.7	11.7
Poorly drained			4.24	12.9	12.9	12.9
V. poorly drain.			4.66	14.2	14.2	14.2
Total Establishment Cost (R.O. per feddan)						
Well drained				79.4		87.4
Mod. well drain.				80.7		88.7
V. Poorly drained				81.9		89.9
V. poorly drain.				83.2		91.2

Table 38

FODDER PRODUCTION IN SALALAH PLAIN
Indicative Fertilizer Application Rates Cost
Kg per Feddan

Crop	N	P	K	Urea	Ammonium Sulphate	Triple Superphos.	Potassium Sulphate
Rhodes grass (*)	353	63	63	767	-	137	121
Buffel grass (*)							
Rhodes grass	353	63	63		1700	137	121
Buffel grass							
Elephant grass	220	92	104	-	1050	200	200

(*) Sprinkler irrigated. All others are irrigated with hydrands (improved surface irrigation)

Table 39 gives the pest and disease control requirement. This information is mostly from Dhofar Cattle Feed Co.

Required irrigation water volumes are 11,000 cu. m. for sprinkler and 13,750 cu.m. for surface irrigation. The pumping cost are respectively R.O. 66 and 82.5.

Table 39

FODDER PRODUCTION IN SALALAH PLAIN
 Recurrent Plant Protection Requirements and Their Cost
 Insecticides, Fungicides and Herbicides
 Rhodes grass

Input	Unit	Unit Price	Quantity	Sprinkler irrigation	Improved surface irrigation
Insecticides					
Malathion	litre	3.000	1.3	3.9	3.9
Nogos 500 E.C.	litre	5.500	1.3	7.2	7.2
Cost of Insecticides (R.O./feddan)				11.1	11.1
Fungicides					
-Polyram Combi WP	kg	3.25			
Well drained			1.7	5.5	5.5
Mod. well drain.			1.7	5.5	5.5
Poorly drained			2.54	8.3	8.3
V. poorly drain.			3.4	11.1	11.1
Herbicides					
-U 46 Combifluid 6	litre	3.500			
Well drained			2.1	7.4	7.4
Mod. well drain.			3.1	10.9	10.9
Poorly drained			4.1	14.4	14.4
V. poorly drain.			5.1	17.9	17.9
Total Annual Cost of Plant Protection (R.O./feddan)					
Well drained				23.9	23.9
Mod. well drain.				27.4	27.4
Poorly drained				33.7	33.7
V. poorly drain.				40.0	40.0

3.5 The proportional yield model

In order to calculate the gross margin of a given LUT it is necessary to calculate the cost of production and the value of the produce. The latter requires the yield to be known for each combination of land qualities. For this a proportional yield model was built as follow:

For each land utilization type the optimum (achievable) was determined. This is the yield per feddan per crop that is expected in the context of the land utilization type (which includes management, input levels, socio-economic conditions, etc.) assuming conditions where there are no limitations. In this study these are all yields actually achieved in Salalah plain.

The next step is to determine in what proportion increasingly limiting land qualities will reduce the optimum yield. This reduced yield is called a "proportional yield" because it is determined as a fraction (0 to 1) of the optimum yield. Proportional yields are determined by proportional yield decision trees.

For each LUT, here individual crops, proportional yields were assigned to land units by using severity levels of land qualities in a decision tree. Hence interactions between land qualities could be taken into account. A proportional yield, on the interval 0 to 1, was specified for each combination of severity levels of the land qualities that are in this proportional yield decision tree.

Only those land qualities (and the land characteristics that influence them) that have a bearing on the yield and that differ among the land units must be used in the proportional yield decision trees. For example although calcium carbonate content has a strong influence on yields, it is very high in all land units, including those where the optimum yield is achieved and therefore cannot be used to determine proportional yields.

Four land qualities were selected. These are: 1) potential for irrigation, 2) soil salinity, 3) potential for root room and 4) irrigation water quality. These land qualities are reviewed in the following sections.

3.5.1 Potential for irrigation

Table 40 gives the rating for this land quality as a function of infiltration rate and water holding capacity for each type of irrigation system. Soils that have an infiltration rate less than 1 cm/hour were considered unsuitable for irrigation.

Table 40

Proportional Yield Decision Tree for Irrigation Potential
As a fraction (0-1) of achievable yield

Type of Irrigation System	Infiltration rate (cm/h)	Available Water Holding Capacity (cm/150cm)				
		0-6.5	6.5-13	13-19	19-25	> 25
Surface	0-1	N2	N2	N2	N2	N2
	1-3	0.6	0.6	0.8	0.8	0.8
	3-5	0.6	0.6	0.9	1	1
	5-10	0.6	0.6	0.9	1	1
	10-15	0.6	0.6	0.8	0.8	0.8
	15-25	0.6	0.6	0.8	0.8	0.8
	> 25	0.6	0.6	0.6	0.6	0.6
Drip	0-1	N2	N2	N2	N2	N2
	> 1	0.8	0.9	1	1	1
Sprinkler	0-1	N2	N2	N2	N2	N2
	1-3	0.6	0.9	1	1	1
	3-5	0.6	0.9	1	1	1
	5-10	0.6	0.9	1	1	1
	10-15	0.6	0.9	1	1	1
	15-25	0.6	0.9	1	1	1
	> 25	0.6	0.9	0.9	0.9	0.9
Bubbler	0-1	N2	N2	N2	N2	N2
	1-3	0.6	0.8	0.8	0.8	0.8
	3-5	0.6	0.9	1	1	1
	5-10	0.6	0.9	1	1	1
	10-15	0.6	0.9	1	1	1
	15-25	0.6	0.8	0.9	0.9	0.9
	> 25	N2	0.6	0.8	0.8	0.8

3.5.2 Soil salinity

This heading actually covers soil salinity and soil aeration. It was considered that if water of good quality is available it is possible to leach the salts. The efficiency of this leaching will depend on soil drainage.

Table 41 gives the rating for this quality.

3.5.3 Potential for root room

Tables 42 and 43 give the rating for this land quality as a function of effective soil depth, topsoil gravel content and subsoil gravel content. This is done for each crop or group of crops separately. Soils that are very shallow (< 25 cm) and those that contain more than 80 percent gravel in the subsoil were considered unsuitable.

3.5.4 Irrigation water quality

This land quality is very important in the study area, therefore a lot of efforts were made in order to get a local validation of the criteria published in the literature which are often too severe. The actual yields of banana and tomato were measured under different water salinity levels and this data helped in setting up the yield model.

It should be noted that water salinity does not affect only yield but also the quality of the produce and it is not possible to take this into account.

Tables 44, 45 and 46 give the rating for vegetables, fruits and fodder.

3.5.5 Global proportional yield decision tree

When printed the complete decision trees for all the crops take several hundreds pages. Indeed the 4 partial trees mentioned in previous sections are combined in the following sequence:

- potential for irrigation
- soil salinity
- potential for root room
- water irrigation quality

The number of possible combinations is enormous. The interested reader should get a copy of the model on diskette from the Directorate of Soil and Water Research of the MAF and explore it in a computer. To do this it is necessary to have a copy of the ALES software.

Table 41

Proportional Yield Decision Tree for Soil Salinity
As a fraction (0-1) of achievable yield

Drainage Class	Soil Salinity (dS/m)	Vegetables	Fodder	Banana Papaya	Coconut	Other Fruit Trees
Well drained	< 4	1	1	1	1	1
	4-8	1	1	1	1	1
	8-16	1	1	1	1	0.9
	16-32	0.9	1	0.9	1	0.8
	32-64	0.8	0.9	0.8	0.9	0.8
	> 64	0.6	0.8	0.6	0.9	0.6
Moderately well drained	< 4	1	1	1	1	0.9
	4-8	0.9	1	0.9	1	0.8
	8-16	0.8	1	0.8	1	0.6
	16-32	0.6	0.9	0.6	0.9	0.6
	32-64	0.4	0.8	0.4	0.8	N2
	> 64	N2	0.6	N2	0.6	N2
Poorly drained	< 4	0.8	0.9	0.8	1	0.8
	4-8	0.8	0.9	0.8	1	0.8
	8-16	0.6	0.8	0.6	0.8	0.4
	16-32	0.4	0.6	0.4	0.6	N2
	32-64	N2	N2	N2	N2	N2
	> 64	N2	N2	N2	N2	N2
Very poorly drained	< 4	0.6	0.8	0.6	0.8	0.6
	4-8	0.6	0.8	0.6	0.8	0.4
	8-16	0.4	0.8	0.4	0.8	N2
	16-32	N2	0.6	0.4	0.6	N2
	32-64	N2	N2	N2	N2	N2
	> 64	N2	N2	N2	N2	N2

Table 42

Proportional Yield Decision Tree for Root Room (part 1)
As a fraction (0-1) of achievable yield

Soil Effective Depth (cm)	Topsoil Gravel Content (%)	Subsoil Gravel Content (%)	Vegetables		Fodder	Banana	Papaya	Coconut	Other Fruit Trees
			Root	Shoot					
-	> 80	-	N2	N2	N2	N2	N2	N2	N2
-	-	> 80	N2	N2	N2	N2	N2	N2	N2
> 150	0-15	0-15	1	1	1	1	1	1	1
		15-35	0.9	0.9	0.9	0.9	0.9	1	0.9
		35-60	0.8	0.8	0.8	0.6	0.6	0.9	0.8
		60-80	0.4	0.4	0.4	N2	N2	0.4	0.4
	15-35	0-15	0.8	0.8	0.8	0.8	0.8	0.9	0.9
		15-35	0.8	0.8	0.8	0.8	0.8	0.9	0.9
		35-60	0.8	0.8	0.8	0.6	0.6	0.9	0.8
		60-80	0.4	0.4	0.4	N2	N2	0.4	0.4
	35-60	0-15	0.4	0.6	0.6	0.6	0.6	0.8	0.8
		15-35	0.4	0.6	0.6	0.6	0.6	0.8	0.8
		35-60	0.4	0.6	0.6	0.6	0.6	0.8	0.8
		60-80	0.4	0.4	0.4	N2	N2	0.4	0.4
	60-80	0-15	N2	N2	N2	N2	N2	0.4	N2
		15-35	N2	N2	N2	N2	N2	0.4	N2
		35-60	N2	N2	N2	N2	N2	0.4	N2
		60-80	N2	N2	N2	N2	N2	0.4	N2
100-150	0-15	0-15	1	1	1	1	1	1	0.8
		15-35	0.9	0.9	0.9	0.9	0.9	1	0.8
		35-60	0.8	0.8	0.8	0.6	0.6	0.9	0.8
		60-80	0.4	0.4	0.4	N2	N2	0.4	0.4
	15-35	0-15	0.8	0.8	0.8	0.8	0.8	0.9	0.8
		15-35	0.8	0.8	0.8	0.8	0.8	0.9	0.8
		35-60	0.8	0.8	0.8	0.6	0.6	0.9	0.8
		60-80	0.4	0.4	0.4	N2	N2	0.4	0.4
	35-60	0-15	0.4	0.6	0.6	0.6	0.6	0.8	0.6
		15-35	0.4	0.6	0.6	0.6	0.6	0.8	0.6
		35-60	0.4	0.6	0.6	0.6	0.6	0.8	0.6
		60-80	0.4	0.4	0.4	N2	N2	0.4	0.4
	60-80	0-15	N2	N2	N2	N2	N2	0.4	N2
		15-35	N2	N2	N2	N2	N2	0.4	N2
		35-60	N2	N2	N2	N2	N2	0.4	N2
		60-80	N2	N2	N2	N2	N2	0.4	N2

Table 43

Proportional Yield Decision Tree for Root Room (part 2)
As a fraction (0-1) of achievable yield

Soil Effective Depth (cm)	Topsoil Gravel Content (%)	Subsoil Gravel Content (%)	Vegetables		Fodder	Banana	Papaya	Coconut	Other Fruit Trees	
			Root	Shoot						
50-100	0-15	0-15	0.9	0.9	0.9	0.9	0.9	0.8	0.6	
		15-35	0.9	0.9	0.9	0.9	0.9	0.8	0.6	
		35-60	0.8	0.8	0.8	0.6	0.6	0.6	0.6	
		60-80	0.4	0.4	0.4	N2	N2	0.4	0.4	
	15-35	0-15	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6
		15-35	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6
		35-60	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.6
		60-80	0.4	0.4	0.4	N2	N2	0.4	0.4	
	35-60	0-15	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6
		15-35	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6
		35-60	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6
		60-80	0.4	0.4	0.4	N2	N2	0.4	0.4	
	60-80	0-15	N2	N2	N2	N2	N2	N2	0.4	N2
		15-35	N2	N2	N2	N2	N2	N2	0.4	N2
		35-60	N2	N2	N2	N2	N2	N2	0.4	N2
		60-80	N2	N2	N2	N2	N2	N2	0.4	N2
25-50	0-15	0-15	0.6	0.6	0.6	0.6	0.8	0.4	N2	
		15-35	0.6	0.6	0.6	0.6	0.8	0.4	N2	
		35-60	0.6	0.6	0.6	0.6	0.6	0.4	N2	
		60-80	0.4	0.4	0.4	N2	N2	0.4	N2	
	15-35	0-15	0.4	0.6	0.6	0.6	0.8	0.4	N2	
		15-35	0.4	0.6	0.6	0.6	0.8	0.4	N2	
		35-60	0.4	0.6	0.6	0.6	0.6	0.4	N2	
		60-80	0.4	0.4	0.4	N2	N2	0.4	N2	
	35-60	0-15	0.4	0.4	0.4	0.4	0.6	0.4	N2	
		15-35	0.4	0.4	0.4	0.4	0.6	0.4	N2	
		35-60	0.4	0.4	0.4	0.4	0.6	0.4	N2	
		60-80	0.4	0.4	0.4	N2	N2	0.4	N2	
	60-80	0-15	N2	N2	N2	N2	N2	0.4	N2	
		15-35	N2	N2	N2	N2	N2	0.4	N2	
		35-60	N2	N2	N2	N2	N2	0.4	N2	
		60-80	N2	N2	N2	N2	N2	0.4	N2	
< 25	-	-	N2	N2	N2	N2	N2	N2		

Table 44

VEGETABLE PRODUCTION IN SALALAH PLAIN
Achievable Marketable Yields Versus Irrigation Water Salinity
As a fraction (o-1)

CROP	Achievable marketable yield (tons/feddan)		ECw 1-2 dS/m	ECw 2-3 dS/m	ECw 3-5 dS/m	ECw 5-7 dS/m	ECw 7-10 dS/m	ECw 10-15 dS/m
	Drip irrig.	Surface irrig.						
Asparagus			1.00	1.00	0.90	0.90	0.80	-
Beets			1.00	1.00	0.80	0.65	0.20	0.00
Gourd	13	11						
Pumpkin	10	8						
Eggplant	18	15	1.00	0.90	0.65	0.35	0.20	0.00
Squash	13	11						
Tomato	22	19						
Cabbage	13	11	1.00	0.80	0.65	0.35	0.20	0.00
Cauliflower	12	10						
Spinach								
Sweet corn								
Sweet potato	12	10						
Cucumber	11	9	1.00	0.80	0.50	0.20	0.00	0.00
Okra	6	5						
Sweet melon	8	7						
Water melon	13	11						
Hot pepper	14	12	1.00	0.80	0.35	0.20	0.00	0.00
Lettuce								
Onion								
Radish								
Sweet pepper	12	10						
Carrot	14	12	1.00	0.65	0.35	0.00	0.00	0.00
Green bean	6	5	1.00	0.65	0.20	0.00	0.00	0.00

Table 45

FRUIT TREE CROPS ACHIEVABLE YIELDS VERSUS IRRIGATION WATER SALINITY
SALINITY
Salalah Plain
As a fraction (0-1) of achievable marketable yield

CROP	Achievable marketable yield (t/feddan/year)	ECw					
		1-2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m	10-15 dS/m
Coconut local Coconut exotic	5,200 nuts 7,800 nuts	1.00	1.00	0.80	0.65	0.50	0.20
Fig Papaya Pomgranate	2 14 3	1.00	1.00	0.80	0.50	0.35	0.00
Banana	14	1.00	0.90	0.80	0.35	0.20	0.00
Grapes	5	1.00	0.80	0.65	0.35	0.00	0.00
Custard Apple Guava Lime Sapota (chico)	6 8 2 8	1.00	0.80	0.50	0.20	0.00	0.00

Table 46

FODDER PRODUCTION IN SALALAH PLAIN
Achievable Yield Versus Irrigation Water Salinity
As a fraction (0-1) of achievable yield

CROP	Achievable Yield (tons/feddan)		ECw					
	Green matter	Hay	1-2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m	10-15 dS/m
Rhodes grass(*)	65	15.0	1.00	0.80	0.65	0.50	0.20	0.00
Rhodes grass	55	12.8	1.00	1.00	0.90	0.65	0.35	0.20
Buffel grass	44	11.1	1.00	0.90	0.65	0.50	0.20	0.00
Elephant grass (Napier)	150	22.8	1.00	0.90	0.65	0.50	0.20	0.00

(*) Sprinkler irrigation all other fodder are surface irrigated

3.6 Selling prices

Farm gate prices are usually used to calculate returns (the value of the produce). In this land evaluation PAMAP purchase prices were used for the following reasons:

- monthly information on prices is available for several years
- PAMAP purchase prices are generally lower than market price and therefore constitute a safer basis of calculation
- Future trading between PAMAP and farmers is proposed as a measure to regulate the market therefore PAMAP prices are the best reference.

Table 47 gives PAMAP's average purchase prices for fruit and vegetable. Since vegetables are seasonal crops instead of using yearly average prices, it is better to use average prices during production season. These prices are shown in table 48.

Rhodes grass hay average price, as obtained from several local sources, was 92 riyals per ton.

3.7 Evaluation results

3.7.1 Introduction

ALES as setup by the project is able to estimate yields, physical suitability and gross margin (returns minus costs). There are 38 soil map units (refer to appendix 4 for complete data) and 6 water quality (salinity) classes which gives a total of 228 land units. Water salinity higher than 10 dS/m is considered physically unsuitable for the crops of the area and therefore was not evaluated. Therefore only 190 land units remain for evaluation (38 x 5). There are also 22 crops (LUTs) that are evaluated giving a total of 4,180 evaluation results. A complete report on yields, physical suitability and gross margins would include 12,540 records!

Four soil units, namely Saada (unit # 12), Salalah 01 (unit # 22), Salalah 02 (unit # 23) and Razat (unit # 29) covering 46 percent of the total study area were chosen as examples. Saada is loamy skeletal, Salalah 01 is the best soil in the area, Salalah 02 has a slight drainage problem and Razat is a shallow soil. This selection is meant to represent the dominant types of soil of the study area.

Table 47

AVERAGE PURCHASE PRICES OF LOCAL FRUIT AND VEGETABLES
1991 (in Baiza)
Source: PAMAP

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Cabbage white	0.053	0.046	0.020	0.025	0.067	0.100	0.100		0.175	0.105	0.117	0.042	0.077
Carrot	0.119	0.100	0.100	0.100	0.100	0.100	0.100					0.100	0.102
Chilli	0.125	0.125	0.098	0.056	0.250	0.350	0.350	0.400	0.400	0.230	0.263	0.220	0.239
Cauliflower (average)	0.213	0.120	0.175	0.225	0.250	0.250	0.250		0.333	0.148	0.121	0.132	0.202
Cucumber small	0.256	0.325	0.250	0.200	0.200	0.200	0.200	0.200	0.283	0.142	0.113	0.095	0.205
Eggplant	0.038	0.046	0.037	0.050	0.142	0.100	0.113	0.175	0.133	0.059	0.042	0.030	0.080
Green beans	0.200	0.250	0.250	0.250	0.250						0.388	0.318	0.272
Okra	0.281	0.320	0.350	0.350	0.283	0.100	0.175	0.250	0.250	0.140	0.146	0.150	0.233
Pepper long	0.100	0.100	0.073	0.043	0.133	0.200	0.200	0.200	0.200	0.120	0.200	0.177	0.146
Squash small	0.088	0.120	0.175	0.200	0.200	0.200	0.200	0.300	0.300	0.180	0.217	0.200	0.198
Sweet melon			0.400	0.288	0.250	0.225	0.175			0.300	0.170	0.176	0.248
Sweet potato	0.250	0.250	0.217	0.200	0.200	0.200	0.200	0.200	0.200	0.120	0.200	0.200	0.203
Tomato (average)		0.078	0.075	0.100	0.250	0.167	0.150		0.100	0.135	0.150	0.157	0.138
Watermelon		0.188	0.150	0.081	0.072	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.089
Banana	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.130	0.130	0.130	0.130	0.130	0.136
Chico	0.250	0.250	0.250		0.250	0.233	0.175	0.150	0.150	0.150	0.150	0.182	0.199
Coconut fresh	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Guava	0.300	0.300	0.300	0.300	0.300		0.350	0.300	0.258	0.156	0.250	0.250	0.279
Papaya	0.070	0.098	0.107	0.144	0.125	0.093	0.073	0.100	0.100	0.060	0.100	0.085	0.096

Table 48

VEGETABLE PRODUCTION IN SALALAH
 Average Purchase Prices During Peak Production Periods in 1991
 Source: PAMAP

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Cabbage white									0.175	0.105	0.117		0.132
Carrot	0.119	0.100	0.100	0.100	0.100							0.100	0.103
Chilli					0.250	0.350	0.350	0.400	0.400	0.230	0.263	0.220	0.308
Cauliflower	0.213	0.120	0.175	0.225	0.250	0.250	0.250		0.333	0.148	0.121	0.132	0.202
Cucumber small	0.256	0.325	0.250	0.200	0.200	0.200	0.200						0.233
Eggplant					0.142	0.100	0.113	0.175	0.133				0.133
Green beans	0.200	0.250	0.250	0.250	0.250						0.388	0.318	0.272
Okra	0.281	0.320	0.350	0.350	0.283			0.250	0.250				0.298
Sweet pepper					0.133	0.200	0.200	0.200	0.200	0.120	0.200	0.177	0.179
Squash small			0.175	0.200	0.200	0.200	0.200	0.300	0.300	0.180	0.217	0.200	0.217
Sweet melon			0.400	0.288	0.250	0.225	0.175			0.300	0.170	0.176	0.248
Sweet potato (red)	0.250	0.250	0.217										0.239
Tomato average		0.078	0.075	0.100						0.135	0.150	0.157	0.116
Watermelon			0.150	0.081	0.072	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.079

3.7.2 Yields

Tables 49, 50, 51 and 52 give the estimated yields for each of the 4 soil units mentioned above according to water salinity levels. These estimated yields are the best way to check the model and improve it.

3.7.3 Physical suitability

The absolute yield alone does not allow to determine how a given land is suitable to a certain crop. The approach in this study is to take a relative yield as a physical suitability indicator according to the following criteria:

- S_1 : 80 to 100 percent of achievable (optimal) yield
- S_2 : 50 to 79 percent of achievable (optimal) yield
- S_3 : 20 to 49 percent of achievable (optimal) yield
- N_2 : less than 20 percent of achievable (optimal) yield

S_1 , S_2 and S_3 correspond to the well known FAO suitability classes highly suitable, moderately suitable and marginally suitable all of the suitability order S (suitable). N_2 is the suitability class of soils that are permanently unsuitable.

Tables 53, 54, 55 and 56 give the results of the physical evaluation. To illustrate the procedure let us take an example:

- table 50 gives for cabbage (for soil unit # 22 and water salinity 3 to 5 dS/m) a yield of 8.45 tons per feddan. On the same table we find that achievable (optimal) yield is 13 tons. Hence the relative yield is $8.45/13 = 65$ percent. The physical suitability class is therefore S_2 .

