2.4 Outline of Regions

2.4.1 Classification of Regions

Oman is divided administratively into 44 wilayat, each governed by a wali (local head). All 44 wilayat are classified into 7 regions, namely Muscat, Al Janubiya, Al Dhahira, Al Batinah, Al Dakhliya, Al Sharqiya and Musandam. MAF divided agriculture productive areas into 9 areas: South Batinah, North Batinah, Sharqiya, Oman Interior, Wasta, Dhahira, Buraimi, Musandam and Southern Region.

2.4.2 The Present Situation of Regional Development

(1) Governmental Organization

The regional development in Oman is carried out by various ministries, agencies related to the government, and public entities according to the regulations provided for their functions. The main organizations concerned with regional development are:

Governorate of Muscat (GOM)
Ministry of Health (MH)
Ministry of Education and Youth (MEY)
Ministry of Interior (MI)
Ministry of Communication (MC)
Ministry of Social Affairs (MSA)
Ministry of Labour and Vocational Training (MLVT)
Ministry of Commerce and Industry (MCI)
Ministry of Agriculture and Fisheries (MAF)
Officer of the State and Wali of Dhofar (OSWD)
Ministry of Housing (MH)
Ministry of Regional Municipalities (MRM)
Ministry of Environment (ME)
Ministry of Water Resources (MWR)
Ministry of Post, Telegraph and Telephone (MPTT)
General Telecommunication Organization (GTO)

Ministry of Electricity and Water (MEW)
Ministry of Petroleum and Minerals (MPM)
Public Authority for Marketing and Agricultural Produce (PAMAP)
Regional Development Committee (RDC)
Musandam Development Committee (MDC)

The Development Council (DC) examines and coordinates projects and programs related to development policy submitted by ministries, in order to formulate long-term targets for development and the Five-year Development Plans.

(2) Regional Development Committee

As examples of integrated regional development projects, the Musandam development, conducted by MDC and the Buraimi development, conducted by RDC are quite typical. RDC prepares detailed plans with cooperation from various related agencies. Thereafter, DC examines the plan. In the implementation of the plan, the related ministries advise and technically support RDC in an effort to smoothly resolve any difficulties. When the development has reached a certain level, the maintenance and administration of the plan are transferred to the appropriate ministry.

MAF participates in the agricultural sector of regional development by planning, constructing and improving facilities such as extension centers, recharge dams and falaj systems.

(3) The Present Situation of Infrastructural Development by Region

The overview of progress in the development of infrastructures by region is as follows. The Muscat area has 22.3 % of the entire population and infrastructural improvement has been high. On the other hand, improvement of infrastructures in rural areas, which have 77.7 % of the population, has tended to be slow. Other comparatively well improved regions, besides the capital area, are Al Janubiya and Musandam. Based on social indicators, the retardation of improvement of medical facilities in Batinah is obvious. Consequently, the

government must to correct differences not only between the capital and other regions, but also between regions.

2.5 Outline of Agricultural Sector

2.5.1 Land Use

2.5.1.1 Land Use and Land Distribution Institutions

(1) Regulations Relating to Land

With respect to land regulation, Royal Decree No. 5/80 was established in 1980. Ministerial Decree No.17/80 was established in the same year by the Ministry of Land Affairs and Municipalities, later named the Ministry of Housing (MH) to enforce the royal decree.

These decrees prescribed the utilization of land in general, including agricultural land, the definition of the qualifications of the people to whom the land should be distributed, its priorities with regard to distribution procedures, etc.

(2) Agricultural Land Distribution Regulation

Since 1970, the government has distributed land to Omani nationals at a low price to promote the agricultural sector. Farmland can be distributed to any nationals on application who intend to use it for agriculture. MH is in charge of the procedure for distribution.

There are two types of actual distribution procedures: one for large-scale commercial management and one for small-scale farm management. The present limit for both is 10 feddan. They are basically similar and described below.

In response to a farmer's request, MH selects the required area of land from the government land suitable for agriculture and at the same time, determines an exact location . Following this, MH asks MAF, MWR and MEI if there are any problems with respect to the soil conditions, water quality and quantity, and environment. On the basis of these three ministries' technical judgments, the area is distributed.

Table 2.5.1 Number of Holdings, Area of Farm Lands, Area of Farm Lands Distribution and Area under Cultivation (in ha)

REGION		WILAYAT		FARM LAND DISTRIBUTION('70-'86)			NUMBER OF HOLDINGS	AREA OF FARM LANDS	FARM LAND /HOLDING	AREA UNDER CULTIVATION	AREA UNDER CULTIVATION
No	NAME	No	NAME	TOTAL (1)	FINAL (2)	PRELIMINARY SURVEY (3)	(78/79) (4)	(78/79) (5)	(78/79) (6)	(78/79) (7)	(1988) (8)
1	SOUTH BATINAH		10	12468.79	6153.02	6315.77	16720	23197.68	1.39	10245.84	16602
		1	SEEB & MUSCAT	26.67	13.76	12.92	1694	2217.38	1.31	1313.62	
		2	WADI HAAWIL	759.26	147.90	611.35	-	-	-	-	
		3	AL AWABI	2.10	0.00	2.10	660	506.22	0.77	294.36	
		4	BARKA	6858.05	3744.75	3113.30	2398	4629.46	1.93	2000.02	
		5	NAKHAL	(INCLUDED IN WADI HAAWIL)			1386	603.24	0.44	498.3	
		6	AL MUSANAA	2198.42	852.60	1345.82	1430	4211.68	2.95	1406.02	
		7	AL SUWAIQ	1616.73	929.42	687.31	2420	7995.02	3.30	2756.6	
		8	AL RUSTAQ	321.89	64.84	257.05	4334	1514.26	0.35	1161.82	
		9	QURIYAT	337.48	113.35	224.13	2244	1501.50	0.67	801.24	
		10	MASIRAH	348.19	286.40	61.79	154	18.92	0.12	13.86	
2	NORTH BATINAH		5	4520.40	2034.17	2486.23	12188	27072.54	2.22	13273.92	14605
		11	AL KHABURA	550.13	277.10	273.03	1892	5328.18	2.82	1074.26	
		12	SAHAM	1914.48	942.48	972.00	3036	6217.20	2.05	2042.92	
		13	SOHAR				3564	6495.94	1.82	4424.42	
		14	LIWA	665.95	262.12	403.83	1298	3002.12	2.31	1615.46	
		15	SHINAS	1389.84	552.46	837.38	2398	6029.10	2.51	4116.86	
3	SHARQIA		10	4607.15	1003.34	3604.23	14696	6252.84	0.43	4705.14	8615
		16	WADI BANI KHALID	7.14	2.94	4.20	550	79.42	0.14	69.3	
		17	IBRA	1005.10	176.61	828.49	902	623.26	0.69	310.86	
		18	BANI ABU HASSAN	371.07	70.73	300.34	1210	581.90	0.48	350.46	
		19	AL QABIL	494.68	190.18	304.50	748	482.46	0.65	345.62	
		20	WADI DIMA	17.64	3.78	14.28	1958	374.66	0.19	364.76	
		21	KAMIL & WAFI	294.03	79.97	214.06	924	677.16	0.73	548.02	
		22	BANI ABU ALI	64.68	0.00	64.68	2266	395.78	0.17	354.64	
		23	SUR	280.39	128.56	151.83	1804	842.82	0.47	631.4	
		24	AL MUDHAIBY	1348.24	128.60	1219.64	3498	1724.80	0.49	1268.96	
		25	BIDIYA	724.18	221.97	502.21	836	470.58	0.56	461.12	
4	OMAN INTERIOR		6	3366.90	905.91	2460.99	6842	10920.36	1.60	3054.26	5619
		26	BAHLA	962.94	243.92	719.01	2068	3452.46	1.67	1075.58	
		27	NIZWA	1529.04	413.31	1115.73	2288	5585.80	2.44	881.54	
		28	AL HAMRA	27.98	1.26	26.72	968	946.00	0.98	664.84	
		29	MANAH	617.58	199.96	417.62	660	465.52	0.71	181.5	
		30	ADAM	229.36	47.46	181.90	374	264.00	0.71	120.56	
		31	JABAL AKHDAR				484	206.58	0.43	130.24	
5	MUSTA		3	1242.48	247.78	994.70	4444	3574.56	0.80	2112.44	2109
		32	IZKI	611.25	121.66	489.59	1628	1265.44	0.78	867.68	
		33	SUMAIL	558.53	93.74	464.79	2024	1662.98	0.82	856.68	
		34	BIDBID	72.70	32.38	40.32	792	646.14	0.82	388.08	
6	DAHIRAH		3	1229.76	287.35	942.40	6402	7202.36	1.13	3303.08	5603
		35	DHANK	372.10	38.75	333.35	836	681.56	0.82	445.94	(INCLUDING
		36	IBRI	495.69	159.80	335.89	4488	6082.78	1.36	2480.72	BURAIMI)
		37	YANQUL	361.97	88.80	273.17	1078	438.02	0.41	376.42	
7	BURAIMI		2	N.A.	N.A.	N.A.	2024	1312.52	0.65	885.50	-
		38	AL BURAIMI	N.A.	N.A.	N.A.	1276	771.76	0.60	447.48	
		39	MUHADHA	N.A.	N.A.	N.A.	748	540.76	0.72	438.02	
8	MUSANDAM		3	N.A.	N.A.	N.A.	2420	1120.46	0.46	1030.04	N.A.
		40	KHASAB	N.A.	N.A.	N.A.	1342	562.98	0.42	545.6	N.A.
		41	AL BIYA	N.A.	N.A.	N.A.	638	321.20	0.50	311.96	N.A.
		42	BUKHA	N.A.	N.A.	N.A.	440	236.28	0.54	172.48	N.A.
9	SOUTHERN REGION		1	N.A.	N.A.	N.A.	17468	2706.66	0.15	2413.62	1488
		43	DHOFAR	N.A.	N.A.	N.A.					
	TOTAL		43	27435.48	10631.57	16804.33	83204	83359.98	1.00	41023.84	54641.00

explanatory notes:
1: (1),(2) and (3) are obtained from the Ministry of Housing (Regional alocation was calculated by the JICA study team according to the present agricultural region)
2: (4),(5),(6) and (7) are obtained from 1978-1979 agricultural census (Regional total was caluculated by the JICA study team according to the present agricultural region)
3: (8) is obtained from the Department of Agricultural Statistics of MAF

At first, the area is leased at the rate of R.O. 3 per feddan per annum. When more than 75 percent of the area has been cultivated for three for three out of five years, and it is approved by MAF, the title of the area is transferred to the farmer by the government at a cost of R.O. 50 per feddan.

Some of the areas which had been distributed were not necessarily appropriate for agriculture from the aspects of soil and/or water resource conditions because the increase of new farm lands was too rapid to examine all of them in detail. They may have been left uncultivated due to salt accumulation resulting from the high salt content of irrigation water, for example.

In order to cope with this problem, the government suspended distribution of agricultural land except to commercial farms, and has been conducting a study on soil and water resource potentials for agricultural land since January 1987. MAF is responsible for determining soil potential, and the results of the Soil Survey Project conducted by the FAO, will be utilized.

Table 2.5.1 shows the wilayats and agricultural lands which were distributed before the end of 1986 and before the above suspension. This table shows the area finally approved under lease or transferred title to be 10,349 ha (24,641 feddan), and the area completed under the preliminary survey, for which the MH specified the location and for which further coordination among the three ministries is needed, to be 16,800 ha (39,999 feddan). The distribution procedure for about 17,000 ha of agricultural land is scheduled to be drawn up.

2.5.1.2 Present Land Use for Agriculture

(1) Area of Farm Land and Land under Cultivation according to Region

Table 2.5.1 shows the number of holdings, the area of farmland under cultivation in each agricultural region obtained from the 1978/79 census, and the area under cultivation in 1988, as provided by the MAF Department of Agriculture Statistics .

According to the 1978/79 census, approximately 60 percent of the agricultural land is concentrated in North and South Batinah. The area of agricultural land per holding in North Batinah is about 2.2 ha. This is the largest of all holdings and those of each wilayat in North Batinah are the same size. In South Batinah, the average holding area is 1.4 ha. Compared with this, farm lands in such wilayats as Barka, Al Musanaa and Al Suwaiq are large (2 or 3 ha), but in most other wilayats the area is less than 1 ha. All of the average areas in other regions are small (less than 1 ha), except for in Bahla and Nizwa in the Interior Region, and Ibri in the Dahirah Region where they are 1.7, 2.4 and 1.4 ha, respectively.

The total area under cultivation has increased by 13,600 ha in the last ten years. Viewed according to region, cropped area of about 6,400 ha has been added in South Batinah (the most marked increase among all the regions), and one of about 3,900 ha in Sharqiya.

(2) Area under Cultivation of Each Crop

Tables 2.5.2 and 2.5.3 show area under cultivation of each crop. The most common cultivated crop in the country is the date palm. It occupies approximately 45 percent of the entire cultivated area. The date palm is the traditional crop in northern Oman and constitutes an important part of the Omani diet. The second largest cultivated area is for alfalfa. One of the typical cultivated crops which illustrates the marked climatic differences between southern and northern Oman is the coconut palm. Three major crops in southern Oman, i.e., coconut, banana and alfalfa occupy nearly 60 percent of the entire cultivated areas there. In contrast, while by far the most common cultivated crop in northern Oman is the date palm, there is actually a great variety of cultivated crops. Viewed from a nationwide perspective, from 78/79 to 88, cropped areas of vegetables, alfalfa and date palm show marked increases.

2.5.1.3 Development Potential

(1) Development Potential for Soil

Table 2.5.2

Area under Cultivation of Each Crop in 1978/79

derived from the Agriculture Census 1978-1979 (in ha)

REGION / CROPS	N.BATINHA	S.BATINAH	SHARQIYA	WASTA	INTERIOR	DHAHIRA BURAIMI	SOUTH R.	MUSANDAM	TOTAL
1.VEGETABLES	468.16	279.62	92.40	120.78	415.36	211.20	346.06	1.10	1934.68
TOMATO	87.56	7.26	14.52	25.52	26.18	24.86	145.42	0.00	331.32
CHILI PEPPER	0.00	9.24	1.54	2.86	188.54	0.22	20.46	0.00	222.86
ONION	198.00	67.10	15.40	37.62	89.10	124.30	5.06	0.44	537.02
GARLIC	24.42	2.64	21.56	39.38	84.26	31.02	0.44	0.00	203.72
OKRA	3.74	10.56	0.00	0.00	0.44	0.00	23.76	0.00	38.50
WATERMELON	128.04	156.42	20.02	3.30	17.38	27.72	56.32	0.44	409.64
S.MELON	0.00	19.58	2.42	0.00	0.00	1.98	5.06	0.00	29.04
CABBAGE	0.44	2.86	0.44	1.98	2.20	0.00	24.42	0.00	32.34
CUCUMBER	0.00	0.88	0.66	0.00	0.00	0.00	7.92	0.00	9.46
POTATO	25.96	3.08	15.84	10.12	7.26	1.10	57.20	0.22	120.78
2.FIELD CROPS	711.48	1068.98	852.94	310.86	567.82	586.74	288.42	13.20	4400.44
WHEAT	4.40	38.72	0.00	3.30	120.78	134.42	0.00	0.00	301.62
ALFALFA	307.56	1030.26	852.94	307.56	447.04	451.66	288.42	13.20	3698.64
TOBACCO	399.52	0.00	0.00	0.00	0.00	0.66	0.00	0.00	400.18
3.FRUITS	9893.40	7868.08	3208.26	1413.72	1179.03	2397.78	647.90	861.30	27469.47
DATES	5627.82	6419.82	2855.60	1200.76	1029.16	2170.96	60.06	829.84	20194.02
LIMES	1001.88	524.48	177.54	64.02	115.33	144.10	18.70	4.84	2050.89
MANGO	1951.18	730.40	103.18	41.14	18.92	64.90	3.30	16.94	2929.96
BANANA	1311.86	191.40	71.50	107.36	15.62	17.60	264.66	9.68	1989.68
COCONUT	0.66	1.98	0.44	0.44	0.00	0.22	301.18	0.00	304.92
4.OTHER CROPS	163.90	295.46	147.40	42.24	289.03	201.74	289.52	7.92	1437.21
TOTAL	11236.94	9512.14	4301.00	1887.60	2451.24	3397.46	1571.90	883.52	35241.80
5.TEMP. FALLOW	2036.98	733.70	404.14	224.84	603.02	791.12	841.72	146.52	5782.04
GRAND TOTAL	13273.92	10245.84	4705.14	2112.44	3054.26	4188.58	2413.62	1030.04	41023.84

Table 2.5.3 Estimated Area under Cultivation of Each Crop in 1988

according to the Department of Agriculture Statistics, MAF (in ha)

REGION / CROPS	N.BATINHA	S.BATINAH	SHARQIYA	WASTA	INTERIOR	DHAHIRA BURAIMI	SOUTH R.	MUSANDAM	TOTAL
1.VEGETABLES	1,354	1,699	998	309	784	759	137	N.A.	6,040
TOMATO	343	280	202	70	169	125	23	N.A.	1,212
CHILI PEPPER	148	233	89	28	61	36	15	N.A.	610
ONION	109	112	83	32	85	131	8	N.A.	560
GARLIC	4	8	13	18	63	44	0	N.A.	150
OKRA	6	33	4	2	4	2	2	N.A.	53
WATERMELON	257	347	192	38	151	240	25	N.A.	1,250
S.MELON	209	222	102	14	32	34	12	N.A.	625
CABBAGE	139	226	94	51	151	79	30	N.A.	770
CUCUMBER	95	171	213	54	64	53	20	N.A.	670
POTATO	44	67	6	2	4	15	2	N.A.	140
2.FIELD CROPS	1,879	1,806	2,065	450	1,738	1,388	321	N.A.	9,647
WHEAT	12	25	85	25	178	143		N.A.	468
ALFALFA	1,458	1,781	1,980	425	1,560	1,245	321	N.A.	8,770
TOBACCO	409	0	0	0	0	0	0	N.A.	409
3.FRUITS	9,155	11,268	4,753	998	2,577	2,906	646	N.A.	32,303
DATES	6,392	7,811	4,177	829	2,197	2,689	75	N.A.	24,170
LIMES	857	901	193	70	213	144	22	N.A.	2,400
MANGO	1,342	2,012	205	87	67	62	5	N.A.	3,780
BANANA	564	544	178	12	100	11	216	N.A.	1,625
COCONUT	0	0	0	0	0	0	328	N.A.	328
4.OTHER CROPS*	2,217	1,829	799	352	520	550	384	N.A.	6,651
TOTAL	14,605	16,602	8,615	2,109	5,619	5,603	1,488	N.A.	54,641

"OTHER CROPS*" includes PAPAYA, CARROT, SWEET POTATO, RADISH, EGGPLANT, SQUASH, PUMPKIN, CAULIFLOWER, BEETROOT, TURNNIP, BEAN, LETTUCE, PEA, BARLEY, SORGUM, CHICKPEA, LUBIA, LEMON, SWEETLIME, FIG, GUAVA, GRAPE, POMEGRANATE, ALMOND

In Oman, only a portion of the land has been surveyed for soil conditions. With respect to this, many areas are considered suitable for agriculture. As far as the preliminary survey is concerned, the total area of land where soil is judged suitable for agriculture is about 198,000 ha for S1, S2 and S3, and about 97,000 ha for S1 and S2. Regional distribution of suitable land is roughly as follows:

(a) Batinah Region
S1-S3(39,000 ha), S1-S2(21,000 ha)
(b) Dahirah Region
S1-S3(24,000 ha), S1-S2(14,000 ha)
(c) Interior Region
S1-S3(19,000 ha), S1-S2(10,000 ha)
(d) Sharqiya Region
S1-S3(40,000 ha), S1-S2(23,000 ha)
(e) Southern Region
S1-S3(76,000 ha), S1-S2(29,000 ha)

(2) Use of Soil Survey Results

In order to carry out effective and systematic selection of suitable agricultural land and provide technical guidance for farmers on the basis of basic data, a data base should be prepared in order to manage, retrieve, process and utilize information effectively.

(3) Soil Management

In Oman, soils contain small amounts of organic matter, have low cation exchange capacity, and low nutrient contents. In order to cope with such disadvantages, careful management of chemical and organic fertilizer application is needed.

(4) Land Use

The potential for agricultural development in the country is determined mainly by the availability of soil and water resources. It is a pre-requisite that the procedure being carried out by the concerned

ministries for the distribution of agricultural land continue. In order to systemize the procedure based on more scientific data, the concerned ministries are suspending land distribution and conducting studies. They are expected to benefit by smoother procedures for farm land distribution.

With respect to sufficient food production, a land use plan should be prepared on the basis of a crop-production plan which considers where, when and how much should be produced.