Table 49

Achievable Yields By Water Salinity Class
Saada Soils (Unit 12)
Modern Irrigation Systems

Crop	Achievable yield tons (tons/fed.)	Water Salinity Class				
		less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	13	10.4	10.4	8.45	4.55	2.6
Carrot	14	11.2	9.1	4.9	0	0
Cauliflower	12	9.6	9.6	7.8	4.2	2.4
Cucumber	11	8.8	8.8	5.5	2.2	0
Eggplant	18	14.4	14.4	11.7	6.3	3.6
Green bean	6	4.8	3.9	1.2	0	0
Hot pepper	14	11.2	11.2	4.9	2.8	0
Okra	6	4.8	4.8	3	1.2	0
Squash	13	10.4	10.4	8.45	4.55	2.6
Sweet melon	8	6.4	6.4	4	1.6	0
Sweet pepper	12	9.6	9.6	4.2	2.4	0
Sweet potato	12	9.6	9.6	7.8	4.2	2.4
Tomato	22	17.6	17.6	14.3	7.7	4.4
Water melon	13	10.4	10.4	6.5	2.6	0
Banana	14	8.4	8.4	8.4	4.9	2.8
Chico	8	6.4	6.4	5.2	4	1.6
Coconut (*)	5200	4160	4160	3380	2600	1040
Grapes	5	2.4	2.4	2.4	1.4	0
Guava	8	6.4	6.4	5.2	4	1.6
Papaya	14	8.4	8.4	8.4	7	4.9
Rhodesgrass-K	15	12	12	9.75	7.5	3
Rhodesgrass-I	12.8	7.68	7.68	7.68	7.68	4.48

Rhodesgrass-K Sprinkler irrigated (*) Coconut yield in nuts per feddan
Rhodesgrass-I Improved surface irrigation Fodder yield in tons of hay per feddan

Table 50

Achievable Yields By Water Salinity Class
Salalah (01) (Unit 22)
Modern Irrigation Systems

Crop	Achievable yield tons (tons/fed.)	Water Salinity Class				
		less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	13	13	10.4	8.45	4.55	2.6
Carrot	14	14	9.1	4.9	0	0
Cauliflower	12	12	9.6	7.8	4.2	2.4
Cucumber	11	11	8.8	5.5	2.2	0
Eggplant	18	18	16.2	11.7	6.3	3.6
Green bean	6	6	3.9	1.2	0	0
Hot pepper	14	14	11.2	4.9	2.8	0
Okra	6	6	4.8	3.0	1.2	0
Squash	13	13	11.7	8.45	4.55	2.6
Sweet melon	8	8	6.4	4	1.6	0
Sweet pepper	12	12	9.6	4.2	2.4	0
Sweet potato	12	12	9.6	7.8	4.2	2.4
Tomato	22	22	19.8	14.3	7.7	4.4
Water melon	13	13.0	10.4	6.5	2.6	0
Banana	14	14	14	11.2	4.9	2.8
Chico	8	8	7.2	5.2	4.0	1.6
Coconut (*)	5200	5200	4680	3380	2600	1040
Grapes	5	4	3.2	2.6	1.4	0
Guava	8	8	7.2	5.2	4.0	1.6
Papaya	14	14	14	11.2	7	4.9
Rhodesgrass-K	15	15	12	9.75	7.5	3.0
Rhodesgrass-I	12.8	12.8	12.8	11.52	8.32	4.48

Rhodesgrass-K Sprinkler irrigated (*) Coconut yield in nuts per feddan
Rhodesgrass-I Improved surface irrigation Fodder yield intons of hay per feddan

Table 51

Achievable Yields By Water Salinity Class
 Salalah (02) (Unit 23)
 Modern Irrigation Systems

Crop	Achievable yield tons (tons/fed.)	Water Salinity Class				
		less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	13	13	10.4	8.45	4.55	2.6
Carrot	14	14	9.1	4.9	0	0
Cauliflower	12	12	9.6	7.8	4.2	2.4
Cucumber	11	11	8.8	5.5	2.2	0
Eggplant	18	18	16.2	11.7	6.3	3.6
Green bean	6	6	3.9	1.2	0	0
Hot pepper	14	14	11.2	4.9	2.8	0
Okra	6	6	4.8	3.0	1.2	0
Squash	13	13	11.7	8.45	4.55	2.6
Sweet melon	8	8	6.4	4.0	1.6	0
Sweet pepper	12	12	9.6	4.2	2.4	0
Sweet potato	12	12	9.6	7.8	4.2	2.4
Tomato	22	22	19.8	14.3	7.7	4.4
Water melon	13	13	10.4	6.5	2.6	0
Banana	14	14	14	11.2	4.9	2.8
Chico	8	7.2	7.2	5.2	4.0	1.6
Coconut (*)	5200	5200	4680	3380	2600	1040
Grapes	5	4	3.2	2.6	1.4	0
Guava	8	7.2	7.2	5.2	4.0	1.6
Papaya	14	14	14	11.2	7	4.9
Rhodesgrass-K	15	15	12	9.75	7.5	3.0
Rhodesgrass-I	12.8	12.8	12.8	11.52	8.32	4.48

Rhodesgrass-K Sprinkler irrigated (*) Coconut Yield in nuts per feddan
 Rhodesgrass-I Improved surface irrigation Fodder yield in tons of hay per feddan

Table 52

Achievable Yields By Water Salinity Class
Razat Soils (Unit 29)
Modern Irrigation Systems

Crop	Achievable yield tons (tons/fed.)	Water Salinity Class				
		less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	13	7.8	7.8	7.8	4.55	2.6
Carrot	14	8.4	8.4	4.9	0	0
Cauliflower	12	7.2	7.2	7.2	4.2	2.4
Cucumber	11	6.6	6.6	5.5	2.2	0
Eggplant	18	10.8	10.8	10.8	6.3	3.6
Green bean	6	3.6	3.6	1.2	0	0
Hot pepper	14	8.4	8.4	4.9	2.8	0
Okra	6	3.6	3.6	3.0	1.2	0
Squash	13	7.8	7.8	7.8	4.55	2.6
Sweet melon	8	4.8	4.8	4.0	1.6	0
Sweet pepper	12	7.2	7.2	4.2	2.4	0
Sweet potato	12	7.2	7.2	7.2	4.2	2.4
Tomato	22	13.2	13.2	13.2	7.7	4.4
Water melon	13	7.8	7.8	6.5	2.6	0
Banana	14	8.4	8.4	8.4	4.9	2.8
Chico	8	0	0	0	0	0
Coconut (*)	5200	2080	2080	2080	2080	1040
Grapes	5	2.4	2.4	2.4	1.4	0
Guava	8	0	0	0	0	0
Papaya	14	11.2	11.2	11.2	7	4.9
Rhodesgrass-K	15	15	12	9.75	7.5	3.0
Rhodesgrass-I	12.8	7.68	7.68	7.68	7.68	4.48

Rhodesgrass-K Sprinkler irrigated (*) Coconut yield in nuts per feddan
Rhodesgrass-I Improved surface irrigation Fodder yield in tons of hay per feddan

Table 53

**Physical Suitability Class By Water Salinity Class
Saada Soils (Unit 12)
Modern Irrigation Systems**

Crop	Water Salinity Class				
	less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	S1	S1	S2	S3	S3
Carrot	S1	S2	S3	N2	N2
Cauliflower	S1	S1	S2	S3	S3
Cucumber	S1	S1	S2	S3	N2
Eggplant	S1	S1	S2	S3	S3
Green bean	S1	S2	S3	N2	N2
Hot pepper	S1	S1	S3	S3	N2
Okra	S1	S1	S2	S3	N2
Squash	S1	S1	S2	S3	S3
Sweet melon	S1	S1	S2	S3	N2
Sweet pepper	S1	S1	S3	S3	N2
Sweet potato	S1	S1	S2	S3	S3
Tomato	S1	S1	S2	S3	S3
Water melon	S1	S1	S2	S3	N2
Banana	S2	S2	S2	S3	S3
Chico	S1	S1	S2	S2	S3
Coconut (*)	S1	S1	S2	S2	S3
Grapes	S2	S2	S2	S3	N2
Guava	S1	S1	S2	S2	S3
Papaya	S2	S2	S2	S2	S3
Rhodesgrass-K	S1	S1	S2	S2	S3
Rhodesgrass-I	S2	S2	S2	S2	S3

Table 54

Physical Suitability Class By Water Salinity Class
 Salalah (01) (Unit 22)
 Modern Irrigation Systems

Crop	Water Salinity Class				
	less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	S1	S1	S2	S2	S3
Carrot	S1	S2	S3	N2	N2
Cauliflower	S1	S1	S2	S3	S3
Cucumber	S1	S1	S2	S3	N2
Eggplant	S1	S1	S2	S3	S3
Green bean	S1	S2	S3	S3	N2
Hot pepper	S1	S1	S3	S3	N2
Okra	S1	S1	S2	S3	N2
Squash	S1	S1	S2	S3	S3
Sweet melon	S1	S1	S2	S3	N2
Sweet pepper	S1	S1	S3	S3	N2
Sweet potato	S1	S1	S2	S3	S3
Tomato	S1	S1	S2	S3	S3
Water melon	S1	S1	S2	S3	N2
Banana	S1	S1	S1	S3	S3
Chico	S1	S1	S2	S2	S3
Coconut (*)	S1	S1	S2	S2	S3
Grapes	S1	S2	S2	S3	S3
Guava	S1	S1	S2	S2	S3
Papaya	S1	S1	S1	S2	S3
Rhodesgrass-K	S1	S1	S2	S2	S3
Rhodesgrass-I	S1	S1	S1	S2	S3

Table 55

Physical Suitability Class By Water Salinity Class
 Salalah (02) (Unit 23)
 Modern Irrigation Systems

Crop	Water Salinity Class				
	less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	S1	S1	S2	S3	S3
Carrot	S1	S2	S3	N2	N2
Cauliflower	S1	S1	S2	S3	S3
Cucumber	S1	S1	S2	S3	N2
Eggplant	S1	S1	S2	S3	S3
Green bean	S1	S2	S3	N2	N2
Hot pepper	S1	S1	S3	S3	N2
Okra	S1	S1	S2	S3	N2
Squash	S1	S1	S2	S3	S3
Sweet melon	S1	S1	S2	S3	N2
Sweet pepper	S1	S1	S3	S3	N2
Sweet potato	S1	S1	S2	S3	S3
Tomato	S1	S1	S2	S3	S3
Water melon	S1	S1	S2	S3	N2
Banana	S1	S1	S1	S3	S3
Chico	S1	S1	S2	S2	S3
Coconut (*)	S1	S1	S2	S2	S3
Grapes	S1	S2	S2	S3	N2
Guava	S1	S1	S2	S2	S3
Papaya	S1	S1	S3	S2	S3
Rhodesgrass-K	S1	S1	S2	S2	S3
Rhodesgrass-I	S1	S1	S1	S2	S3

Table 56

Physical Suitability Class By Water Salinity Class
 Razat Soils (Unit 29)
 Modern Irrigation Systems

Crop	Water Salinity Class				
	less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	S2	S2	S2	S3	S3
Carrot	S2	S2	S3	N2	N2
Cauliflower	S2	S2	S2	S3	S3
Cucumber	S2	S2	S2	S3	N2
Eggplant	S2	S2	S2	S3	S3
Green bean	S2	S2	S3	N2	N2
Hot pepper	S2	S2	S3	S3	N2
Okra	S2	S2	S2	S3	N2
Squash	S2	S2	S2	S3	S3
Sweet melon	S2	S2	S2	S3	N2
Sweet pepper	S2	S2	S3	S3	N2
Sweet potato	S2	S2	S2	S3	S3
Tomato	S2	S2	S2	S3	S3
Water melon	S2	S2	S2	S3	N2
Banana	S2	S2	S2	S3	S3
Chico	N2	N2	N2	N2	N2
Coconut (*)	S3	S3	S3	S3	S3
Grapes	S3	S3	S3	S3	N2
Guava	N2	N2	N2	N2	N2
Papaya	S1	S1	S1	S2	S3
Rhodesgrass-K	S1	S1	S2	S2	S3
Rhodesgrass-I	S2	S2	S2	S2	S3

3.7.4 Economic evaluation

ALES calculates the gross margin for each land unit. Normally fixed costs are not included in the this type of calculation. However in order to give a better idea of the real profit of the farmer the cost of the motor and pump capital and depreciation costs were included in pumped water cost. For perennial crops under modern irrigation, the cost of the main line, the laterals and the emitters were counted. This was not possible for vegetables under drip because more than one crop can be grown in a year. Therefore an annualized cost of R.O. 170 per feddan must be added for vegetable under drip.

For all modern irrigation systems it was not possible to add the annualised cost of the filter and fertilizer tank (about R.O 175) because there must be one of each in each farm independently from the area. Similarly leaching equipment was not included. It amounts to R.O. 44 for banana, papaya and grapes. For vegetables it is R.O. 54. It must also be realized that input levels are kept constant for fertilizers and for both fertilizers and plant protection they are independent of yield levels. This approximation is quite valid but for the cases where the yield is very low the farmer is likely to cut on inputs and therefore his gross margin will be slightly better than is shown by ALES.

Despite these limitations the evaluation allows to determine the crops that are presently profitable and to rank them.

Tables 57, 58, 59 and 60 give the gross margin for the four sample soil units discussed in previous sections. Land units that have a negative gross margin are labelled N_1 which is the symbol of the FAO suitability class unsuitable for economic reasons. Physically unsuitable land units are labelled N_2 .

These tables highlight the following facts:

- Vegetables are always the most profitable crops
- among vegetables chillies are the most profitable when there is very good water whereas squash, sweet potato and tomato are more profitable if water is saline.
- water melon has a low profitability even with the best water and soil.
- Among perennial crops guava , banana and sprinkler irrigated rhodes grass are very close

Table 57

Gross Margin By Water Salinity Class
Saada Soils (Unit 12)
Modern Irrigation Systems

Crop	Water Salinity Class				
	less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	973	973	716	201	N1
Carrot	617	400	N1	N2	N2
Cauliflower	1446	1446	1082	355	N1
Cucumber	1579	1579	810	41	N2
Eggplant	1322	1322	962	244	N1
Green bean	798	553	N1	N2	N2
Hot pepper	2816	2816	876	229	N2
Okra	914	914	377	N1	N2
Squash	1844	1844	1421	575	152
Sweet melon	1124	1124	529	N1	N2
Sweet pepper	1109	1109	143	N1	N2
Sweet potato	1744	1744	1313	453	23
Tomato	1394	1394	1011	246	N1
Water melon	369	369	60	N1	N2
Banana	259	259	259	N1	N1
Chico	505	505	314	123	N1
Coconut (*)	281	281	181	82	N1
Grapes	162	162	162	N1	N2
Guava	897	897	629	362	N1
Papaya	102	102	102	N1	N1
Rhodesgrass-K	723	723	516	309	N1
Rhodesgrass-I	75	75	75	75	N1

Table 58

Gross Margin By Water Salinity Class
 Salalah (01) Soils (Unit 22)
 Modern Irrigation Systems

Crop	Water Salinity Class				
	less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	1316	973	716	201	N1
Carrot	905	400	N1	N2	N2
Cauliflower	1931	1446	1082	355	N1
Cucumber	2091	1579	810	41	N2
Eggplant	1800	1561	962	244	N1
Green bean	1124	553	N1	N2	N2
Hot pepper	3679	2816	876	229	N2
Okra	1271	914	377	N1	N2
Squash	2409	2126	1421	575	152
Sweet melon	1521	1124	529	N1	N2
Sweet pepper	1539	1109	143	N1	N2
Sweet potato	2317	1744	1313	453	23
Tomato	1905	1649	1011	246	N1
Water melon	574	369	60	N1	N2
Banana	1021	1021	640	N1	N1
Chico	760	633	314	123	N1
Coconut (*)	413	347	181	82	N1
Grapes	682	422	227	N1	N2
Guava	1254	1076	629	362	N1
Papaya	639	639	371	N1	N1
Rhodesgrass-K	999	723	516	309	N1
Rhodesgrass-I	546	546	428	134	N1

Table 59

Gross Margin By Water Salinity Class
 Salalah (02) Soils (Unit 23)
 Modern Irrigation Systems

Crop	Water Salinity Class				
	less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	1313	970	713	198	N1
Carrot	890	385	N1	N2	N2
Cauliflower	1928	1443	1079	352	N1
Cucumber	2076	1564	795	26	N2
Eggplant	1785	1546	947	229	N1
Green bean	1121	550	185	N2	N2
Hot pepper	3664	281	861	214	N2
Okra	1256	899	362	N1	N2
Squash	2405	2123	1418	572	149
Sweet melon	1506	1109	514	N1	N2
Sweet pepper	1524	1094	128	N1	N2
Sweet potato	2302	1729	1298	438	8
Tomato	1890	1634	996	231	N1
Water melon	559	354	45	N1	N2
Banana	1000	1000	619	N1	N1
Chico	628	628	309	118	N1
Coconut (*)	408	342	176	77	N1
Grapes	677	417	222	N1	N2
Guava	1071	1071	625	357	N1
Papaya	623	623	354	N1	N1
Rhodesgrass-K	995	719	512	305	N1
Rhodesgrass-I	542	542	424	130	N1

Table 60

Gross Margin By Water Salinity Class
Razat Soils (Unit 29)
Modern Irrigation Systems

Crop	Water Salinity Class				
	less than 2 dS/m	2-3 dS/m	3-5 dS/m	5-7 dS/m	7-10 dS/m
Cabbage	630	630	630	201	N1
Carrot	328	328	N1	N2	N2
Cauliflower	961	961	961	355	N1
Cucumber	1066	1066	810	41	N2
Eggplant	843	843	843	244	N1
Green bean	471	471	N1	N2	N2
Hot pepper	1954	1954	876	229	N2
Okra	556	556	377	N1	N2
Squash	1280	1280	1280	575	152
Sweet melon	728	728	529	N1	N2
Sweet pepper	680	680	143	N1	N2
Sweet potato	1170	1170	1170	453	23
Tomato	884	884	884	246	N1
Water melon	163	163	60	N1	N2
Banana	259	259	259	N1	N1
Chico	N2	N2	N2	N2	N2
Coconut (*)	16	16	16	16	N1
Grapes	162	162	162	N1	N2
Guava	N2	N2	N2	N2	N2
Papaya	371	371	371	N1	N1
Rhodesgrass-K	447	447	447	309	N1
Rhodesgrass-I	75	75	75	75	N1

3.8 Global analysis

3.8.1 Import substitution

In order to find out which crops have a guaranteed market the list of imports of vegetables and fruits was obtained from PAMAP. Table 61 gives the monthly imports of fruit and vegetables for the year 1991. Only very few vegetables such as onions that are not significant in Salalah are not taken into account.

This table shows that imports of vegetable are very important and that there is scope for vegetable import substitution.

Since the area under vegetables in the Batinah is very large when compared with Salalah, no valid analysis can be made without considering both simultaneously. A production calendar was prepared with the assistance of the MAF vegetables researchers in Salalah and Rumais as shown in table 62.

This calendar shows for each major vegetable when Salalah can substitute imports. It is noteworthy that sweet and water melons are imported in huge quantities the year round and that tomato, carrot and cucumber are imported during most of the year.

Water melon production season is the same in Salalah and the Batinah which together with the low purchase price explains that this crop is not very popular in Salalah.

3.8.2 Impact of land evaluation on research.

Tables 63, 64, 65 and 66 give the breakdown of production costs by crop for vegetables, fruits and fodder.

On the average labor represents 53 percent of production cost for surface irrigated vegetables whereas it represents 36 percent for drip irrigated vegetables, 54 percent for fruits and 57 percent for surface irrigated rhodes grass and 39 percent for sprinkler irrigated rhodes grass. Therefore labour is always the first cost.

Fertilizers represent on the average 23 to 34 percent of total cost whereas plant protection represents 10 to 17 percent for vegetable and fruits and only about 5 percent for grass.

Water represents only 4 to 5 percent for vegetables, 11 percent for fruit and 15 percent for fodder.

From these tables and others in this report it can be concluded that:

- modern irrigation systems are nearly always profitable.
- fertilizers and crop protection should have a high priority in research.

Table 61

SELECTED VEGETABLE AND FRUIT IMPORTS
Year 1991 (In tons)
Source : PAMAP

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Cabbage	0.0	0.0	0.0	0.0	0.0	109.6	347.8	1738.3	268.9	358.2	102.9	4.0	2929.7
Carrot	82.0	56.4	3.4	0.8	77.1	135.6	63.3	722.0	134.6	231.7	192.3	178.9	1877.9
Chilli	0.0	0.0	0.1	0.0	8.9	17.8	60.5	622.8	143.8	237.1	14.3	6.8	1111.9
Cauliflower	57.5	6.2	6.9	45.4	141.5	147.9	67.4	439.9	23.8	45.5	0.4	0.0	982.3
Cucumber	82.5	104.6	63.6	88.1	108.4	204.2	137.5	1014.4	97.9	94.0	0.8	4.7	2000.5
Eggplant	0.0	0.0	0.0	0.0	22.7	6.8	18.3	233.0	14.4	0.4	0.0	0.0	295.6
Okra	0.0	0.0	0.0	0.0	0.0	80.1	0.0	4.9	0.0	0.0	0.0	0.0	85.0
Pepper rounded	0.0	0.0	0.0	0.0	1813.5	24.8	55.9	381.1	31.3	64.0	54.7	20.2	2445.4
Pepper long	0.0	0.0	0.0	0.0	0.0	0.3	0.0	10.4	0.0	0.4	0.5	0.0	11.6
Squash	9.5	0.0	2.9	21.5	118.9	96.9	351.1	333.9	21.8	58.0	32.0	0.3	1046.7
Sweet melon	269.4	389.7	406.2	664.1	332.7	289.6	604.6	3964.9	1173.2	606.4	1041.8	681.6	10424.2
Sweet potato	1.5	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
Tomato	177.8	0.0	0.0	0.9	1225.0	1354.1	952.5	4372.4	1442.0	553.3	674.2	649.4	11401.5
Watermelon	636.7	1989.2	553.9	1171.6	1985.5	858.4	1350.7	5436.5	1400.0	1288.7	1222.1	1564.3	19457.6
Banana	80.6	128.2	95.6	162.7	23.7	25.5	5.2	0.0	0.0	0.0	0.0	0.0	521.4
Coconut	0.0	5.4	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	11.9

Table 62

SELECTED VEGETABLE PRODUCTION AND IMPORT CALENDAR
National

Crop		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Cabbage	Imports	.....											
	Batinah	+++++												
	Salalah											XXXXXXXXXXXXXXXXXXXX		
Carrot	Imports	.....											
	Batinah	+++++												
	Salalah	XXXXXXXXXXXXXXXXXXXX										XXXXXXXXXXXX		
Chilli	Imports	.....											
	Batinah	+++++												
	Salalah	XX												
Cauliflower	Imports	.....											
	Batinah	+++++												
	Salalah	XXXXXXXXXXXXXXXXXXXX										XXXXXXXXXXXXXXXXXXXX		
Cucumber	Imports	.....											
	Batinah	+++++												
	Salalah	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX												
Eggplant	Imports	.....											
	Batinah	+++++												
	Salalah	XX												
Sweet pepper	Imports	.....											
	Batinah	+++++												
	Salalah	XX												
Squash	Imports	.....											
	Batinah	+++++												
	Salalah	XXXXXXXXXXXXXXXXXXXX										XXXXXXXXXXXX		
Sweet melon	Imports	.....											
	Batinah						+++++							
	Salalah	XXXXXX		XXXXXXXXXXXXXXXXXXXX						XXXXXXXXXXXXXXXXXXXX				
Tomato	Imports	.....											
	Batinah	+++++												
	Salalah	XXXXXXXXXXXXXXXXXXXX										XXXXXXXXXXXXXXXXXXXX		
Watermelon	Imports	.....											
	Batinah						+++++							
	Salalah						XXXXXXXXXXXX				XXXXXXXXXXXX			

Table 63

VEGETABLE PRODUCTION IN SALALAH PLAIN
Surface Irrigation
Breakdown of Operating Costs

Crop	Labour		Tractor Services		Seeds		Fertilisers		Plant Protection		Water Pumping		Totals R.O.
	R.O.	%	R.O.	%	R.O.	%	R.O.	%	R.O.	%	R.O.	%	
Cabbage	184.5	50	24.0	7	2.1	1	115.0	31	31.6	9	11.2	3	368.4
Carrot	293.2	53	20.0	4	37.5	7	121.0	22	60.0	11	21.0	4	552.7
Cauliflower	317.8	62	24.0	5	3.4	1	114.0	22	31.6	6	23.2	5	513.9
Cucumber	184.5	41	22.0	5	27.4	6	122.0	27	87.7	19	11.2	2	454.8
Eggplant	430.5	62	24.0	3	1.6	0	137.0	20	67.9	10	28.8	4	689.8
Green beans	262.4	53	24.0	5	38.3	8	116.0	24	31.1	6	18.8	4	490.6
Hot pepper	463.3	63	24.0	3	8.6	1	140.0	19	71.0	10	33.2	4	740.1
Okra	287.0	53	24.0	4	21.2	4	117.0	22	71.8	13	19.2	4	540.2
Squash	174.3	46	22.0	6	10.9	3	115.0	30	45.7	12	12.8	3	380.6
Sweet melon	225.5	48	22.0	5	7.7	2	112.0	24	87.7	19	14.4	3	469.3
Sweet pepper	430.5	61	24.0	3	4.6	1	140.0	20	79.7	11	30.4	4	709.2
Sweet potato	307.5	54	20.0	4		0	157.0	28	59.1	10	25.6	4	569.2
Tomato	410.0	56	22.0	3	4.6	1	159.0	22	113.9	15	28.8	4	738.3
Water melon	194.8	44	22.0	5	16.6	4	107.0	24	87.7	20	13.6	3	441.6
Average	297.5	53	22.7	4	14.2	3	126.6	24	66.2	12	20.9	4	547.0

The cost for moderately well drained soils was used for plant protection

Table 64

VEGETABLE PRODUCTION IN SALALAH PLAIN
Drip Irrigation
Breakdown of Operating Costs