2.5.2 Water Resources and Irrigation

2.5.2.1 Water Use

(1) Water Supply (Domestic and Industrial Use)

The water supply in Oman has increased rapidly recently, in step with Oman's economic development. The total water supply volume, excluding that from aflaj and private wells, increased from 46.3 m.c.m. in 1986, to 53.9 m.c.m. in 1988. The average annual growth rate in this period was 7.9 %.

In the capital area, the quantity of water available from wells in 1976 was 1.95 m.c.m., but with the first installation of a water desalination plant in Ghubra in 1977 and subsequent expansions, water production increased substantially from 3.1 m.c.m. in 1977, to 31.8 m.c.m. in 1988. In northern Oman, including the capital area, total water production rose from 39.0 m.c.m. in 1986, to 45.7 m.c.m. in 1988. Of that, 87 % was consumed in the capital area in 1988. It is significant that the ratio of annual water supply from wells decreased from 50 % in 1985 to 30 % in 1988.

The water-supply records for each month, and seasonal fluctuations of water supply in the capital area are shown in Figure 2.5.1. The water demand exceeds the annual average water supply in the summer (May - October) but is below it in the winter (December - March). The minimum water consumption per month in a year is about 70 % of that of the maximum per month. No remarkable fluctuations are observed.

In the Southern Region, water production increased from 2.0 m.c.m. in 1977, to 6.8 m.c.m. in 1985, and then to 8.0 m.c.m. in 1988. Wells dominated as water sources, except for a small desalination plant for brackish water at Dhalqut.

(2) Agricultural Water Use

The amount of water used for agriculture is difficult to measure

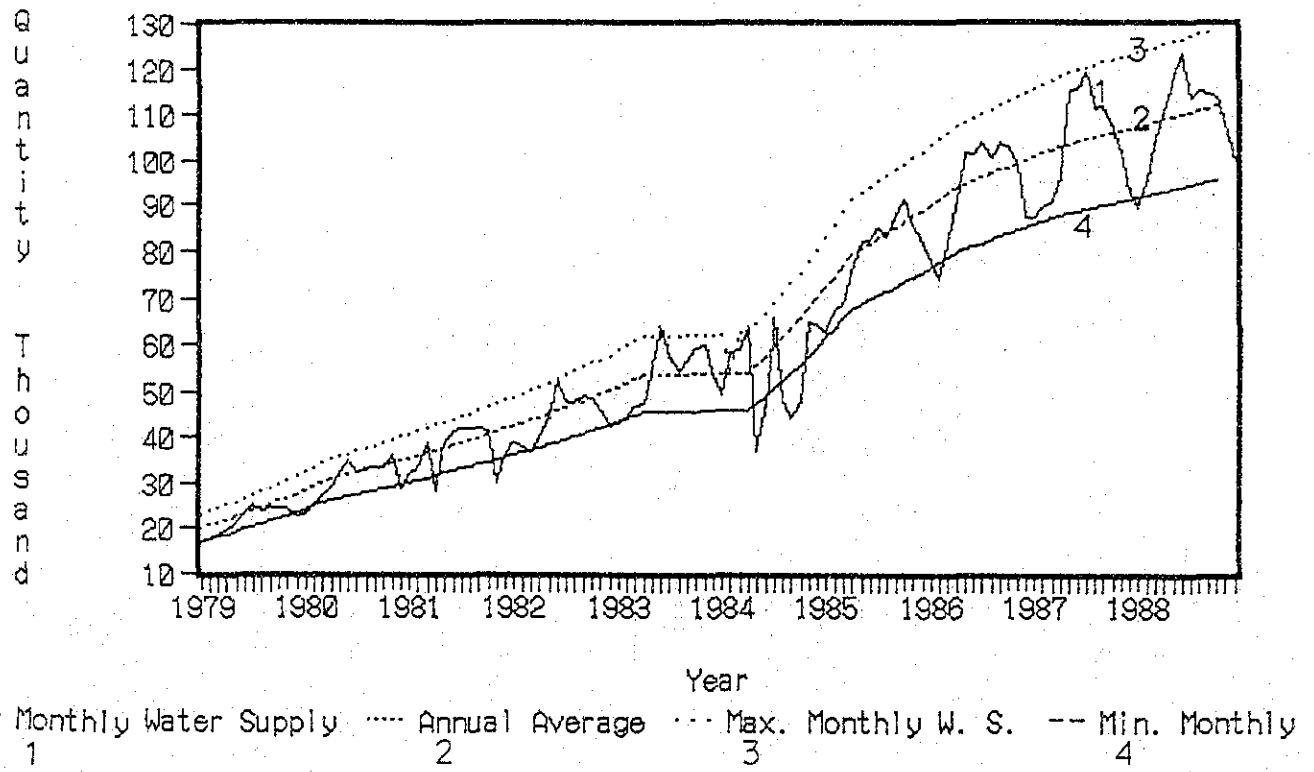


Figure 2.5.1 Seasonal Fluctuation of Water Supply in Capital Area

conclusively. A lot of estimates have been made by studies concerned with water-resources development. In 1982, PAWR (the predecessor to the Ministry of Water Resources) estimated that 1,260 m.c.m. of water was used for agriculture. On the other hand, 380 m.c.m. per year for agricultural use, which is one-fourth of the former result, was estimated by Hydroconsult in 1985. Arthur D. Little International Inc. estimated total agricultural water demand in 1985 at 2,184 m.c.m. These estimates do not take into account the potential for reuse of water.

In 1986, JICA reported that the annual average amount of water used from 1983 to 1984, in the Batinah coast area (about 10,000 ha) was approximately 233 m.c.m., most of which was consumed by irrigation. This was based on actual records taken from hydrological observation networks established by a technical cooperation scheme of the Japanese government. As a result of the survey, annual water use was estimated at 3,000 mm/year in mountainous areas and 2,258 mm/year in coastal areas.

The estimates for groundwater use vary widely. Given the uncertainties, agricultural water use on a regional basis was estimated in order to identify the general trends of water use in Oman, taking into account the characteristics of cropping patterns, irrigation methods in each agricultural region, results of the above-mentioned JICA study and regional recharge dam study reports submitted by MacDonald in 1989, and data on cultivated areas from MAF.

As shown in Table 2.5.4, annual agricultural water use in 1985 and 1988 was estimated to be 1,132 m.c.m. and 1,295 m.c.m., respectively. The annual growth rate was 4.6 % and approximately 53 % of the total agricultural water was consumed in the Batinah Region. Agricultural operations account for more than 92 % of the water used in Oman.

Estimates of agricultural water use are as follows:

Pattern A: Annual consumption: 2,200 mm/year
Crops: tree crops like date palms, limes, mangoes, etc. alfalfa, vegetables, etc. grown in combination. Dates are cultivated more than other major crops.

Table 2.5.4 Annual Agricultural Water Use

Year / Region	Pattern	1985		1986		1987		1988	
		Cultivated Area (ha)	Water Use (thousand c.m./year)	Cultivated Area (ha)	Water Use (thousand c.m./year)	Cultivated Area (ha)	Water Use (thousand c.m./year)	Cultivated Area (ha)	Water Use (thousand c.m./year)
North Batinah	A	12,872	283,184	13,384	294,448	13,995	307,890	14,605	321,310
South Batinah	A	14,667	322,674	15,219	334,818	15,920	350,240	16,602	365,244
Sharqiya	C	7,490	179,760	7,829	187,896	8,215	197,160	8,615	206,760
Dakhliya(Wusta)	B	1,816	54,480	1,911	57,330	2,005	60,150	2,109	63,270
Dakhliya	B	4,804	144,120	5,071	152,130	5,329	159,870	5,619	168,570
Dhahira	C	4,850	116,400	5,085	122,040	5,338	128,112	5,603	134,472
Al Janubiya	C	1,303	31,272	1,359	32,616	1,424	34,176	1,488	35,712
Total		47,802	1,131,890	49,858	1,181,278	52,226	1,237,598	54,641	1,295,338

Water source: wells
Region: North Batinah, South Batinah

Pattern B: Annual consumption: 3,000 mm/year
Crops: tree crops like date palms, limes, mangoes, etc. alfalfa, vegetables, etc. grown in combination. The ratio of alfalfa to dates is higher than that in Pattern A.
Water source: aflaj
Region: Dakhliya (Interior, Wasta)

Pattern C: Annual consumption: 2,400 mm/year
Crops: tree crops like date palms, limes, mangoes, etc. alfalfa, vegetables, etc. grown in combination. Cropping pattern is between Pattern A and Pattern B.
Water source: wells
Region: Sharqiya, Dhahira, Al Janubiya.

(3) Availability of Groundwater

Most of Oman is arid. Annual rainfall is about 130 mm, except for desert areas. Potential evaporation is quite high, around 2,000 mm/yr. This means that, basically, water resources are equivalent to groundwater resources. Most of the surface flow from catchment areas in the mountains percolates underground at the foot of the mountains.

It is important to estimate the availability of groundwater resources to assess the potential for agricultural development. As explained in section 2.5.2.1 (2), estimates of agricultural water use vary widely. In addition, uncertainty about groundwater-recharge rates and surface-run-off rates makes it difficult to estimate available water resources accurately. Groundwater endowments, however, have been estimated in order to understand the recent general trend of groundwater availability in Oman. This was done using the results of past studies, and a medium year's rainfall. The result is that groundwater recharge is 1,240 m.c.m/yr. However, agricultural operations require 1,309 m.c.m/yr. Water supply and

agriculture combined require 1,323 m.c.m/yr (see Table 2.5.5).

These calculations indicate that there are few groundwater resources available for development. More effective water conservation methods are required in most areas before groundwater-resources development will be possible.

General trends of regional water balance are as follows:

(a) Batinah region indicates serious overdrafting as seen in areas where salinization occurs.
(b) Dhahira Region is reasonably balanced.
(c) Dakhliya Region shows signs of overdrafting.
(d) Sharqiya Region might have additional available groundwater resources.
(e) Salalah Region reveals great disparity of available water resources, i.e. considerable additional water resources are available in some areas although salinization has already occurred in the central Salalah plain.

These regional assessments are also depicted on maps, namely "Regional Availability of Groundwater to Support Additional Agricultural Development in Oman" (scale: 1/500,000) drawn by MWR. These assessments are made on a regional basis. New water-resources development in catchment basins of individual wadi will be possible following a further, detailed water-balance study to be conducted by MWR. The results will be very useful in planning future water-resources development.

One of the potential areas for agricultural development is Nejd, where non-renewable groundwater is widely available. The volume of fresh water able to be extracted economically and reliably is estimated to be 10 m.c.m/yr, although its total availability is estimated to be about 80,000 m.c.m. Fossil water has to be carefully developed from a long-term point of view because of its non-renewable nature.

Another potential area for groundwater-resources development is the deep aquifers in the tertiary limestone in northern Oman, especially on

Table 2.5.5 Regional Groundwater Balance

Region Number	Region Name	Catchment Area (km2)	Mean Annual Precipitation (mm)	Mean Annual Precipitation (MCM)	Runoff Rate (%)	Catchment Runoff (MCM)	Flood Loss (MCM)	Gr.Water Recharge (MCM)	Estimated Agri.Use (MCM)	Water Supply (MCM)	Gr.Water Balance (MCM)
1	N.Batinah	4,860	137	665.82	40.0	266.3	26.1	240.2	321.3	0.0	-81.1
2	S.Batinah	7,757	125	969.63	35.0	339.4	22.5	316.9	428.5	8.7	-120.3
3	Dhahira	7,143	135	964.31	20.0	192.9	56.3	136.6	134.5	0.6	1.5
4	Dakhliya	4,280	168	719.04	30.0	215.7	58.3	157.4	168.6	3.2	-14.4
5	Sharqiya	10,597	105	1,112.69	25.0	278.2	46.2	232.0	206.8	1.1	24.1
6	Musandam	693	255	176.72	20.0	35.3	5.3	30.0	13.4	0.2	16.4
7	Al Janubiya	3,655	156	570.18	25.0	142.5	15.8	126.7	35.7	0.0	91.0
Total		38,985	133	5,178.37	28.4	1,470.3	230.5	1,239.8	1,308.8	13.8	-82.8

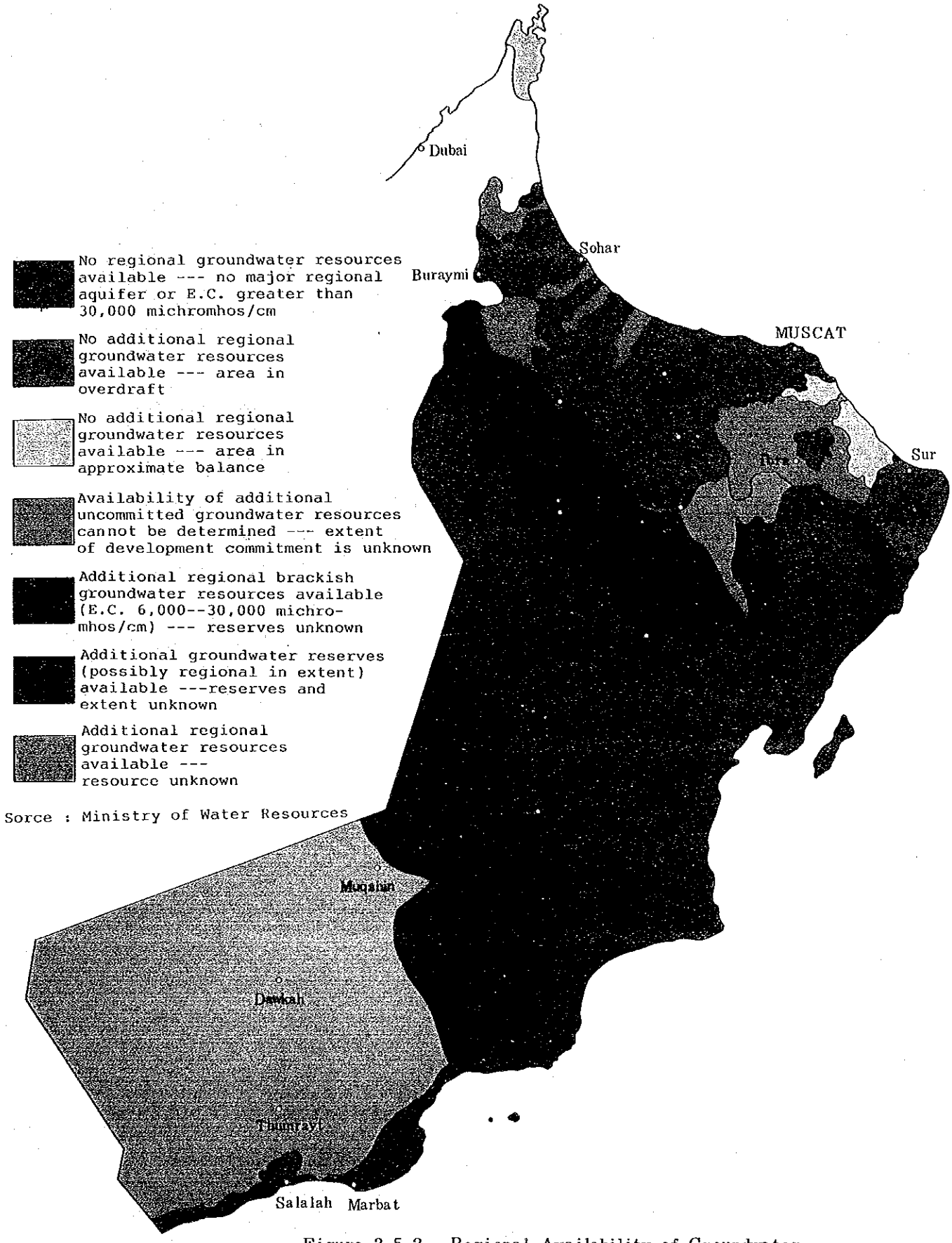


Figure 2.5.2 Regional Availability of Groundwater

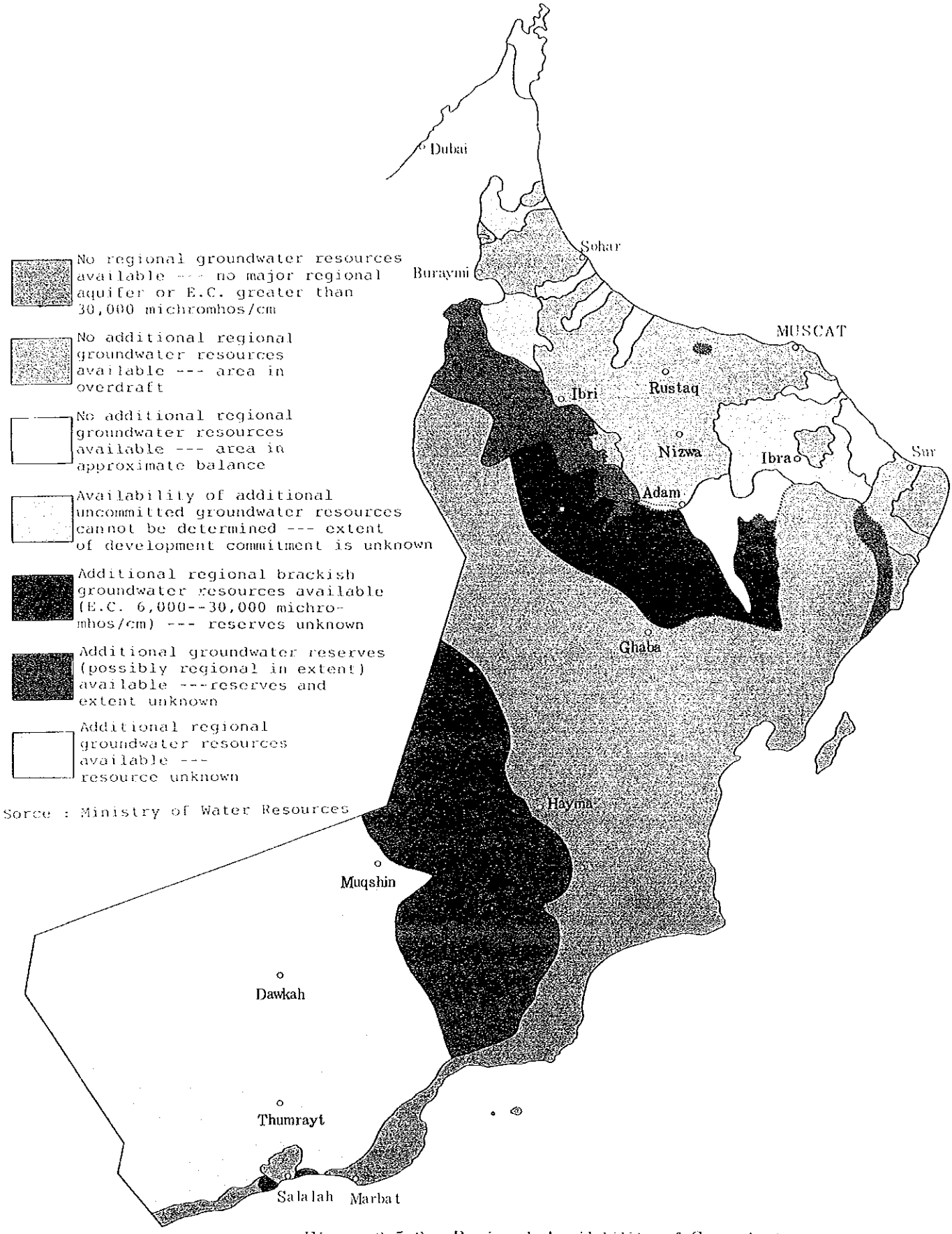


Figure 2.5.2 Regional Availability of Groundwater

the Batinah coast. Detailed investigations have not yet been completed, so only the possibility for development potential can be indicated at this stage.

There is one exception to this process of groundwater development. No attempts can be made to utilize the brackish water (more than E.C. 6,000 micro mho/cm) which is underneath the desert areas. It is impossible to plant ordinary crops there due to the water's high salinity, so it will be necessary to select special, more tolerant species.

2.5.2.2. Water-Resources-Utilization System

The present situation and the constraints affecting aflaj, wells and recharge dams are described below.

(1) Aflaj

(a) Present Situation

The aflaj of Oman have provided communities with water for domestic and irrigation purposes for 1,500 - 2,000 years. They are the dominant, traditional means of obtaining water in all areas of northern Oman except for the Batinah coast. Many of them in operation at present are over a thousand years old, and some may even date back to the fifth century B.C. They are controlled by well established social and financial structures which have evolved from ancient times.

From the standpoint of spontaneous water management, which takes into account the seasonal fluctuations of water flow, falaj systems adapt themselves very well to the amount of water flow, especially in dry season. Water from a falaj is utilized for farm irrigation at the end of the system, where date palm trees are major crops and seasonal crops such as wheat, alfalfa etc. are cultivated around date palm trees in wet seasons. In dry seasons, however, seasonal crops are not cultivated and water is mostly allocated to the date palm

trees which are traditionally so important to the Omani. The sources of falaj water are classified as follows.

(i) natural springs from alluvial and fractured bedrock

(ii) perennial wadi flow

(iii) groundwater contained in wadi gravel (beneath both present-day and former wadi courses), and often fractured bedrock layers as well.

Each falaj system comprises three basic sections:

(i) water-collecting section;

(ii) water-conveyance section; and

(iii) water-distributing section;

To maintain the underground water-collecting section and carry out major repairs, administrations and finances for aflaj are required. Although the total number of aflaj is unknown, it is estimated that there are more than 4,000. MAF lists names of around 2,000 aflaj and the locations of 300 aflaj are indicated on a map prepared by the Department of Surveys.

(b) Problems

In the past twenty years, Oman has achieved rapid economic growth and this has brought with it major socio-economic changes. Unfortunately, the traditional institution of the falaj systems has not really been able to keep up with these changes. The following problems have occurred in recent years.

(i) Shortage of maintenance funds

Income increases in rural communities have often led

landholders who have insufficient water rights to irrigate the crops they wish to grow to establish private wells instead of using falaj water. The decrease in the number of participants has caused a shortage of funds, because the maintenance fund for a falaj depends on the lease of its water.

(ii) Lack of local labor

The creation of job opportunities in the cities has drawn people of working age away from rural areas. Even though they come back, they usually do not work unless they are paid high wages. This lack of a labor force results in infrequent communal maintenance work on the aflaj.

In addition to these problems, aflaj face physical and institutional constraints as follows:

(i) Decline of groundwater table

Recent establishment of pumping wells has caused a decline of the groundwater table where falaj water is collected, so that its water flow is adversely affected.

(ii) Difficulty of flexible water management in introducing new crops

The traditional arrangement for water use in which water is distributed based on eight- or sixteen-day rotation intervals makes it difficult to grow highly valued vegetables such as watermelons, fruit, and spices on falaj land.

(iii) Water losses in falaj water distribution systems

Water losses in a falaj system are attributed primarily to un-lined, inefficient channels and water distribution which follows no sequence from one farm to the next. It is likely to be especially difficult to adjust the water rotation system

without offending water-right holders, since water-rights are hereditary and personal property.

(iv) Inefficiency of mechanization on farm

The introduction of agricultural machinery into farming to fill the labor shortage is difficult because the small size of the farms prevents suitable mechanization.

(2) Wells

(a) Present Situation

There are two types of wells in the country. One is the hand-dug well which can be seen mainly in the coastal areas at Batinah and Salalah. The other is a drilled well which supplies water to most of the drinking water supply systems. This type of well has been introduced to agriculture relatively recently, but it has spread rapidly, mainly on the Batinah coastal plain. It is intended mainly for unconfined groundwater but sometimes taps into semi-confined groundwater. It is drilled mainly by the rotary method.

Since wells are private property, no water management system is currently able to prevent excessive pumping. The actual number of wells is not known for certain, although it is roughly estimated at 40,000, based on the number of pumps sold. Of these, 30,000 wells are the hand-dug type. However, the number of drilled wells is increasing.

(b) Problems

The following three items can be pointed out as major problems in utilization of wells:

(i) Reduced function of old hand-dug wells

Since most of the hand-dug wells were constructed quite a

long time ago, there are many wells where the well wall is severely damaged or the well has become shallow due to deposits at the bottom. MAF has extended a subsidy to rehabilitate these old wells under the Third Five-year Development Plan. Unfortunately, further support shall be required in the future.

(ii) Lowering of groundwater table

Lowering of the groundwater table is observed in various inland areas due to the proliferation of drilled wells. This has resulted in reducing the functionability of the existing aflaj and hand-dug wells, and of drilled wells themselves. The reason is clearly over-pumping, however, it is important to take practical measures against this.

(iii) Sea-water intrusion

Over-pumping in the coastal plain does not reduce the groundwater table as rapidly as observed in inland areas, but instead induces sea-water intrusion. Considerable areas have already suffered from salinization and it is particularly serious in the vicinity of Barka on the Batinah coast and in Salalah.

(3) Recharge Dams

(a) Present Situation

In order to increase agricultural production and groundwater resources, the government investigated the viability of artificial groundwater-recharge methods and proposed the construction of recharge dams in the Second Five-year Development Plan. In 1983, the construction of Al Khawd Dam commenced as a pilot project, and subsequently Hilti/Salahi Dam and Wadi Quriyat Dam were also begun. In parallel with these operations, a preliminary survey for a countrywide recharge-dam plan was conducted. It identified 58 proposed recharge-dam sites, including the existing ones. After

observing the effect of the three pilot projects, three recharge dams, i.e. Wadi Al Jizzi, Wadi Ghul and Wadi Tanuf have been completed under the Third Five-year Development Plan, and recently, the final designs of four dams in the Barka/Rumais area have been prepared. One of them is now under construction. Three dams in other areas are under construction as well.

The first three dams were located on the Batinah coast (two dams) and in Dakhliya (one dam) and constructed relatively far downstream of the respective wadi. The three dams constructed later were located on the Batinah coast (one dam), and in Dakhliya (two dams). They were constructed relatively far upstream compared with the first dams. The dam being constructed on the Batinah coast is located downstream, like the first ones.

(b) Problems and Considerations

In planning the existing recharge dams, flood discharge from the catchment area and conditions of the downstream aquifer were studied to the extent possible. However, since basic data, such as precipitation and river discharge were generally not fully available, it was rather difficult to estimate the dams' effectiveness beforehand. Accordingly, it is vital to analyze the observation records obtainable from the existing dams and to use the results in planning new projects. In order to analyze the effects of the recharge dam, hydrological records observed before the construction of the dam are essential; unfortunately, studies were seldom conducted. Therefore, it is strongly recommended that such observations be performed prior to the construction of more dams.

A considerable amount of data has been made available by the initially constructed dams. These data must be analyzed and the results applied to the fullest possible extent to future projects.

Some of the existing dams have been constructed at locations relatively distant from the mountain foot. In general, the infiltration capacity is higher in areas closer to the mountain foot,

which suggests that the farther upstream the recharge dam is, the larger its effect will be.

2.5.2.3 Irrigation

(1) Present Situation

(a) Irrigated Area

There are no statistics regarding the extent of irrigated area in the country except in the First Agricultural Census of 1974-79.

Table 2.5.6 shows the estimated area equipped with irrigation systems as compared to the total area irrigated by region. Of the total area, 65 % was supplied with irrigation systems, 26 % of the total irrigated area was irrigated by aflaj, and 67 % by wells (see Table 2.5.7). At present it is roughly calculated by MAF that 50 % of the area is irrigated by aflaj, and the remaining 50 % by wells.

(b) Irrigation System Efficiency

Several studies have been conducted with regard to irrigation system efficiency. Generally speaking, traditional flood irrigation systems are unlikely to rise above an irrigation efficiency rate of 65 % and are more likely, given unlined canals and uneven basins, to drop to 30 - 45 %. The efficiencies of modern irrigation systems like sprinklers, and drip are 70 - 85 % (see Table 2.5.8).

The most common irrigation system in Oman is flood irrigation. Its irrigation efficiency, as mentioned above, varies from 30 % to 65 % (30 % to 45 % if an unlined channel is used). The application efficiency of flood irrigation is, naturally, reduced by the over-irrigation which is necessary in order to adequately irrigate the least watered area, i.e. the farthest area from the intake of a field.

Table 2.5.6 Estimated Area Equipped with Irrigation Systems

(Unit: ha)

Region	Total area	Area supplied with irrigation systems			Area not equipped with irrigation systems
		Total area	Irrigated	Not irrigated	
Batinah & Capital	46,126.08	25,400.10	21,121.98	4,278.12	20,725.98
Mussandam	1,120.46	1,120.46	903.98	216.48	0.00
Hajar Al Gharbi	2,623.72	2,623.28	1,892.00	731.28	0.44
Hajar Al Sharqiya	1,955.58	1,685.20	1,211.32	473.88	270.38
Jqh & Buraimi	1,312.52	1,312.52	795.30	517.22	0.00
Al Dahira	7,202.36	5,953.42	2,584.78	3,368.64	1,248.94
Oman Interior	14,494.92	8,045.84	4,341.26	3,704.58	6,449.08
Sharqiya & Gaal	5,817.68	5,769.06	3,866.06	1,903.00	48.62
Dhofar	2,706.66	2,486.88	1,594.78	892.10	219.78
Total	83,359.98	54,396.76	38,311.46	16,085.30	28,963.22

Source: First Agricultural Census, 1978-79

Table 2.5.7 Distribution of Irrigation Area by Irrigation Source by Region

(Unit: ha)

Region	Total area	Area irrigated by				More than 1 source
		Falaj	Well	Spring	Rain	
Batinah & Capital	21,112.96	2,935.46	17,697.24	72.16	198.88	209.22
Mussandam	1,324.84	0.00	1,252.68	0.00	40.92	31.24
Hajar Al Gharbi	1,901.02	1,627.56	104.50	3.30	1.10	164.56
Hajar Al Sharqiya	10,010.44	788.04	9,152.88	0.00	3.96	65.56
Jqh & Buraimi	795.30	581.24	132.66	11.44	0.00	69.96
Al Dahira	2,603.48	1,364.88	559.24	0.00	3.08	676.28
Oman Interior	4,337.52	2,244.44	1,010.46	1.54	0.00	1081.08
Sharqiya & Gaal	3,883.44	2,868.36	508.64	21.12	1.32	484.00
Dhofar	1,826.00	0.00	1,586.20	11.00	228.80	0.00
Total	47,795.00	12,409.98	32,004.50	120.56	478.06	2,781.90

Source: First Agricultural Census, 1978-79

Table 2.5.8 Irrigation System Efficiency

System	Irrigation Efficiency		
Traditional	45%	40%	30%
Traditional lined canals	65%	-	-
Piped supply and flood	70%	-	-
Modern sprinkler (pump)	75%	60%	60%
Drip/Trickle	85%	80%	85%

Source: Hydroconsult(1985), Arthur Little(1985), Atkins(1989)

(c) Introduction of Modern Irrigation Systems

In order to rationalize agricultural water consumption, MAF has adopted financial subsidies and policies to encourage farmers to use modern irrigation systems and to teach them about the benefits and required water for each crop.

A Royal Decree regarding adopting modern irrigation systems in Batinah was issued on July 23rd, 1989 (Royal Decree 72/89). It decreed that MAF and MWR shall issue, under the authority of each ministry and subject to the approval of the ministers' cabinet, the necessary regulations and resolutions for the adoption of modern irrigation systems in the Batinah Region.

MAF is carrying out two detailed integrated studies in Batinah with regard to the introduction of modern irrigation. One is the "Study of a New Organization of Irrigation in Barka-Rumais Area in View of the Conservation of Water Resources and Optimization of Their Use" and the other is the "FAO/MAF Soil Survey Project".

Modern irrigation systems such as bubbler, sprinkler, center pivot and trickle have been installed in some newly established modern farms and have achieved higher agricultural productivity. Small farmers, however, hardly ever use them. The main reasons for this are that farmers do not understand the importance of saving water, even though a Royal Decree was issued on the subject, nor do they have the capital or knowledge required to install the modern systems. Another constraint is the shortage of instructors to teach the correct water management methods to them. Extension services from private contractors and extension officers are not sufficient to foster whole-hearted participation.

2.5.2.4 Administration for Water-Resources Development

(1) Governmental Organizations Concerning Water-Resources Development

Ministries concerned with water-resources development and their responsibilities are as follows.

(a) Ministry of Water Resources

(i) To be responsible for the development and maintenance of water resources in the Sultanate.
(ii) To propose general policies for the formulation of a long-term water plan in line with the socio-economic plan of the country and submit the same for government approval.

(b) Ministry of Agriculture and Fisheries

(i) To organize and manage agricultural water use.
(ii) To supervise maintenance work on aflaj, wells and springs.
(iii) To construct groundwater-recharge dams in order to provide water for agricultural development.
(iv) To save farmland from erosion and damage due to flooding from nearby wadi by erecting suitable protection.
(v) To provide the statistics and survey data on falaj, wells, springs and dams.

(c) Ministry of Electricity and Water

(i) To construct desalinization plants for the water supply in the Capital area and to control their operation and maintenance.
(ii) To construct pump stations, storage tanks, and to expand the pipeline network in the Capital area.
(iii) To expand water-distribution networks in major cities.
(iv) To provide potable water to rural areas.

(d) Office of the Minister of State and Wali of Dhofar, Directorate General of Water Supply and Transport

(i) To construct pump stations, storage tanks, and to expand the pipeline network in Salalah.
(ii) To expand water-distribution networks in major cities of Dhofar.

(e) Ministry of Defense

(i) To supply water to military bases.

(2) Legislation and Regulation

The Sultanate depends heavily on groundwater resources, which are obtained by means of wells and aflaj. Due to the scarcity of rainfall, the groundwater level in aquifers is subject to change. Considerable attention has been paid to conserving water resources by applying laws, regulations and issuing Royal Decrees.

MWR (formerly PAWR) has been responsible for issuing permits for the drilling of new wells, in accordance with rules concerning restricted areas and specifying distances from mother wells of aflaj.

A Royal Decree regarding water resources as a national wealth was issued in November, 1988 (Royal Decree No.82/88).

MWR is preparing a national water resources master plan for sustainable development, management and conservation of the water resources of the Sultanate.

(3) Coordination Between MAF and MWR

Many studies have been carried out by MAF in the field of agricultural development. Studies of land resources and water resources are indispensable for agricultural development. Without proper water-resource studies, deliberate agricultural development plans cannot be worked out. Therefore, coordination between these two agencies is very important in expanding new farmland and ensuring the availability and suitability of water for irrigation with a nation-wide water-resources development and conservation framework.

2.5.2.5 Development Potential

(1) View of Irrigation and Dams

On the whole, the potential for large-scale water-resource development is low in the Sultanate of Oman, although there are viable places for it in some regions. Therefore, emphasis should be placed on improving water-use efficiency. In the meantime, action to augment the quantity of groundwater should be taken from a medium-term point of view. The following four subjects are important in planning agricultural development projects.

(a) Water conservation
(b) Augmentation of available groundwater resources
(c) Utilization of new water resources
(d) Establishment of a legal framework

It will be most effective if these subjects are integrated.

(2) Water Conservation

It is obvious that appropriate water-saving methods could create great potential for new agricultural developments and water conservation. It will, however, take a long time to complete water-saving programs since they need the understanding and cooperation of farmers who are, in general, conservative and do not pay much attention to optimizing water management. Installation of modern irrigation systems and an improvement of irrigation efficiency in Oasis are very important subjects to achieve effective water conservation.

(a) Installation of Modern Irrigation Systems

Flood irrigation is the most common irrigation method in Oman. Its irrigation efficiency is generally estimated to be 30 to 40 %. Efficiency could be doubled by introducing new irrigation methods such as bubbler, sprinkler and trickle i.e. up to 60 to 80 %. This would result in doubling available arable land with the same amount of water presently utilized for agriculture. At the same time, water

balance deficits in overdrafted areas could be made up for by reducing groundwater discharge. New irrigation systems are, therefore, a promising solution on the Batinah coast, where sea-water intrusion occurs.

Modern irrigation systems save water and improve agricultural productivity by means of properly controlling the amounts of water used. Furthermore, manpower required for management is reduced. Organizing and managing the use of agricultural water are important duties for MAF, so emphasis should be placed on improving irrigation systems, which will play an important role in improving agricultural productivity.

(b) Improvement of Irrigation Efficiency in Falaj Systems

Aflaj are well suited to closed, self-sufficient societies so several problems, mentioned in section 2.5.2.1, arose in the relatively open society brought about by rapid economic growth. Maintenance problems in the transporting section and the collecting section can be resolved by the 'Maintenance and Repair of Aflaj Project', which is entirely subsidized by MAF. However, the resolution of physical and institutional problems in oases, which is crucial to improving irrigation efficiency, is mandated to local falaj organizations. It is likely that MAF will have to persuade farmers to adopt appropriate water-management systems, although each falaj organization ought to select one by itself. Modern irrigation should not be required to replace the falaj system. Ways of re-instating and utilizing the advantages of traditional falaj systems, and of rectifying their disadvantages, little by little should be considered. The following are difficulties to be solved.

(i) Improvement of distribution channels

(ii) Effective usage of surplus water in wet seasons

(iii) Rebuilding of efficient water-distribution systems in oases

The first two subjects will not be difficult to resolve from a technical standpoint. The most difficult subject is the third one. It is impossible to introduce modern irrigation systems before traditional water-distribution systems are rebuilt.

An example of how to improve the efficiency of water-distribution systems is described in volume 2, chapter 5, section 5.2.4.2.

(3) Augmentation of Groundwater

It is extremely important to rationalize irrigation methods and to refrain from wasting water resources, and also to augment groundwater from a medium-term viewpoint. The combination of the following three subjects, taking into account regional situations, will have a profound effect on efforts to increase groundwater.

- Increase groundwater recharge
- Store essential groundwater outflow
- Rationalize groundwater-intake facilities

(a) Groundwater Recharge

Recharge dams are the most common way of augmenting groundwater in Oman. It will become even more important to connect the construction of recharge dams with recharged-water usage. One of the main objectives in constructing recharge dams is agricultural land development. It is, therefore, vital that implementation of agricultural development projects such as modern irrigation projects, which help to improve agricultural production, be carefully planned within the limits of the replenished groundwater.

The dams which have been constructed were pilot projects to monitor recharge effects. MAF is monitoring and collecting hydrological data for the purpose of analyzing recharge effects and

establishing proper maintenance and operation procedures.

The special feature of recharge dams constructed to date is that in most cases they are downstream of the wadi and store the entire peak discharge temporarily. Considering the importance of groundwater-recharge schemes, there is a need to study every kind of potential recharge technique depending on the characteristics of each dam site.

An example of a possible method is the combined dam network which is shown in volume 2, chapter 5, section 5.2.4.3.

(b) Storage of Essential Groundwater

Recharge dams are one of the methods by which to increase groundwater by making surface flow percolate into the ground. It is very beneficial for a groundwater-recharge method to store essential outflow bound for the sea or desert. Every year, even if there is no rain, large quantities of essential groundwater flow out to the sea and into the desert. Artificially recharged groundwater might also be escaping.

A sub-surface dam (underground dam) is another effective method for retaining essential groundwater outflow. It can dam groundwater and store it behind a cut-off wall which extends down from near the ground surface to the bedrock, provided an appropriate underground valley fenced by an impermeable bedrock stratum is identified.

Such a wall can prevent sea-water intrusion along the coast as well. If the impermeable bedrock is so deep that construction of high sub-surface dams is not economical, then low sub-surface dams should be considered. These will also contribute to the reduction of sea-water intrusion. If they are used in combination with recharge dams, this will further increase their effect. Sub-surface dams, the bottoms of which, the cut-off walls, are sealed to the bedrock have already been constructed and made excellent use of in Japan.