Crop	Labour		Tractor Services		Seeds		Fertilisers		Plant Protection		Water Pumping		Totals R.O.
	R.O.	%	R.O.	%	R.O.	%	R.O.	%	R.O.	%	R.O.	%	
Cabbage	86.0	33	14.0	5	2.1	1	115.0	44	31.6	12	11.4	4	260.1
Carrot	137.0	35	14.0	4	37.5	10	121.0	31	60.0	15	21.0	5	390.5
Cauliflower	148.0	44	14.0	4	3.4	1	114.0	34	31.6	9	23.4	7	334.4
Cucumber	86.0	25	14.0	4	27.4	8	122.0	35	87.7	25	11.4	3	348.5
Eggplant	201.0	45	14.0	3	1.6	0	137.0	30	67.9	15	29.4	7	450.9
Green beans	122.0	36	14.0	4	38.3	11	116.0	34	31.1	9	19.2	6	340.6
Hot pepper	216.0	45	14.0	3	8.6	2	140.0	29	71.0	15	33.6	7	483.2
Okra	134.0	36	14.0	4	21.2	6	117.0	31	71.8	19	19.2	5	377.2
Squash	81.0	29	14.0	5	10.9	4	115.0	41	45.7	16	12.9	5	279.5
Sweet melon	105.0	31	14.0	4	7.7	2	112.0	33	87.7	26	14.4	4	340.8
Sweet pepper	201.0	43	14.0	3	4.6	1	140.0	30	79.7	17	30.0	6	469.3
Sweet potato	144.0	36	14.0	4		0	157.0	39	59.1	15	25.8	6	399.9
Tomato	191.0	37	14.0	3	4.6	1	159.0	31	113.9	22	28.8	6	511.3
Water melon	91.0	28	14.0	4	16.6	5	107.0	32	87.7	27	13.5	4	329.8
Average	138.8	36	14.0	4	14.2	4	126.6	34	66.2	17	21.0	5	379.7

The cost for moderately well drained soils was used for plant protection

Table 65

FRUIT PRODUCTION IN SALALAH PLAIN
Breakdown of Costs

	Banana	Chico	Coconut	Grapes	Guava	Papaya	Totals
Establishment Costs							
-Planting materials	0.0	123.0	68.0	123.0	31.0	59.0	67.3
%	0.0	29.3	30.3	24.7	9.4	20.6	20.4
-Labour	33.0	21.0	16.0	62.0	21.0	33.0	31.0
%	14.5	5.0	7.1	12.4	6.4	11.5	9.4
-Tractor services	14.0	14.0	14.0	14.0	14.0	14.0	14.0
%	6.2	3.3	6.2	2.8	4.3	4.9	4.2
-JCB services	0.0	40.0	20.0	78.0	40.0	0.0	29.7
%	0.0	9.5	8.9	15.7	12.2	0.0	9.0
-Fertilisers	168.0	210.0	94.0	209.0	210.0	168.0	176.5
%	73.9	50.0	41.9	42.0	64.0	58.7	53.4
-Crop protection	12.2	12.2	12.2	12.2	12.2	12.2	12.2
%	5.4	2.9	5.4	2.4	3.7	4.3	3.7
Total establishment cost	227.2	420.2	224.2	498.2	328.2	286.2	330.7
Annual Costs							
-Labour	394.0	279.0	49.0	197.0	300.0	246.0	244.2
%	52.4	65.8	34.1	48.6	72.1	43.1	54.0
-Fertilisers	246.0	68.0	50.0	145.0	59.0	214.0	130.3
%	32.7	16.0	34.8	35.8	14.2	37.5	28.8
-Crop protection	79.1	45.1	22.7	36.2	25.3	77.7	47.7
%	10.5	10.6	15.8	8.9	6.1	13.6	10.5
-Water pumping	48.6	48.0	33.0	40.2	48.0	50.4	44.7
%	6.5	11.3	23.0	9.9	11.5	8.8	9.9
Total recurrent cost	751.5	424.1	143.7	405.0	416.3	571.3	452.0

The cost for moderately well drained soils was used for plant protection

Table 66

FODDER PRODUCTION IN SALALAH PLAIN
Breakdown of Costs for Rhodes Grass

Input	Sprinkler Irrigation	Improved Surface Irrigation
Establishment Cost		
Tractor Services	14.0 17.3%	22.0 24.8%
Seeds	55.0 68.2%	55.0 62.0%
Herbicides	11.7 14.4%	11.7 13.1%
Total Establishment Cost (R.O. per feddan)	80.7 100.0%	88.7 100.0%
Annual Costs		
Labour	98.4 38.9%	328.0 57.4%
Fertilisers	77.0 30.4%	133.2 23.3%
Plant Protection	11.7 4.6%	27.4 4.8%
Water pumping	66.0 26.1%	82.5 14.4%
Total Annual Cost (R.O. per feddan)	253.1 100.0%	571.1 100.0%

3.9 Cropping pattern

3.9.1 Global considerations

The main purpose of the land evaluation is to rank the crops by physical and economical suitability, hence allowing the selection of a suitable cropping pattern.

Although ALES evaluates each farm separately and this should be the basis for cropping pattern recommendations for the individual farmer, general conclusions can be drawn:

- Below 3 dS/m

+ all crops can be grown profitably but since vegetable are by far more profitable, especially when we consider that a 200 percent cropping intensity can be achieved, their share should be dramatically increased.

+ The cropping pattern should tend towards 50 percent vegetable and 50 percent banana.

- From 3 to 5 dS/m

+ Several vegetables are still highly profitable. Banana and sprinkler irrigated rhodes grass are close and still profitable.

+ Coconut should be kept at no more than 20 percent of the area whereas vegetables and banana may tend towards 30 percent each and rhodes grass 20 percent.

- from 5 to 7 dS/m

+ Rhodes grass should be the dominant crop at about 50 percent whereas coconut should not exceed 25 percent and vegetables 25. Squash, sweet potato and cauliflower are the best vegetables to grow.

- 7 to 10 dS/m

+ No agriculture is really profitable although if the farmer cuts on fertilizer and other inputs he may maintain a very small positive margin with squash, sweet potato and rhodes grass.

- More than 10 dS/m

+ No crop should be grown. This land may be used for urban development or other non agricultural uses.

3.9.2 Cropping pattern for the individual farmer

For the individual farmer the following must be done by an MAF land evaluator:

- locate the farm on the soil and water quality maps and determine the land unit number.
- run the evaluation for that particular land unit in ALES and determine the physical and economic suitability for each crop.
- rank the crops by physical suitability first then by economic suitability. Eliminate crops that are N_1 or N_2 .
- Discuss with the farmer to know his preference and advice him according to the evaluation results and to the general guidelines of section 3.9.1.

3.9.3 Incentives for influencing the cropping pattern

Cropping pattern should never be imposed and it is much better to induce farmers to adopt it. In Salalah the following measures are recommended:

- Future trading

PAMAP or another marketing body can regulate the market by giving the farmers contracts to produce vegetables according to an agreed calendar. ALES and the production calendar included in this report can serve to determine the real potential of each farmer and to determine a "fair purchase price". When running ALES to determine fair prices, actual average yields should be used and not potential yields. This future trading is surely the best way to convince the farmers to increase vegetable production.

- Subsidies for modern irrigation systems

There are ideal conditions for starting an irrigation subsidy scheme since all the necessary information is available.

- Technological support

Farmers need efficient extension services which have to rely on pilot farms. These pilot farms have to be representative, therefore use can be made of the maps produced by the project to select suitable locations. Fertilizers and plant protection must be given due importance in this on-farm research.

4. LABORATORY METHODS

4.1 Reception and preparation of samples

Soil samples were collected and transported to the laboratory in polytene bags. Soils were allowed to dry at room temperature on polytene sheets before being carefully crushed by hand to breakdown soil aggregates. Coarse fragments (i.e. stones and concretions larger than 2 mm) were removed by passing the crushed soil through a 2 mm sieve. The weight of coarse fragments and fine earth (the fraction smaller than 2 mm) was recorded.

All the chemical analyses described were performed on the less than 2 mm fraction following International convention.

4.2 Particle size

The soil sample was treated to remove soluble salts where appropriate and then dispersed with sodium hexametaphosphate (five percent solution). The sand fraction was separated by wet sieving, then dried and sieved into subfractions. The quantities of coarse silt, fine silt and clay were determined by sedimentation using the hydrometer method.

Soils high in gypsum were pre-treated by shaking with barium chloride (BaCl_2) and triethanolamine before dispersion, following the method of Vieillefon (1979) cited by FAO (1990).

4.3 Saturation extract

An extract was drawn under vacuum from a soil paste saturated with distilled water and the following determinations made:

4.3.1 Saturation percentage

A subsample of soil paste was oven-dried at 105°C to determine the water content of the soil at saturation. Water content is expressed gravimetrically as a percentage of the oven-dry weight of soil.

4.3.2 Electrical conductivity

It was measured with a temperature compensated conductivity meter. Readings are in dS/m .

4.3.3 Reaction

It is expressed as a pH value and was measured with a glass electrode.

4.3.4 Calcium and magnesium concentrations

They were measured in the extract using atomic absorption spectrophotometry and are expressed as milliequivalent per litre.

4.3.5 Sodium and potassium concentrations

They were measured in the extract using flame photometry and are expressed as milliequivalent per litre.

4.3.6 Carbonate and bicarbonate concentrations

They were measured in the extract by acid titration and are expressed as milliequivalent per litre.

4.3.7 Chloride concentrations

They were measured in the extract by titration with silver nitrate (AgNO_3) using potassium chromate (K_2CrO_4) as an indicator and is expressed as milliequivalent per litre.

4.3.8 Sulphate concentrations

They were determined by a turbidimetric method after precipitation with barium chloride (BaCl) and are expressed as milliequivalent per litre.

4.3.9 Nitrate concentrations

They were determined with a specific electrode and are expressed in milliequivalent per litre.

4.3.10 Cation exchange capacity

The soil sample was leached with a 60% solution of ethanol to remove soluble salts. Sodium acetate (NaOAc) 1M (buffered at Ph 8.2) was used to saturate the soil cation exchange complex with Na ions. Excess NaOAc was removed by leaching with 60% ethanol. Ammonium acetate (NH_4OAc) 1M (buffered to Ph 7) was used to exchange the Na ions with NH_4 ions. The cation exchange capacity (CEC) was calculated from the concentration of Na ions in the leachate.

4.3.11 Extractable bases

The soil sample was leached with 60% ethanol to remove soluble salts and then NH_4OAc 1M to replace extractable cations with NH_4 . The extractable cations (calcium, magnesium, sodium and potassium) in the leachate were determined as for the paste extract.

4.3.12 Organic carbon

This was determined by sulfuric acid (H_2SO_4) and potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) digestion. Excess dichromate remaining after

digestion was titrated against ferrous ammonium sulphate using 1,10 phenanthroline as an indicator.

4.3.13 Total nitrogen

The soil sample was digested with concentrated H_2SO_4 . The ammonium in the digest was determined using a steam distillation method.

4.3.14 Available phosphorus

The soil was extracted with sodium bicarbonate ($NaHCO_3$) 0.5 M at Ph 8.5. The extract was treated to produce the blue phosphorus-molybdenum complex which was measured colorimetrically at 660nm.

4.3.15 Total calcium carbonate

The carbon dioxide CO_2 produced upon reaction of soil carbonate with Hcl was measured using a calcimeter. The volume of CO_2 is proportional to the calcium carbonate content of the soil sample.

4.3.16 Gypsum

Gypsum was extracted from soil using water and precipitated with acetone. The precipitate was washed again with acetone and redissolved in water. The conductivity of the resulting solution, which is proportional to the concentration of gypsum in the solution, was measured.

4.3.17 Soil water content

The water content of the soil at field capacity (0.33 bars) and wilting point (15 bars) was determined using pressure plate and pressure membrane apparatus respectively.

4.3.18 Bulk density

Soil samples were taken from the field in cylinders of known volume. They were oven dried and weighed and the bulk density calculated.

APPENDICES

APPENDIX 1
CLIMATIC DATA

STATION: Salalah airport. Monthly Mean Air Temperature (Degree C)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1942										24.9	24.5	23.2	
43	23.0	22.9	26.5	26.4	28.7	29.4	25.6	24.6	25.2	25.3	26.5	24.3	25.7
44	23.6	24.3	24.5	27.1	28.9	29.6	25.9	25.3	26.0	24.8	25.2	25.3	25.9
45	22.8	23.3	24.9	26.7	28.6	29.4	26.1	25.8	26.7	25.3	24.9	23.6	25.7
46	22.6	23.6	25.0	27.1	28.6	29.4	26.5	25.3	26.2	26.6	25.9	23.4	25.9
47	22.6	23.3	24.7	26.9	28.1	29.3	26.4	25.0	24.8	24.7	25.6	24.0	25.5
48	22.6	24.3	25.8	27.3	29.1	29.8	26.4	25.2	25.5	26.1	24.9	23.4	25.9
49	21.4	22.9	25.3	27.1	29.1	28.8	26.3	25.2	26.4	24.9	23.7	24.0	25.4
50	22.2	21.4	24.7	26.1	27.9	28.1	25.7	26.1	27.3	25.5	23.9	23.1	25.2
1951	22.0	22.9	24.7	25.9	28.8	29.7	26.6	25.4	27.1	26.5	26.3	24.3	25.9
52	22.4	23.4	25.6	27.1	28.4	28.4	25.3	24.5	25.6	25.5	24.2	23.5	25.3
53	22.4	24.3	25.9	27.3	28.7	28.2	26.5	24.8	26.7	25.7	25.3	24.2	25.8
54	22.5	24.2	26.2	27.6	29.2	28.9	25.5	25.3	25.9	25.3	24.6	24.1	25.8
55	23.9	22.7	24.7	26.2	28.7	27.7	25.6	23.8	25.7	25.2	24.8	24.1	25.3
56	22.0	22.4	25.2	27.6	28.6	28.6	24.7	24.7	26.8	26.4	25.8	23.6	25.5
57	21.9	21.5	24.4	27.1	28.6	28.8	25.3	25.0	26.1	25.7	26.2	24.5	25.4
58	23.5	24.2	24.9	27.1	28.5	29.3	26.6	25.5	25.4	25.7	25.3	23.3	25.8
59	22.2	22.5	24.6	26.8	28.1	29.1	25.7	23.9	25.9	26.2	24.4	22.5	25.2
60	22.5	23.4	25.1	26.7	28.8	29.1	26.3	25.0	26.3	25.8	25.9	24.2	25.8
1961	22.9	24.1	25.2	27.4	29.1	29.1	27.2	25.4	25.8	25.9	25.7	23.7	26.0
62	22.5	23.7	24.4	26.8	28.1	28.5	26.1	25.0	26.9	25.9	26.5	23.7	25.7
63	22.5	23.4	25.7	27.5	28.8	28.4	26.0	24.6	25.3	25.9	26.4	23.7	25.7
64	22.2	23.0	24.9	28.3	29.2	28.7	26.0	24.4	26.4	25.5	25.4	22.4	25.5
65	23.3	24.9	25.5	27.1	28.3	28.6	25.5	25.2	27.3	27.3	27.1	24.2	26.2
66	23.5	24.7	24.9	27.2	28.9	29.8	26.6	25.8	26.9	27.9	25.4	23.7	26.3
67	23.3	23.9	25.8	27.0	29.1	29.3	26.8	25.2	25.9	26.7	26.3	23.7	26.1
68	21.6	23.3	24.1	26.9	27.8	29.1	27.3	25.0	27.3	26.1	25.8	23.7	25.7
69	23.7	23.0	26.3	27.9	29.1	28.8	27.1	25.1	26.7	26.3	26.3	24.7	26.3
1970	23.0	23.8	26.0	27.5	30.0	29.6	26.8	26.6	26.4	25.6	24.4	23.1	26.1
71	22.8	23.0	25.1	27.6	28.6	27.7	25.9	25.0	25.2	24.8	24.9	22.5	25.3
72	22.0	22.6	24.7	26.9	27.6	28.9	27.1	25.3	27.1	26.6	25.8		
73					28.9	29.6	24.7	24.1	25.1	25.4	25.3	23.2	
74	22.1	23.0	24.9	27.3	28.0	27.9	27.2	25.9	26.6	26.0	24.9	24.1	25.7
75	23.1	23.8	24.7	27.0	28.7	28.6	26.4	26.1	26.2	25.7	24.7	23.4	25.7
76	22.3	24.6	25.5	27.6	28.9	29.3	26.9	25.4	25.1	26.0	26.4	24.2	26.0
77			25.9	27.7	29.3	29.4	26.1	24.7	25.8	26.5	26.7	24.3	
78	23.7	23.4	25.0	28.0	29.9	29.1	25.2	24.3	25.1	25.6	25.9	24.0	25.8
79	23.0	22.2	25.1	26.5	28.7	28.6	26.4	24.1	26.6	26.9	26.1	24.1	25.7
1980	23.2	23.9	25.7	28.1	28.8	29.5	26.1	25.1	26.1	26.2	26.0	23.2	26.0
81	23.3	23.2	26.1	28.0	29.6	29.6	25.5	25.4	27.0	26.8	25.8	24.0	26.2
82	22.9	24.5	26.4	27.7	28.9	29.0	27.4	25.0	27.1	27.6	26.4	24.2	26.4
83	23.1	22.7	25.7	27.3	29.0	29.7	27.9	26.0	26.7	26.2	25.4	23.7	26.1
84	22.4	22.6	25.3	27.9	29.0	28.8	25.7	24.5	24.9	25.6	25.5	24.8	25.6
85	24.0	24.0	26.1	28.0	28.6	28.4	25.3	25.8	26.4	26.3	25.9	23.3	26.0
86	22.1	23.9	26.3	28.2	29.8	29.8	26.1	24.2	26.0	26.4	26.3	23.7	26.1
87	23.3	23.9	26.2	28.2	29.6	30.2	27.4	26.2	26.3	27.2	27.0	24.6	26.7
88	22.6	25.1	26.4	28.4	29.3	29.7	26.5	24.9	27.1	26.6	25.9	24.3	26.4
89	22.2	24.3	25.0	27.5	29.3	28.4	25.3	24.8	26.5	26.9	26.3	24.5	25.9
1990	23.9	25.7	26.0	28.1	30.2	29.3	26.0	25.4	26.4	26.9	26.5	25.1	26.6
AVERAGE													
1942-90	22.8	23.5	25.4	27.3	28.8	29.0	26.2	25.1	26.2	26.0	25.6	23.8	25.8

STATION: Salalah Airport, Monthly Mean Relative Humidity (%)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1979								89	77	66	46	60	
1980	53	61	63	65	75	81	89	91	82	71	60	47	70
1981	61	55	69	70	74	78	91	88	77	64	54	48	69
1982	52	67	68	72	79	84	87	91	80	65	59	58	72
1983	50	66	57	72	78	80	87	90	83	65	52	47	69
1984	44	51	60	67	75	81	89	90	83	63	56	56	68
1985	57	40	55	70	79	81	90	86	78	70	57	50	68
1986	46	60	61	69	73	80	88	90	77	65	53	48	68
1987	45	56	68	65	72	78	85	91	83	72	51	48	68
1988	49	60	56	66	74	79	90	94	81	64	47	50	68
1989	40	53	67	65	72	82	91	89	81	68	60	54	69
1990	58	68	58	71	74	81	88	91	84	67	51	49	70
AVERAGE													
1979-90	50	58	62	68	75	80	89	90	81	67	54	51	69

STATION: Salalah Airport, Monthly Mean Sunshine (Hours/day)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1978									6.7	10.0	10.0	9.3	
1979	8.2	10.0	9.5	10.7	11.1	6.6	1.5	1.8	7.0	10.4	10.2	8.6	8.0
1980	9.4	9.6	9.9	11.1	10.7	5.8	1.4	1.2	6.6	9.4	9.8	9.4	7.9
1981	8.9	10.2	8.5	10.5	10.5	7.6	0.4	1.6	7.4	10.0	10.1	9.4	7.9
1982	8.9	7.3	9.8	9.1	10.2	6.3	2.8	0.8	6.8	10.0	9.6	9.3	7.6
1983	8.4	7.6	9.3	9.0	10.5	7.4	2.0	1.3	5.3	9.8	10.0	9.4	7.5
1984	9.5	10.1	10.0	11.3	10.6	5.1	0.8	0.9	5.8	10.1	10.3	9.9	7.9
1985	9.7	10.0	10.2	10.0	10.4	6.1	1.1	2.5	6.6	10.4	10.2	9.7	8.1
1986	9.8	7.7	10.0	9.2	11.6	6.5		0.9	7.3	10.5	10.3	9.7	
1987	10.3	10.3	8.8	10.8	11.4	7.3	3.8	2.0	7.3	10.3	10.5	9.7	8.5
1988	9.6	9.3	9.9	10.8	10.9	8.6	1.2	0.4	5.3	10.3	10.3	10.1	8.1
1989	9.9	9.6	8.8	10.6	11.2	5.6	0.5	1.6	6.7	10.7	10.5	9.6	7.9
1990	9.5	7.4	10.5	10.2	10.6	6.9	1.5	1.4	3.1	9.9	10.1	10.1	7.6
AVERAGE													
1978-90	9.3	9.1	9.6	10.3	10.8	6.7	1.5	1.4	6.3	10.1	10.1	9.6	7.9

STATION: Salalah Airport, Monthly Mean Total Rainfall (mm)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1942										0.0	0.0	TR	
43	TR	TR	0.0	0.0	0.0	3.3	28.0	15.4	10.2	0.0	TR	25.4	82.3
44	0.0	TR	TR	TR	1.4	3.9	29.6	16.4	TR	0.0	0.3	60.9	112.5
45	TR	TR	0.0	TR	0.0	0.6	30.7	32.8	6.2	0.0	15.2	0.0	85.5
46	0.0	0.0	0.0	0.0	0.0	0.3	17.8	33.5	0.2	0.0	0.0	0.0	51.8
47	0.9	0.1	0.0	0.0	0.4	4.0	27.1	48.6	3.7	0.0	6.9	0.0	91.7
48	4.2	TR	0.0	TR	TR	TR	16.0	26.6	2.0	156.8	0.0	0.0	205.6
49	2.2	0.0	TR	0.0	0.5	1.8	25.9	30.5	1.9	0.0	0.0	0.0	62.8
1950	2.6	1.6	0.0	0.0	0.0	0.8	48.7	7.2	0.8	0.0	0.0	TR	61.7
51	0.0	0.0	22.2	0.0	TR	0.8	23.3	10.2	6.1	0.0	TR	4.0	66.6
52	2.3	0.0	0.0	TR	0.0	4.0	29.2	39.8	TR	1.3	0.0	0.4	77.0
53	5.3	0.0	0.0	0.0	TR	34.4	13.0	37.3	2.1	0.0	0.0	5.0	97.1
54	0.8	17.0	0.2	5.5	0.0	0.2	47.9	22.9	2.6	0.0	0.0	5.2	102.3
55	1.4	0.0	2.0	14.4	0.0	28.5	42.7	54.6	15.0	0.0	0.0	2.8	161.4
56	TR	TR	0.0	0.0	0.0	0.6	30.9	21.4	1.4	9.2	0.0	0.0	63.5
57	0.5	TR	TR	16.9	TR	2.1	31.5	35.1	0.5	0.0	TR	TR	86.6
58	0.5	0.0	0.3	0.0	TR	4.1	34.3	13.3	8.0	0.0	0.0	5.2	65.7
59	TR	0.0	TR	0.0	120.6	0.1	33.4	40.9	6.3	0.0	TR	0.0	201.3
1960	0.0	0.0	69.1	0.0	4.1	10.1	28.1	11.6	4.9	0.0	6.1	0.0	134.0
61	TR	0.0	0.0	0.3	0.0	2.4	17.2	16.6	2.6	0.0	TR	0.0	39.1
62	0.0	0.0	0.0	TR	TR	1.0	10.3	23.1	TR	0.0	TR	1.2	35.6
63	0.0	0.0	0.9	81.1	269.4	3.9	60.8	63.1	1.6	0.0	28.4	0.2	509.4
64	TR	TR	0.0	12.9	0.0	0.8	32.9	24.7	2.4	0.0	0.2	TR	73.9
65	1.1	0.0	0.0	1.0	0.0	0.2	29.7	13.8	0.0	0.8	0.0	TR	46.6
66	0.0	2.1	0.0	0.0	0.3	TR	20.6	23.3	0.8	7.3	202.7	0.0	257.1
67	0.0	0.0	91.1	0.1	0.0	0.1	38.7	29.4	7.7	0.1	0.0	4.5	171.7
68	0.0	7.1	0.0	TR	0.0	0.1	10.7	17.0	TR	0.0	0.6	TR	35.5
69	7.0	TR	TR	0.0	TR	1.4	12.6	19.6	TR	16.5	TR	0.0	57.1
1970	TR	2.8	0.3	0.2	0.0	0.1	28.1	25.7	4.3	5.1	0.0	TR	66.6
71	TR	0.1	0.1	TR	TR	7.3	10.8	21.2	1.5	24.0	1.0	0.1	66.1
72	0.1	TR	4.4	18.9	TR	9.7	3.1	5.9	0.2	7.4	2.1	TR	51.8
73	TR	TR	TR	TR	TR	4.6	29.9	30.2	4.5	TR	0.0	0.0	69.2
74	TR	TR	0.0	0.0	TR	4.8	8.2	8.2	TR	0.0	0.0	TR	21.2
75	1.4	0.2	TR	0.0	0.1	1.1	14.2	7.6	11.0	TR	0.0	6.0	41.6
76	0.0	1.8	0.0	26.0	TR	0.2	31.7	15.0	1.7	0.0	0.0	0.0	76.4
77	0.7	0.0	TR	123.0	59.6	124.0	27.3	23.6	0.9	34.0	0.0	0.0	393.1
78	0.0	10.8	2.1	0.0	0.0	5.0	23.7	23.2	6.1	0.0	1.0	0.0	71.9
79	0.0	0.0	0.5	19.8	0.0	55.8	21.6	18.9	1.9	0.0	0.0	0.0	118.5
1980	0.0	0.0	TR	0.0	0.4	TR	28.2	21.0	11.0	19.9	0.0	0.0	80.5
81	0.2	0.0	15.4	TR	TR	1.9	21.5	12.4	2.0	0.0	0.0	0.0	53.4
82	1.1	59.3	1.6	0.0	0.0	27.6	16.7	30.8	6.3	0.0	3.6	0.4	147.4
83	24.8	77.4	0.2	150.9	27.5	0.4	13.0	59.5	6.5	0.0	0.0	0.0	360.2
84	0.0	0.0	0.0	0.0	11.0	1.9	27.1	21.4	12.3	0.0	0.0	0.0	73.7
85	1.5	0.0	0.0	0.0	0.0	4.5	37.0	11.9	0.0	0.0	0.0	0.0	54.9
86	TR	1.4	0.0	0.0	0.0	3.7	36.3	31.0	TR	0.4	0.0	TR	72.8
87	0.0	0.0	14.2	0.0	6.5	4.8	13.9	26.6	TR	0.0	TR	0.1	66.1
88	TR	0.0	0.0	42.1	0.0	TR	41.7	52.4	8.5	0.0	0.0	0.0	144.7
89	0.0	TR	26.2	0.0	0.0	15.0	45.9	19.4	1.9	0.0	0.0	12.0	120.4
1990	10.3	5.1	0.0	TR	1.6	3.0	23.4	37.7	2.1	0.0	0.0	0.0	83.2
Average 1942-90	1.4	3.9	5.2	10.7	10.5	8.0	26.6	25.7	3.5	5.8	5.5	2.7	109.5