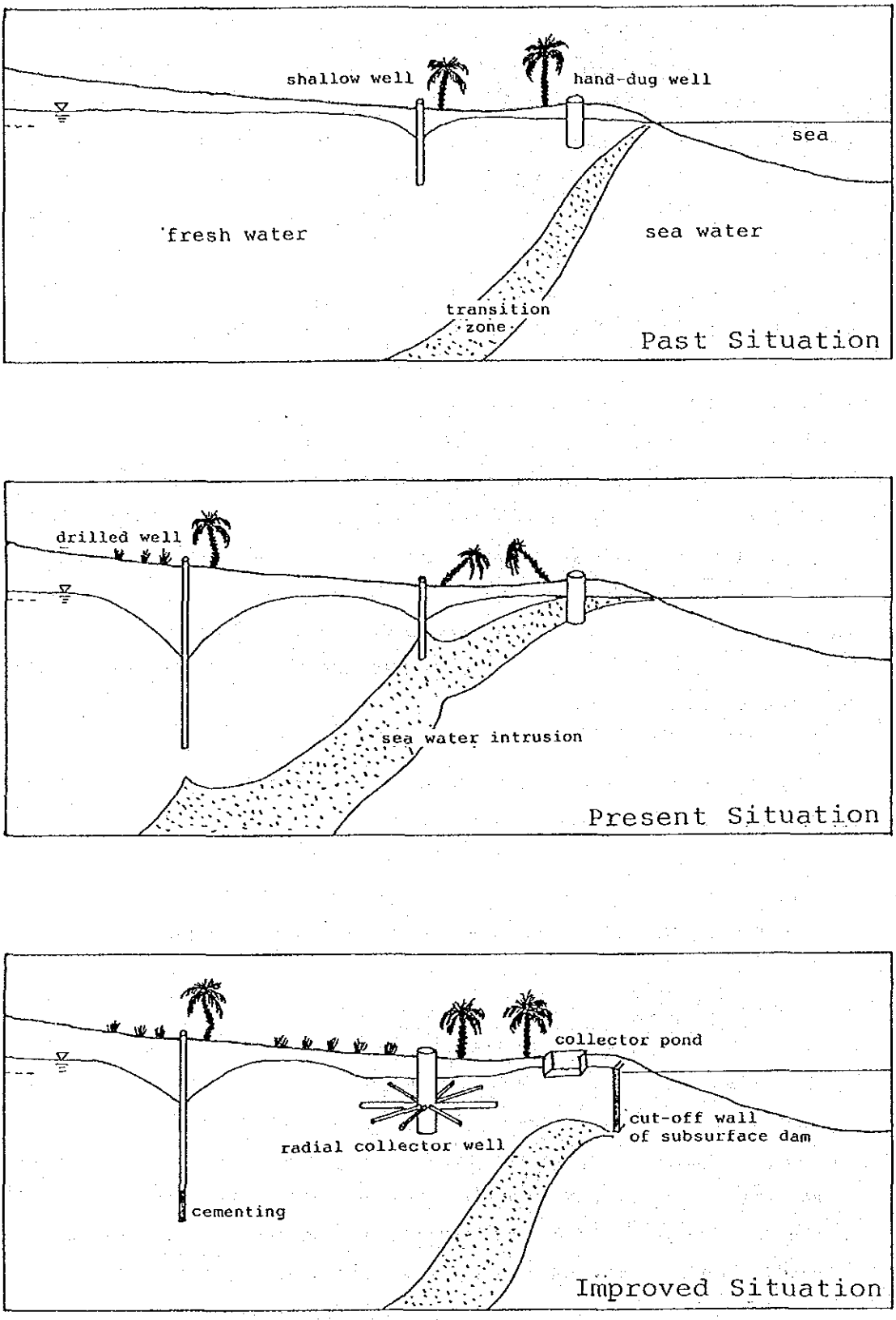


Figure 2.5.3 Effect of Subsurface Dam

In planning sub-surface dams, hydrogeological surveys play an extremely important role. First of all, test drillings are required in order to select an appropriate project site and identify aquifer constants, etc. Then, detailed data analysis and computer simulation utilizing adequate hydrogeological data must be performed to ensure that the dam is designed properly.

Since there are a number of uncertainties with regard to implementing a sub-surface dam project in Oman, a survey to identify proper dam sites should be initiated. Subsequently, a pilot project to construct a sub-surface dam can be considered.

(c) Diversification of Well-Type

Hand-dug wells and drilled wells are common in Oman. As a result, the country is suffering from a decline of the groundwater table and salinization caused by groundwater overdrafting. For the sake of water-resources conservation, the following three types of wells are considered more favorable.

- collector pond

- collector culvert

- radial collector well

Adoption of these three types of wells is a short-term solution as it only eases constraints occurring in limited areas. It should be understood that they will not contribute significantly to an improvement of the long-term groundwater balance. In addition, since drilling costs for these well-types are rather high compared with those of existing wells, individual users will probably not be able to install them. They should be utilized as public wells which serve several farms, and will probably require some sort of official assistance.

(4) Utilization of New Water Resources

It takes time from a study phases to realize agricultural production which utilizes groundwater reserved by recharge dams and sub-surface dams. Other new groundwater-resources-utilization techniques which yield more immediate results and therefore can be readily incorporated into regional development are also important.

There are some promising areas for new agricultural development using shallow aquifers. Examples are as follows.

- Wadi Dayqah (near Quryat)
- Wadi Bani Khalid (near Al Kamil)
- Wadi Andam (near Mudaybi)
- Wadi Darbat (near Taqah, Salalah)

Optimum water-resources utilization methods in each wadi should be considered, taking into account their individual hydrogeological features. Some detailed agricultural development surveys in each wadi have already been begun by MAF.

A preliminary study on Al Kamil area was conducted in 1983; however because of the increase of groundwater use in the area after the study, a review is probably necessary. Feasibility studies on the Buraimi area and the L'Ajrid area have been completed.

At the same time, groundwater in deep aquifers, which has not been fully developed should be tapped by drilling deep wells. As examples of this kind of new water-resources development, fossil-water developments in Nejd and the tapping of groundwater in the tertiary limestone which lies under the Batinah coast are promising. The information necessary for agricultural development in Nejd has been accumulated and initial development should proceed as quickly as possible. Further investigation, however, on the Batinah coast is necessary to identify precise potential for agricultural development. It is necessary to conduct a proper study

for the Batinah coast as early as possible, because of its important role in agricultural production.

(5) Establishment of Legal Framework

It is necessary for MWR to establish a conservation and development strategy for each drainage basin on the basis of deliberate water-balance control, i.e. to establish a groundwater control framework for each drainage basin taking long-term forecasts of supply and demand into consideration as well as the physical characteristics and social conditions of agricultural communities. MAF is in a position to make the utmost effort to maintain and improve agricultural productivity. Under these circumstances, the most effective and important policy that MAF should take is to create an efficient water-conservation scheme on farms, and facilitate water-saving management and the installation of modern irrigation systems. Oman must save water in order to improve productivity.

Heightening farmer willingness to improve their irrigation systems will be most effective in trying to popularize water-saving irrigation. Certain incentives are necessary. One of them is the provision of a subsidy.

Provision of subsidies which oblige farmers to save agricultural water and to install flow meters in order to report to extension officers their water consumption with kinds of crops cultivated, will contribute to the expansion of modern irrigation systems and the extension of water-management technology to farmers. It will be even more effective if such assistance is applied in those areas where the water balance is negative, and where wells are the main water source.

2.5.3 Cultivation

2.5.3.1 Kinds of Cultivated Crops

(1) Present Situation

(a) Fruit Trees

Fruit trees occupy approximately 65 percent of the entire cultivated crop area, and the area for date palms accounts for nearly 75 percent of all the fruit trees. The number of major varieties of date palms is about 10, and each has a specific color and season for maturing. The areas cultivated for mangoes and limes are next to date palms in rank, and both have been cultivated in Oman for many years. The Omani lime is a local variety and is used for juice the same way a lemon is. Dried limes are used for seasoning and spice.

Four crops - the three mentioned above and bananas - occupy nearly 93 percent of the area cultivated for fruit trees. Other major fruits are papayas, pomegranates, guavas, apples, quince, grapes, plums, apricots, walnuts, figs, and almonds.

(b) Vegetables

Vegetables occupy slightly more than 15 percent of the entire cultivated area, and again various kinds are cultivated. Watermelons and tomatoes are remarkable for their cultivated area which corresponds to slightly more than 25 percent of the entire vegetable crop. Other major kinds are cabbage, cucumbers, sweet-melons, chili peppers, onions; although, the total cultivated areas for all seven of these vegetables is still only slightly more than 60 percent of the entire vegetable crop.

The major crops other than the above are garlic, potatoes, okra, eggplants, squash, pumpkins, carrots, cauliflower, radishes, turnips, lettuce, spinach, leeks, beans, peas, etc.

(c) Field Crops

Field crops are classified into upland crops and forage crops. Major upland crops are sorghum and wheat.

Other than these, barley, maize, cowpeas, chick-peas, etc., are cultivated. Barley and maize are also used as green fodder.

With regard to forage crops, alfalfa is by far the most common, occupying more than 80 percent the total area devoted to field crops, and cultivated on the most farms. MAF has recommended the production of Rhodes grass in recent years, because it is superior to alfalfa in terms of drought, salinity tolerance and yield. The area cultivated for this grass is increasing, especially on commercial farms.

(d) Industrial Crops

Industrial crops consist mainly of tobacco, sugar cane, and cotton. However, the area cultivated for these is still small. Tobacco prevails in North Batinah as frankincense does in the Southern Region. Coffee is being cultivated under experimental conditions on the Plateau of the Southern Region.

(e) Flowers and Others

Roses are cultivated to produce rose water at Jabal Akhdar. Some commercial farms produce and sell many kinds of ornamental plants such as croton, dracaena, caratea, and others. For example, a certain commercial farm raises flowers, flowering trees, ornamental plants, succulent plants, etc., and has recently decided to cultivate orchids.

(2) Development Potential

Among those crops cultivated in the country are temperate vegetables, tropical fruit trees, flowers, and ornamental plants. They are deemed useful for the future development of agricultural management.

Regarding seed production, there is a further possibility on the Dhofar plateau of the Southern Region and Jabal Akhdar of northern Oman of producing potatoes; in the Interior, producing onions, carrots, chilly peppers, etc. In the mountainous area (Jabal Akhdar), in addition to the production of various temperate vegetables during the off-crop season, and temperate fruit trees, vernalization will be made feasible by temporarily planting strawberry seedlings in the summer for cultivation in the plain area. With respect to the utilization of brackish water and land damaged by salt, the introduction of appropriate crops and the expansion of cultivable land are worth examining, since there are various salt-tolerant and drought-tolerant crops such as coconuts, Rhodes grass, sisal, Burbank's spineless cactus (Opuntia ficus - indica), Atriplex, Salicornia, etc.

2.5.3.2 Cropping System

(1) Present Situation

(a) Northern Oman

The cropping pattern is generally monoculture on new large-scale farms and commercial farms. However, on small-scale traditional farms, there are many cases where intercropping has been adopted to grow feed crops, etc. beneath and between the date palms. Crops of this kind are primarily barley, sorghum, alfalfa, etc.

In summer, extremely high temperatures and the dry climate make cultivation difficult. Most of the one-season crops in the north of Oman are cultivated in the winter season, which starts at the beginning of September and ends at the end of March, since that is when a little extra precipitation is available and the temperature stays relatively low. The farmers generally employ single cropping systems, a typical example of which is illustrated in Figure 2.5.4. As clearly depicted in the figure, almost all crops are seeded from July to November and harvested from November to April the next year, except watermelons and sweet-melons, which are generally seeded in

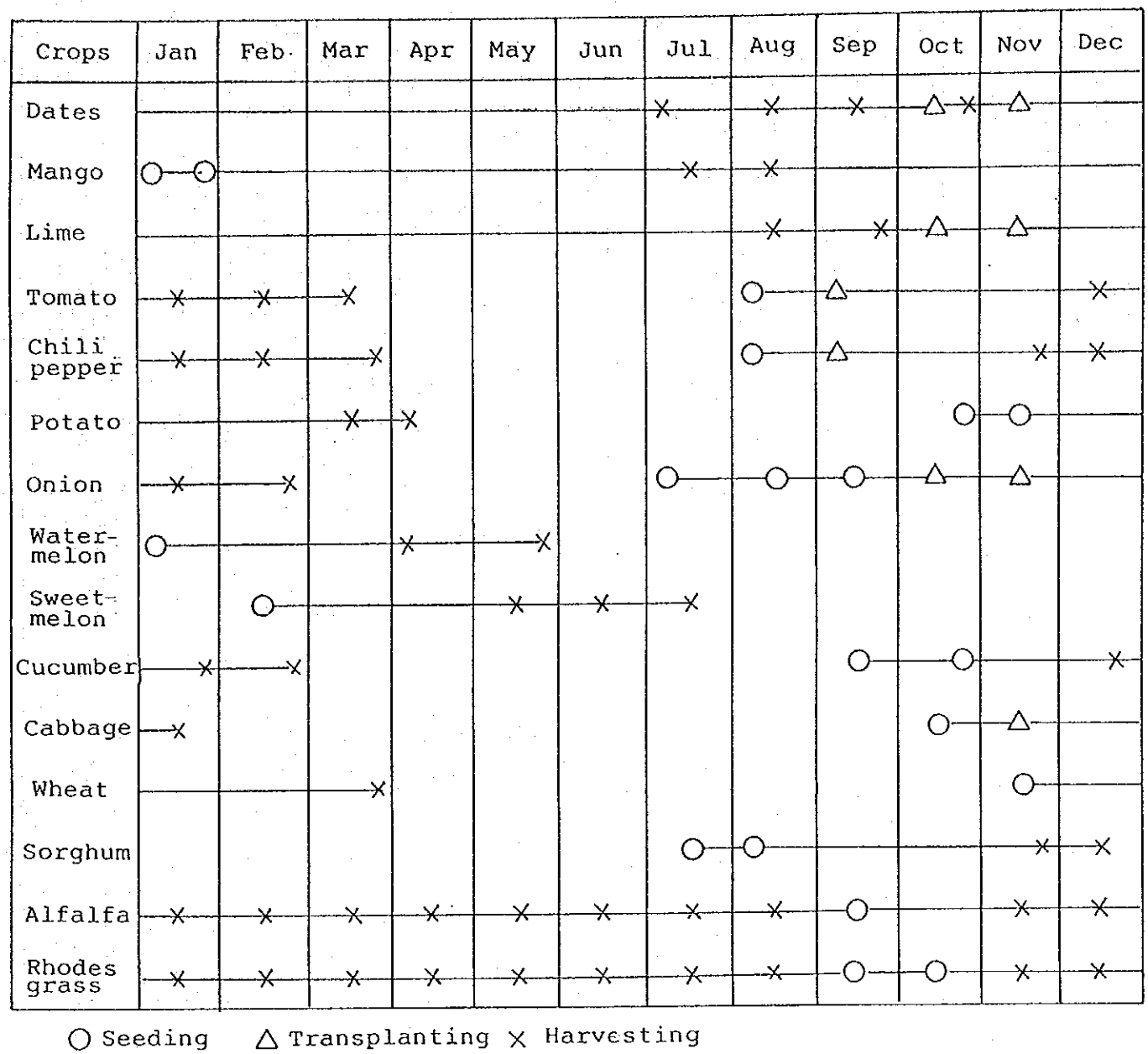


Figure 2.5.4 Example of Cropping Season of Major Crops in North Batinah Region

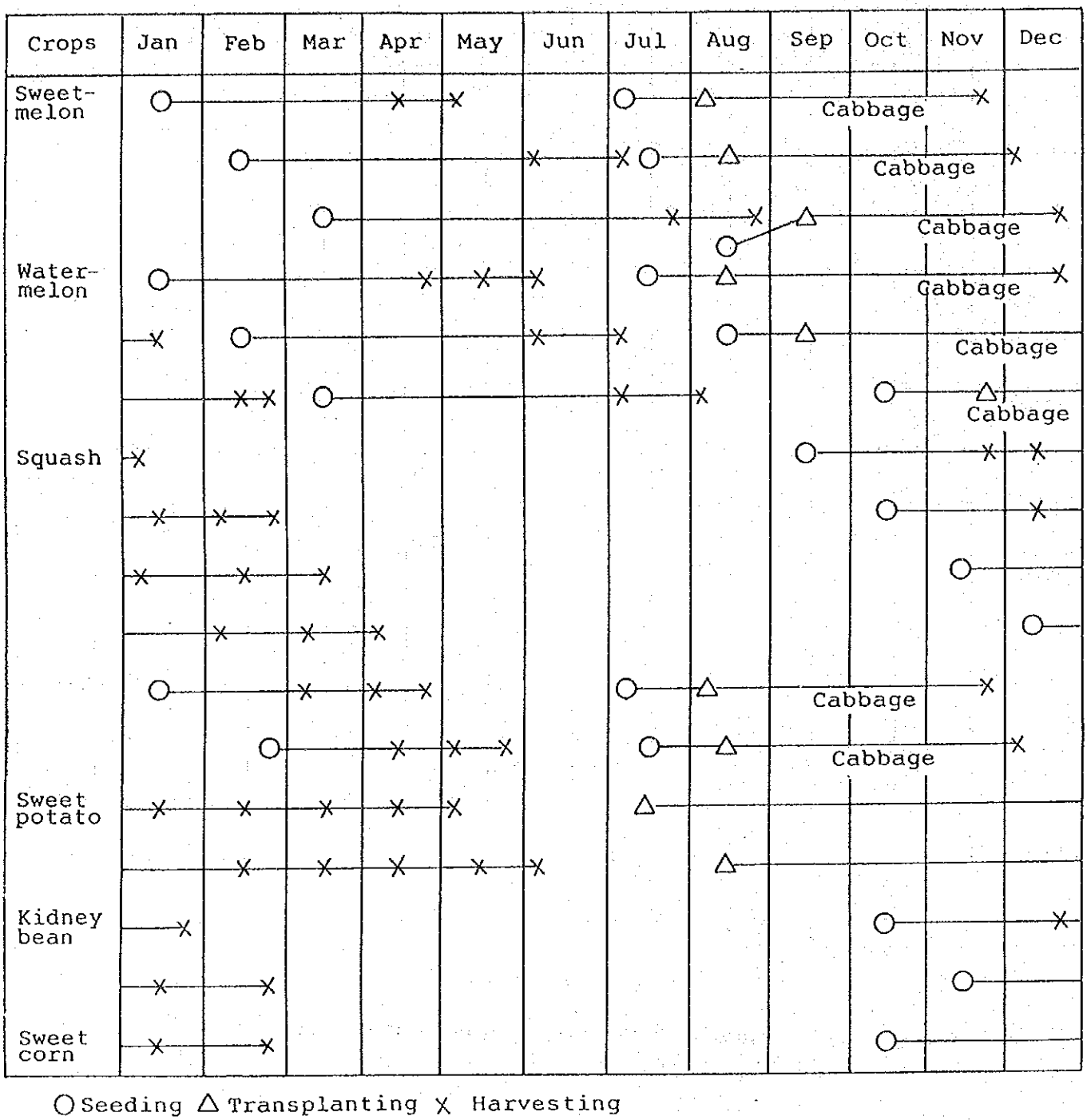


Figure 2.5.5 Example of Cropping Season in Double Croppings in the Oman Modern Farm

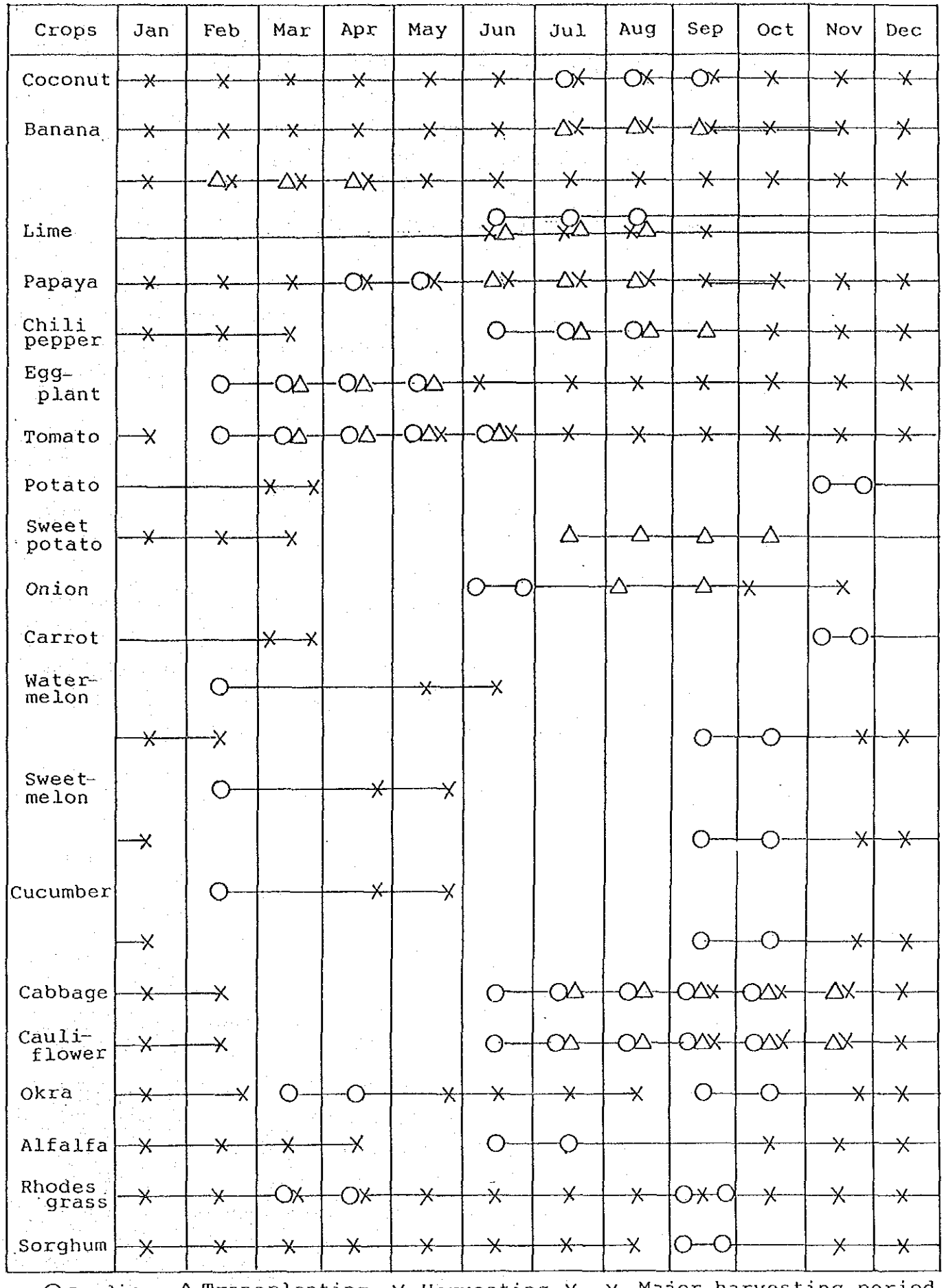


Figure 2.5.6 Example of Cropping Season of Major Crops in Southern Region

January and February and are harvested from April to July.