STATION: Salalah Airport, Monthly Maximum Rainfall in 24 hours (mm)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
1942										0.0	0.0	TR		
43	0.0	TR	0.0	0.0	0.0	2.5	5.3	2.6	2.0	0.0	TR	25.4	25.4	08 Dec
44	0.0	TR	TR	TR	1.2	1.2	6.6	2.5	TR	0.0	0.3	27.9	27.9	30 Dec
45	TR	TR	0.0	TR	0.0	0.6	3.4	4.0	1.3	0.0	15.2	0.0	15.2	27 Nov
46	0.0	0.0	0.0	0.0	0.0	0.3	3.3	8.0	0.2	0.0	0.0	0.0	8.0	11 Aug
47	0.9	0.1	0.0	0.0	0.4	1.9	3.9	5.3	0.7	0.0	6.0	0.0	6.0	14 Nov
48	2.0	TR	0.0	TR	TR	TR	3.8	3.4	0.9	47.7	0.0	0.0	47.7	23 Oct
49	2.2	0.0	TR	0.0	0.5	0.9	3.7	3.8	0.6	0.0	0.0	0.0	3.8	14 Aug
50	1.6	1.6	0.0	0.0	0.0	0.8	5.8	3.4	0.5	0.0	0.0	TR	5.8	18 Jul
1951	0.0	0.0	10.2	0.0	TR	0.8	6.1	1.6	6.1	0.0	TR	2.6	10.2	22 Mar
52	2.3	0.0	0.0	TR	0.0	1.4	4.8	4.8	TR	1.3	0.0	0.4	4.8	08 Jul
53	5.3	0.0	0.0	0.0	TR	8.2	2.4	7.2	0.5	0.0	0.0	2.8	8.2	29 Jun
54	0.8	6.2	0.2	4.5	0.0	0.2	5.9	5.6	0.7	0.0	0.0	2.1	6.2	08 Feb
55	1.4	0.0	2.0	14.4	0.0	3.9	4.4	7.0	2.3	0.0	0.0	2.8	14.4	28 Apr
56	TR	TR	0.0	0.0	0.0	0.6	3.9	3.5	0.7	9.2	0.0	0.0	9.2	25 Oct
57	0.5	TR	TR	10.6	TR	1.2	2.7	4.7	0.3	0.0	TR	TR	10.6	08 Apr
58	0.5	0.0	0.3	0.0	TR	3.9	8.6	2.3	2.0	0.0	0.0	3.2	8.6	08 Jul
59	TR	0.0	TR	0.0	81.8	0.1	6.6	7.0	2.3	0.0	TR	0.0	81.8	23 May
1960	0.0	0.0	62.0	0.0	3.3	4.5	3.6	2.5	2.3	0.0	5.9	0.0	62.0	15 Mar
61	TR	0.0	0.0	0.3	0.0	1.6	3.1	2.4	1.3	0.0	TR	0.0	3.1	21 Jul
62	0.0	0.0	0.0	TR	TR	0.9	4.3	3.2	TR	0.0	TR	1.2	4.3	18 Jul
63	0.0	0.0	0.9	33.8	174.0	1.1	5.9	5.0	0.6	0.0	22.1	0.2	174.0	27 May
64	TR	TR	0.0	10.5	0.0	0.4	5.2	5.1	1.0	0.0	0.2	TR	10.5	04 Apr
65	1.1	0.0	0.0	1.0	0.0	0.2	3.6	2.4	0.0	0.8	0.0	TR	3.6	08 Jul
66	0.0	2.1	0.0	0.0	0.3	TR	3.4	4.4	0.6	4.6	185.9	TR	185.9	12 Nov
67	0.0	0.0	38.8	0.1	0.0	0.1	15.1	4.5	3.0	0.1	0.0	2.8	38.8	28 Mar
68	0.0	5.2	0.0	TR	0.0	0.1	2.5	3.4	TR	0.0	0.6	TR	5.2	15 Feb
69	6.6	TR	TR	0.0	TR	0.6	1.8	3.2	TR	16.5	TR	0.0	16.5	31 Oct
1970														
71														
72														
73														
74														
75														
76														
77				39.1	32.6	70.3	3.7	2.9	0.6	18.0	0.0	0.0	70.3	17 Jun
78	0.0	4.2	2.1	TR	0.0	3.0	4.0	8.7	2.0	0.0	1.0	0.0	8.7	02 Aug
79	TR	0.0	0.5	19.6	0.0	54.2	2.9	2.6	1.3	0.0	0.0	TR	54.2	22 Jun
1980	TR	0.0	TR	0.0	0.4	TR	6.6	3.3	4.5	19.5	0.0	0.0	19.5	17 Oct
81	0.2	0.0	5.2	TR	TR	1.5	2.4	2.9	1.5	0.0	0.0	0.0	5.2	15 Mar
82	1.1	49.0	1.6	0.0	0.0	14.1	4.4	2.8	3.8	0.0	3.6	0.4	49.0	26 Feb
83	20.5	30.5	0.2	127.0	23.8	0.4	4.6	10.0	2.0	0.0	0.0	0.0	127.0	04 Apr
84	0.0	0.0	0.0	0.0	10.0	1.6	4.1	3.7	6.1	0.0	0.0	0.0	10.0	09 May
85	1.1	0.0	0.0	0.0	0.0	1.9	4.1	1.6	0.0	0.0	0.0	0.0	4.1	17 Jul
86	TR	1.1	0.0	0.0	0.0	1.1	4.4	3.4	TR	0.4	0.0	TR	4.4	13 Jul
87	0.0	0.0	7.1	0.0	5.9	4.8	3.4	5.0	TR	0.0	TR	0.1	7.1	14 Mar
88	TR	0.0	0.0	41.7	0.0	TR	5.2	5.8	2.7	0.0	0.0	0.0	41.7	Apr
89	0.0	TR	21.0	0.0	0.0	7.3	4.9	2.6	1.8	0.0	0.0	12.0	21.0	Mar
1990	10.3	4.8	0.0	TR	1.6	2.2	5.6	6.7	1.1	0.0	0.0	0.0	10.3	Jan

STATION: Salalah Airport, Absolute Maximum Air Temperature (Degree C)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
1942														
43	28.9	31.1	34.4	33.9	42.2	42.8	30.6	28.3	30.6	34.4	37.8	34.4	42.8	03 Jul
44	32.2	34.4	30.6	36.1	40.0	46.1	31.7	30.6	31.1	36.1	33.3	32.2	46.1	14 Jul
45	31.7	31.7	38.3	36.1	35.0	33.9	30.6	29.4	30.6	34.4	33.9	31.7	38.3	28 Mar
46	29.4	33.3	35.0	35.0	41.7	47.2	31.7	30.6	30.0	35.0	33.9	31.7	47.2	02 Jun
47	30.6	31.7	36.1	40.0	33.3	33.3	31.1	28.3	28.3	31.7	33.3	31.1	40.0	20 Apr
48	28.9	32.2	36.1	33.9	33.3	33.9	32.2	28.3	29.4	37.2	35.0	33.9	37.2	23 Oct
49	28.3	31.1	34.4	35.0	33.9	33.9	31.7	29.4	30.0	33.3	31.7	30.0	35.0	10 Mar
1950	30.0	27.8	33.3	36.1	33.3	32.8	30.6	29.4	31.7	35.6	33.3	30.6	36.1	11 Mar
51	30.0	33.9	33.3	33.9	33.3	33.9	31.7	29.4	31.1	33.9	35.6	32.8	35.6	11 Nov
52	29.4	32.2	36.1	33.9	33.9	33.9	30.6	27.8	30.0	32.8	33.3	32.2	36.1	15 Mar
53	30.0	32.8	35.6	35.6	32.8	33.3	30.0	28.3	31.1	33.9	32.2	32.2	35.6	11 Mar
54	30.0	33.9	34.4	33.3	34.4	33.3	30.0	29.4	30.0	33.9	30.0	32.2	34.4	30 Mar
55	30.6	31.7	35.6	34.4	38.9	32.2	31.7	30.0	31.7	32.2	35.6	32.2	38.9	08 May
56	28.3	31.1	32.2	38.3	40.6	33.3	30.0	29.4	30.6	35.6	34.4	32.8	40.6	11 May
57	28.3	30.0	32.8	35.0	34.4	33.9	30.6	28.9	30.6	31.7	35.0	30.6	35.0	11 Apr
58	29.4	32.8	33.9	37.2	35.6	33.9	32.2	30.6	30.0	31.1	33.9	31.1	37.2	01 Apr
59	30.0	31.1	33.9	38.9	35.0	32.8	31.7	28.3	31.1	38.3	35.0	30.6	38.9	10 Mar
1960	31.7	32.8	31.7	35.0	34.4	45.0	30.6	28.9	31.1	33.9	36.1	31.1	45.0	09 Jun
61	29.7	32.2	37.0	35.1	41.2	39.4	31.7	30.3	30.8	33.3	33.4	30.6	41.2	30 May
62	32.1	33.8	35.0	33.3	33.6	40.0	31.4	28.5	32.1	38.2	35.9	31.1	40.0	11 Jun
63	30.6	32.2	35.6	31.7	38.9	32.9	30.0	28.8	30.4	34.5	33.3	32.8	38.9	25 May
64	28.9	31.7	33.5	41.6	33.6	33.3	31.0	31.4	30.6	32.4	34.4	30.0	41.6	26 Apr
65	30.6	33.3	32.3	33.8	34.8	32.7	30.2	28.8	31.4	36.7	34.8	31.6	36.7	19 Oct
66	31.0	32.2	35.8	37.4	33.7	33.7	31.5	30.6	30.8	34.5	35.5	30.7	37.4	13 Apr
67	31.4	33.3	33.4	33.3	34.6	42.5	32.1	30.6	31.0	33.9	33.0	29.8	42.5	11 Jun
68	29.7	31.3	33.6	37.1	32.0	34.5	32.1	29.5	31.5	34.6	33.2	30.9	37.1	13 Apr
69	28.7	31.7	36.1	38.5	33.3	32.8	32.1	30.2	30.5	34.8	35.0	32.3	38.5	20 Apr
1970														
71														
72														
73														
74	30.2	30.3	35.4	36.8	32.3	31.9	30.7	30.6	30.9	32.8	33.8	31.0	36.8	Apr
75	30.9	31.7	33.7	34.0	33.1	32.7	29.9	30.5	29.9	37.0	34.4	31.2	37.0	Oct
76	29.0	31.7	31.9	37.1	35.1	33.5	31.6	29.3	29.4	32.8	35.4	32.7	37.1	Apr
77	31.0	32.8	35.2	37.5	33.3	33.7	30.6	28.5	30.0	36.5	35.8	33.4	37.5	Apr
78	31.5	31.2	34.7	39.0	39.6	43.0	31.4	28.6	30.2	35.1	36.8	30.8	43.0	05 Jun
79	31.7	31.5	35.0	37.3	33.8	33.7	31.0	29.9	33.0	33.9	36.4	30.3	37.3	19 Apr
1980	29.9	30.8	33.0	38.3	34.0	34.0	30.1	30.0	30.4	33.9	35.1	31.8	38.3	21 Apr
81	29.2	30.6	35.2	37.8	34.6	33.6	29.5	30.7	31.6	34.0	37.1	32.4	37.8	20 Apr
82	29.7	30.2	34.6	36.3	33.4	33.7	32.2	29.4	31.5	35.5	32.9	32.3	36.3	04 Apr
83	30.3	31.8	34.5	35.5	33.1	34.0	32.7	31.3	31.3	32.2	34.8	31.4	35.5	30 Apr
84	30.4	33.2	34.6	36.4	34.1	34.2	29.4	28.2	29.5	35.5	34.3	31.5	36.4	05 Apr
85	30.1	32.7	35.6	38.3	34.7	32.7	29.2	30.7	30.5	31.5	35.3	29.4	38.3	11 Apr
86	28.4	31.5	36.7	35.0	34.3	34.2	31.2	30.1	29.9	34.5	34.8	30.4	36.7	28 Mar
87	32.3	31.9	32.1	43.6	34.5	34.1	32.7	30.3	30.6	33.7	36.5	32.2	43.6	24 Apr
88	30.9	33.8	36.1	36.2	33.2	33.7	30.5	28.8	32.2	40.1	33.1	32.5	40.1	Oct
89	31.6	32.6	32.0	36.0	38.4	33.6	29.4	29.2	31.4	34.1	36.8	31.6	38.4	
1990	32.1	30.7	35.7	33.3	42.3	33.9	30.5	29.8	30.5	33.1	37.4	34.2	42.3	May

STATION: Salalah Airport, Absolute Minimum Air Temperature (Degree C)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
1942										17.2	17.2	16.1		
43	15.0	15.0	16.7	19.4	20.6	25.0	21.1	21.1	19.4	17.8	17.8	16.1	15.0	29 Jan
44	16.1	16.7	16.7	20.0	22.8	24.4	22.2	21.7	18.9	16.7	15.6	17.8	15.6	01 Nov
45	13.3	16.1	16.7	17.2	22.8	25.6	23.3	22.8	22.8	18.3	18.9	16.1	13.3	09 Jan
46	13.3	15.0	16.7	20.6	22.8	22.8	22.8	22.2	21.1	19.4	18.3	16.1	13.3	17 Jan
47	14.4	16.1	15.6	19.4	21.7	25.6	22.8	21.7	18.9	17.2	17.2	13.9	13.9	30 Dec
48	14.4	17.2	18.3	19.4	23.3	26.7	22.8	22.2	22.2	18.3	17.2	15.6	14.4	11 Jan
49	11.7	11.7	18.9	20.6	21.7	24.4	23.3	22.8	22.8	16.1	15.6	17.2	11.7	02 Jan
1950	12.2	11.7	17.2	18.3	22.2	24.4	22.8	22.8	20.6	17.8	17.2	15.6	11.7	09 Feb
51	15.0	15.6	17.2	17.2	24.4	25.0	22.8	22.8	22.2	19.4	17.8	16.7	15.0	20 Jan
52	15.0	12.8	18.3	19.4	21.7	22.8	22.2	22.2	20.0	17.2	16.7	14.4	12.8	17 Feb
53	13.9	16.1	18.3	20.0	23.9	23.9	23.3	22.2	21.7	18.3	18.3	16.7	13.9	06 Jan
54	13.9	13.3	18.9	20.6	24.4	24.4	22.8	22.8	20.6	16.7	17.8	14.4	13.3	04 Feb
55	13.3	14.4	14.4	18.3	22.8	24.4	21.7	21.1	21.7	16.7	17.2	16.7	13.3	31 Jan
56	15.0	15.0	16.7	20.0	20.6	23.9	21.7	22.2	23.3	18.3	18.3	17.2	15.0	28 Jan
57	10.6	10.0	13.9	21.7	23.3	23.9	22.8	22.8	20.6	18.9	19.4	16.1	10.0	09 Feb
58	15.0	15.6	15.6	19.4	21.1	23.9	22.2	22.2	21.7	18.9	17.8	13.9	13.9	31 Dec
59	15.0	14.4	15.6	20.6	21.1	25.0	21.7	21.1	20.0	18.3	16.1	15.0	14.4	01 Feb
1960	13.3	14.4	17.2	18.9	21.7	23.3	23.3	22.2	22.2	18.9	17.2	15.6	13.3	31 Jan
61	15.8	17.8	16.6	18.3	22.8	23.8	23.2	22.7	20.3	17.4	18.9	15.2	15.2	
62	15.3	16.0	17.3	19.0	21.8	23.8	22.9	22.8	19.3	18.5	19.6	17.2	15.3	
63	15.1	16.7	17.8	21.6	23.3	24.9	23.9	22.4	18.9	19.3	18.8	14.0	14.0	
64	12.1	15.6	16.0	20.0	22.8	24.1	23.3	21.2	21.6	17.5	17.2	11.8	11.8	
65	10.9	15.8	16.5	20.1	20.1	24.5	22.5	22.2	22.2	18.2	18.4	16.3	10.9	
66	14.8	16.5	16.7	19.0	19.1	26.6	23.6	22.9	20.2	19.4	15.4	15.4	14.8	
67	14.8	15.2	17.6	16.7	21.0	23.0	22.9	22.1	21.5	18.5	18.6	12.5	12.5	
68	13.8	15.4	17.0	19.2	22.0	24.0	23.7	22.3	21.9	20.9	19.0	16.4	13.8	
69	16.4	15.2	17.6	19.7	23.4	24.3	23.4	22.6	22.2	18.8	19.8	17.8	15.2	
1970														
71														
72														
73														
74	14.9	15.2	17.2	20.7	23.0	23.5	24.4	21.9	22.1	18.0	16.8	17.3	14.9	Jan
75	14.6	16.3	16.8	20.3	23.8	25.2	23.3	23.2	22.0	19.1	18.3	16.1	14.6	Jan
76	15.8	18.5	17.0	21.4	23.7	25.3	22.8	22.8	19.1	19.7	16.3	17.9	15.8	Jan
77	14.2	16.0	16.9	21.4	23.8	24.4	22.5	22.4	19.9	19.2	16.8	16.7	14.2	Jan
78	13.4	14.6	15.7	21.0	21.8	24.4	22.1	21.6	21.3	18.4	17.7	16.4	13.4	30 Jan
79	15.2	13.9	18.0	18.5	20.6	24.1	21.9	20.5	21.4	20.4	15.0	16.1	13.9	20 Feb
1980	15.2	16.6	14.5	20.4	23.0	25.6	22.4	21.9	22.0	18.8	18.8	15.0	14.5	09 Mar
81	14.9	15.2	17.6	19.9	24.0	24.4	22.0	21.2	21.7	18.8	16.0	16.0	14.9	06 Jan
82	15.7	18.3	19.2	18.5	22.8	24.5	23.0	21.4	21.1	19.6	18.0	15.0	15.0	29 Dec
83	12.9	10.8	17.3	18.0	22.2	24.5	23.9	21.6	21.8	18.6	17.2	16.0	10.8	15 Feb
84	14.9	14.2	15.3	20.8	23.9	25.2	23.6	22.3	21.3	18.0	17.8	17.5	14.2	03 Feb
85	17.2	15.4	17.5	21.2	23.2	24.8	23.2	23.2	21.4	20.4	18.5	15.6	15.4	16 Feb
86	13.9	15.5	18.4	22.0	24.5	25.2	22.7	21.2	22.0	18.7	18.0	14.1	13.9	23 Jan
87	14.2	14.9	18.8	20.4	23.6	25.6	23.1	22.9	21.2	20.1	18.6	15.6	14.2	23 Jan
88	14.5	15.4	17.6	21.0	22.0	25.3	22.8	22.0	22.2	16.5	16.2	14.5	14.5	
89	12.6	16.2	16.0	20.5	22.4	24.2	22.0	21.6	21.7	18.4	16.9	14.4	12.6	
1990	15.2	18.8	16.7	22.1	25.2	24.8	23.0	22.9	23.3	19.8	18.7	15.8	15.2	

STATION: Salalah Airport, Absolute Maximum Relative Humidity (%)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
1983	95	98	87	99	97	93	98	100	99	92	78	80	100	25 Aug
1984	79	91	93	94	92	97	99	100	98	93	81	85	100	09 Aug
1985	94	81	91	92	97	97	99	98	92	96	78	87	99	12 Jul
1986	77	90	92	93	92	94	99	99	92	89	80	83	99	20 Jul
1987	87	83	91	89	92	92	100	100	100	98	86	84	100	Jul
1988	87	83	86	97	92	93	99	100	97	88	79	82	100	Aug
1989	80	91	93	92	95	99	99	99	98	92	85	98	99	Jun
1990	92	91	86	92	92	97	99	99	99	93	81	85	99	Jul

STATION: Salalah Airport, Absolute Minimum Relative Humidity (%)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
1983	8	20	7	16	40	60	67	67	58	21	10	8	7	02 Mar
1984	9	6	12	13	54	56	65	71	57	7	11	18	6	11 Feb
1985	9	5	7	7	38	59	69	62	53	32	10	7	5	19 Feb
1986	7	10	8	22	47	57	73	64	53	18	14	12	7	22 Jan
1987	7	8	15	6	32	60	61	69	56	34	12	9	6	Apr
1988	8	7	5	16	41	58	70	72	56	21	12	15	5	Mar
1989	5	8	18	9	30	61	73	58	56	25	18	13	5	Jan
1990	9	12	9	42	6	57	71	71	59	25	6	12	6	May

STATION: Salalah Airport, Monthly Mean Wind Speed (m/s)

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
1981			4	4	4	5	2	4	4	4	2	3		
1982	3	4	4	4	4	5	5	4	4	3	3	4	3.6	
1983	4	3	4	4	5	5	4	4	4	4	2	4	3.7	
1984	4	3	2	3	3	5	4	3	4	2	3	4	3.1	
1985	3	4	3	3	3	5	3	3	3	3	3	4	3.3	
1986	4	4	3	3	3	4	4	3	3	2	2	4	3.0	
1987	3	3	3	3	3	4	4	4	3	2	3	4	3.0	
1988	4	3	3	3	3	4	3	2	3	2	2	3	2.7	
1989	4	3	2	3	2	3	3	2	3	2	2	4	2.6	
1990	3	3	2	2	3	4	3	2	3	2	2	3	2.5	
Average														
1981-90	3.4	3.2	2.9	2.9	3.2	4.2	3.2	2.9	3.2	2.5	2.3	3.4	3.1	