Nevertheless, some commercial farms conduct double cropping with a cropping intensity of 150 percent. One such example is presented in Figure 2.5.5, wherein cabbage is cultivated as an autumn and winter crop, after spring and summer crops such as sweet-melons, watermelons and squash.

It seems there is no definite crop-rotation pattern in the country; although, extension centers have prepared model patterns and endeavor to propagate them.

(b) Southern Region

In the Salalah area of the Southern Region, the summer (from the middle of June to the middle of September) is the rainy season, affected by southwest monsoons, and it is not as hot as it is in Northern Oman. This relatively moderate climate enables farmers to cultivate one season crop through the entire year, if irrigation water is available. Some even cultivate twice a year, particularly watermelons, sweet-melons, cucumbers and okra as depicted in Figure 2.5.6.

On the plateau, rain-fed cultivation of cow-peas, sorghum, local feed grass, etc. is conducted in the rainy season in limited upland areas. This type of cultivation may be the only exceptional case of the methods of water utilization in agriculture in Oman.

(2) Development Potential

With regard to cropping patterns, incremental production can be achieved through intercropping, mixed cropping, double cropping, and appropriate crop rotation. Intercropping and mixed cropping have been carried out traditionally in areas under and between coconut palms and date palms, but further promotion is still quite possible.

Large increases in double cropping are definitely possible, with a

special focus on vegetables.

Crop rotation is essential to maintaining soil fertility, to prevent the prevalence of crop pests and to continue production of high quality crops. A rational crop-rotation system should be widely used, especially for vegetables and field crops.

2.5.3.3 Cultivation Methods

(1) Present Situation

MAF endeavors to introduce and distribute high quality, disease-tolerant, productive varieties which are fairly easy to cultivate. However, the majority of fruit trees and field crops are still local varieties.

Plowing and land preparation -- except for very small areas -- are generally carried out by tractor. Threshing of wheat is also done by mechanical threshers, rarely by a combine. Fertilization, seeding, transplanting, weeding, harvesting, etc., are done manually. Since manual pollination of tall date palms has always required intensive labor, MAF has developed and is recommending the use of a pollen duster for such work. Required cultivation parameters and techniques for major crops are presented in manuals prepared by the extension centers.

MAF has prepared fertilization criteria and has been trying to promote them among farmers; however, application rates of fertilizers by farmers are still less than 50 percent of the amount recommended.

Some of the large farms and commercial farms carry out weeding by tractor or garden tractor with implements attached for intertillage and weeding; however, they still employ manual labor for weeding between plants. Small farms still employ intensive labor for all weeding. Herbicides have been used by commercial farms but not yet by the small farms.

(2) Development Potential

There are various ways of improving productivity through the introduction of quality varieties, adjustment of cropping time, improvement of cultivation type, use of new material, labor-saving methods, etc.

Moreover, the adjustment of cropping time is a very effective method for alleviating losses through excessive production during an ordinary production period. Shading plants and shading nets would be useful in northern Oman. The major harvesting time in Salalah and the mountainous area (Jabal Akhdar) corresponds with the post-harvest period in northern Oman. Considering this seasonal difference, an annual crop supply would be possible if a suitable transportation system existed.

Although modern irrigation systems are being introduced by farmers, further expansion is required in order to increase water-use efficiency.

Taking soil and irrigation characteristics into account, the amount and frequency of the fertilizer supply should be increased in accordance with the criteria prepared by MAF.

On the basis of studies and the clarification of the biology and ecology of weeds, the minimum amount of herbicide should be applied and the cost of labor considered.

Mechanized agriculture should also be promoted in order to save labor expenses and to improve profitability. Some of the commercial farms and large-scale new farms have started mechanization for feed crops, wheat, etc. Further mechanical operation should be adopted for plowing, land leveling, intertillage/weeding, pollination, pest control, etc.

2.5.3.4 Pest Control

(1) Present Situation

The white fly is common all over the country, especially in fields of alfalfa, tomatoes, chili peppers, egg-plants, cucumbers, etc. Crops other than alfalfa suffer severe damage from virus diseases transmitted by this insect, in addition to injuries from its sucking of plant sap. Thus, the pest is one of the greatest factors in production reduction and the deterioration of crop quality. Other examples can also be cited: cucumber damaged by leaf miners, cabbage by the diamond-back moth, date palms by the dubas bug, mangoes by the mango leaf gall midge, etc.

Pest control methods in Oman can be categorized into the chemical method which uses pesticide sprays, and biological method which uses natural enemies to destroy the pests. There are many sites where MAF has applied the aerial spray method by helicopter. The pest control teams of MAF carry out pesticide applications to 30,000 ha of vegetables and 14,000 ha of field crops.

Extension staff advise the farmers to use safe chemicals with low toxicity levels. Chemicals with high residual toxicity, e.g. organic chlorides, and those which damage the environment, e.g. dusts, are not applied.

Large farms and commercial farms utilize high-pressure sprayers for the application of agricultural chemicals. Small farms use manually-operated sprayers.

Biological control methods utilizing natural enemies were adopted against some fruit insect pests, and some of them are showing successful results. For instance, since 1987, chemical control has not been required at the citrus orchard in Salalah where the release of parasitic wasps (Encarcia) was begun in 1985, against the citrus blackfly. Following its successful application in Malaysia, the Baculo virus was introduced to control the Rhinoceros beetle on coconut palms in 1989. With regard to the introduction and release of parasites against the mango leaf gall midge, the suitability of Chrysonotomyia has already been confirmed. For caterpillar control on cabbage, etc., bio-chemicals like Thuricid HP have been recommended for application since 1980. Regarding the white fly, introduction of a parasite like Encarsia formosa is now being considered

by MAF.

(2) Development Potential

Pest control is not sufficiently practiced at present. Further improvements must be extended to the selection of adequate pesticides, effective application, timing and frequency, pest control implements, etc. Considering the preservation of bio-ecosystems and safety of the producer and the products, an integrated control needs to be maintained on the basis of an economic threshold needful for chemical control. There are some promising results and trials with respect to biological control of fruit insects. For example, biological suppression of the white fly population density will be examined further in order to protect such important crops as vegetables, alfalfa, etc. from injury.

2.5.3.5 Salinity Problem

(1) Present Situation

In some of the coastal areas within about 3km of the sea, especially in North and South Batinah, saline accumulation is observed at the ground surface of irrigated areas because of an increase in salt concentration of groundwater caused by recent saline water intrusions.

The JICA team conducted a survey of such areas about 0.5 km and 2 km from the coast in Barka. A farmer 0.5 km from the sea, where the result of an electric-conductivity test indicated about 6,000 to 12,000 micro mhos/cm, had cultivated alfalfa and barley by applying a flood irrigation method and large amounts of stable manure. In the first year, alfalfa grew without any damage. However, in the second year a lot of it died. The ratio of live crop was below 30 percent. Barley was also observed as growing less favorably.

A farmer with a field about 2 km from sea had initiated cultivation of field crops and various vegetables on a large scale where the result of the electric-conductivity test indicated about 4,000 to 8,000 micro

mhos/cm. Although marked saline accumulation was observed at the ground surface, various herbaceous crops such as alfalfa, barley, Rhodes grass, sorghum, tomatoes, egg-plants, watermelons, sweet-melons, cucumbers, cabbage, carrots and others were growing without any damage. With regard to mangoes (a perennial crop), however, necrosis at the tops and peripheries of the leaves were observed. This was regarded as the result of saline accumulation. Dying leaves at the lower portions of date palms were also obvious.

Areas where saline accumulation is due to brackish water were observed even in inland areas such as Dhahira, Sharqiya, Nejd, etc.

(2) Development Potential

In order to cope with the saline problem observed along the coastal area of the North and South Batinah Regions, a comprehensive method composed of the combination of the following measures will be most effective in reducing the salinity of the water to within tolerable limits for crops.

(a) Application of irrigation methods which account for the leaching effect
(b) Introduction of crops with high tolerance
(c) Supply of larger amounts of organic fertilizer

2.5.3.6 New Materials and New Facilities in Use

(1) Present Situation

Shadow nets are used by commercial farms, etc. for the cultivation of flowers and ornamental plants. Greenhouses, as well as hydroponic facilities are employed by some of them. In these cases, management is reconciled to deficit operation due to excessive costs both in construction and operation. New technology using plastic-film to provide such things as plastic-film houses, plastic-film tunnels and plastic-film mulching have not yet been introduced. Water-preservation material such

as water absorptive polymers and porous ceramics have also not yet been adopted in Oman.

(2) Development Potential

Various plastic-films with different characteristics which have been developed enable farmers to improve agricultural production.

Again, water-preservation material such as water absorptive polymers and porous ceramics have been developed, and are ready for use in desert and arid areas. These materials increase the irrigation water supply, which enables farmers to minimize irrigation-related labor.

2.5.3.7 Apiculture

In Oman, beekeeping has been conducted in a traditional manner for a long time.

Honey in Oman is of high quality so its price is about three to four times higher than that of imported honey. Therefore, apiculture is a profitable supplement for farmers. The number of beekeeping farms, however, is not high and the practicing scale is small. Also, there are some problems like a shortage of honey-production plants, an outbreak of the American foulbrood disease and others.

MAF has put high priority on operating honey-bee projects in the Five-year Development Plan for agriculture from the first year. Under the project, three apiculture research centers were constructed in Rustaq, Nizwa and Salalah, and a modern apiary is being promoted by experts and extension workers.

At present, however, research center stock, the number of experts, quality and number of extension workers, the budget, etc. are not sufficient and more support is needed for the future.

2.5.4 Farming

2.5.4.1 Farming Scale of Farm

The total number of farmers in the country is about 83,000 and the average area of arable land per farm family is 1.0 ha (i.e. 0.6 ha of cropped area) as shown in Table 2.5.1.

The farming scale differs markedly depending on the region: about 1.6 ha in the region along the Batinah Coast and about 0.15 ha in Salalah in the Southern Region. In the Batinah Region and the Oman Interior Region, there is a considerable number of new farmers who have moved onto uncultivated land. These new farmers manage relatively large-scale farms of about 4 to 10 ha.

2.5.4.2 Farming Types

Farming can be classified into three types: new farms at settlement, traditional farms, and commercial farms. After a discussion with persons concerned, the JICA study team conducted a current farming- condition survey of typical farmers in the five major agricultural regions, i.e. eight new farms, four traditional farms and one commercial farm as shown in Table 2.5.9.

(1) Farming of New Farm in Settlement

The new farms in settlement can be characterized by the following:

(a) The capital and farming scale are large and there is high management vitality compared to traditional farms.
(b) The possession and utilization rate of agricultural machinery, such as tractors and high-pressure sprayers, is high, but further mechanization is intended.
(c) The management rate, in agriculture exclusively, is high, as is the employment rate of expatriates.
(d) The cropping ratio of dates and coconuts is low, while that of crops

Table 2.5.9 Outline of Economic Survey Conducted by the JICA Team

Region	Number of farmers	Type of farmer	Size of farm (ha)	Net balance in farming for the past year (RO)*1
North Batinah	1	New	4.20	293.800
	2	New	4.20	4,671.410
	3	New	4.20	3,199.310
South Batinah	1	Traditional	0.63	-384.960
	2	Traditional	0.53	-165.510
	3*2	Traditional	14.70	3,591.990
Oman Interior	1	New	27.72	17,529.750
	2	New	6.30	3,552.544
Sharqiya	1	New	29.40	6,039.056
	2	New	8.40	3,555.958
Southern	1	New	1.89	1,220.370
	2	Traditional	1.89	1,679.600
Average		New	10.79	5,442.272
		Traditional	4.44	1,180.280

＊1 Net balances were calculated from unit values obtained by the Department of Agriculture and statistics (Volume 2,Table 5.4.1). Production costs do not include depreciation costs.

＊2 This farm has new farm characteristics.

with high profitability is high, but, there is still a lot of room for further improvement.

(e) Monoculture still prevails and intercropping is rare. Therefore, there is a high potential for future introduction of double-cropping and intercropping systems.

(f) The irrigation areas developed by mechanically-drilled wells are dominant, but aflaj are not used. So far, both water quality and quantity are adequate but unpredictable.

(g) The intention to introduce new technology is high. The introduction rate of modern irrigation systems like sprinkler, drip or others is higher here than with traditional farmers, but is still quite low. Therefore, there is a large potential for introducing such technology.

(h) Although farming profitability is high, there is considerable potential for improvement.

(2) Farming of Traditional Farms

For a very long time, along the seashore of the Batinah Coast, in the mountainous areas, at the foot of the Oman Mountain range, and in the Salalah area and the Musandam area, agriculture has been conducted through the use of aflaj and hand-dug wells. Such agricultural methods have been defined as traditional farming.

The low profitability of farming in the traditional manner is a result of the higher proportion of date palm cultivation, whose productivity is low.

The following characteristics are generally observed about the traditional farmers:

(a) Both capital and farming scale are small with management vitality being low.

(b) Less agricultural machinery, such as tractors and high-pressure sprayers, is owned, and there is a higher dependence upon mechanical operation provided by the extension centers.

(c) There is a heavy dependence on non-farm income and employment of

expatriates is low.

(d) There is less profitability due to the high cropping ratio of the originally and naturally vegetated fruit trees, such as date palms and coconuts.

(e) Intercropping under and between date palms is practiced with barley and other feed crops, vegetables and small fruit trees (papayas, etc.) The ratio of such intercropping is about 20 percent in northern Oman and about 30 percent or more in Salalah.

(f) Groundwater irrigation by aflaj is common in the mountain and foothill areas, while along the Batinah Coast and Salalah hand-dug wells prevail. In addition, small farmers who practice rain-fed cultivation, are distributed on the plateau of the Southern Region.

(g) Management of agriculture is rather conservative and the farming techniques are still primitive. Therefore, there is considerable potential for improvement.

(h) The farming profitability is low and requires improvement. This is viable.

(3) Farming of Commercial Farms

Located mainly alongside National Highway Route No.1 of the North and South Batinah Regions, and in Salalah, commercial farms number more than 100 and carry out large-scale agricultural production. Some of the commercial farms are Oman Sun Farm, Oman Modern Farm, Al Raja Farm, Dhofar Cattle Feed Company, and Royal Razat Farm.

The crops produced on these farms vary considerably: Rhodes grass and other feed crops, tomatoes and other vegetables, lemon and other fruit trees, flowers, flowering trees, ornamental plants, and others.

Both modern and mechanized irrigation are fully employed on these farms. Modern irrigation systems were introduced to use the groundwater obtained from the mechanically-drilled deep wells and springs (in Salalah). Heavy agricultural machinery is employed for plowing, land leveling, intertillage, weeding, and spraying of herbicides and pesticides. Such machinery is also used efficiently for harvesting and processing (drying) of such crops as feed crops. There are farms which

utilize greenhouse and hydroponic facilities as well.

A commercial farm, of which the JICA team conducted a farm survey, was highly profitable.

This is considered to be a result of comparatively high standards of management and the cultivation techniques examined below.

(a) Introduction of high-quality and high-yielding varieties and an increase in cropped areas for profitable crops.
(b) An increase in the efficiency of land use by double-cropping and better spacing between plants.
(c) Improvement of efficiency of irrigation water and fertilizers supplied by means of drip irrigation systems.
(d) Increased weeding efficiency by effective application of herbicides.
(e) Enhancement of crop quality and yield by complete pest control.

However, in greenhouses and hydroponic facilities, the financial balance indicates a deficit operation even though the management and cultivation are carried out by modern and high standards. Judging from these facts, it is assumed that a commercial farm which is not equipped with such modern facilities and only concentrates on highly profitable vegetables and field crops, may be able to manage at a high profit.

2.5.4.3 Cultivated Crops, Management Scale and Farming Profitability

All the above results, which have been analyzed by the JICA study team on the basis of the contents of the agricultural situation survey (i.e. Annual Updates of Important Statistic Series), suggest that profitability varies considerably depending on the kind of crop. The difference in profitability can be clearly indicated by such relationships as: vegetable > field crop > fruit.

Furthermore, such profitability also differs in terms of the management scale. This can also be indicated by large-scale > medium-scale > small-scale.

2.5.4.4 *Development Potential*

The development potential varies according to farm type. Their respective potentials are discussed below.

(1) New Farms in Settlement

Improvement potential in farming is regarded as significant. The selection of profitable kinds and varieties of cultivated crops, new cropping patterns, cultivation methods and other advances will raise the present farming level of the individual farmer toward that of the commercial farms.

(2) Traditional Farms

The scale of the traditional farm is generally small, and date palms and coconut palms are the major crops. Consequently, development potential is not very large. It can be provided by:

(a) effective use of land beneath both palms through the cultivation of beneficial crops such as feed crops and vegetables,
(b) increased productivity of feed crops and vegetables in the vicinity of palm gardens,
(c) reduction of water-loss by lining the irrigation canals with concrete, and
(d) more efficient water supply and distribution.

(3) *Commercial Farms*

Commercial farms still have ample room for improvement, especially in the kinds and varieties of cultivated crops, cropping systems, cultivation methods, etc. In some of the commercial farms, excessive investment in facilities induces pressure on management due to the present economic circumstances.

2.5.5 Agricultural Research

2.5.5.1 Historical Background

Agricultural research in Oman was initiated some 18 years ago. The agricultural research center and stations were established one by one in selected areas such as Rumais, Salalah and Jimmah. Since experiments and research conducted at the above facilities support agriculture in Oman, the government named 1988/89 "Agriculture Year" and has been promoting their expansion and influence. The government is also endeavoring to conduct agricultural research based on the latest information obtained from international research organizations.

2.5.5.2 Research Organization

(1) Organization

The Agricultural Research Department at Rumais (Rumais Center) comes under the control of the Directorate General of Agriculture, while the Department of Agricultural Research at Salalah (Salalah Station) comes under the control of the Directorate General of Agriculture and Fisheries of the Southern Region, and the Research Station in the Interior (Jimmah Station) comes under that of the Supervisory General of the Interior. The research in the Interior operates under a unified technical plan coming from the Headquarters at Rumais, while research in the Southern Region is operating independently.

(a) Rumais Center

In the Rumais Center, there are twelve research units, several farm management and nursery units, an administration section, general services including workshops (machine and carpentry), and transport units. This center extends its services to five regions, i.e. South Batinah, North Batinah, Sharqiya, Musandam and Buraimi.

(b) Interior Station

The Interior Station consists of a research farm (Wadi Quriyat

Farm) and a research station at Jimmah (Jimmah Station). This farm and station cover three regions, i.e. Dhahira, Interior and Wasta.

(c) Salalah Station

The Salalah Station consists of nine research units, two research farms, one fruit nursery and one forestry nursery. This station only covers the Southern Region.

(2) Personnel

There are 30 researchers (of these, 17 are foreign) and 38 technicians (12 foreigners) in the Rumais Center and the Salalah Station. Since only 13 researchers are Omanis, research activities depend largely on foreign researchers.

2.5.5.3 Research Management

(1) Management System

The center and station are independent organizations, take charge of research for their respective regions, and are supervised by each Director General. Each center and station is able to find and research a subject which closely relates to its region or regions and apply it to agricultural policy and technical guidelines.

(2) Planning and Evaluation of Research

The procedure for planning and evaluation at the Salalah Station is shown in items (a) to (c).

(a) Planning

A program of research is created for each unit. Each researcher puts his program into a standard form in December for the next year's activities, which start in July and end in June. These programs are discussed by a technical committee in the department first, and then discussed with the agricultural department of the region. After that, they are submitted to the ministry where a higher committee discusses

and approves research programs throughout the whole country.

(b) Approvals

Approvals of research programs are given by the National Higher Technical Committee. These programs will be implemented during the July-June period.

(c) Evaluations

A technical committee within the research department will review the research done, and after approving it, will send it to be published in scientific journals. Also, the ministry brings in outside consultants to evaluate research projects.

(3) Agricultural Research

(a) Rumais Center

The Rumais Center provides the thrust for agricultural research in Oman. The major subjects of research cover areas such as soil, irrigation, plant analysis, plant protection (nemetology, entomology, chemical control and biological control, pathology, virology, weed control), plant physiology and seed testing, and cultivation tests of vegetables and fruit. The most recent research report was summarized and published in 1983. In particular, the development of a new wheat variety was highlighted. Researchers succeeded in developing two high yield, high quality and disease-tolerant varieties through breeding local and foreign varieties. These new varieties were named Wadi Quriyat 151 and 160 and have been available to farmers since 1988.

(b) Salalah Station

The Salalah Station is the center of agricultural research in the Southern Region. The research activities in this station include variety tests, fertilizer tests, suitability-of-area tests, tests for disease tolerance, and cropping-season tests for fruits, vegetables and field crops.

(c) Annual Research Report

No annual report except the 1983 report has been published. Therefore, research activities, products and accomplishments are not clear. The annual report is indispensable for planning future research programs as it is prepared on the basis of the evaluation of the research results. Currently, the research results from 1989 are being prepared as an annual report for publication in 1990.

(d) Necessity of Continuous Research

When a foreign researcher's assignment finishes after one to three years, it takes one or two years to fill the vacancy. Often, if no applicant is available from the same field, the research is terminated.

2.5.5.4 Linkage of Research and Extension

The long-term results obtained through the trials conducted at research stations provide the basis for established crop recommendations utilized by extension services. The recommendations are routed through subject matter specialists attached to each of the regions. Regular discussions are held between the research staff, extension subject matter specialists and extension engineers. These meetings help to formulate extension programs, and at the same time, highlight the problems faced by farmers for research consideration. In addition, the research staff provides specialized knowledge needed to implement development programs formulated by the ministry. This research work requires a great deal of time from the research staff. Agricultural research provides extension bulletins for use by extension services.

2.5.5.5 Research Support System

(1) Research Information

The International Symposium on Agriculture & Fisheries Development in Oman was held at the Sultan Qaboos University from October 15 to 19, 1989. At this symposium, 131 subjects were reported, and of these, about 50 were

research results for crops, soil, pests, etc. which gave great incentive to Omani research-related personnel.

(2) Shortage of Technicians

In order to conduct the development research, two to three technicians are generally required per researcher. However, at present, the number available is far less than that.

(3) Research Facilities

The research facilities greatly influence accomplishments. In the Rumais Center, various research facilities are being upgraded. For instance, a research building has just been completed, and modern equipment such as microscopes, and soil- and nutrient-analysis equipment, has been recently introduced. Moreover, controlled-environment greenhouses were completed quite recently. On the other hand, in the Salalah Station, each research unit is equipped with research facilities but most of these need to be replaced, with the exception of the soil- and nutrient-analysis equipment.

2.5.6 Extension Services

2.5.6.1 Present Situation

(1) Guidelines for Extension Services

The extension of agricultural techniques is essential for agricultural growth. Therefore, the government has endeavored to promote extension services for a long time, and in particular, the theories behind the techniques. In order to provide practical extension services, MAF has established guidelines which focus on the following:

(a) Annual training to assist farmers in their farming practices
(b) Increase of agricultural production
(c) Reduction of costs of agricultural production
(d) Improvement of traditional farming practices
(e) Introduction of better agricultural management
(f) Securing high yields through modern irrigation methods and improvement of water management
(g) Linked activities between extension and research
(h) Intensive training programs for extension workers and farmers

The extension services are carried out in accordance with the target of the Yearly Action Program (which is also established by MAF) by summarizing the proposed targets of the Action Programs prepared and submitted by every extension center in the country.

The main target of the Action Program in 1989 is "Suitable Cropping in Suitable Land".

2.5.6.2 Organizational Structure

In MAF, the Director of Agricultural Affairs and the Director General of Agriculture are responsible for extension services; one expatriate and one Omani specialist take charge of the services.

There are nine regional offices in the country and the 13 extension centers belong to respective offices as shown in Table 2.5.10. For instance, in southern Oman, there are five extension centers which are supervised by the Director of the Agricultural Extension Services Section (Southern Region) who is located in Salalah.

The area for which each extension center is responsible varies from 700 to 2,400 ha. The distance between the centers is 25 to 30 km in the Batinah Coast and 20 to 40 km in the inland area. This distribution, as well as the area for which they are responsible, is regarded as appropriate.

Each regional office is assigned one extension supervisor, and under his supervision extension officers provide the services in each extension center. At the same level as the extension supervisor, the subject matter specialist (SMS) provides technical guidance to the extension officers in regions concerned with specific technical fields.

However, there are as few as two SMSs for vegetables, one for fruit trees and two for field crops. Of these, one is stationed in the regional office in north Batinah, and two SMSs for both vegetables and field crops are stationed in Sharqiya and the Oman Interior.

More than half of these extension-concerned positions are occupied by expatriate experts: nine extension supervisors out of a total of ten, and all of the SMSs and 38 extension officers -- a total of 85 -- are expatriate experts.

2.5.6.3 Substances of Extension Services

As will be described, the extension services consist of general services for all farmers, programs focusing on encouraging specific farmers to whom particular attention must be paid, and others.

(1) General Services

Table 2.5.10 Number of Extension Experts in Each Extension Center

REGION		EXTENSION CENTER		EXTENSION			SUBJECT MATTER SPECIALISTS						PLANT PROTECTION		STATISTICS		
				SUPER-	OFFICER		VEGETABLE		FRUIT		FIELD CROPS		ENGI-	ASS-	SPRAY	STAT-	ENUM-
No.	NAME	* No.	NAME	VISOR	TOTAL	EXPAT-RIATE	TOTAL	EXPAT-RIATE	TOTAL	EXPAT-RIATE	TOTAL	EXPAT-RIATE	NEER	IST-ANT	TEAM	ISTI-CIAN	ERAT-OR
1	SOUTH BATINAH	1	SEEB & MUSCAT		2	1									5		1
		②	BARKA	1	2	1							1		7	1	2
		3	AL MASNA'AH		2	1									6		1
		4	A'SUNAIQ		1	1									2		
		5	A'RUSTAQ		1	1									4		1
		6	QURIYAT		2	0									4		2
		7	MASIRAH		0	0									0		
	TOTAL			1	10	5	0	0	0	0	0	0	1	0	28	1	7
2	NORTH BATINAH	1	AL KHABURAH		2	1									3		
		2	SAHAM		2	1									3		
		③	SOHAR	1	2	1			1	1			1		12	1	1
		4	LIWA		2	1									2		
		5	SHINAS		3	2									2		
		6	AL MURAYR		2	1									2		
	TOTAL			1	13	7	0	0	1	1	0	0	1	0	24	1	1
3	SHARQIA	①	IBRA	1	3	1	1	1			1	1	1		8	1	1
		2	DIMA TAYEEN		1	0									3		
		3	KAMIL & WAFI		2	1									4		2
		4	SUR		3	0									4		2
		5	SANAW		2	1									5		2
		6	SAMAD		3	1									2		1
	TOTAL			1	14	4	1	1	0	0	1	1	1	0	26	1	8
4	OMAN INTERIOR	1	BAHLA		3	1									6		1
		2	WADI QURIYAT		2	1									6		1
		③	NIZWA	1	3	0	1	1			1	1	1		7	1	1
		4	AL HAMRA		3	1									4		1
		5	MANAH		3	1									4		
		6	ADAM		4	1									4		
		7	JABAL AKHDAR		2	0									2		
	TOTAL			1	20	5	1	1	0	0	1	1	1	0	33	1	4
5	MUSTA	1	IZKI		3	1									2		1
		②	SAMAIL	1	1	1							1		3	0	1
		3	BIDBID		1	0									3		1
	TOTAL			1	5	2	0	0	0	0	0	0	1	0	8	0	3
6	DAHIRAH	1	DHANK		2	2									5		
		②	IBRI	2	3	1							1		6	1	0
		3	WADI AL AYN		3	1									1		
		4	YANQUL		2	1									4		
	TOTAL			2	10	5	0	0	0	0	0	0	1	0	16	1	0
7	BURAIMI	①	AL BURAIMI	1	1	1							1		2	1	0
		2	AL SANENA		1	1									0		
		3	MAHDHA		1	1									2		
	TOTAL			1	3	3	0	0	0	0	0	0	1	0	4	1	0
8	MUSANDAM	1	KHASAB		1	1									2	0	0
		②	DIBA AL BAYAH	1	3	3									2		
	TOTAL			1	4	4	0	0	0	0	0	0	0	0	4	0	0
9	SOUTH REGION	①	SALALAH	1	2	1							1	2	3	1	4
		2	TAQAH		1	0									0		
		3	DHAREEZ		1	1									3		
		4	MUQADEEN		1	0									3		
		5	AL HAFA QARAD		1	1									3		
	TOTAL			1	6	3	0	0	0	0	0	0	1	2	12	1	4
	GRAND TOTAL		43	10	85	38	2	2	1	1	2	2	8	2	155	7	27

explanatory notes:
1) ○ in the column of No.* indicates the location of regional department of agriculture
2) These data are derived from the Department of Agricultural Affairs in MAF

(a) Periodical visit to farmers for guidance

On average, an extension officer visits five to seven farmers daily, and provides consultation on practical issues for each crop on their farms. However, only an average of 1.9 extension officers are located in each extension center, which means that each officer is compelled to give advice on all technical aspects.

(b) Farmer's visit to the extension center to ask questions

In some cases, a farmer will visit the center directly, to ask questions. This type of farmer tackles agricultural management actively. Therefore, the officer can deal with the problem much more easily.

(c) Discussions among small groups of farmers

Each extension center schedules a field day and organizes farmers into small groups to provide extension services at the extension farm. The farmers discuss each others' problems concerning cultivating crops and the officer provides technical advice. In the meeting, realistic issues with which every farmer is familiar are discussed.

(d) Demonstration of farming techniques

Good varieties of crops and cultivation techniques recommended by the research center are actually demonstrated in the farmers' fields with the consent of farmers. There are about 20 such demonstration fields established by each extension center.

(2) Extension Services to New Farmers

In addition, there is an extension program for 2,500 new farmers in the country which commenced in 1987. This program aims to encourage selected farmers who are expected to become leading farmers. The major objectives of this program are summarized below.

(a) To provide new farmers with guidance on the basis of the techniques taught by the Agricultural Research Center and to extend their effects to all other new farmers.
(b) To instruct new farmers on the most appropriate use of agricultural input material, i.e. application of proper amount of seed, fertilizers, chemicals, etc..
(c) To assist new farmers in reducing production costs by introducing new technology, such as modern irrigation methods.
(d) To inform new farmers about suitable crop-rotation patterns which match the soil on their farms.

(3) Other Extension Services

In addition to technical guidance, the extension officers are engaged in administrative activities for the distribution of seeds, fertilizers and chemicals which are provided by the government. This administrative work includes the verification of the necessity of fertilizer for the crops cultivated by the farmers. Based on this verification, the farmers are able to obtain a government subsidy and free materials.

Also, each extension center organizes a spray team for plant protection and a tractor-service team for plowing. For plant protection, the extension officer evaluates the situation and instructs the team on what kinds of pesticides, etc. to use. In this case, there is free labor for the spray service and a government subsidy covers 50 percent of the pesticide cost. With respect to the tractor services, the extension center provides the services at a cost of R.O. 1 per feddan, but the government has an additional subsidy of R.O. 5 per feddan.

(4) Publicity Services of the Extension Center

The Publicity Section, under the Directorate General of General Diwan Information, is in charge of publicity for each extension center. This includes the introduction of new technology developed by the research center, yearly targets of extension services, advice on current farming issues, etc.. Publicity is done by means of pamphlets, video tapes, and

television and radio broadcasts. This service endeavors to increase the technical level of the farmers through broadcasting two times a month on TV and two times a week on radio.

(5) Training for Extension Officers

Training for the extension officers is being conducted eagerly. The training program, intended for all officers, is conducted three times a year. The first program is carried out at the research center, and is mainly for the introduction of new technology and recommended varieties of crops. The other two programs are carried out at the regional offices where a specialist from MAF is in charge as a lecturer. A training program intended for Omani officers is carried out at each regional office once every month.

2.5.6.4 Issues in Extension Services

(1) Shortage of Extension Officers

At present, the total number of extension officers is 85. Assuming that the total number of farmers is 83,204,the number of farmers under the care of each extension officer is about 1,000. The number of farmers under one officer in the U.S., West Germany, and Japan is 190, 220 and 393, respectively. Compared to Japan, Omani extension officers are in charge of 2.5 times more farmers.

(2) Shortage of Subject Matter Specialists

The SMS is responsible for training extension officers in agricultural techniques. However, there are too few of them. In particular, the SMSs for the cultivation management of dates, which are the major product of the country, and for irrigation, which is the most important policy that needs to be tackled, are extremely short in number.

(3) Publicity Services for the Improvement of Living Conditions in Rural Areas

Since the rural areas combine both production activities and family living, the improvement of living conditions there is closely related to the farmer's activities with respect to agricultural production. Therefore, the publicity services should aim to improve living conditions and to promote, in close coordination with improvement programs being carried out by other concerned agencies, awareness in the fields of nutrition and hygiene.

(4) Training Opportunities for Extension Officers

Training the extension officers is essential and must be continued determinedly. However, it should also be pointed out that technical knowledge is increased and accumulated through the daily activities of the extension services. Therefore, all necessary technical documents and data should be collected, sorted, filed and arranged in order that the officers can educate themselves as well. This process is still poorly organized in some extension centers.

2.5.7 Livestock

2.5.7.1 Livestock Holding Type

According to a recent announcement issued by MAF (the MAF Minister's statement in the Consultative Council in September, 1989), the number of livestock in the country was 1,232 thousand in 1988: 783 thousand goats, 225 thousand cattle, 153 thousand sheep, and 71 thousand camels.

On the other hand, it has been reported that there was 56,500 animal holders in Oman in 1982 (Source: Range and Livestock Survey, 1982; GRM).

Present livestock management methods in the country can be classified into four types according to the GRM report (Range and Livestock Survey, 1982). Most livestock owners follow traditional methods of management.

(1) Domestic Holding Type

The livestock holders of this type do not have their own feed resources within their management area so their livestock is mainly dependent upon purchased forage. Almost all of the family income of these owners is derived from the non-agricultural sector. The number of livestock in this type system is estimated at slightly less than 40 percent of all livestock in the country. The holders generally own one to ten livestock on average and more than 90 percent of holders breed goats for meat and milk.

Approximately 33 percent of holders of this type feed livestock in a shed. Purchased feed such as alfalfa, dates, graminaceous fodder and dried sardines are normally provided. The remaining 66 percent of holders graze their livestock in the vicinity of their houses during the day and feed them in sheds at night. The grazing area is generally limited to within 5km of the house. Again, most holders depend mostly on purchased alfalfa, dates, etc. This is because the rangelands, which are gradually degrading, are unable to provide livestock with vital nutrients.

(2) Agriculture-based Holding Type

Livestock holders of this type have their own feed resources in their management area, since the majority of them engage in both agriculture (mainly annual crops and feed) and animal husbandry. The number of livestock in this type is estimated at slightly less than 45 percent of the entire livestock in the country.

The holders feed 10 to 15 animals on average, and cattle are owned by nearly 65 percent. Although approximately 80 percent of this holding type graze livestock, the majority of required nutrients are provided with hand-fed green fodder, dates, etc. The advantage of this holding type, i.e. the combination of stockholding and cultivation, is that it allows holders to re-use crop residues or by-products as feed and the manure of livestock as fertilizer. The daily care of livestock herds in this type is the responsibility of women and young children; however, a foreign labor force is sometimes employed if the farm or the number of livestock are large (farm area exceeding 10 feddans or 4.2 ha).

(3) Nomadic and Semi-Nomadic Holding Type

The number of livestock in this type is estimated at a little less than 15 percent of the entire livestock in the country. This type is characterized by its mobility and ability to utilize large areas of rangeland, from which most necessary nutrients for livestock are obtained. Management size is normally 20 head of livestock or more, in some cases more than 100 head. Herds consist mainly of goats in the northern area. In southern Jabal, livestock traditionally graze in rangelands where abundant grass is available owing to rainfall during the monsoon season in summer. In southern Oman, cattle are also grazed in the daytime and fed in sheds at night, except during outbreaks of biting flies in the monsoon season.

The nutrient supply in the rangelands has declined recently due to the rapid increase in the number of grazing livestock. As a result, a significant increase in purchased feed is a major constraint in livestock management in southern Jabal.

(4) Commercial Holding Type

There are large-scale and commercial livestock businesses in Oman such as the Oman Sun Farm and Modern Poultry in the North, and Dhofar Cattle Feed Company in the South, where dairy cattle and poultry are bred. These animals are fed in sheds with green fodder harvested on irrigated farms, and with concentrates. Productivity of the commercial type is much higher than the other three types. Nevertheless, only limited numbers of livestock are classified in this type at present.

In general, livestock feeding in Oman is not profitable. According to the survey conducted in 1982 by foreign consultants (GRM), the productivity of livestock in this country is generally low. Among the four types, the domestic holding type which is mainly dependent on purchased feed, is managed with the most significant deficit even after family consumption has been taken into account. Accordingly, it can be regarded that the ownership of the livestock itself is of more concern than the management method of this type of holding.

On the other hand, even in the agriculture-based holding type or the nomadic holding type, the larger the share of purchased feed is, the lower the profit. In southern Jabal particularly, where the nutrient supply has declined because of recent degradation of natural pasture, most of the stock holders have fallen into serious deficit operations due to the considerable increase in purchased feed. This is also mainly due to the high cost of purchased feed in comparison with the market price of livestock products in the country. It is, therefore, essential for livestock holders to minimize the share of purchased feed to the extent possible, unless the price of purchased feed drops markedly.

2.5.7.2 Feed Resources

The following can be considered as major feed resources:

(1) Rangeland
(2) Forage produced on irrigated farm land

(3) Manufactured compound stockfeeds

(4) Other local resources

(1) Rangeland

The rangeland is the most extensive feed resource in Oman. It is approximately 200,000 km^2. This resource has been reduced by overgrazing. According to the Rangeland Livestock Survey conducted and prepared by GRM, the estimated rangeland capacity is 185,600 goats, 14,500 sheep, 12,000 cattle and 4,000 camels. Contrast this to the estimated number of livestock in 1982 i.e. 696,200 goats, 135,700 sheep, 77,900 cattle and 54,400 camels. The proportion of grazing animals within the carrying capacity of rangeland corresponds to only 22 percent, if supplemental feed is not taken into consideration.

The number of livestock should be increased by livestock development projects which aim at food self-sufficiency in Oman. The following measures need to be simultaneously promoted in order not to reduce feed resources for the livestock holders who are dependent on rangeland:

(a) Research on improvement of the vegetation on rangeland, through introduction of fodder trees, cactus, etc.
(b) Adjustment of grazing pressure by reducing the number of animals
(c) Research and development of other feed resources.

(2) Forage Produced on Irrigated Farm

A few feddan of alfalfa are cultivated on most farms with an irrigation system. This alfalfa is supplied to the livestock, and distributed to the market for sale as a cash crop. Irrigated Rhodes grass, initiated by commercial dairy farms, has increased recently on both large-scale farms with center pivot irrigation systems, and on small-scale farms with sprinkler systems. Rhodes grass suffers less damage from the harmful white fly than alfalfa and is appropriate for cultivation in the areas with less groundwater since a lower water requirement per yield is allowed than for alfalfa.

Forage production on irrigated land is essential for livestock development in the country. Furthermore, the introduction of high yielding, less water-dependent, more salt-tolerant feed crops, and the development of water-saving irrigation techniques are particularly important for feed supply increases in the future.

(3) Manufactured Compound Stockfeeds

There are two feed mill factories in Oman, one for the Oman Feed Mill in the north, the other for Oman Cattle Feed in the south. The annual production capacity of both factories is around 60,000 tons. As clearly indicated in Table 2.5.11, both factories have been operating to the fullest extent in order to cope with the recent demand for feed.

An increase of concentrate production is a prerequisite for further livestock development aimed at food self-sufficiency for the nation. Oman Feed Mill is now planning to expand its production capacity. However, it can only double of its present supply capacity because of its limited building site. Particularly regarding the poultry industry, all of the feed depends on concentrate, and therefore, the expansion program of the feed mill must commence immediately.

(4) Other Local Resources

Other local resources such as dates and their by-products, dry fish and agricultural residue are utilized, supplementing quantities of feed shortage. However, no precise data regarding the amounts used is available. Among the various kinds of local resources, dry fish, which rots easily, breeds bacteria and causes botulism, etc. often results in serious damage to livestock.

The major constraints on future livestock development are shortages of water and feed. In connection with feed, no further marked increase in supply capacity can be expected from rangeland. Also, any significant rise in irrigated forage production is also impossible due to limited underground water resources which must be shared with other irrigated agricultural crops. Furthermore, with respect to manufactured compound

stockfeeds, which consist entirely of imported materials, excessive reliance on them is risky from the point of view of national food resources. It is vital for that the expansion of feed resources be promoted by research and by the development of various feeds such as by-products from agricultural processing and fish-processing mills, and petrochemical factories, etc.