APPENDIX 2
LABORATORY ANALYSES

PEDON IDENTIFICATION : SALALAH 13 PHOTO 27 Typic Calciorthids fine loamy, moderately deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)									
			Total			Silt			Sand																
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2 -20	20 -50	50 -100	100 -250	250 -500	500 -1000	1000 -2000													
<=====Pct. of <2 um =====>																									
0-13	Ap	13	49.3	28.4	22.3	13.6	14.8	53.6	21.3	16.2	7.8	1.2	15.1	L+	7.44										
13-25	C1	12	46.4	30.3	23.3	11.5	18.8	53.1	22.5	14.9	7.7	1.8	15.4	L+	8.34										
25-37	Ck2	12.5	49.3	25.2	25.5	14.1	11.1	41.0	20.2	21.7	13.3	3.9	13.7	SCL	8.35										
37-62	Ck3	27.5	35.8	31.9	32.3	23.7	8.2	49.2	21.9	16.6	9.0	3.3	12.2	CL	8.26										
0-25			49.2	31.9	18.9	14.4	17.5	54.1	20.9	14.7	8.2	2.0	20.1	L+	8.39										
Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)											
								Ca	Mg	Na	K														
								<=====meq/100g=====>																	
0-13	51.0	TR	7.2	16.0	5237	1000	5.2	4.6	35.9	2.3	0.5	0.6	8.0	6.5	5.2										
13-25	49.3	0.0	8.3	16.3	3380	360	9.4	0.7	33.6	2.0	0.6	0.6	6.1	10.0	0.2										
25-37	52.3	0.0	8.6	15.9	2971	220	13.5	4.2	30.7	2.1	0.4	0.4	6.4	6.8	0.2										
37-62	48.5	0.0	7.9	19.2	2765	240	11.5	1.1	36.0	2.5	0.8	0.3	9.0	8.7	0.2										
0-25	49.3	0.0	6.3	16.2	4778	490	9.8	6.0	33.2	2.1	0.7	1.0	9.0	7.8	0.2										
Saturated paste extract																									
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY											
															<=====meq/l=====>										
0-13	32.6	197.5	27.5	356.5	5.1	0.0	1.0	305.9	265.6			33.6	64.9	7.42											
13-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-											
25-37	-	-	-	-	-	-	-	-	-	-	-	-	-	-											
37-62	-	-	-	-	-	-	-	-	-	-	-	-	-	-											
0-25	31.6	20.0	29.2	13.0	0.8	0.5	2.9	6.7	46.8			2.6	1.6	8.51											

PEDON IDENTIFICATION: SALALAH 21 PHOTO 27 Aquic Entropepts fine loamy, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand				Coarse fragm. pct.		
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000			
Pct. of <2 mm															
0-20	Ap	20	69.3	18.4	12.3	12.2	6.2	36.4	20.6	19.2	14.8	8.9	68.8	SL	8.06
20-45/50	C1	27.5	69.5	18.3	12.2	11.1	7.1	38.2	20.5	19.8	14.9	6.7	12.0	SL	8.43
45/50-75	C2	17.5	63.3	15.7	21.0	8.3	7.4	41.6	19.8	16.7	14.0	7.8	23.7	SCL	8.46
75-120	Ckg3	45	49.4	25.3	25.3	16.1	9.1	33.6	22.3	18.2	16.4	9.6	70.2	SCL	8.41
120-150	Ckg4	30	43.2	31.4	25.4	2.0	29.5	30.9	23.4	22.6	14.6	8.6	54.7	L+	8.31
0-25			67.8	19.1	13.1	12.0	7.1	35.0	20.9	20.4	15.0	8.7	17.1	SL	8.14
Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases Ca Mg Na K neq/100g				C E C	ESP	EC (1:5)	
0-20	61.7	0.0	4.8	16.6	3315	440	7.5	10.2	28.2	3.0	0.3	0.8	4.1	6.4	1.0
20-45/50	59.7	0.0	4.9	17.6	3343	380	8.8	6.2	26.5	2.6	0.3	0.5	3.6	7.3	0.2
45/50-75	54.8	0.0	6.2	25.8	-	-	-	-	29.4	3.0	0.2	0.3	3.7	4.7	0.2
75-120	64.3	0.0	8.6	26.5	-	-	-	-	30.9	3.1	0.3	0.4	5.1	5.1	0.2
120-150	57.9	0.0	9.8	28.0	-	-	-	-	29.0	3.1	0.3	0.4	3.7	7.0	0.2
0-25	64.3	0.0	4.4	14.2	3368	550	6.1	16.6	28.0	2.7	0.3	0.7	3.4	10.3	0.8
Saturated paste extract															
Depth (cm)	Water at sat.pct	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	Water at sat. pct.	
neq/l															
0-20	25.5	60.0	29.2	87.0	5.1	0.0	1.3	135.0	30.0		13.0	16.6	8.15	25.5	
20-45/50	-	-	-	-	-	-	-	-	-		-	-	-	-	
45/50-75	-	-	-	-	-	-	-	-	-		-	-	-	-	
75-120	-	-	-	-	-	-	-	-	-		-	-	-	-	
120-150	-	-	-	-	-	-	-	-	-		-	-	-	-	
0-25	21.7	74.8	31.3	60.9	3.6	0.0	2.2	75.6	80.0		8.4	11.2	8.30	21.7	

PEDON IDENTIFICATION : SALALAH 22 PHOTO 27 Typic Torrifuvents loamy, shallow

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse (fragm. pct.)	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000				
<=====Pct. of < 2 mm =====>																
0-10	Ap	10	67.5	16.6	15.9	5.2	11.4	37.0	24.6	18.9	13.8	5.8	9.3	SL	7.73	
10-27	C1	17	68.6	15.5	15.9	5.2	10.4	38.0	24.9	19.2	13.3	4.6	22.5	SL	8.14	
27-40	C2	13	61.8	14.7	23.5	6.3	8.4	42.9	21.6	21.6	10.2	3.7	45.5	SCL	8.09	
0-25			67.6	13.9	18.5	3.2	10.7	36.0	25.3	20.0	13.9	4.8	15.4	SL	7.97	

Depth (cm)	CaCO3 < 2 mm pct.	CaSO4 < 2 mm pct.	Water content pct. 15 bar	Organ. C p.p.e.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)	
								Ca	Mg	Na	K				
								<=====neq/100g=====>							
0-10	63.4	0.0	5.2	12.9	5558	780	7.1	14.4	29.0	1.5	0.3	0.4	5.2	5.0	0.6
10-27	61.7	0.0	5.8	12.0	4680	580	8.1	6.7	26.3	1.5	0.2	0.3	7.4	2.4	0.2
27-40	57.4	0.0	6.9	14.4	2872	400	7.2	2.3	29.1	1.7	0.2	0.2	5.1	3.4	0.2
0-25	64.3	0.0	6.2	12.7	5460	700	7.8	13.3	29.5	1.5	0.2	0.3	5.4	3.2	0.3

Saturated paste extract																												
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY														
															<===== neq/l =====>													
															0-10	32.8	22.5	37.5	13.0	0.8	0.8	3.5	20.5	46.8		2.4	4.8	7.89
10-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-														
27-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-														
0-25	35.2	12.5	35.4	10.9	0.3	0.7	4.6	5.2	46.0		2.2	1.6	8.05															

PEDON IDENTIFICATION: SALALAH 50 PHOTO 27 Typic Calciorthids fine loamy, very deep

Depth (cm)	Horizon (cm)	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand	Silt	Clay	2	20	50	100	250	500	1000				
			(50-2000)	(2-50)	(<2)	-20	-50	-100	-250	-500	-1000	-2000				
Pct. of <2 mm																
0-10	Ap	10	65.5	18.1	16.4	6.0	12.1	34.2	27.6	21.2	12.7	4.2	30.8	SL	8.15	
10-40	C1	30	63.5	18.1	18.4	5.0	13.1	34.4	27.3	20.6	12.8	4.9	34.8	SL+	8.03	
40-56	Ck2	16	49.3	23.7	27.1	13.4	10.3	43.8	27.8	16.6	8.3	3.5	27.0	SCL	8.16	
56-90	Ck3	34	35.1	28.1	36.8	19.8	8.3	39.4	38.9	13.6	5.9	2.2	41.0	CL+	8.25	
90-110	Ck4	20	44.7	23.6	31.7	15.7	7.9	28.2	52.0	14.9	4.2	0.7	44.0	CL	8.17	
110-132	Ck5	12	54.7	32.3	13.0	26.4	5.9	20.7	58.4	17.9	2.6	0.3	51.5	SCL	8.23	
132-150	C6	18	64.7	25.2	10.0	19.4	5.8	11.5	63.9	22.3	2.2	0.1	30.2	SCL	8.23	
0-25		25	67.7	13.4	18.9	4.1	9.3	35.2	27.4	20.8	12.2	4.3	34.2	SL+	8.11	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content		Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)
			pct.	pct.					Ca	Mg	Na	K			
			15 bar	1/3 bar					neq/100g						
0-10	68.3	0.0	5.6	15.4	11310	1060	10.7	14.7	26.8	1.5	0.2	1.2	6.9	2.5	0.3
10-40	68.9	0.0	4.7	14.5	5021	560	9.0	13.6	35.3	1.6	0.3	0.6	4.8	5.5	0.4
40-56	54.8	0.0	6.6	17.6	3510	450	7.8	4.9	32.9	2.3	0.2	0.5	7.3	2.4	0.3
56-90	59.7	0.0	7.3	21.0	-	-	-	-	32.9	2.7	0.2	0.4	8.7	2.0	0.2
90-110	66.9	0.0	6.6	18.1	-	-	-	-	22.3	1.6	0.3	2.6	4.7	6.1	0.2
110-132	76.6	0.2	7.0	14.5	-	-	-	-	-	-	-	-	2.9	-	0.2
132-150	81.8	0.2	4.0	10.9	-	-	-	-	-	-	-	-	2.6	-	0.2
0-25	67.9	0.0	4.6	12.6	4193	450	9.3	8.3	19.5	1.2	0.2	0.6	4.9	4.1	0.3

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40-56	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56-90	-	-	-	-	-	-	-	-	-	-	-	-	-	-
90-110	-	-	-	-	-	-	-	-	-	-	-	-	-	-
110-132	-	-	-	-	-	-	-	-	-	-	-	-	-	-
132-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	31.3	10.0	10.4	8.7	1.3	0.3	1.6	8.8	19.5		2.7	2.8	7.87	

PEDON IDENTIFICATION: SALALAH 53 PHOTO 27 Typic Calciorthis clayey, very deep

Depth (cm)	Horizon	THICKNESS (cm)	Size class and particle diameter (microns)										Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand						
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000			
Pct. of <2 mm															
0-14	Ap	14	45.8	25.3	28.8	13.7	11.6	56.5	25.0	13.8	3.8	0.8	34.9	SCL	8.13
14-30	C1	16	45.1	26.2	28.7	14.7	11.5	56.3	24.6	13.9	4.1	1.2	50.7	SCL	8.22
30-48	Ck2	18	30.9	32.6	36.6	24.0	8.5	52.3	28.7	12.3	4.7	2.0	22.6	CL+	8.15
48-80	CK3	32	32.1	30.4	37.4	11.9	18.5	39.2	28.1	12.7	7.2	12.8	26.6	CL+	8.17
80-100	CK4	20	47.3	17.9	34.9	12.8	5.1	23.0	49.2	18.5	5.2	4.2	43.2	SCL	8.02
100-150	C5	50	74.6	4.5	20.9	1.5	2.9	15.3	55.7	25.2	3.2	0.6	21.5	SCL	8.04
0-25			48.2	22.7	29.1	12.8	9.9	54.6	24.9	13.7	4.6	2.2	37.5	SCL	8.04

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar	Organ. C p.p.m. 1/3 bar	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)	
								Ca	Mg	Na	K				
								meq/100g							
0-14	47.9	0.0	8.0	19.9	7595	760	10.0	13.6	21.0	1.6	0.3	1.4	8.8	3.7	0.3
14-30	47.9	0.0	7.8	18.3	5363	570	9.4	10.2	22.4	1.8	0.3	1.2	7.5	4.1	0.4
30-48	52.9	0.0	7.8	20.9	2470	280	8.8	1.9	22.3	2.0	0.3	0.9	8.2	3.4	0.3
48-80	51.0	0.0	8.3	18.8	1314	250	5.3	1.1	21.3	2.7	0.5	0.5	9.1	5.1	0.2
80-100	66.2	0.0	7.2	17.8	-	-	-	-	21.3	1.8	0.3	0.2	4.7	7.0	0.2
100-150	85.1	0.0	7.6	9.3	-	-	-	-	-	-	-	-	-	-	0.2
0-25	45.7	0.0	8.3	5.0	6463	710	9.1	12.1	33.2	2.0	0.3	1.2	7.9	3.6	0.3

Saturated paste extract																								
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY										
															meq/l									
0-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
14-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
30-48	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
48-80	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
80-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
100-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
0-25	42.7	25.0	16.7	4.3	1.5	0.5	1.8	7.0	39.2		1.0	1.8	2.17											

PEDON IDENTIFICATION : SALALAH 63 PHOTO 27 Typic Torrifuvents fine loamy, moderately deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)										Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand						
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000			
0-15	Ap	15	66.7	14.7	18.6	4.2	10.5	46.4	22.0	16.1	10.5	4.9	26.2	SL+	7.42
15-30	C1	15	62.6	15.2	22.2	5.8	9.4	48.1	21.0	14.8	10.0	6.1	32.3	SCL	8.22
30-55	C2	25	53.9	22.6	23.4	11.1	11.5	53.3	21.7	13.2	7.8	4.0	40.7	SCL	8.04
55-75	C3	20	52.4	20.3	27.3	11.0	9.3	49.0	17.0	11.9	10.3	11.8	55.2	SCL	8.09
0-25			64.5	13.6	21.9	6.0	7.6	46.8	22.1	15.2	10.4	5.5	35.1	SCL	8.02

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)	
								Ca	Mg	Na	K				
								(<-----meq/100g----->)							
0-15	51.2	0.0	5.3	12.3	5906	920	6.4	8.7	27.4	1.1	0.2	0.2	5.3	3.9	4.0
15-30	51.4	0.0	5.3	12.2	3380	390	8.7	4.5	27.4	1.0	0.1	0.2	4.8	3.1	0.2
30-55	50.6	0.0	6.3	14.0	2496	340	7.3	2.3	24.5	1.3	0.2	0.6	5.1	3.9	0.2
55-75	54.8	0.0	5.9	13.6	-	-	-	-	27.0	1.8	0.3	1.4	4.4	5.9	0.2
0-25	53.1	0.0	5.7	11.9	3803	420	9.1	3.8	29.4	2.0	0.3	1.2	5.0	6.4	0.5

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-55	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55-75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	32.4	15.0	16.7	26.1	2.6	1.0	0.5	32.8	23.6			6.6	6.4	2.06

PEDON IDENTIFICATION: SALALAH 81 PHOTO 27 Typical Calciorthids loamy skeletal, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)										Coarse fragm. pct.	PARTIC. SIZE CLASS
			Total			Silt			Sand					
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2 -20	20 -50	50 -100	100 -250	250 -500	500 -1000	1000 -2000		
<-----Pct. of < 2 mm ----->														
0-12	Ap	12	57.3	19.4	23.3	10.0	9.4	45.7	21.2	17.6	10.9	4.6	35.5	SCL
12-45	C1	33	64.2	16.0	19.9	8.8	7.2	32.1	16.0	16.3	19.3	16.3	56.6	SL+
45-70	Ck2	25	51.1	18.0	31.0	9.8	8.2	30.4	16.8	20.6	17.9	14.3	65.0	SCL
70-110	Ck3	40	45.4	19.9	34.7	14.6	5.4	34.1	25.1	21.6	13.8	5.4	79.5	SCL
110-150	Ck4	40	48.7	26.9	24.4	12.7	14.2	50.2	24.2	19.1	5.6	0.9	81.9	SCL
0-25		25	53.4	20.8	25.8	7.0	13.8	52.9	24.1	17.4	5.0	0.6	42.4	SCL
Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar | 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP		
								Ca	Mg	Na	K			
<-----meq/100g----->														
0-12	48.5	0.0	7.1	16.5	3120	270	11.6	3.8	33.5	1.8	1.2	0.5	7.8	14.9
12-45	60.4	0.0	5.4	13.3	2301	200	11.5	2.1	40.2	1.6	0.7	0.2	4.4	16.7
45-70	62.1	0.0	10.9	17.1	2886	200	14.4	0.0	33.2	1.6	0.8	0.2	4.7	16.5
70-110	52.3	0.0	10.2	20.0	-	-	-	-	34.5	1.2	1.0	0.3	4.9	20.5
110-150	55.3	0.0	9.2	12.2	-	-	-	-	33.0	1.5	1.1	0.3	9.7	11.2
0-25	52.7	0.0	6.7	15.6	5906	540	10.9	5.0	30.2	1.2	1.2	0.4	10.0	11.7
Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-12	33.8	10.0	12.1	60.9	0.5	0.5	1.7	53.0	25.0		18.3	8.1	8.02	
12-45	30.5	15.5	9.2	47.2	0.3	0.5	1.3	42.0	30.0		13.6	7.7	8.12	
45-70	25.7	11.5	4.2	20.2	0.3	0.4	1.2	23.0	20.0		7.4	4.0	8.27	
70-110	-	-	-	-	-	-	-	-	-		-	-	-	
110-150	-	-	-	-	-	-	-	-	-		-	-	-	
0-25	29.3	25.0	31.7	73.9	1.5	0.8	4.1	100.0	20.0		13.9	9.2	7.87	

PEDON IDENTIFICATION: SALALAH 108 PHOTO 21 Calcic Gypsiorthids loamy skeletal, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)										Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt		Sand							
			Sand {50 -2000}	Silt {2-50}	Clay {<2}	2 -20	20 -50	50 -100	100 -250	250 -500	500 -1000	1000 -2000			
Pct. of <2 mm															
0-10	Ap	10	48.2	30.9	20.9	20.9	10.0	42.8	25.6	18.2	8.9	4.4	77.6	L+	7.96
10-25	C1	15	53.2	26.9	19.9	18.9	8.0	33.3	31.6	21.2	8.9	5.1	67.8	SL+	8.00
25-50	Ck2	25	46.0	28.0	26.0	22.8	5.2	37.3	36.2	15.2	6.8	4.5	72.7	L+	7.96
50-80	Ck3	30	36.7	52.1	11.2	44.9	7.2	33.7	28.5	18.1	12.0	7.7	74.1	SiL+	7.63
80-110	Cky4	30	36.6	31.1	32.2	27.0	4.2	27.6	27.3	22.6	14.5	8.0	80.0	CL	7.50
110-150	Cky5	40	31.6	33.2	35.2	29.1	4.0	21.5	19.9	22.1	21.4	15.2	77.5	CL+	7.50
0-25			49.4	23.8	26.8	15.8	7.9	36.2	26.0	23.1	9.8	5.0	64.5	SCL	8.06

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	EC ESP (1:5)		
								Ca	Mg	Na	K				
								Pct. of <2 mm							
0-10	57.8	0.0	2.6	21.7	6230	810	7.7	14.5	33.1	3.0	1.2	0.8	9.0	13.6	0.9
10-25	60.8	0.0	7.8	22.9	4875	520	9.4	0.0	31.9	3.2	1.1	0.8	4.9	23.2	0.9
25-50	68.7	0.0	7.4	22.4	3413	350	9.8	0.0	35.2	2.8	0.9	0.7	4.5	19.2	0.9
50-80	71.4	0.0	8.1	19.9	-	-	-	-	33.7	1.5	0.9	0.6	3.3	26.3	1.2
80-110	59.5	9.6	8.9	20.4	-	-	-	-	109.5	1.0	0.5	0.6	1.6	33.3	2.6
110-150	61.7	5.4	9.9	17.8	-	-	-	-	91.8	1.0	0.4	0.6	2.0	21.7	2.3
0-25	55.9	0.0	8.3	18.6	6407	750	8.5	13.3	31.6	2.0	1.3	0.9	8.8	14.9	0.8

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-10	36.7	70.0	21.0	87.0	1.5	0.0	2.4	88.9	80.0		12.9	11.2	8.36	
10-25	34.2	25.0	50.0	52.2	1.8	0.0	1.8	96.4	40.0		8.5	11.7	8.43	
25-50	37.7	12.8	20.8	87.0	1.5	0.0	1.8	95.0	40.0		31.2	9.8	8.49	
50-80	43.4	70.0	11.7	19.1	2.1	0.0	2.3	52.2	31.2		3.0	10.8	8.35	
80-110	37.1	17.5	10.0	47.8	2.1	0.0	1.3	44.4	37.1		12.9	9.4	7.13	
110-150	29.3	22.5	8.3	39.1	1.8	0.0	1.0	35.4	23.4		10.0	7.7	8.03	
0-25	33.9	19.8	10.0	78.3	2.1	0.8	3.3	88.1	23.4		20.3	10.0	7.86	

Depth (cm)	Horizon (cm)	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000	<===== Pct. of <2 mm =====			
0-15	Ak	15	59.6	26.9	13.5	17.6	9.3	50.1	19.1	13.5	10.4	7.0	-	SL	8.44	
15-40/45	Ck1	27.5	56.6	24.8	18.6	19.6	5.2	14.5	30.5	21.0	17.6	16.3	-	SL+	7.73	
40/45-85	Ck2	42.5	63.4	16.8	19.8	13.8	3.0	18.8	17.9	19.3	20.1	23.8	-	CoSL+	7.99	
85-120	Ck3	35	71.7	10.7	17.6	9.7	1.0	10.9	10.9	19.8	27.2	30.7	-	CoSL	7.89	
120-160	Ck4	40	81.7	7.7	10.6	6.7	1.0	8.3	9.4	17.1	34.4	30.8	-	LCoS	7.85	
0-25			51.0	30.0	19.0	21.0	9.0	45.2	19.7	14.0	11.7	9.4	-	L+	8.1	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content		Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)
			15 bar	1/3 bar					Ca	Mg	Na	K			
			<===== neq/100g =====												
0-15	59.0	0.0	5.9	17.6	4046	610	6.6	4.0	27.5	2.2	0.4	0.8	7.9	5.5	0.2
15-40/45	63.7	0.0	6.4	17.5	3023	440	6.9	0.1	30.1	1.8	0.8	0.5	6.2	12.7	1.7
40/45-85	72.4	0.0	4.5	11.2	1755	240	7.3	0.6	27.6	1.3	0.7	0.4	4.0	17.4	1.4
85-120	83.1	0.0	4.6	9.6	-	-	-	-	30.3	1.3	0.4	0.4	2.4	17.9	1.2
120-160	87.3	0.0	2.7	7.1	-	-	-	-	28.8	1.3	0.3	0.3	5.3	6.6	1.0
0-25	55.1	0.0	11.9	23.5	3608	590	6.1	4.0	28.1	1.7	0.7	0.8	10.4	6.7	0.7

Saturated paste extract																												
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY														
															<===== neq/l =====													
															0-15	-	-	-	-	-	-	-	-	-	-	-	-	-
15-40/45	26.8	75.0	83.3	60.9	2.1	0.0	1.3	213.0	8.0	-	-	6.8	30.6	7.88														
40/45-85	23.7	25.0	91.7	139.1	2.6	0.0	1.7	224.3	0.0	-	-	18.2	25.4	8.14														
85-120	24.9	20.0	82.5	165.2	2.1	0.0	1.6	103.5	160.0	-	-	23.1	15.0	8.35														
120-160	21.4	70.0	87.5	78.3	2.6	0.0	2.2	68.1	160.0	-	-	8.8	14.2	8.31														
0-25	33.1	47.5	62.5	30.4	1.5	0.0	0.8	62.0	78.0	-	-	4.1	7.7	8.31														

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000				
Pct. of < 2 mm																
0-20	Ap	20	73.3	14.3	12.4	7.0	7.3	23.5	23.8	21.2	19.6	11.9	35.6	SL	7.63	
20-45	Cy1	25	84.5	5.6	9.8	3.7	2.0	19.5	19.5	23.7	23.2	14.0	44.2	LCoS	7.71	
45-65	Cy2	20	80.7	11.0	8.4	8.2	2.8	22.6	22.6	25.8	19.3	9.7	24.9	CoSL	7.65	
65-90	Cy3	25	85.5	5.3	9.2	3.4	1.9	19.2	17.8	25.3	21.7	16.0	50.6	LCoS	7.77	
90-110	Cy4	20	85.6	5.7	8.6	3.8	1.9	3.0	7.7	18.6	32.8	37.8	28.4	LCoS	7.70	
110-160	Cy5	50	83.5	4.8	11.7	4.8	0.0	3.6	9.6	22.3	27.1	37.4	44.2	LCoS	7.75	
0-25			77.8	9.4	12.8	4.0	5.4	19.6	24.1	22.0	20.2	14.2	83.1	CoSL	7.75	

Depth (cm)	CaCO3 < 2 mm pct.	CaSO4 < 2 mm pct.	Water content pct. 15 bar; 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								Ca	Mg	Na	K				
								neq/100g							
0-20	77.5	7.8	5.7	10.8	3120	410	7.6	16.3	63.6	2.0	0.4	0.5	1.0	41.7	4.6
20-45	79.3	12.9	5.2	6.5	1422	170	8.4	3.4	108.7	1.7	0.2	0.2	1.7	10.0	3.3
45-65	81.8	11.6	10.2	3.8	4937	350	14.1	0.6	97.0	1.6	0.1	0.2	1.0	8.3	3.2
65-90	81.3	10.8	4.3	6.8	-	-	-	-	77.6	1.4	0.1	0.2	1.1	7.7	2.9
90-110	99.4	0.9	2.2	2.7	-	-	-	-	26.2	2.0	0.2	0.2	1.0	16.7	1.8
110-160	98.5	2.4	2.9	4.8	-	-	-	-	47.4	2.0	0.1	0.3	1.2	7.1	2.5
0-25	77.0	11.6	5.1	10.4	2265	260	8.7	11.8	89.2	1.1	0.3	0.2	2.2	12.0	3.1