2.5.7.3 Animal Hygiene and Prevention of Epidemics

(1) Animal Clinics

Table 2.5.12 outlines the animal clinics and veterinary staff in each region. In northern Oman, each clinic has been established as an annex to the agricultural extension center of its respective area. In southern Oman, the Jabal Qara Plateau is studded with clinics since most livestock is raised by Jaweli (semi-nomadic people). Generally, a foreign veterinary doctor and Omani veterinary assistant provide services in each clinic. The assignment of a veterinary doctor to each clinic is difficult at present because of personnel shortages. In order to supplement this, a number of Omani veterinary assistants are being trained at the Salalah Veterinary Hospital and the Nizwa Agricultural Center, etc. However, only limited applicants are available, partly due to the hard work which is required in veterinary services. Specifically in southern Oman, the training of a number of Jaweli, who hold most of the livestock in the region, is urgently required, since the number of veterinary assistants there is dangerously low.

(2) The Central Veterinary Investigation Laboratory (CVIL)

CVIL is located at Rumais, and its major activities of can be summarized as follows:

(a) Diagnosis of pathological samples collected from clinics
(b) Field survey of livestock diseases
(c) Training of Omani researchers, and others.

Table 2.5.11 Annual Production of Animal Feed in Oman

producer/product	annual production (tonnes)			
	1984/5	1985/6	1986/7	1987/8
Oman Flour Mills				
Poultry feed	6,496	3,552	5,307	—
Non-manufactured (re-sale barley)	—	443	517	—
Ruminant feed	39,973	50,962	49,702	—
Subtotal	46,469	54,957	55,526	70,000
Dhofar Cattle Feed Co				
Ruminant feed	21,273	48,920	49,680	56,000
Natinal total	67,742	103,877	105,206	126,000

Source : Draft Report, F/S for the Establishment of a National Company for the Supply of Agriculture Inputs and Services to Farmers in the Sultanate of Oman, R Travers Morgan Ltd., 1988.

Table 2.5.12 Geographical Distribution of Veterinary Clinics and Staff

Region	Clinic	Sub-Clinic	Veterinary Officers	Veterinary Assistants	Veterinary Nurses
North Batinah	Sohar	Khaburah, Liwa, Saham, Shins, Mureir	2	4	3
South Batinah	Darsait, Seeb Barka, Misarah	Quriyat, Rustaq Suwayq	2	8	3
Middle Region	Samail, Izki	Bid-bid	2	1	2
Interior Oman	Bahla, Nizwa Haima	Marah, Jabal Akhdar, Hamra Adam, Wadi Quriyat	3	8	10
Dhahira	Ibri, Dhank	Wadi Al Ain, Yanqul	2	—	5
Eastan Region	Ibra, Sinau Bilad Bani Bu Ali	Sur, Samad Sham Kamil, Tiwi	3	6	10
Musandam	Khasad	Bukha, Bayah	1	3	—
Bureimy	Bureimy	Mordah Sinena	3	—	—
Sub-Total	18	23	18	30	33
Southern Region	Salalah Clinic Salalah Vet.Hospital, Tawi Afta	Zeak, Al-Saan Hagaif, Ghadow Madinat Al-Haq, Jafah	7	8	32
Sub-Total	3	7	7	8	32
Total	21	30	25	38	65

Source : Ministry of Agriculture and Fisheries, Department of Animal Wealth.

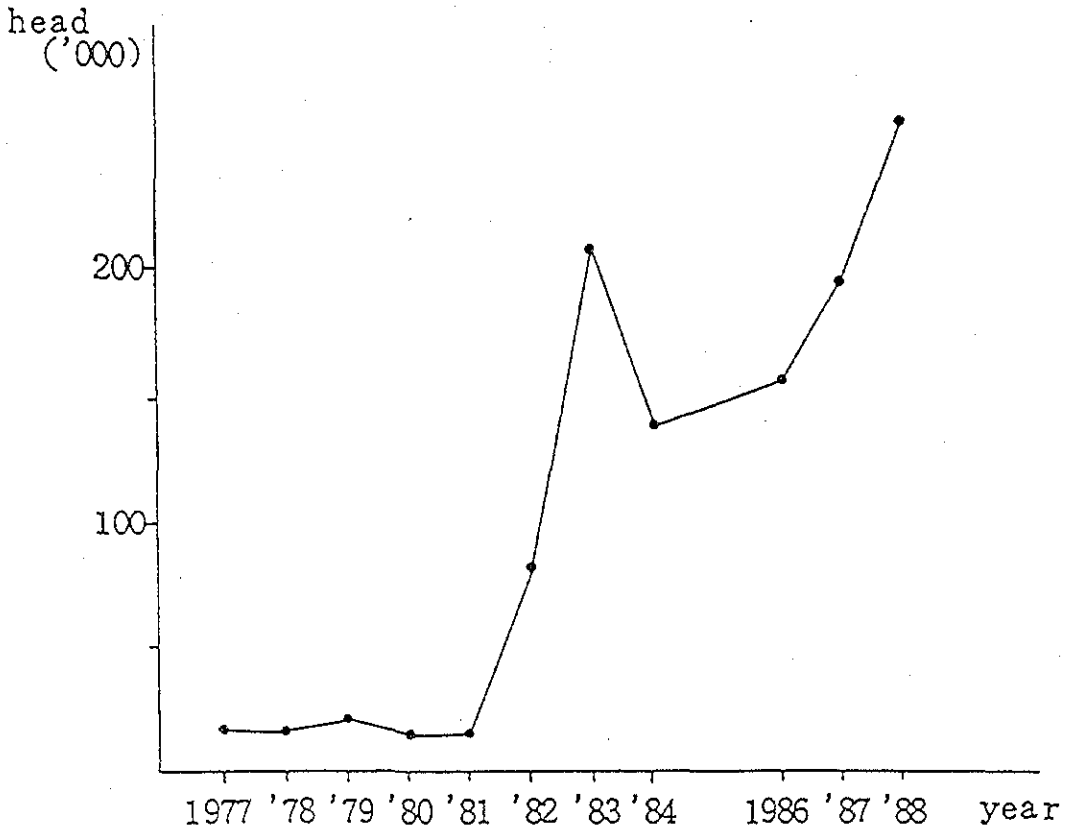
The activity of item (a) above is to inform the clinic and simultaneously report to MAF results of examinations and diagnoses for pathological samples collected from the central clinic of each region every week. Since most of the efforts in CVIL are spent on these activities, investigation and research into the prevention of livestock epidemics is lagging. Circumstances could be improved by measures such as expansion of facilities as well as increasing the number of veterinary staff, or decentralizing and transferring similar weekly activities to the central clinic in each region.

(3) Animal Quarantine

Since the Animal Disease Control Law was enacted in 1977, the livestock epidemic control system in the country has steadily improved in its ability to conserve domestic livestock. With respect to animal quarantine services, five quarantine offices have been established to inspect animals at borders and ports. There are two quarantine centers equipped with tethering facilities, one at Seeb in northern Oman and the other at Raysut in southern Oman. In addition, a third quarantine center is being constructed at Sur port in northern Oman. However, total inspection capacity of these facilities is less than 20,000 head of animals per inspection period (about 5 weeks). Figure 2.5.7 illustrates the number of imported animals from 1977 to 1988. It clearly indicates a sharp increase. The establishment of more quarantine centers equipped with tethering facilities is needed because the inspection capacity in the two existing quarantine centers has become inadequate due to this increase in imported animals caused by improved inland transportation from the UAE and other countries.

(4) Vaccination Program

Economic loss due to serious epidemic damage to livestock, which occasionally occurs in Oman is significant. In this context, nation-wide vaccination programs divided into three stages are being carried out by GRM from 1982 to 1991. Table 2.5.13 and 2.5.14 reveal the vaccination records for each stage, and in 1988, respectively.



year	number
1977	13,039
78	14,241
79	19,196
80	13,532
81	13,809
82	81,005
83	205,439
84	134,089
86	154,938
87	196,887
88	254,511

Figure 2.5.7 Number of Imported Animals

Table 2.5.13

Number of Animals Injected in Each Vaccination Stage

	Cattle	Goats/Sheep
Stage '1'	48,788	404,953
Stage '2'	76,361	697,327
Stage '3'	136,232	1,319,818

Source : G.R.M. International Pty Ltd.

Table 2.5.14

Number of Injected Animals by Disease in 1988

Disease	Cattle	Goats/Sheep
F.M.D.	63,395	10,087
Rinderpest/P.P.R.	42,194	504,941
Pox	—	248,823
Botulism	248,189	—
Blackquarter	248,189	
Enterotox aemia	122	42,424
Brucellosis	3,000	4,635

Source : MAF, Dep. of Animal Wealth.

Table 2.5.15 Morbidity of Diseases by Area

Area	FMD	Rinder pest	PPR	Small Pox	CCPP	Orf	Brucell-osis	Botu-lism	Black-leg	Entero-toxqenia	Surra	Gastro Int. Parasites
Muscat	+	+	+++	+	+++	++	+	—	—	+	+	+
Sharqiya	++	—	+++	++	+++	++	+	—	—	+	++	++
Wasta	+	+	+++	+	+++	++	—	—	—	+	+	++
Dakhilia	++	+	+++	+	+++	++	—	—	—	+	++	++
Dhahira	+	+	+++	+	+++	++	—	—	—	+	++	++
S.Batina	+++	+	+++	++	+++	++	++	+	—	+	+++	++
N.Batina	+++	+	+++	++	+++	++	++	+	+	+	+++	++
Buraimi	+++	++	+++	++	+++	++	+	—	—	+	+++	++
Musandam	+	—	++	+	+++	++	+	—	—	+	—	++
Southern	+++	—	+	—	+++	++	+++	+++	++	+	+++	+++

Legend +++ High morbidity
++ Medium morbidity
+ Low morbidity
— Disease not recorded

Source : M A F,
Dep. of Animal Wealth.

Fifteen teams of vaccinators have been organized for the implementation of the vacation program in the country, to give vaccinations in villages one by one. Each team normally consists of one foreign veterinary surgeon, one Omani trainee and two foreign livestock handlers. The team carries out two rounds of vaccination per stage.

The number of head of livestock covered by this vaccination program is estimated at about 50 - 60 percent of the entire livestock in the country. As a result, the epidemic morbidity has been gradually declining. The promotion of this vaccination program contributes directly to a marked reduction of the economic losses of livestock resources, and contributes greatly toward the training of Omani staff, raising consciousness about the importance of livestock hygiene while obtaining estimates of the number of livestock.

The vaccination program has not been able to inoculate every animal in Oman as it is carried out at the livestock holders' request, and there are some areas where the team has been unable to contact the animal holders.

According to Table 2.5.15, epidemic outbreaks spread over the entire country, though minor differences in morbidity can be found between regions. Further promotion of the vaccination program is a prerequisite for future epidemic control and the development of the livestock industry.

2.5.7.4 Research and Extension

(1) Research Activity

There are three livestock research centers in Oman, located at Rumais in the Batinah area, Wadi Quriyat in the Oman Interior, and Salalah in the Southern Region. This situation is now being considered and expanded to encourage new livestock development in the country. New facilities in the centers at Wadi Quriyat and Salalah will be completed by the end of 1989. Rumais Livestock Center is also scheduled to be renovated and expanded.

(a) Rumais Livestock Center

This center, attached to a nutrition laboratory, carries out experiments and research in three sectors: dairying, goat production, and fodder production.

In the dairying sector, a comparative study is being carried out on milk productivity among such species as local Balladi cattle from Batinah, Exotic Jersey, and Gravieh cattle. The same productivity study is also being conducted on the cross-breeds of the above species.

In the goat-production sector, the following research is being done:

(i) Growth and breeding performance of local goats
(ii) *Influence of early weaning for Anglo Nubian in Exotic and three* local species, namely Batinah, Dhofari and Jabal Akhdar.

In the fodder production sector, using experimental fields for Rhodes grass and alfalfa, water requirements and productivity are being studied.

As a follow-up, efforts will be made to establish support services for small-scale holder milk production at the on-farm level based on the results obtained from dairying research. The proposal procedure is as follows.

(i) Execution of on-farm artificial insemination (AI) for the purpose of cross-breeding Jersey and local cattle at local farms.
(ii) Extension of rational management methods for feeding and milk production for cross-breeds.
(iii) Provision of the facilities which enable farmers to process milk for market in the early stages.

The study on cross-breeding of local breeds of goat, sheep, and

Exotics, and on intensive management methods are also proposed for the development of small-scale farmers. In parallel with such studies, research on the expansion of feed resources, which is the primary base of livestock productivity, through strengthening nutritional studies and the fodder research program, has been also recommended.

(b) Wadi Quriyat Livestock Improvement Center

In Wadi Quriyat, a selective breeding shed for 900 female goats and 40 male goats is now under construction, together with all other necessary facilities such as a fodder farm, clinic and storage areas. These facilities are expected to play a major role as a breeding center which annually supplies 237 and 332 improved, highly-reproductive goats to general livestock holders. Selective breeding aims to raise the productivity of the local breeding stock.

(c) Salalah Livestock Research Station

Two thirds of the cattle in the nation are raised in the Southern Region, and this area is believed to possess the largest potential for future livestock development. In this context, the new Salalah Livestock Research Station will aim at the establishment of a complete system with facilities for all the necessary activities for development and research connected with livestock development in southern Oman. In the same area, a recent marked increase in the number of animals has caused a deterioration of rangeland productivity due to over-grazing. Since optimum livestock development in concert with the natural environment is urgently required, the collection and accumulation of basic data shall be promoted through the investigation of the present condition of livestock and farms. In parallel with such activities, marketable livestock improvements shall also be pursued in line with the necessary research on milk productivity and livestock reproductivity.

Improvement of local livestock has been lagging. Basic data related to breeding, prolification, and productivity levels of meat

and milk have been collected. Selective breeding of local livestock will be one of the major subjects in the future. Consequently, the identification of targets and a methodology for the improvement of each breed is necessary, with due consideration of the local breeds.

(2) Extension

The extension services for livestock holders are provided by the Agricultural Extension Centers established in each region. The number of livestock extension specialists in the centers is still limited as the on-farm level intensive livestock project started quite recently. From an organizational standpoint, truly effective extension services have not been organized yet. This is mainly due to the shortage of effective extension methods and relevant information from Research Stations, and the interpretation of established husbandry and management principles for local use.

2.5.7.6 Livestock Marketing and Processing

(1) Red Meat

The general marketing flow for cattle, goat and sheep is illustrated in Figure 2.5.8. Local livestock is normally sold live, which is to say, the retailer himself brings the animal to the slaughterhouse for slaughtering and sells it as fresh meat. There are some instances where the consumer can purchase a live animal at a farm or market.

As for imported live animals and cut meat, import traders sell these directly to retailers. Most live animals are sold face-to-face but there are a few auction markets exclusively for livestock. Accordingly, an appropriate market price has not yet been formed due to the limited marketing activity for local animals. Those local animals are generally consumed as fresh meat, not processed.

(2) Eggs and Poultry Meat

The marketing route of local eggs and poultry meat is illustrated in Figure 2.5.8. It shows that these products are sold directly from farm to retailer in almost the same way as red meat. Local broilers are also sold as live poultry through a similar route. All eggs are consumed as table eggs with the only packing process conducted at the farm.

(3) Dairy Products

There are several commercial dairy farms equipped with processing units which can provide consumers with home delivery services of fresh-packed milk and yogurt or deliver to retailers (refer to Figure 2.5.8). There are also some dairy companies that import dairy products in the form of fresh milk or skim milk, then sell it after processing into reconstituted milk, etc. at factories in Oman. The milk cows raised by local farmers provide milk mainly for family-consumption, therefore, warm milk from there is distributed only to a limited extent.

(4) Estimate of Livestock Consumption Volume

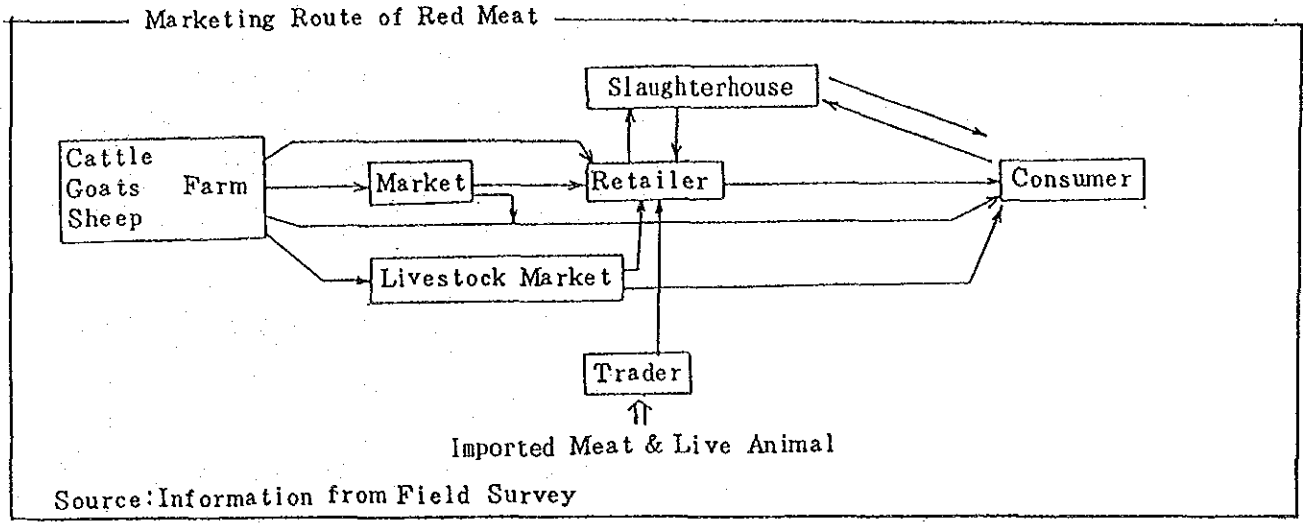
As depicted in Table 2.5.16, the present self-sufficiency rate is low for mutton, table eggs and poultry meat. The self-sufficiency rate of poultry will rise shortly with the recent commencement of operation of a large commercial farm. Mutton consumption has declined lately; although, beef consumption has increased with lowering self-sufficiency. Among dairy products, fresh milk maintains a high self-sufficiency rate, despite a steady increase in consumption.

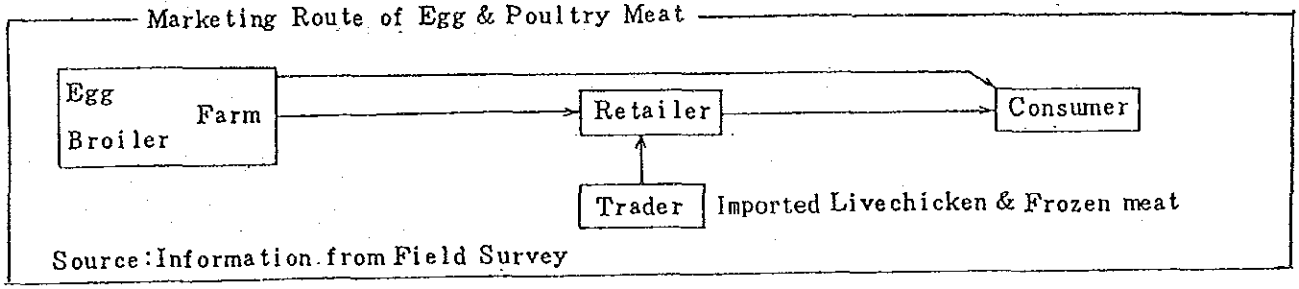
(5) Marketing Issues concerning Cattle in the Southern Region

The first nation-wide livestock and rangeland survey was conducted by a foreign consultant in 1982. The excessive numbers of livestock compared with the available grass feed resources in the rangelands was reported in this survey. It was disclosed that the deterioration of the rangelands was in progress. To resolve this problem, the government initiated a destocking program in 1984 in order to protect the rangelands from over-grazing. In this program, the government purchased local cattle from holders at higher prices than the free market price, then covered the

difference between the consumer price and the holder price with a subsidy. The main purpose of this program was to expedite reduction of the number of livestock, especially in the Jabal Plateau. The accomplishments of the program from 1984 to March 1989 are presented in Table 2.5.17.

After five years, the number of cattle purchased by the government is estimated at 62,000 heads or 11,000 tons (average 177 kg per head). In this program, the initial target, i.e. alleviation of over-grazing, has not been achieved. On the contrary, the number of livestock increased to over 100,000 head in 1988, an estimated by 50% increase from 1982. It was decided that the program stimulated livestock holders to increase the number of head with the expectation of a higher market price. It is crucial to reduce the number of cattle head in the Southern Region, where demand is lower due to limited population. Otherwise, the improvement of the distribution flow from South to North, where demand is high should be promoted.