Saturated paste extract																												
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY														
															neq/l													
															0-20	22.9	120.0	112.5	87.0	8.7	0.0	1.8	239.4	90.0		8.1	54.0	7.84
20-45	28.4	47.5	95.8	526.1	2.8	0.0	1.5	276.1	392.0		62.1	22.7	8.24															
45-65	28.4	63.0	145.8	130.4	3.6	0.0	1.3	161.9	160.0		12.8	24.0	8.22															
65-90	29.1	120.0	108.3	8.7	4.1	0.0	1.3	120.5	120.0		0.8	17.4	8.40															
90-110	26.6	45.0	75.0	52.2	4.1	0.0	0.9	67.5	80.0		6.7	11.1	8.60															
110-160	25.5	77.5	208.3	434.8	5.1	0.0	1.1	32.8	600.0		36.4	12.0	8.39															
0-25	24.2	115.0	100.0	130.4	3.1	0.0	1.7	236.6	120.0		12.6	25.4	8.07															

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											PARTIC. SIZE CLASS	pH (1:2.5)										
			Total			Silt			Sand							Coarse fragn. pct.									
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000													
Pct. of <2 mm																									
0-20	Ap	20	57.5	20.7	21.8	16.6	4.2	41.7	21.0	18.1	12.2	7.1	35.6	SCL	8.13										
20-33	C1	13	53.8	22.1	24.1	15.0	7.1	43.1	22.5	18.1	11.2	5.1	44.2	SCL	8.23										
33-55/60	C2	24.5	55.1	22.9	22.0	13.9	9.0	42.0	22.5	18.1	12.2	5.2	24.9	SCL	8.16										
55/60-75	2Ckg3	17.5	51.6	22.2	26.3	18.1	4.0	13.6	17.3	24.2	27.8	17.1	50.6	SCL	8.14										
75-110	2Ckg4	35	73.1	12.5	14.4	10.5	1.9	6.6	17.8	28.5	28.6	18.5	28.4	CoSL	8.36										
0-25			55.2	21.4	23.4	14.2	7.1	40.5	23.3	18.5	11.5	6.1	44.2	SCL	8.28										
Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)												
								Ca	Mg	Na	K														
								neq/100g																	
0-20	66.5	0.0	9.2	18.1	6240	680	9.2	15.2	33.2	0.3	0.3	0.4	6.1	4.3	0.5										
20-33	60.4	0.0	9.2	16.7	5970	550	9.2	9.6	31.0	0.3	0.3	0.3	1.0	25.0	0.3										
33-55/60	63.8	0.0	8.2	13.7	3803	420	9.1	13.5	27.5	0.2	0.3	0.4	4.6	5.7	0.3										
55/60-75	84.0	0.0	5.7	6.7	-	-	-	-	28.5	0.2	0.2	0.1	4.3	4.0	0.3										
75-110	90.8	0.0	2.1	15.2	-	-	-	-	26.6	0.2	0.1	0.1	2.6	3.3	0.2										
0-25	63.8	0.0	7.5	25.1	7605	720	10.6	18.5	31.2	0.3	0.3	0.4	5.1	5.1	0.3										
Saturated paste extract																									
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY											
															neq/l										
															neq/l										
0-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-											
20-33	-	-	-	-	-	-	-	-	-	-	-	-	-	-											
33-55/60	-	-	-	-	-	-	-	-	-	-	-	-	-	-											
55/60-75	-	-	-	-	-	-	-	-	-	-	-	-	-	-											
75-110	-	-	-	-	-	-	-	-	-	-	-	-	-	-											
0-25	31.1	-	-	-	-	0.0	0.1	-	-	-	-	1.9	7.88	-											

PEDON IDENTIFICATION: SALALAH 311 PHOTO 31 Typic Ferrifluvents coarse loamy, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand	Silt	Clay	2	20	50	100	250	500	1000	2000			
			(50-2000)	(2-50)	(<2)	-20	-50	-100	-250	-500	-1000	-2000	<=====Pct. of <2 mm=====>			
0-18	Ap	18	70.8	14.1	15.1	8.0	6.1	26.5	24.7	31.4	14.1	3.2	10.8	SL	7.94	
18-43	C1	25	70.1	12.9	17.0	5.9	7.0	27.2	25.3	31.9	12.8	2.9	7.7	SL	8.24	
43-63	C2	20	69.7	10.1	20.3	5.0	5.1	30.5	25.6	31.4	10.2	2.4	7.5	SCL	8.15	
63-93	C3	30	73.1	9.9	17.0	4.9	5.0	36.1	24.6	24.1	11.6	3.5	0.0	SL	8.16	
93-113	C4	20	74.7	9.7	15.6	3.8	5.9	26.1	23.5	28.1	17.2	5.2	2.7	SL	8.17	
113-130	C5	17	68.8	15.3	15.9	9.0	6.4	45.9	19.1	19.8	12.3	2.9	4.7	SL	8.05	
130-160	C6	30	73.7	8.4	17.9	6.4	2.0	17.5	21.8	32.4	23.4	4.9	5.1	SL	8.09	
0-25			68.5	13.3	18.1	9.0	4.3	23.7	23.9	34.2	16.4	2.8	7.8	SL+	7.99	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar | 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								Ca	Mg	Na	K				
								<=====meq/100g=====>							
0-18	67.7	0.0	5.0	15.7	5460	1050	5.20	9.5	27.9	2.2	0.8	0.6	8.3	9.4	1.2
18-43	68.7	0.0	5.3	12.8	6864	850	8.08	12.2	23.0	1.8	0.9	0.3	5.9	14.7	0.4
43-63	71.3	0.0	5.3	11.2	4903	540	9.08	8.9	25.6	1.6	0.5	0.3	6.3	8.3	0.4
63-93	64.8	0.0	4.3	9.8	-	-	-	-	23.2	1.3	0.4	0.4	5.1	8.5	0.3
93-113	69.5	0.0	3.7	8.3	-	-	-	-	22.2	1.1	0.3	0.3	4.5	7.7	0.3
113-130	60.9	0.0	4.4	11.3	-	-	-	-	23.4	1.4	0.6	0.3	5.0	12.3	0.5
130-160	78.1	0.0	5.6	10.5	-	-	-	-	20.8	1.7	0.5	0.2	5.2	16.0	0.4
0-25	65.5	0.0	5.5	12.3	7540	830	9.08	11.2	27.3	2.2	0.8	0.5	8.7	9.0	0.8

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-18	26.2	4.5	60.4	121.7	3.8	0.6	3.5	149.9	31.2			21.4	20.0	8.08
18-43	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43-63	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63-93	-	-	-	-	-	-	-	-	-	-	-	-	-	-
93-113	-	-	-	-	-	-	-	-	-	-	-	-	-	-
113-130	-	-	-	-	-	-	-	-	-	-	-	-	-	-
130-160	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	28.0	3.0	41.7	60.9	2.1	0.5	1.9	102.5	15.6			12.9	10.8	8.18

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)	
			Total			Silt			Sand								
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000					
0-10	Ap	10	-	-	-	-	-	-	-	-	-	-	-	-	-	SL	8.41
10-30	C1	20	-	-	-	-	-	-	-	-	-	-	-	-	-	LS	8.33
0-25			-	-	-	-	-	-	-	-	-	-	-	-	-	LS	8.34

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar | 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)
								Ca	Mg	Na	K			
								p.p.m. (equiv/100g)						
0-10	70.7	-	-	-	-	-	-	-	-	-	-	-	-	0.3
10-30	72.4	-	-	-	-	-	-	-	-	-	-	-	-	0.2
0-25	75.3	-	-	-	-	-	-	-	-	-	-	-	-	0.2

PEDON IDENTIFICATION: SALALAH 336 PHOTO 31 Typic Torrifuvents sandy, deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)	
			Total			Silt			Sand								
			Sand (50 -2000)	Silt (2-50)	Clay (<2)	2 -20	20 -50	50 -100	100 -250	250 -500	500 -1000	1000 -2000	Pct. of <2 mm				
0-15	Ap	15	-	-	-	-	-	-	-	-	-	-	-	-	-	SL	8.46
15-32	C1	17	-	-	-	-	-	-	-	-	-	-	-	-	-	SL	8.38
32-54	C2	22	-	-	-	-	-	-	-	-	-	-	-	-	-	LS	8.4
54-77	C3	23	-	-	-	-	-	-	-	-	-	-	-	-	-	LS	8.42
77-105	C4	28	-	-	-	-	-	-	-	-	-	-	-	-	-	LS	8.38
105-135	Ck5	30	-	-	-	-	-	-	-	-	-	-	-	-	-	SL	8.42
0-25			-	-	-	-	-	-	-	-	-	-	-	-	-	SL	8.5

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar | 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)
								Ca	Mg	Na	K			
								meq/100g						
0-15	65.4	0.0	-	-	-	-	-	-	-	-	-	-	-	0.3
15-32	67.1	0.0	-	-	-	-	-	-	-	-	-	-	-	0.2
32-54	70.8	0.0	-	-	-	-	-	-	-	-	-	-	-	0.2
54-77	65.2	0.0	-	-	-	-	-	-	-	-	-	-	-	0.2
77-105	78.2	0.0	-	-	-	-	-	-	-	-	-	-	-	0.2
105-135	72.5	0.0	-	-	-	-	-	-	-	-	-	-	-	0.2
0-25	67.6	0.0	-	-	-	-	-	-	-	-	-	-	-	0.2

PEDON IDENTIFICATION: SALALAH 341 PHOTO 31 Typic Torripsannents, moderately deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000	<2000			
0-8	C1	8	77.1	12.4	10.5	6.0	6.3	13.5	14.0	53.4	16.9	2.2	10.9	SL	7.85	
8-40	C2	32	88.0	1.8	10.2	0.7	1.0	3.7	14.0	59.5	19.8	2.9	5.8	LS	7.86	
40-55	C3	15	90.4	3.1	6.4	3.1	0.0	1.6	37.4	48.2	12.5	0.2	2.6	S	8.47	
0-25			86.3	5.0	8.8	4.0	1.0	4.5	11.5	56.4	23.8	3.8	43.9	LS	7.84	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								Ca	Mg	Na	K				
								(<=====meq/100g=====)							
0-8	73.7	4.5	3.0	12.5	3727	290	12.9	9.6	62.3	3.0	0.4	0.4	1.8	23.8	8.7
8-40	89.1	1.3	1.5	5.8	1682	200	8.4	6.2	37.6	2.5	0.3	0.2	0.9	30.0	4.0
40-55	95.5	0.0	1.0	2.0	2383	170	14.0	1.2	15.1	2.2	0.1	0.1	0.8	11.1	0.2
0-25	87.8	2.7	1.8	6.6	1853	230	8.1	8.0	43.5	2.8	0.3	0.2	1.7	15.0	4.7

Saturated paste extract																												
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY														
															(<===== meq/l =====>)													
															0-8	79.7	115.0	154.2	236.1	19.0	0.0	2.6	541.7	120.0			19.5	145.8
8-40	22.1	150.0	170.8	147.8	1.0	0.0	1.8	444.4	0.0			11.7	60.0	8.37														
40-55	30.2	180.0	50.8	8.7	0.5	0.0	1.9	81.1	120.0			0.8	1.6	9.22														
0-25	23.8	105.0	116.7	217.4	7.7	0.0	1.6	270.4	160.0			20.6	46.8	8.33														

PEDON IDENTIFICATION: SALALAH 409 PHOTO 31 Typic Torrifuvents fine loamy, moderately deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000				
Pct. of <2 mm																
0-22	Ap	22	62.8	16.9	20.3	7.0	10.0	38.1	24.4	22.2	12.4	3.0	12.8	SCL	7.94	
22-49	C1	27	56.4	21.8	21.8	10.5	11.3	40.8	25.6	23.2	9.2	1.2	15.0	SCL	8.01	
49-70	C2	21	42.2	27.7	30.1	14.9	12.8	49.2	23.5	18.5	7.4	1.3	30.9	CL	8.05	
70-79	C3	9	58.4	18.0	23.6	7.4	10.6	51.3	24.1	17.5	6.7	0.4	20.3	SCL	8.05	
0-25			60.2	17.2	22.6	7.1	10.1	40.4	24.9	23.2	10.1	1.4	13.8	SCL	8.08	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								Ca	Mg	Na	K				
								neq/100g							
0-22	60.0	0.0	6.8	13.3	6500	710	9.2	12.8	32.3	2.0	0.4	0.2	1.4	31.3	0.4
22-49	59.5	0.0	8.2	14.3	3705	730	5.1	20.9	31.7	2.0	0.6	0.2	7.4	8.2	0.3
49-70	51.6	0.0	9.7	19.8	3900	470	8.3	0.2	36.2	2.1	0.9	0.2	12.8	6.8	0.3
70-79	57.2	0.0	6.6	14.3	-	-	-	-	31.4	1.5	0.5	0.1	5.6	9.4	0.3
0-25	62.8	0.0	7.2	14.1	6565	710	9.2	4.6	30.1	2.0	0.5	0.2	7.6	6.9	0.3

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
neq/l														
0-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-49	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49-70	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70-79	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	33.1	12.5	35.0	13.0	0.0	0.6	3.5	12.9	39.2		2.7	1.9	8.26	

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000				
			Pct. of <2 mm													
0-20	Ap	20	43.7	29.4	26.9	15.6	13.8	67.9	17.6	10.4	3.5	0.5	20.3	L+	7.92	
20-40	C1	20	43.1	29.7	27.2	12.9	16.8	75.7	15.5	6.6	1.8	0.5	27.8	L+	8.35	
40-58	C2	18	50.4	16.8	32.8	10.3	6.5	31.3	27.5	29.4	10.2	1.6	20.8	SCL	8.15	
58-80	C3	22	70.7	14.8	14.5	6.1	8.7	36.8	18.4	27.8	13.4	3.7	40.8	SL	8.17	
80-90	C4	10	56.0	22.1	21.8	9.2	12.9	62.0	22.8	9.4	4.2	1.6	24.8	SCL	8.17	
90-107	Ck5	17	54.7	23.9	21.4	12.8	11.1	60.7	23.1	11.4	4.0	0.8	22.3	SCL	8.13	
107-150	Ckg6	43	48.7	24.2	27.1	16.0	8.2	29.5	32.2	18.8	11.5	8.0	45.4	SCL	8.12	
0-25			62.7	18.8	18.5	9.7	9.1	44.9	21.9	19.2	13.8	0.1	36.7	SL+	7.92	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content		Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)	
			15 bar	1/3 bar					Ca	Mg	Na	K			
			p.p.m.						neq/100g						
0-20	55.3	0.0	5.6	13.9	15000	1380	10.9	15.4	28.8	1.7	0.4	0.6	9.7	3.8	0.6
20-40	63.8	0.0	4.0	9.2	5038	460	11.0	5.5	28.4	1.7	0.3	0.4	4.9	7.1	0.2
40-58	57.4	0.0	8.3	17.7	5400	560	9.6	7.2	27.5	1.5	0.3	0.3	8.3	3.8	0.2
58-80	57.8	0.0	7.9	15.5	-	-	-	-	29.2	2.3	0.4	0.6	8.2	4.6	0.2
80-90	45.7	0.0	9.8	22.7	-	-	-	-	29.5	4.1	0.6	0.3	13.1	4.7	0.5
90-107	49.5	0.0	8.3	18.0	-	-	-	-	29.2	2.9	0.5	0.4	8.2	6.4	0.2
107-150	70.3	0.2	12.0	20.2	-	-	-	-	33.8	4.3	0.6	0.2	6.6	8.4	0.2
0-25	61.7	0.0	6.1	12.9	11440	1160	9.9	11.6	25.2	2.0	0.3	0.7	8.7	3.6	0.4

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40-58	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58-80	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80-90	-	-	-	-	-	-	-	-	-	-	-	-	-	-
90-107	-	-	-	-	-	-	-	-	-	-	-	-	-	-
107-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	30.1	10.0	17.5	8.7	1.5	1.2	4.5	15.0	15.6		2.3	4.0	7.48	

PEDON IDENTIFICATION : SALALAH 417 PHOTO 31 Typic Torrfluvents fine loamy, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand	Silt	Clay	2	20	50	100	250	500	1000				
			(50-2000)	(2-50)	(<2)	-20	-50	-100	-250	-500	-1000	-2000				
<-----Pct. of <2 mm ----->																
0-14	Ap	14	66.3	17.5	16.2	8.0	9.5	35.8	19.1	26.8	14.0	4.4	33.9	SL	7.56	
14-40	C1	26	74.2	13.0	12.8	5.8	7.3	27.8	18.3	33.7	16.1	4.0	23.3	SL	8.12	
40-65	C2	25	47.5	27.9	24.6	16.5	11.5	58.3	26.6	12.2	1.8	1.1	33.7	SCL	8.08	
65-87	C3	22	38.0	34.4	27.6	21.9	12.5	61.5	24.1	11.9	1.2	1.3	37.0	CL	8.08	
87-120	C4	33	36.3	32.4	31.3	19.8	12.6	66.0	22.8	9.9	0.2	1.1	21.7	CL	8.03	
120-150	C5	30	49.1	23.8	27.1	12.6	11.1	61.5	27.1	9.1	1.3	1.0	37.2	SCL	8.13	
0-25			57.4	23.4	19.2	11.9	11.5	63.6	23.0	8.6	3.6	1.2	31.9	SL+	7.19	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct.	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)	
								Ca	Mg	Na	k				
								<-----meq/100g----->							
0-14	55.7	0.0	7.3	16.0	7670	870	8.8	7.2	32.1	2.0	0.7	0.8	7.8	8.7	0.8
14-40	56.3	0.0	7.3	15.1	7020	730	9.6	9.4	29.2	2.0	0.7	0.7	9.6	7.1	0.2
40-65	57.4	0.0	2.1	17.9	5330	500	10.7	6.1	33.5	1.8	0.4	1.1	8.7	4.1	0.2
65-87	57.8	0.0	9.4	19.5	-	-	-	-	31.8	1.7	0.3	1.0	7.6	4.5	0.2
87-120	56.5	0.0	8.2	18.9	-	-	-	-	35.7	1.9	0.4	0.5	7.7	5.5	0.2
120-150	58.7	0.0	6.6	16.2	-	-	-	-	32.7	1.4	0.3	0.3	5.8	5.7	0.2
0-25	51.0	0.0	7.3	16.9	8450	1080	7.8	10.5	28.7	1.7	0.4	0.6	9.6	4.1	0.7

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-14	36.8	34.0	16.7	17.4	1.5	0.5	2.2	37.5	31.2			2.8	8.8	7.78
14-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40-65	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65-87	-	-	-	-	-	-	-	-	-	-	-	-	-	-
87-120	-	-	-	-	-	-	-	-	-	-	-	-	-	-
120-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	38.8	27.5	11.7	21.7	1.0	1.1	3.6	32.0	23.6			4.9	5.9	7.81

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2 -20	20 -50	50 -100	100 -250	250 -500	500 -1000	1000 -2000				
<=====Pct. of <2 mm =====>																
0-5	Ap	5	50.5	28.9	20.5	17.8	11.2	50.6	24.4	16.0	7.4	1.6	30.3	L+	8.36	
5-25	C1	20	56.1	25.2	18.7	15.9	9.2	52.4	25.6	14.4	6.1	1.4	26.1	SL+	8.2	
25-52	C2	27	-	-	-	-	-	-	-	-	-	-	-	-	-	
52-70	Ck3	18	29.3	40.1	30.7	34.0	6.1	36.1	30.4	19.2	11.1	3.1	48.8	C	8.27	
70-120	Ck4	50	38.3	34.5	27.2	30.5	4.0	18.3	39.4	25.3	12.4	4.6	49.7	L+	8.21	
0-25			54.0	24.7	21.3	15.3	9.5	51.5	25.8	16.5	5.7	0.4	27.5	SCL	8.35	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content		Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)
			pct.						Ca	Mg	Na	K			
			15 bar	1/3 bar												<=====neq/100g=====>
0-5	60.4	0.0	10.7	21.1	8060	770	10.5	-	35.3	1.9	0.4	0.3	8.2	4.8	0.3
5-25	60.8	0.0	9.4	18.6	2808	350	8.0	-	36.3	1.4	0.4	0.2	3.8	10.2	0.3
25-52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52-70	68.0	0.0	11.1	23.1	-	-	-	-	29.2	1.2	0.4	0.3	5.4	7.1	0.2
70-120	72.7	0.0	8.7	17.2	-	-	-	-	31.5	1.1	0.3	0.2	4.0	7.2	0.2
0-25	62.5	0.0	8.3	16.4	5850	510	11.5	8.5	36.1	1.7	0.4	0.3	7.6	5.2	0.2

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. ds/m	pH	BULK DENSITY
0-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-52	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52-70	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70-120	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	31.8	5.0	52.1	1.3	0.3	1.2	2.2	10.3	39.2	-	0.2	1.5	8.87	-

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand	Silt	Clay	2	20	50	100	250	500	1000	2000			
			(50-2000)	(2-50)	(<2)	-20	-50	-100	-250	-500	-1000	-2000	<=====			
0-10/15	Ap	12.5	68.7	22.2	9.1	17.3	4.9	20.1	21.0	23.5	21.2	14.2	40	CoSL	8.16	
10/15-34	C1	21.5	82.8	11.1	6.0	10.2	1.0	9.3	17.3	28.0	28.0	17.5	70	LCoS	8.09	
34-66	C2	32	81.7	12.2	6.1	9.7	2.5	26.2	22.1	26.7	16.9	8.0	40	LS	8.27	
66-83	C3	17	76.7	15.9	7.4	14.8	1.2	26.7	21.4	25.5	17.2	9.2	10	LCoS	8.1	
83-102	C4	19	66.3	19.1	14.7	18.0	1.0	26.9	23.1	28.5	17.2	4.3	30	SL	7.77	
102-160	Ck5	58	36.9	43.2	19.9	39.9	3.3	28.7	25.7	7.2	25.1	13.3	20	L+	7.97	
0-25			66.7	22.2	11.1	16.3	5.9	19.2	20.3	23.3	22.2	14.9	50	SL	8.14	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar 1/3 bar	Organ. C p.p.e.	Total N p.p.e.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								Ca	Mg	Na	K				
								<=====neq/100g=====>							
0-10/15	79.3	0.0	7.0	9.2	6000	230	26.1	1.0	32.9	1.1	0.4	0.5	2.0	17.6	0.6
10/15-34	90.8	0.0	3.4	5.5	5200	120	43.3	1.0	27.1	0.9	0.2	0.3	1.0	21.7	0.8
34-66	73.3	0.9	5.2	6.4	4333	90	48.2	0.6	23.9	0.8	0.5	0.3	2.0	23.0	0.6
66-83	75.8	0.0	2.8	6.2	-	-	-	-	25.0	0.8	0.5	0.3	3.5	13.8	0.9
83-102	70.3	0.0	6.0	9.7	-	-	-	-	31.7	1.0	0.6	0.4	3.4	16.9	2.0
102-160	71.1	0.0	8.7	18.0	-	-	-	-	29.8	1.3	0.8	0.4	3.4	23.1	1.4
0-25	82.3	0.0	5.2	8.9	8667	320	27.1	0.2	27.9	0.9	0.4	0.5	2.8	12.5	0.6

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-10/15	21.5	27.5	10.4	6.1	3.3	0.4	0.8	102.5	86.0		1.4	9.5	7.88	
10/15-34	18.2	19.5	50.0	18.3	2.6	0.7	1.3	149.9	97.6		3.1	14.4	8.34	
34-66	24.1	25.5	10.4	10.4	1.5	0.4	1.1	95.0	48.8		2.5	9.4	8.77	
66-83	24.0	12.5	10.7	10.4	1.8	0.2	0.9	94.9	11.7		2.7	10.5	8.58	
83-102	33.2	25.0	23.8	14.8	2.6	0.6	0.7	138.9	15.6		3.0	13.7	8.50	
102-160	37.2	37.5	29.2	14.8	2.1	0.0	1.3	149.9	117.2		2.6	14.0	8.57	
0-25	20.2	65.0	34.2	15.7	7.7	0.3	1.1	138.9	27.4		2.2	10.9	8.35	

PEDON IDENTIFICATION: SALALAH 523 PHOTO 33 Typic Torrfluvents coarse loamy, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000				
0-13	Ap	13	57.8	25.4	16.8	17.1	8.3	36.0	24.3	23.4	12.6	3.6	46.8	SL	8.07	
13-27	C1	14	67.8	18.8	13.4	16.8	2.0	27.0	28.7	27.9	13.4	3.0	20.9	SL	8.09	
27-64	C2	37	71.6	16.9	11.5	13.8	3.1	35.2	27.1	22.8	11.3	3.6	14.6	SL	8.11	
64-94	C3	30	69.7	17.8	12.5	12.7	5.1	36.1	26.9	22.4	11.7	2.9	26.4	SL	8.09	
94-105	C4	11	42.7	33.1	24.2	28.8	4.2	72.4	16.4	7.2	3.4	0.7	56.2	L+	8.06	
0-25			62.6	24.9	12.4	17.8	7.1	34.8	25.6	23.5	13.0	3.1	33.8	SL	8.02	

Depth (cm)	CaCO3 pct.	CaSO4 pct.	Water content pct.	Organ. C	Total R	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								p.p.m.							
								Ca	Mg	Na	K				
0-13	64.3	0.0	8.8	19.0	15990	1340	11.9	6.8	33.2	2.1	0.3	0.3	10.4	2.4	0.2
13-27	72.1	0.0	6.4	13.2	4457	390	11.4	10.0	32.0	1.3	0.2	0.3	3.9	4.7	0.2
27-64	65.9	0.0	5.8	12.3	2925	290	10.1	6.8	32.5	1.3	0.1	0.3	4.4	3.3	0.2
64-94	69.4	0.0	5.8	11.6	-	-	-	-	34.1	1.1	0.3	0.3	3.0	10.0	0.2
94-105	71.8	0.0	8.9	17.2	-	-	-	-	36.2	1.4	0.2	0.3	3.5	5.5	0.3
0-25	63.9	0.0	8.6	17.6	12740	1110	11.5	16.0	38.7	2.1	0.3	0.3	7.6	3.3	0.2

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-64	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64-94	-	-	-	-	-	-	-	-	-	-	-	-	-	-
94-105	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	31.3	4.0	4.1	4.3	0.3	0.9	3.4	7.0	0.0	-	2.2	1.6	8.15	-

PEDON IDENTIFICATION: SALALAH 536 PHOTO 33 Typic Torripsanments, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)										Coarse fragn. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand						
			Sand	Silt	Clay	2	20	50	100	250	500	1000			
			(50-2000)	(2-50)	(<2)	-20	-50	-100	-250	-500	-1000	-2000			
Pct. of <2 mm															
0-18	Ap	18	77.5	7.1	15.4	3.6	3.6	19.5	21.6	25.3	21.9	11.8	12.5	SL	7.76
18-40	C1	22	90.5	5.4	4.1	5.4	0.0	2.7	25.3	46.0	24.1	1.9	9.2	S	8.33
40-180	C2	140	90.9	6.1	3.0	4.2	1.9	0.9	27.2	50.5	20.0	1.4	2.4	S	8.18
0-25		25	89.6	7.3	3.1	6.3	1.0	2.2	29.4	49.0	18.4	1.1	1.8	S	7.89

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar; 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								Ca	Mg	Na	K				
								meq/100g							
0-18	83.5	0.0	2.1	5.1	5850	390	15.0	0.0	21.6	1.1	0.3	0.2	1.6	17.8	2.9
18-40	88.2	0.0	2.5	6.2	2600	170	15.3	-	17.2	0.8	0.2	0.2	0.7	30.0	0.3
40-180	92.0	0.0	1.5	4.9	1242	100	12.9	-	12.4	0.6	0.2	0.1	0.3	63.3	0.2
0-25	89.0	0.0	2.1	4.1	4388	270	16.3	2.0	19.2	0.9	0.3	0.2	2.3	12.6	1.5

Saturated paste extract																								
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY										
															meq/l									
0-18	67.9	50.0	34.2	36.5	15.9	0.9	1.2	156.0	43.0			4.5	20.4	8.24										
18-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
40-180	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
0-25	30.2	60.0	67.5	30.4	17.9	0.8	1.5	148.4	37.1			3.8	19.2	8.65										

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											PARTIC. SIZE CLASS	pH (1:2.5)	
			Total			Silt			Sand							Coarse Fragm. pct.
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000				
Pct. of <2 mm																
0-9	Ap	9	54.3	31.9	13.8	22.5	9.4	39.7	25.8	19.2	11.4	3.8	23.8	SL	8.24	
9-29	C1	20	56.4	26.0	17.6	18.9	7.1	26.7	28.9	28.7	12.2	3.5	31.5	SL	8.33	
29-45	C2	26	60.3	23.5	16.2	18.5	5.0	23.1	27.8	33.4	12.9	2.7	32.5	SL	8.33	
45-84	C3	39	47.2	29.2	23.5	10.3	19.0	49.7	21.1	23.1	5.9	0.3	40.4	CL	8.33	
84-105	C4	21	34.0	36.7	29.3	19.0	17.6	35.6	20.5	39.7	3.7	0.5	20.5	CL	8.30	
105-122	Ck5	17	21.6	40.7	37.6	26.9	13.9	83.4	6.4	0.2	8.1	1.9	26.2	CL+	8.26	
122-150	Ckg6	28	32.0	32.2	35.8	25.9	6.4	33.4	20.0	19.1	20.9	6.6	65.0	CL+	8.28	
0-25			-	-	-	-	-	-	-	-	-	-	-		8.00	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar | 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								Ca	Mg	Na	K				
								Pct. of <2 mm							
0-9	45.4	0.0	14.3	22.1	25350	2490	10.2	6.8	26.3	3.4	1.1	0.9	19.0	5.6	0.3
9-29	63.8	0.0	8.9	17.2	10270	1000	10.3	-	22.2	1.9	0.5	0.3	10.7	4.8	0.2
29-45	67.7	0.0	7.2	15.6	5070	500	10.1	-	21.8	1.4	0.4	0.2	8.0	5.1	0.3
45-84	58.3	0.0	9.7	19.8	4680	420	11.1	-	22.7	1.7	0.6	0.3	9.1	6.1	0.2
84-105	46.7	0.0	12.5	25.9	-	-	-	-	24.0	2.4	0.9	0.3	17.0	5.0	0.3
105-122	52.3	0.0	18.2	36.6	-	-	-	-	25.6	3.4	1.1	0.3	14.3	7.4	0.3
122-150	70.7	0.0	21.8	37.3	-	-	-	-	25.8	3.7	0.9	0.2	17.7	5.0	0.4
0-25	87.0	0.0	-	-	-	-	-	4.0	15.8	0.9	0.3	0.3	2.4	14.3	1.1

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-9	28.2	17.5	20.8	21.7	13.8	0.3	1.4	15.0	54.8			5.0	11.8	8.74
9-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-45	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45-84	-	-	-	-	-	-	-	-	-	-	-	-	-	-
84-105	-	-	-	-	-	-	-	-	-	-	-	-	-	-
105-122	-	-	-	-	-	-	-	-	-	-	-	-	-	-
122-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)										Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand						
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000			
Pct. of <2 mm															
0-20	Ap	20	75.1	8.1	16.7	6.0	2.2	10.8	26.7	41.7	18.8	1.9	28.8	SL	8.07
20-54	C1	34	70.3	9.0	20.7	2.6	6.4	10.2	28.3	44.5	15.8	1.2	9.6	SCL	8.10
54-95	C2	41	82.1	1.6	16.4	1.6	0.0	5.9	29.3	45.9	17.8	1.1	7.6	SL	8.21
95-110	C3	15	79.7	7.2	13.1	6.2	1.0	4.9	32.1	45.8	16.2	1.0	6.5	SL	8.18
110-170	C4	60	90.9	1.3	7.9	0.3	0.9	0.6	14.2	55.8	27.8	1.6	0.9	S	8.11
0-25			67.9	14.5	17.6	12.5	2.0	10.6	27.2	41.9	18.5	1.8	16.7	SL	8.17

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar | 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								Ca	Mg	Na	K				
								meq/100g							
0-20	76.7	0.0	4.9	11.6	7644	790	9.7	4.4	30.0	1.8	0.3	0.2	4.2	7.7	1.4
20-54	76.3	0.0	3.9	11.0	5645	490	11.5	4.9	30.2	1.7	0.3	0.2	4.0	8.0	0.3
54-95	83.9	0.0	3.8	8.4	-	-	-	-	27.7	1.5	0.2	0.1	2.6	8.0	0.2
95-110	83.5	0.0	4.4	8.5	-	-	-	-	25.6	1.2	0.2	0.1	2.4	7.5	0.3
110-170	94.7	0.0	1.4	3.0	-	-	-	-	15.9	0.6	0.1	0.0	1.2	6.4	0.2
0-25	76.7	0.0	5.8	13.1	7800	810	9.6	6.6	30.7	1.7	0.3	0.2	4.2	7.5	0.3

Saturated paste extract														
Depth (cm)	water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-54	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54-95	-	-	-	-	-	-	-	-	-	-	-	-	-	-
95-110	-	-	-	-	-	-	-	-	-	-	-	-	-	-
110-170	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	24.8	4.8	4.6	21.7	0.3	1.0	1.7	27.2	4.0	-	10.1	3.0	8.32	-

PEDON IDENTIFICATION: SALALAH 589 PHOTO 33 Aquic Eutropepts clayey, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)	
			Total			Silt			Sand								
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000	Pct. of <2 mm				
0-1.5	Ap1	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	L	7.92
2-4	Ap2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	L+	8.01
5-13	Ck1	8	-	-	-	-	-	-	-	-	-	-	-	-	-	gSCL	8.12
13-110	Ckg2	97	-	-	-	-	-	-	-	-	-	-	-	-	-	gSiC	8.03
0-25			-	-	-	-	-	-	-	-	-	-	-	-	-	gL+	8.16

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar | 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)
								Ca	Mg	Na	K			
0-1.5	32.6	3.7	-	-	-	-	-	-	-	-	-	-	-	39.2
1.5-4	52.7	0.0	-	-	-	-	-	-	-	-	-	-	-	15.4
5-13	57.8	0.0	-	-	-	-	-	-	-	-	-	-	-	9.2
13-110	82.3	0.0	-	-	-	-	-	-	-	-	-	-	-	2.2
0-25	61.7	0.0	-	-	-	-	-	-	-	-	-	-	-	5.6

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000				
			Pct. of <2 mm													
0-8	Ap1	8	46.4	29.5	24.1	23.3	6.2	45.5	18.4	14.9	13.3	7.8	39.6	L+	8.05	
8-30	Ap2	22	48.2	30.1	21.7	23.0	7.1	47.6	19.1	15.1	12.7	5.5	42.6	L+	8.13	
30-46	Bk1	16	42.3	33.2	24.5	31.1	2.1	41.1	20.9	17.8	11.7	8.6	19.4	L+	8.12	
46-60	Bk2	14	42.0	29.6	28.4	25.6	4.0	32.2	18.0	18.3	18.0	13.5	54.1	CL	8.20	
60-85	Bk3	25	38.0	32.2	29.8	27.1	5.1	33.0	18.3	18.1	17.6	13.1	25.4	CL	8.20	
85-150	Bk4	65	35.2	33.0	31.7	29.0	4.1	35.6	18.6	17.2	17.0	11.5	63.2	CL	8.09	
0-25			-	-	-	-	-	-	-	-	-	-	-	-	-	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	water content pct.	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)	
								Ca	Mg	Na	K				
								meq/100g							
0-8	54.4	0.0	10.7	20.8	14430	1530	9.4	-	27.3	1.4	0.4	0.6	9.7	3.7	0.4
8-30	52.7	0.0	9.2	16.2	5460	550	9.9	-	31.8	1.4	0.4	0.3	7.1	5.1	0.3
30-60	59.1	0.0	11.1	21.0	3454	340	10.2	-	32.4	1.4	0.4	0.3	7.7	4.7	0.3
60-57	60.4	0.0	10.4	20.2	2925	240	12.2	-	33.3	1.4	0.4	0.2	8.2	4.9	0.3
57-85	54.6	0.0	10.0	19.4	-	-	-	-	31.2	1.3	0.5	0.2	5.2	8.8	0.3
85-150	51.2	0.0	12.3	21.4	-	-	-	-	20.0	1.1	0.3	0.2	9.6	3.3	0.3
0-25	54.6	0.0	10.2	18.4	9360	970	9.6	1.2	25.3	1.4	0.4	0.5	9.5	3.7	0.3

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-8	47.2	95.0	20.0	1.7	3.8	0.0	3.3	15.0	93.6		0.2	4.3	7.81	
8-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-60	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60-57	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57-85	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	37.4	15.0	21.0	1.7	0.5	0.6	2.3	12.9	23.6		0.4	2.3	8.33	

PEDON IDENTIFICATION: SALALAH 659 PHOTO 17 Typic Torrifuvents coarse loamy, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)										Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand						
			Sand (50 -2000)	Silt (2-50)	Clay (<2)	2 -20	20 -50	50 -100	100 -250	250 -500	500 -1000	1000 -2000			
<-----Pct. of <2 mm ----->															
0-19	Ap	19	65.8	20.3	13.9	5.0	15.2	39.0	29.0	17.7	10.2	4.2		SL	8.05
19-51	C1	32	64.2	18.7	17.0	11.6	7.2	29.6	29.0	20.5	14.6	6.4		SL	8.22
51-70	C2	19	52.7	26.2	21.1	15.4	10.8	39.4	32.3	14.4	9.7	4.1		SCL	8.12
70-90	C3	20	64.3	18.7	17.0	0.3	18.4	23.7	23.3	19.7	19.1	14.3		CoSL	8.13
90-112	C4	22	80.1	6.3	13.6	2.3	4.0	9.0	12.7	18.9	35.6	23.8		CoSL	8.16
112-160	C5	48	85.2	2.3	12.6	0.3	2.0	8.4	13.3	31.6	26.5	20.1		LCoS	8.22
0-25			65.4	17.7	17.0	8.5	9.2	37.5	27.1	18.4	12.3	4.7		SL	8.12

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar, 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)	
								Ca	Mg	Na	k				
								<-----meq/100g----->							
0-19	69.1	0.0	4.6	-	6338	580	10.93	-	16.0	0.9	0.4	0.4	6.4	5.8	0.3
19-51	79.8	0.0	4.9	11.7	2886	240	12.03	-	19.5	0.9	0.4	0.2	2.3	16.4	0.3
51-70	73.8	0.0	5.4	13.7	-	-	-	-	19.5	1.0	0.4	0.2	5.1	6.8	0.2
70-90	77.7	0.0	3.1	-	-	-	-	-	19.5	0.9	0.6	0.1	5.6	11.1	0.2
90-112	90.5	0.0	1.9	-	-	-	-	-	23.4	0.8	0.5	0.1	2.5	20.6	0.2
112-160	64.6	0.0	1.2	-	-	-	-	-	17.8	0.8	0.6	0.1	2.3	24.8	0.2
0-25	74.0	0.0	5.1	11.2	3998	400	9.99	3.3	18.0	1.0	0.3	0.4	3.7	8.5	0.2

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-51	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51-70	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70-90	-	-	-	-	-	-	-	-	-	-	-	-	-	-
90-112	-	-	-	-	-	-	-	-	-	-	-	-	-	-
112-160	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0-25	30.3	7.5	10.4	1.7	0.8	0.6	2.1	6.6	11.6		0.6	2.2	8.72	

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2 -20	20 -50	50 -100	100 -250	250 -500	500 -1000	1000 -2000				
Pct. of <2 mm																
0-5	Ap1	5	48.0	26.7	25.3	12.8	13.9	36.4	22.0	26.4	13.2	2.0	18.1	SCL	7.73	
5-25	Ap2	20	48.9	24.4	26.8	11.5	12.9	34.9	23.4	28.2	12.5	1.0	33.2	SCL	7.72	
25-48	B1	23	47.8	32.0	20.2	21.5	10.5	30.6	23.9	30.7	13.1	1.7	19.1	L+	7.99	
48-70	Bk2	22	47.7	35.7	16.6	26.7	9.0	30.9	26.2	23.7	13.8	5.4	30.4	L	7.99	
70-88	Ck3	18	19.2	49.0	31.8	36.3	12.6	62.8	21.1	11.3	4.2	0.7	43.0	SiCL	7.94	
88-125	Ckg4	37	20.8	54.4	24.7	46.6	7.8	32.8	29.8	21.4	12.1	3.9	62.5	Sil+	7.79	
125-160	Cg5	35	81.9	11.1	7.0	10.2	1.0	5.6	32.0	34.1	25.0	3.3	9.0	LCoS	8.07	
0-25			47.8	42.4	9.8	29.3	13.1	39.0	21.0	25.0	13.1	1.9	23.6	L	7.68	

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	water content pct. 15 bar/1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)	
								Ca	Mg	Na	K				
								meq/100g							
0-5	51.4	0.9	10.1	21.8	15340	1420	10.8	10.0	41.0	3.9	2.2	0.7	0.9	249.0	3.2
5-25	50.2	3.0	9.4	19.7	9384	220	11.4	10.8	58.9	3.5	1.5	0.5	7.8	18.9	2.7
25-48	52.2	0.0	10.3	20.8	4810	460	10.5	4.0	31.1	2.8	1.4	0.6	9.0	15.2	0.7
48-70	39.5	0.0	15.4	34.9	3714	380	9.8	1.0	34.5	4.3	2.0	0.9	14.1	14.1	0.8
70-88	45.1	0.0	17.3	32.5	-	-	-	-	32.9	4.6	2.1	1.3	15.4	13.3	1.0
88-125	70.1	0.0	-	-	-	-	-	-	31.9	3.1	1.0	0.8	6.3	16.4	1.2
125-160	93.1	0.0	3.1	11.9	-	-	-	-	27.1	1.5	0.3	0.2	1.2	22.9	0.6
0-25	48.9	4.1	17.7	20.6	10864	950	11.4	9.4	67.2	3.6	1.2	0.4	9.7	12.7	2.8

Saturated paste extract														
Depth (cm)	water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
		meq/l												
0-5	40.9	37.5	35.0	134.8	1.5	0.8	2.2	188.3	31.2		22.4	21.6	7.83	
5-25	34.7	25.0	15.7	56.5	0.5	0.5	1.3	70.1	35.2		12.4	10.4	8.12	
25-48	37.1	12.5	12.5	39.1	0.5	0.4	1.0	51.7	3.3		11.1	7.2	8.06	
48-70	49.2	23.9	12.8	38.3	0.5	0.3	1.0	52.0	31.3		8.9	6.6	8.04	
70-88	59.5	7.6	12.1	39.1	1.0	0.4	0.9	44.4	37.1		12.5	6.1	8.11	
88-125	52.7	10.5	14.2	34.8	1.0	0.3	0.8	44.4	23.4		9.9	6.0	8.12	
125-160	29.3	11.0	20.8	47.8	2.1	0.4	1.1	74.1	2.3		12.0	12.7	8.15	
0-25	36.6	46.5	16.3	47.4	0.8	0.5	2.0	60.0	46.9		8.5	8.4	7.99	

PEDON IDENTIFICATION: SALALAH 778 PHOTO 37 Typic Torrfluvents coarse loamy, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand	Silt	Clay	2	20	50	100	250	500	1000	-2000			
			(50-2000)	(2-50)	(<2)	-20	-50	-100	-250	-500	-1000	-2000	<-----Pct. of <2 mm----->			
0-26	Ap	26	-	-	-	-	-	-	-	-	-	-	-	-	gSL	7.8
26-43	C1	17	-	-	-	-	-	-	-	-	-	-	-	-	EgLCOS	8.3
45-63	C2	18	-	-	-	-	-	-	-	-	-	-	-	-	L	8.3
64-90	C3	26	-	-	-	-	-	-	-	-	-	-	-	-	L	7.5
90-106	C4	16	-	-	-	-	-	-	-	-	-	-	-	-	L	7.6
106-133	Ckg5	27	-	-	-	-	-	-	-	-	-	-	-	-	sgL	8.0
133-170	Ckg6	37	-	-	-	-	-	-	-	-	-	-	-	-	VgSCL	7.7
0-26			-	-	-	-	-	-	-	-	-	-	-	-	gSL	-

Depth (cm)	CaCO3	CaSO4	water content	Organ.	Total	C/N	Avail.	Extractable bases				C E C	ESP	EC (1:5)
	<2 mm	<2 mm	pct.	C	N	phosp.	Ca	Mg	Na	k				
	pct.	pct.	15 bar 1/3 bar	p.p.m.	p.p.m.	p.p.m.	-----meq/100g-----							
0-26	57.2	0.0	-	-	-	-	-	-	-	-	-	-	-	3.1
26-43	72.8	0.0	-	-	-	-	-	-	-	-	-	-	-	0.7
45-63	60.4	0.0	-	-	-	-	-	-	-	-	-	-	-	0.6
64-90	38.6	0.0	-	-	-	-	-	-	-	-	-	-	-	2.0
90-106	41.4	0.0	-	-	-	-	-	-	-	-	-	-	-	2.4
106-133	39.8	0.0	-	-	-	-	-	-	-	-	-	-	-	1.5
133-170	39.4	0.0	-	-	-	-	-	-	-	-	-	-	-	2.0
0-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PEDON IDENTIFICATION: SALALAH 803 PHOTO 31 Typic Calciorthis loamy skeletal, moderately deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)	
			Total			Silt			Sand								
			Sand (50 -2000)	Silt (2-50)	Clay (<2)	2 -20	20 -50	50 -100	100 -250	250 -500	500 -1000	1000 -2000	Pct. of <2 mm				
0-17	Ap	17	-	-	-	-	-	-	-	-	-	-	-	-	-	sgL	7.8
17-36	Bk1	19	-	-	-	-	-	-	-	-	-	-	-	-	-	VgL+	7.9
36-53	Bk2	17	-	-	-	-	-	-	-	-	-	-	-	-	-	VgCL	7.7
0-25			-	-	-	-	-	-	-	-	-	-	-	-	-	gL	7.8

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. (15 bar / 1/3 bar)	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)
								Ca	Mg	Na	K			
								meq/100g						
0-17	82.5	0.0	-	-	-	-	-	-	-	-	-	-	-	1.3
17-36	63.2	0.0	-	-	-	-	-	-	-	-	-	-	-	1.0
36-53	79.7	0.0	-	-	-	-	-	-	-	-	-	-	-	1.0
0-25	67.3	0.0	-	-	-	-	-	-	-	-	-	-	-	1.1

PEDON IDENTIFICATION : SALALAH 808 PHOTO 37 Calcic Gypsiorthids loamy skeletal, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand				Coarse fragm. pct.		
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000			
Pct. of <2 mm															
0-8	Ap	8	52.6	23.5	23.9	10.4	13.1	46.5	24.2	14.9	9.1	5.3	19.9	SCL	7.90
8-25	Bk1	17	32.7	29.8	37.5	19.3	10.5	33.6	26.2	17.8	15.6	12.2	66.2	CL+	7.98
25-45	Bk2	20	35.1	28.8	36.1	21.9	6.9	39.5	21.3	17.3	12.6	9.2	33.1	CL+	7.75
45-83	Cky1	38	61.8	16.4	21.8	8.3	8.1	23.8	27.5	32.8	13.0	2.2	67.3	SCL	7.53
83-112	Cky2	29	36.0	40.0	34.0	31.8	8.1	23.3	34.4	22.9	14.9	4.5	24.4	L+	7.49
0-25			42.2	26.7	31.1	16.6	10.2	43.1	22.8	16.7	10.5	6.2	47.9	CL	7.92

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar/1/3 bar:	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. enosp. p.p.m.	Extractable bases				C E C ESP	EC (1:5)		
								Ca	Mg	Na					
								meq/100g							
0-8	55.0	0.0	7.9	16.9	2840	790	11.2	-	19.5	1.2	0.3	0.9	5.0	18.6	1.7
8-25	57.6	0.0	11.1	19.0	2860	340	8.4	-	19.0	1.0	0.5	0.6	5.2	8.8	0.7
25-45	64.4	0.0	10.1	18.6	1795	180	10.0	-	20.0	1.0	0.3	0.5	2.9	9.4	0.2
45-83	62.3	4.2	8.6	20.1	1341	110	12.2	-	31.5	0.5	0.1	0.3	0.8	14.4	2.3
83-112	74.5	6.3	7.9	17.2	-	-	-	-	35.5	0.5	0.1	0.2	0.6	11.4	2.5
0-25	56.6	0.0	8.6	17.5	4023	520	7.9	6.2	18.5	1.0	0.6	0.9	4.0	15.0	1.0

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
0-8	36.3	70.0	37.5	14.3	4.6	0.7	2.6	93.7	13.5			2.0	15.9	8.35
8-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-45	49.5	12.5	11.5	34.2	1.0	0.5	1.2	24.3	37.1			10.0	4.6	2.66
45-83	43.4	25.0	14.1	26.1	0.5	0.2	1.2	19.7	52.0			5.9	4.6	8.51
83-112	43.5	30.0	12.5	26.1	0.8	0.4	0.8	20.5	48.2			5.7	4.7	8.51
0-25	22.6	29.5	22.9	6.5	2.8	0.8	1.6	32.1	37.1			1.3	7.0	2.52

PEDON IDENTIFICATION : SALALAH 821 PHOTO 37 Aquic Eutropepts clayey, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											Coarse fragm. pct.	PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand							
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000				
			Pct. of <2 mm													
0-23	Ap	23	54.9	20.6	24.5	11.9	8.7	23.4	28.1	30.5	15.8	2.3	24.8	SCL	7.74	
23-52	B1	29	47.5	35.4	17.1	22.7	12.7	35.2	28.9	24.7	10.1	1.1	26.8	L+	7.86	
52-97	Bkg2	45	25.4	29.3	45.3	21.1	8.2	16.6	27.5	30.4	23.5	2.0	36.8	C	7.73	
97-122	Bkg3	25	21.6	34.2	44.2	24.9	9.3	43.1	34.3	16.4	5.4	0.8	16.1	C	7.54	
122-160	Ckg1	38	24.0	34.9	41.1	25.1	9.8	34.4	33.7	22.2	8.7	0.9	8.0	C	7.66	
0-25			55.4	20.3	24.3	11.8	8.6	23.9	27.2	32.1	15.1	1.8	19.6	SCL	7.65	

Depth (cm)	CaCO3 <2 mm	CaSO4 <2 mm	Water content pct.	Organ. C	Total N	C/N	Avail. phosp.	Extractable bases				C E C	ESP	EC (1:5)	
	pct.	pct.	15 bar	1/3 bar	p.p.m.	p.p.m.	p.p.m.	Ca	Mg	Na	K				
	meq/100g														
0-23	58.2	0.3	11.3	22.0	5571	520	10.7	7.2	51.5	5.3	1.6	0.6	11.6	13.5	2.5
23-52	56.5	0.0	13.9	27.2	3398	330	12.1	3.4	44.6	5.1	2.2	1.2	9.3	23.5	1.7
52-97	74.0	0.0	17.5	36.9	-	-	-	-	34.3	3.4	2.0	1.2	3.7	54.0	6.9
97-122	30.0	0.0	11.7	35.3	-	-	-	-	42.0	1.3	0.9	0.5	10.2	2.2	6.7
122-160	72.2	0.0	12.6	47.5	-	-	-	-	34.4	3.0	2.3	0.7	8.2	27.2	4.4
0-25	58.2	1.1	10.0	21.1	6143	570	10.2	10.2	51.3	4.5	1.3	0.7	2.8	15.3	2.8

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C. dS/m	pH	BULK DENSITY
meq/l														
0-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-52	6.2	33.4	19.4	74.8	3.1	0.3	1.1	54.0	22.0	-	-	14.6	16.7	2.17
52-97	51.6	47.0	65.0	434.8	9.2	0.4	0.1	450.0	27.9	-	-	52.1	50.6	2.05
97-122	33.0	50.2	61.7	327.0	8.7	0.3	0.2	450.0	52.7	-	-	51.6	49.6	2.11
122-160	72.7	5.3	7.9	347.8	4.5	0.3	0.9	350.0	31.3	-	-	133.1	32.0	1.27
0-25	33.9	47.9	23.5	24.3	2.1	0.4	1.3	100.0	27.9	-	-	14.1	14.2	2.19

PEDON IDENTIFICATION : SALALAH 838 PHOTO 37 Typic Salorthids clayey, very deep

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand				Coarse Fragm. pct.		
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000			
Pct. of <2 mm															
0-4	Az1	4	48.3	27.5	24.2	13.0	14.5	41.5	24.4	20.6	11.8	1.8	35.5	SCL	7.85
4-28	Az2	24	32.0	27.8	40.2	16.7	11.1	26.7	17.9	41.3	6.5	7.6	36.8	C	8.03
28-60	C1	32	67.4	11.7	20.9	5.3	6.4	23.8	25.6	31.6	15.8	3.2	14.8	SCL	8.16
60-95	Cgk2	35	28.0	27.6	44.3	19.1	8.5	41.7	24.2	22.7	10.4	1.0	36.0	C	7.89
95-150	Cg3	55	23.1	32.4	44.5	24.0	8.3	45.9	35.5	14.8	3.2	0.6	33.3	C	7.75
0-25			51.9	20.6	27.5	12.1	8.5	33.2	23.2	25.4	15.6	2.6	33.7	SCL	7.61

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar / 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. phosp. p.p.m.	Extractable bases				C E C	ESP	EC (1:5)	
								Ca	Mg	Na	K				
								meq/100g							
0-4	40.1	11.6	9.4	24.9	17550	1020	17.2	8.7	138.0	7.0	2.1	0.8	2.9	74.5	39.3
4-28	59.9	0.0	9.7	20.5	9750	740	13.2	4.3	31.5	3.4	4.0	1.5	2.3	48.1	11.83
28-60	68.0	0.0	7.9	16.6	3705	290	12.8	4.3	30.1	2.0	2.4	1.1	4.8	50.5	2.77
60-95	74.0	0.0	14.2	32.7	-	-	-	-	37.3	1.2	1.3	0.8	3.3	40.0	2.94
95-150	91.8	0.0	11.5	38.1	-	-	-	-	32.5	1.3	0.7	0.4	3.5	20.8	2.75
0-25	54.0	3.2	9.8	25.0	11798	1020	11.6	7.1	72.7	5.3	1.7	1.4	5.4	31.1	19.54

Saturated paste extract																											
Depth (cm)	water at sat. pct.	Ca	Mg	Na	K	Cl	SO4	NO3	NH4	CO3	HCO3	Sulf	Total	DENSITY													
															meq/l												
															dS/m												
0-4	43.1	62.5	112.5	2826.1	41.3	0.0	1.0	2833.8	125.2					302.1	307.0	7.75											
4-28	40.1	32.5	75.0	1391.3	310.3	0.2	0.8	1287.5	296.8					189.8	128.0	7.85											
28-60	33.1	11.3	20.8	291.3	74.4	0.2	0.7	299.2	46.8					72.7	31.7	8.30											
60-95	54.1	11.3	20.8	173.9	43.6	0.2	0.8	209.9	66.4					43.4	21.8	8.26											
95-150		11.3	21.0	160.9	33.3	0.3	0.7	185.6	48.3					40.1	20.5	8.18											
0-25		90.0	154.2	1958.5	40.5	0.2	0.8	2026.6	156.8					177.1	191.2	7.75											

Depth (cm)	Horizon	Thickness (cm)	Size class and particle diameter (microns)											PARTIC. SIZE CLASS	pH (1:2.5)
			Total			Silt			Sand				Coarse fragm. pct.		
			Sand (50-2000)	Silt (2-50)	Clay (<2)	2-20	20-50	50-100	100-250	250-500	500-1000	1000-2000			
			Pct. of <2 mm												
0-21	Ay	21	64.2	20.3	15.5	7.4	12.9	40.3	0.0	38.6	17.9	3.2	24.8	SL	7.66
21-29	C1	8	-	-	-	-	-	-	-	-	-	-	-	-	7.90
29-64	Ck1	35	80.5	5.9	13.6	2.0	4.0	8.4	7.8	19.7	40.3	23.8	75.4	CgSL	7.61
64-85	Ck3	21	51.0	22.6	26.4	10.3	12.3	29.1	14.5	18.0	20.7	17.7	85.0	SCL	7.85
85-130	Ck3	45	85.0	11.0	4.0	10.0	1.0	4.6	5.1	16.1	41.1	33.0	80.7	LCoS	8.00
0-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Depth (cm)	CaCO3 <2 mm pct.	CaSO4 <2 mm pct.	Water content pct. 15 bar | 1/3 bar	Organ. C p.p.m.	Total N p.p.m.	C/N	Avail. Phosp. p.p.m.	Extractable bases				CEC	ESP	EC (1:5)	
								Ca	Mg	Na	K				
								meq/100g							
0-21	57.8	6.3	4.5	13.2	3432	320	10.7	8.0	78.1	3.1	0.9	0.5	2.4	37.9	3.1
21-29	51.9	0.0	4.7	13.6	2340	340	6.9	1.0	38.7	1.8	1.7	0.2	5.7	30.2	1.6
29-64	65.0	0.0	6.9	15.7	3900	370	10.5	0.2	43.3	1.9	1.9	0.2	5.6	33.2	4.5
64-85	38.2	0.0	-	-	1365	100	13.7	-	32.1	1.1	0.3	0.3	1.0	30.0	2.3
85-130	93.1	0.0	2.6	2.9	-	-	-	-	23.1	0.8	0.2	0.2	0.9	27.0	1.8
0-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Saturated paste extract														
Depth (cm)	Water at sat. pct.	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	S.A.R.	E.C.	pH	BULK DENSITY
		meq/l										dS/m		
0-21	24.7	10.5	17.5	73.9	1.3	0.2	1.2	70.1	23.6		19.8	10.6	8.15	
21-29	24.5	11.3	14.2	221.7	3.3	0.3	1.3	174.5	62.4		62.2	27.6	8.00	
29-64	25.4	7.8	77.1	956.5	8.2	0.1	1.2	1649.2	403.2		146.9	97.1	7.50	
64-85	25.0	6.3	114.6	565.2	4.1	0.6	1.8	1611.9	61.2		72.7	67.0	7.50	
85-130	26.1	37.5	41.7	234.8	3.1	0.3	1.3	1261.1	15.5		37.3	30.4	8.22	
0-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 3

EXAMPLES OF STANDARD ALES LUT DESCRIPTIONS

Vegsal3 (Salalah shoot vegetable, drip irrig) Land Utilization Type Specifications

LUT Id	Land Utilization Type Name	PSC	years	int rat
Output code	Output name	S1 yield	f crops/rotation	
LUR	Requirement	* Proportional Yield Factors		
LUR	Requirement	≤ Limiting Yield Factors		
Annual Input	Input name	£ units		
1-time Input	Input name	Number of units		
LUR Id	Land Use Requirement name	Max. severity level		
Annual Input	Input name	£ Units (level 1; level 2 ...;max.		
1-time Input	Input name	£ Units (level 1; level 2 ...;max.		

Tomato-D	Tomato, drip irrigation	2 [Dt £448]	1	2
tomato	Tomato	22 tons	1 [Dt £449]	

Actellic	Insecticide (Actellic)	1.6 litres
Decis	Insecticide (Decis)	1.6 litres
Dimetho	Insecticide (Dimethoate)	2 litres
Dipterex	Insecticide (Dipterex)	1.6 kg
Dripveg	Annualised cost of drip	1 unit
Fetrilon	Fetrilon Combi micronutr	1 kg
Furadane	Nematicide (Furadan 5G)	25 kg
Fusilade	Herbicide (Fusilade)	1.7 litres
Labour	Labour man/month	2.3 m/m
Mancozeb	Fungicide (Mancozeb)	14.4 kg
Manure	Farm yard manure	16 cu.m
Mitac	Insecticide (Mitac)	1.2 litres
Nimrod	Fungicide (Nimrod)	.3 litres
Phosphat	Triple superphosphate	100 kg
Pirimor	Insecticide (Pirimor)	.25 kg
Potas	Potassium sulphate	125 kg
Roundup	Herbicide (Roundup)	2 litres
Seedtom	Seed/ tomato (Pakmor)	.2 kg
Sencor	Herbicide (Sencor)	.4 kg
Tractor	Tractor hire	7 hours
Urea	Urea	210 kg
WatdiesM	Volume of pumped water (	4800 cu.m

pa	Potential for aeration	4 [Dt £450]
Furadane	Nematicide (Furadan	0;10;15;20 kg
Roundup	Herbicide (Roundup)	0;1;2;3 litres

pir	Potential for irrigation	5 [Dt £451]
pr	Potential for rooting room	6 [Dt £452]
ss	Soil salinity	6 [Dt £453]
wq	Irrigation water quality	8 [Dt £454]

Fruitsal (Salalah fruit trees)		Land Utilization Type Specifications		
LUT Id	Land Utilization Type Name	PSC	years	int rat
Output code	Output name	\$1 yield	£ crops/rotation	
LUR	Requirement	* Proportional Yield Factors		
LUR	Requirement	≤ Limiting Yield Factors		
Annual Input	Input name	£ units		
1-time Input	Input name	Number of units		
LUR Id	Land Use Requirement name	Max. severity level		
Annual Input	Input name	£ Units (level 1; level 2 ...;max.		
1-time Input	Input name	£ Units (level 1; level 2 ...;max.		
Banana	Banana, drip irrigation	2 [Dt £182]	5	2
banana	Banana	14 tons	5 [Dt £189]	
Cuprasan	fungicide (Cuprasan)	1.2 kg		
Dimetho	Insecticide (Dimethoate)	1 litres		
Fetrilon	Fetrilon Combi micronutr	2.5 kg		
Furadane	Nematicide (Furadan 5G)	25 kg		
Fusilade	Fusilade herbicide	1.7 litre		
Labour	Labour man/month	4.8 m/m		
Mancozeb	Fungicide (Mancozeb)	2.4 kg		
Manure	Farm yard manure	17 cu.m		
Oil	Mineral oil	.4 litres		
Phosphat	Triple superphosphate	224 kg		
Potas	Potassium sulphate	448 kg		
Roundup	Roundup herbicide	3.4 litre		
Urea	Urea	767 kg		
WatdiesM	Volume of pumped water (	8100 cu.m		
dripban	Annualised cost of drip	1 feddan		
Labour	Labour man/month	.4 m/m		
Manure	Farm yard manure	28 cu.m		
Tractor	Tractor hire	7 hour		
Vydat-EC	Nematicide (Vydate E.C.)	.14 litres		
pa	Potential for aeration	4 [Dt £254]		
Furadane	Nematicide (Furadan	0;10;45;80 kg		
Fusilade	Fusilade herbicide	0;1.7;3.3;5.1 litre		
pir	Potential for irrigation	5 [Dt £185]		
pr	Potential for rooting room	6 [Dt £186]		
ss	Soil salinity	6 [Dt £187]		
wq	Irrigation water quality	8 [Dt £213]		

Fodsal (Salalah fodder crops)		Land Utilization Type Specifications		
LUT Id	Land Utilization Type Name	PSC	years	int rat
Output code	Output name	St yield	£ crops/rotation	
LUR	Requirement	* Proportional Yield Factors		
LUR	Requirement	≤ Limiting Yield Factors		
Annual Input	Input name	£ units		
1-time Input	Input name	Number of units		
LUR Id	Land Use Requirement name	Max. severity level		
Annual Input	Input name	£ Units (level 1; level 2 ...;max.		
1-time Input	Input name	£ Units (level 1; level 2 ...;max.		
Rhodes-k grass	Rhodes grass, sprinkler irrigation Grass hay	2 [Dt £246] 15 ton	3 3 [Dt £253]	2
Labour	Labour man/month	1.2 m/m		
Malathion	Malathion	1.3 l		
Nogos	Nogos 500 E.C. insectici	1.3 l		
Phosphat	Triple superphosphate	137 kg		
Polyram	Polyram Combi WP	1.7 kg		
Potas	Potassium sulphate	121 kg		
Sprinfod	Annualised cost of sprin	1 feddan		
U46	U 46 Combifluid 6 herbic	2.1 l		
Urea	Urea	767 kg		
WatdiesM	Volume of pumped water (	11000 cu.m		
Roundup	Roundup herbicide	3.4 litre		
Seedrhod	Seeds for rhodes grass (	10 kg		
Tractor	Tractor hire	7 hour		
pa	Potential for aeration	4 [Dt £262]		
U46	U 46 Combifluid 6 he	0;1;2;3 l		
Roundup	Roundup herbicide	0;.48;.84;1.26 litre		
pir	Potential for irrigation	5 [Dt £249]		
pr	Potential for rooting room	6 [Dt £250]		
ss	Soil salinity	6 [Dt £251]		
wq	Irrigation water quality	8 [Dt £252]		

APPENDIX 4

SOILS MAPS UNITS CHARACTERISTICS

Map unit Symbol and No	TOPSOIL (25 cm)							Particle -Size Class	SUBSOIL (25-100 cm)				
	Texture	Gravel	ECe	Lime	Gypsum	Infiltra- tion Rate	Gravel		ECe	Lime	Gypsum	Permeability	
AQN 1	SCL	N	E	V	Sl	ML	FL	Sl	S	V	N	MS	
RRI 2	L	G	Sl	V	N	L	FL	Sl	M	V	Sl	MS	
SNT 3	SL	G	Sl	V	N	L	LSK	V	M	V	Sl	M	
MRH 4	SL	V	Sl	V	N	L	SSK	V	Sl	V	Sl	VR	
NHZ 5	L	G	Sl	V	N	L	FL	G	M	V	Sl	MS	
ETN 6	SL	G	M	S	Sl	L	LSK	V	V	V	M	M	
HMR 7	SL	G	S	V	M	L	SSK	V	S	E	Sl	VR	
DFR01 8	HL	N	N	V	N	L	FL	N	N	V	N	MS	
DFR02 9	SCL	Sl	N	V	N	L	FL	G	N	V	N	MS	
SLM 10	L	N	N	V	N	L	FL	Sl	N	V	N	MS	
GZZ 11	SL	N	N	V	N	L	CoL	Sl	N	V	N	M	
SDA 12	SL	G	Sl	V	N	L	LSK	V	Sl	V	N	M	
GDD 13	L	G	M	V	N	L	LSK	V	Sl	V	N	M	
HGF 14	SL	V	Sl	V	N	L	SSK	V	Sl	E	N	R	
MTZ 15	L	N	M	V	N	MH	FL	Sl	Sl	V	N	MR	
MST 16	SL	N	M	V	N	MH	FL	Sl	M	E	N	MR	
RST 17	SL	N	M	V	N	MH	FL	Sl	Sl	V	N	MR	
QRM 18	SL	N	Sl	V	N	MH	CoL	Sl	Sl	V	N	MR	
MHS 19	SL	G	Sl	V	N	MH	LSK	V	Sl	V	N	MR	

Map unit Symbol and No	SUBSTRATUM (100-150)		Whole Profile			
	Texture	Gravel %	Available Water Capacity	Drainage class	Effective depth	Limiting layer
AQN 1	FL	Sl	M	VP	VD	
RR1 2	FL	Sl	M	W	VD	
SNT 3	LSK	V	L	W	VD	
MRH 4	SSK	V	VL	W	VD	
NHZ 5	FL	Sl	M	W	VD	
ETN 6	LSK	V	L	W	D	
HMR 7	SSK	V	VL	W	VD	
DFR01 8	S	N	M	W	D	
DFR02 9	FL	G	M	W	VD	
SLM 10			L	W	MD	R
GZZ 11	CoL	G	M	W	VD	
SDA 12	LSK	V	L	W	VD	
GDO 13			VL	W	MD	R
HGF 14	SSK	V	VL	W	VD	
MTZ 15	FL	Sl	H	P	VD	
MST 16	FL	G	H	VP	VD	
RST 17			L	P	MD	R
QRM 18	FL	G	M	P	VD	
MHS 19	LSK	V	L	P	VD	

Map unit Symbol and No	TOPSOIL (25 cm)							SUBSOIL (25-100 cm)					
	Texture	Gravel	ECe	Lime	Gypsum	Infiltration Rate	Particle Size Class	Gravel	ECe	Lime	Gypsum	Permeability	
BLO 20	LS	N	S	E	N	VH	S	N	N	E	N	VR	
MGS 21	LS	G	V	E	Sl	VH	S	Sl	S	E	N	VR	
SALO1 22	L	N	N	V	N	ML	FL	N	N	V	N	M	
SALO2 23	L	N	N	V	N	ML	FL	N	N	V	N	M	
MSL 24	SCL	N	N	V	N	ML	FL	N	N	V	N	M	
QOF01 25	SL	N	N	V	N	M	CoL	N	N	V	N	MR	
QOF02 26	SL	N	N	V	N	M	CoL	Sl	N	V	N	MR	
QOF03 27	SL	N	Sl	V	N	ML	CoL	N	N	V	N	MR	
GRF 28	SL	N	N	V	N	ML	CoL	Sl	N	V	N	MR	
RZT 29	SL	N	N	V	N	L	CoL	Sl	N	V	N	MR	
RBT 30	L	G	Sl	V	N	L	LSK	V	Sl	V	N	MR	
LUB01 31	L	Sl	M	V	N	L	LSK	V	M	V	N	MR	
LUB02 32	L	G	M	V	N	L	LSK	V	M	V	N	MR	
HSL01 33	SL	N	N	V	N	M	S	Sl	N	V	N	R	
HSL02 34	SL	N	Sl	V	N	M	S	N	Sl	V	N	R	
JHD 35	LS	N	N	V	N	H	S	Sl	N	V	N	R	
DRZ 36	SL	G	M	E	N	L	SSK	V	M	V	N	VR	
HFA 37	SCL	N	N	V	N	ML	FL	Sl	N	V	N	MS	
HSN 38	SL	N	N	V	N	M	CoL	Sl	N	V	N	M	

Map unit Symbol and No	SUBSTRATUM (100-150)		Whole Profile			
	Texture	Gravel %	Available Water Capacity	Drainage class	Effective depth	Limiting layer
BLD 20	S	N	L	W	D	
MGS 21			VL	W	MD	CS
SAL01 22	FL	N	H	W	VD	
SAL02 23	FL	S1	H	M	VD	
NSL 24			M	W	MD	R
QOF01 25	CoL	N	M	W	VD	
QOF02 26	LSK	V	M	W	VD	
QOF03 27	FL	S1	M	M	VD	
GRF 28			L	W	MD	R
RZT 29			VL	W	S	R
RBT 30	LSK	V	L	W	VD	
LUB01 31			L	W	MD	R
LUB02 32			VL	W	S	R
HSL01 33	S	S1	L	W	VD	
HSL02 34	FL	N	M	M	VD	
JHD 35			VL	W	S	R
DRZ 36	SSK	V	VL	W	VD	
HFA 37	FL	G	M	W	VD	
HSN 38	FL	G	M	W	VD	

Explanation of Symbols Used for Map Units Description

Texture of fine earth

C	Clay
CL	Clay loam
CoS	Coarse sand
CoSL	Coarse sandy loam
L	Loam
HC	Heavy clay
HL	Heavy loam
FS	Fine sand
FSL	Fine sandy loam
LS	Loamy sand
S	Sand
SCL	Sandy clay loam
SiC	Silty clay
SiCL	Silty clay loam
SiL	Silt loam
SL	Sandy loam

Coarse fragments content (percent)

N	Non gravelly	less than 5
SL	Slightly gravelly	5 to 15
G	Gravelly	15 to 35
V	Very gravelly	35 to 60
E	Extremely gravelly	60 to 80
VE	Very extremely gravelly	more than 80

Salinity class (EC of saturated paste extract, dS/m)

N	Non saline	less than 4
SL	Slightly saline	4 to 8
M	Moderately saline	8 to 16
S	Strongly saline	16 to 32
V	Very strongly saline	32 to 64
E	Extremely saline	more than 64

Lime content (percent)

N	Non calcareous	less than 1
SL	Slightly calcareous	1 to 15
M	Moderately calcareous	15 to 35
S	Strongly calcareous	35 to 50
V	Very strongly calcareous	50 to 80
E	Extremely calcareous	more than 80

Gypsum content (percent)

N	Non gypsiferous	less than 1
SL	Slightly gypsiferous	1 to 10
M	Moderately gypsiferous	10 to 25
S	Strongly gypsiferous	25 to 40
V	Very strongly gyps.	more than 40

Infiltration rate (cm/h)

VL	Very low	less than 1
L	Low	1 to 3
ML	Moderately low	3 to 5
M	Moderate	5 to 10
MH	Moderately high	10 to 15
H	High	15 to 25
VH	Very high	more than 25

Particle size class

F	Fragmental
SSK	Sandy-skeletal
LSK	Loamy-skeletal
CSK	Clayey-skeletal
S	Sandy
L	Loamy
CoL	Coarse-loamy
CoSi	Coarse-silty
FL	Fine-loamy
FSi	Fine-silty
C	Clayey

Permeability (cm/h)

VS	Very slow	less than 1
S	Slow	1 to 3
MS	Moderately Slow	3 to 5
M	Moderate	5 to 10
MR	Moderately Rapid	10 to 15
R	Rapid	15 to 25
VR	Very rapid	more than 25

Available water capacity (cm/150 cm)

VL	Very low	less than 6.5
L	Low	6.5 to 13
M	Moderate	13 to 19
H	High	19 to 25
VH	Very high	more than 25

Drainage class

W	Well drained
M	Moderately well drained
P	Poorly drained
VP	Very poorly drained

Soil effective depth (cm)

VS	Very shallow	less than	25
S	Shallow	25 to	50
MD	Moderately deep	50 to	100
D	Deep	100 to	150
VD	Very deep	more than	150

Limiting layer

CS	Cemented sand in alluvium
R	Hard compact rock