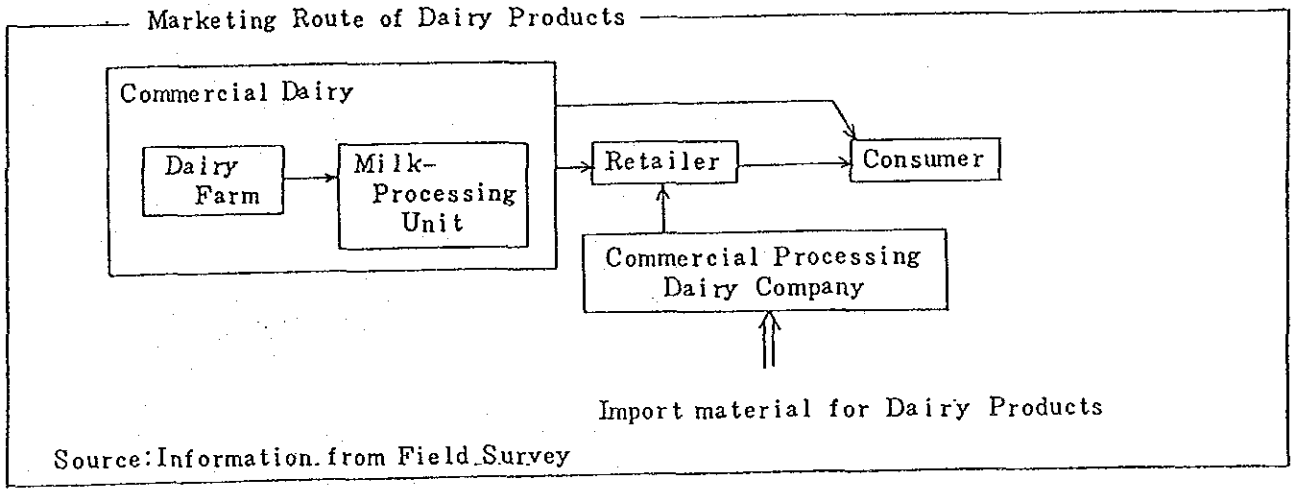


Figure 2.5.8 Marketing Route of Livestock Products

Table 2.5.16 Animal Products Consumption Patterns in Oman
During the Period 1982 — 1988

Year	1982	1983	1984	1985	1986	1987	1988
Red Meat(tonnes)							
Mutton							
Local Production	3,188	3,283	3,382	3,483	3,588	3,695	3,806
Net Imported Live	1,674	2,762	1,771	2,157	1,864	2,746	3,537
Net Imported Meat	9,881	9,559	12,576	12,539	14,146	10,574	9,485
Total	14,742	15,604	17,728	18,179	19,598	17,015	16,828
Self-Sufficiency Rate (%)	21.6	21.0	19.1	19.2	18.3	21.7	22.6
Beef(tonnes)							
Local Production	2,448	2,497	2,547	2,598	2,650	2,703	2,757
Net Imported Live	63	127	-5	-7	-60	-26	-34
Net Imported Meat	1,384	1,301	1,896	2,593	2,947	2,507	3,335
Total	3,894	3,924	4,438	5,184	5,537	5,183	6,057
Self-Sufficiency Rate (%)	62.9	63.6	57.5	50.3	48.9	52.7	46.1
Table Eggs(millions)							
Local Production	7	40	31	19	19	19	39
Importation	88	105	134	166	192	172	168
Total	95	145	165	185	211	191	207
Self-Sufficiency Rate (%)	7.4	27.6	18.8	10.3	9.0	9.9	18.8
Poultry Meat(tonnes)							
Local Production	2,613	1,179	1,048	1,401	1,970	1,580	1,580
Importation	13,987	18,821	24,952	25,099	25,430	22,915	24,863
Total	16,600	20,000	26,000	26,500	27,400	24,495	26,443
Self-Sufficiency Rate (%)	15.7	5.9	4.0	5.3	7.2	6.5	6.0
Fresh Milk(tonnes)							
Local Commercial	3,000	3,500	3,500	4,500	5,000	6,638	
Net Imported Milk	561	1,477	1,364	1,037	615	672	
Total	3,561	4,977	4,864	5,537	5,615	7,310	
Self-Sufficiency Rate (%)	84.2	70.3	72.0	81.3	89.0	90.8	

Source: Sultanate of Oman, Royal Oman Police, Foreign Trade Statistics 1986,1988
F/S for Establishment of Animal Production in the SULTANATE OF OMAN, Arab Company for Livestock Development, 1988. F/S for Establishment of Poultry Projects in SULTANTE OF OMAN, G.R.M. Interrational Pty. Ltd., 1988.

Table 2.5.17 Actual Results of Destocking Program

Destocking Program of the Jabal Cattle in the Period 1984 — 1989

Year	Purchasing Price	Selling Price	Subsidy rate	Total herd	Total weight
1984	1.5R.O./kg	0.9R.O./kg	0.6R.O./kg	11,361	2,190t
1985	1.5	0.9	0.6	20,563	3,348
1986	1.5	0.9	0.6	17,523	3,072
1988/89	1.1	0.9	0.4 ※	12,962	2,462
Total				62,409	11,072

Source: PAMAP. ※ this figure includes commission

2.5.8 Distribution and Agricultural Produce Processing

2.5.8.1 Distribution

(1) Present Situation

The present situation of distribution for agricultural produce in Oman is described below.

(a) The nation has modernized rapidly depending on oil revenues, and substantial infrastructures have been improved, including the development of rural areas. In the agricultural sector, in this context, rapid development resulted in farmers drifting toward urban areas to earn non-agricultural income, and foreign labor was introduced to cope with the labor vacancy in order to maintain agricultural production. The government has established various support programs for the farmers and has endeavored to promote agricultural development. Nevertheless, present agricultural productivity is still low, while production costs are high compared with other GCC countries, and developing countries.

(b) Due to climatic conditions, the season suitable for agricultural production is limited and short in Oman. For this reason, farmers are forced cultivate the same crops at the same time. Furthermore, lack of information regarding current distribution conditions prevents farmers from taking advantage of the commercialization of crops. Consequently, several kinds of crops are produced in excessive amounts, which causes low selling prices. On the farmer side, the low selling price results in an increase of unharvested crops (i.e. low commercialization rate) and in a decrease of incentive to enhance the quality of crops, or to introduce new crops and advanced production techniques.

(c) Nationwide purchasing power has increased along with the increase in both the national income and foreign labor, caused by rapid economic development. As a result, the demand for agricultural produce is rising continuously. As domestic production has not been

able to catch up with the demand for agricultural produce, the deficiency has been supplemented by a rapid surge in imports. Although the government has intended to control these with such measures as permits in terms of crops, the results have not shown tangible effects yet. The major exporting partner is the UAE, which also imports produce from U.S.A., Brazil and India, which are major agricultural producers. Imported produce is low in price and very high in quality. Most of the imported produce is regarded as superior in both price and quality compared with domestic produce.

(d) Lack of farmer understanding of the distribution processes such as grading, packing, storing, transporting, etc. is also an obstacle to effective distribution of farm produce. Due to lack of farmer awareness of the importance of quality, crops of sub-competitive quality in markets are produced, which results in such produce up being utilized for family consumption only. Neither grading in terms of crop standard, volume and quality nor packing for marketing are done; most of the crops are sold in their originally-harvested form. Furthermore, available storage facilities are limited and cold storage facilities are rare. Produce is generally transported to the market by the farmer himself. However, there are many farmers who have no vehicles and so transport the produce by taxi or rented car. Further, there is no available information source for them to determine which trader or market is the most advantageous for them to sell to, and so they must determine those details after visiting a few markets by themselves. In any case, the handling cost of the produce borne by the farmers is considerable.

(e) Wholesale markets for agricultural products are currently not operating. Many wholesalers are engaged independently in collection and shipping of agricultural products to the retailer. At the retail level, public management by the Ministry of Municipalities is present, with produce sold through numerous souqs.

(f) Wholesalers generally determine at the farmgate the price of agricultural products in negotiation with the farmer. Prices as so determined take into consideration past trends. However, in some

cases, product price is set by auction in the retail market square.

(g) Administration of agricultural product distribution is performed by such agencies as MAF, PAMAP, the Royal Oman Police, the Ministry of Commerce and Industry, and the Ministry of Municipalities. These agencies largely act independently, and overall coordination is necessary. Also administrative efforts for the consumption sector have yielded inadequate results.

(2) Stage-wise Distribution Development and Distribution Structure for Agricultural Produce in Oman

The development stage of the distribution process for agricultural produce can be generally outlined as follows.

(a) The initial stage where the producer sells directly to the consumer at the market with the relationship of: producer - consumer.
(b) When the market expands, the merchant appears and participates in the following relationship: producer - merchant - consumer.
(c) When the market expands further and the difference between producer and consumer becomes large in terms of the social aspects, the commodities in the distribution process are increased, classified and specialize. Thus, the following distribution channel appears: producer - collector - distributor - consumer.
(d) Finally, the following channel emerges : producer - collector - middleman - distributor - consumer.

As indicated above, the distribution system becomes more complex according to the maturity of the marketing structure for produce.

Since the establishment of PAMAP, the following channel has begun to emerge: producer - collector - distributor - consumer.

The present unbalanced demand and supply of agricultural produce in Oman is adjusted by the imported amount, because any kind and any amount of low-priced agricultural produce can enter the Omani market at any time from Dubai, which is only about 400 km from Muscat with good road access.

Due to the proximity of Dubai, the wholesalers in Oman transport agricultural produce obtained in Dubai to Omani markets, and sell it directly from 2-3 ton class trucks with no cooling facilities. Retailers in Oman have only about 10 m^2 of shopping space and monthly sales of less than R.O. 500. Regardless of quality and quantity, selling stock is always sufficient without the wholesale market. This is one of the reasons why the wholesale market, which was constructed several years ago by the Ministry of Regional Municipalities (MRM), has not opened yet.

Consumers purchase agricultural produce at various places: rural souqs, retailing stores, supermarkets and public retailing centers constructed by the MRM. At present, there are 940 supermarkets and 6,200 grocery stores in the country which are sponsored by Omanis and managed by foreign personnel.

The supply of cereals, which is the primary staple, depends on import except for a limited amount of wheat and some barley which is cultivated in and around date trees in Oman. In order to supply cereals consistently and with reasonably low prices, the government established the Oman Flour Mills (OFM) and began flour milling in May 1977. OFM was founded under capital sharing, 60 percent by the government and the remaining 40 percent by the private sector, and produces 120,000 tons of flour and 60,000 tons of feed crop annually. All rice is imported through trade companies and is sold by retailers and by supermarkets.

(3) Public Authority for Marketing Agricultural Produce (PAMAP)

PAMAP was established to provide incentives to farmers to increase agricultural produce, and to supply necessary amounts of produce to the market at appropriate prices.

In November 1981, His Majesty issued a Royal Decree for PAMAP and construction work began. The present facilities were completed in 1985, and PAMAP started its collection and distribution services for agricultural produce at the beginning of 1986. The present major services of PAMAP can be summarized as follows.

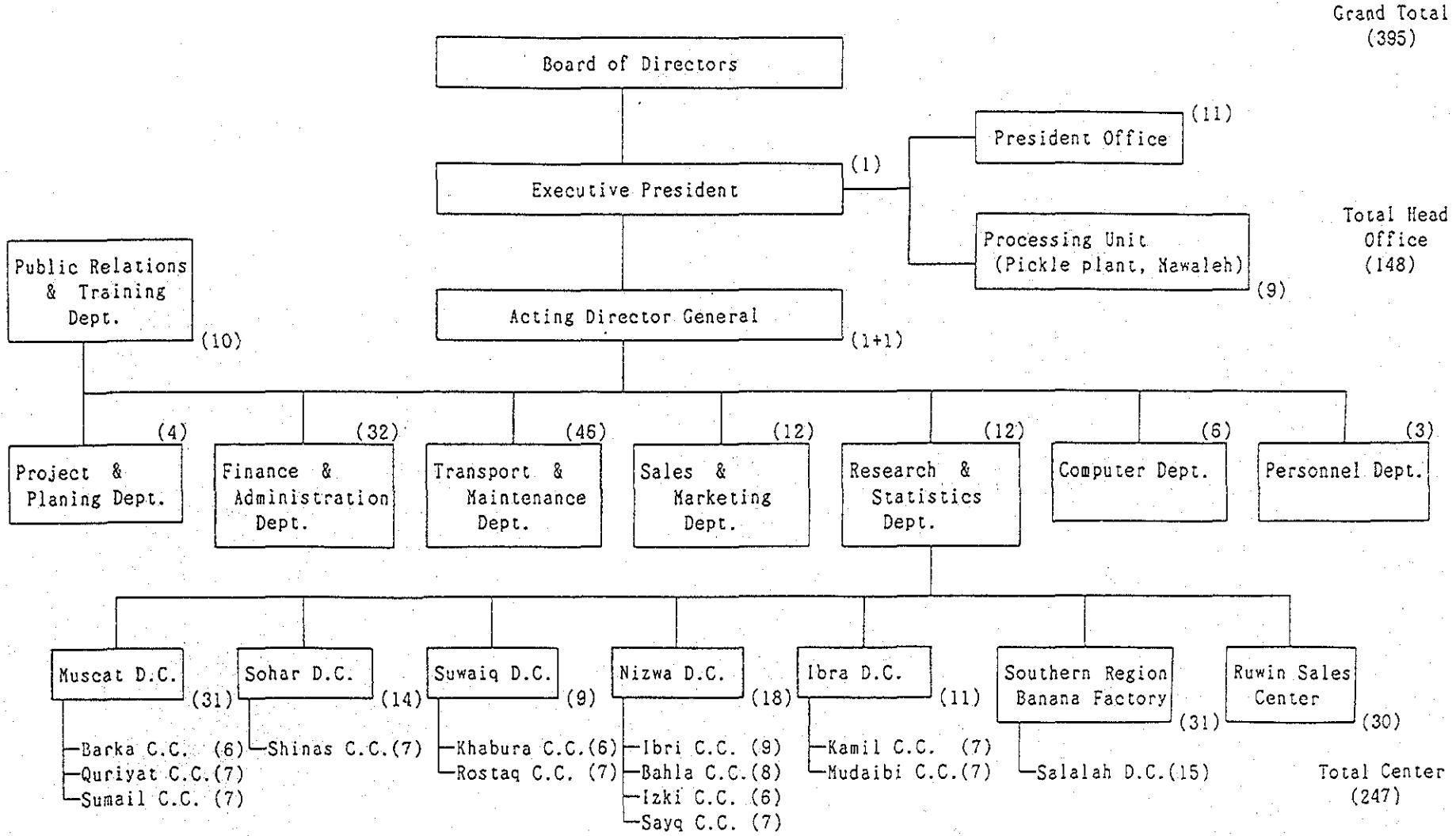


Figure 2.5.9 PAMAP Organization Structure in December, 1989

(a) To purchase agricultural produce brought into centers by the farmers and to distribute it to the consumer area.
(b) To sell produce through each center.
(c) To manage agricultural processing facilities.
(d) To issue import permits for agricultural produce to traders.

The organization of PAMAP is shown in Figure 2.5.9. The headquarters, with its associated facilities in Muscat, supervises the services of (a) and (b), and executes (c) and (d), while six collection and distribution centers and twelve distribution centers also execute (a) and (b).

The farmers' advantages in distributing through PAMAP can be summarized as follows.

(a) The produce is purchased cash on delivery if the quality satisfies PAMAP standards.
(b) The time and labor to select the trader are minimized.
(c) The purchasing price at PAMAP is more stable than that of traders.

Total handling amounts for both purchasing and distribution in 1989 show a great increase (more than three times that in 1986, the first year of operation). PAMAP dealt with around 8 % of the entire production amount in the country in 1988. The amount purchased by PAMAP is characterized by the large seasonal variation. The management of PAMAP needs improvement. This is due to the following reasons.

(a) Management is at an initial stage, and facilities are still not beingused to their fullest.
(b) PAMAP is carrying out functions which the private sector at presentfails to perform (refrigeration, nation-wide collecting and shippingof produce, etc.).
(c) PAMAP purchases goods which are sub-standard.
(d) Selling prices must be suppressed at present.
(e) Staff does not have sufficient training.

The following are observations on PAMAP's services ranging from purchasing to distributing the produce to the centers.

(a) Grading and Packing

Grading and packing are techniques primarily required for the commercialization of produce, they are vital factors. PAMAP has established standard criteria for agricultural produce. However, no criteria for size, weight and packing are included. The importance of grading is not well understood. This is mainly due to the following reasons:

(i) Insufficient education of farmers, related to the importance of grading.
(ii) Lack of a system for impartial grading.
(iii) Consideration of farmers claims which might arise against PAMAP'S refusal of unacceptable produce.

In connection with packing, the packing material is delivered by the Distribution Center in Muscat. However, due to a lack of awareness about the importance of packing, there are times when produce is damaged owing to poor packing.

(b) Transportation

The private transportation business is still underdeveloped in Oman because the population is small in relation to the size of the country and industries are centralized in the capital area. Furthermore, industries which require refrigeration are limited. Therefore, PAMAP owns a considerable number of vehicles at each center to transport produce in the peak season or as required. The present PAMAP administration for transportation is insufficient, particularly, in the following areas.

(i) Minimizing the transportation time.
(ii) Maintaining appropriate temperatures during transportation.
(iii) Loading the produce appropriately.

(c) Storage

The agricultural products handled by PAMAP are collected during their harvest seasons. Therefore, each PAMAP center has refrigerators in order to prolong to the maximum extent the sales period by storage. Optimum storage conditions and the appropriate supervision are not presently utilized in PAMAP. Freezer-burn and rotting are frequently found. Moreover, the delay of removing damaged produce decreases the quality of the normal produce. With long-term storage of agricultural produce, the pre-storage quality is extremely important. Therefore, a careful inspection of produce quality before storage should be a prerequisite to eliminate the poor quality or damaged produce.

(d) Price Formulation

PAMAP determines its purchase price for agricultural products through its committee for demand and supply. A survey is made of the retail market auction price for agricultural products as well as consideration given to amounts of products being handled at collecting and shipping centers, and demand and supply trends.

The PAMAP selling price is determined by added commission (10-15% in the case of wholesalers and 20% in the case of retailers) and the cost of refrigeration to the original purchasing price. Table 2.5.18, indicates expenses incurred by the private sector and PAMAP at each stage of distribution. Despite some differences in refrigeration cost, the selling price by PAMAP is considered appropriate.

(4) Agricultural Product Price

At present, full-fledged wholesale markets which function to distribute and set prices for agricultural products are not in operation. However, auctions for some products, representing an embryonic stage in wholesale market development, are being held. Such auctions are performed in the retail market square. Planned shipment of agricultural products is not performed, with amounts of produce governed by the size of farmer

Table 2.5.18 Farmgate Prices and Retail Prices (Private and PAMAP)

Crop	Distribution between the farmer and the retailer					Distribution between the farmer and PAMAP					Note
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	
Banana	138	287	149	48.9	51.9	140	266	120	54.9	45.1	
Cabbage	85	199	114	57.2	42.8	52	91	39	57.1	42.9	
Cauli Flower	191	387	196	–	–	294	381	87	77.3	22.8	
Potato	153	238	85	64.3	35.7	128	186	58	68.8	31.2	
Tomato	236	308	72	76.6	23.4	135	179	44	75.4	24.6	

Note :

(1) Farm Gate Price (Producer's Price) Baiza/kg
(2) Retail Price Baiza/kg
(3) Profit (2) − (3) Baiza/kg
(4) [(1)/(2)] × 100 %
(5) [(3)/(2)] × 100 %

Each figure is weighted year averaged price in 1988.

SOURCE : ABSTRACT IN INTERNATIONL SYMPOSIUM ON AGRICULTURE & FISHERIES DEVELOPMENT IN OMAN IN MUSCAT ON 15-19 OCTOBER 1989

harvests.

The mainstay of the present distribution system is the wholesaler. The wholesaler engages in shipping, and both wholesaling and retailing of agricultural products. Products are purchased directly from the farmer, packed in cardboard boxes once a certain amount of produce is collected, and then shipped and sold to retailers, or in small amounts directly to consumers.

However, amounts of produce handled by the wholesaler are small and marketing strategy is virtually nonexistent. The purchasing price of produce is determined at the farm gate in negotiation with the farmer. Storage of produce for release to the market in response to supply and demand trends is not performed. Thus under the present system, neither price formulation reflecting supply and demand, nor a stable supply of good produce to the consumer can be expected.

PAMAP determines its purchase price for agricultural products as mentioned before. As can be seen from Table 2.5.19, the market price for agricultural products is higher than the farmer production cost, except for certain crops. Products for which market prices fall below that for production represent 10% of total agricultural products traded in terms of volume, and 3% in terms of value. Thus 1988 data indicates price formulation favorable to the farmer.

In general, the price for domestic agricultural products (purchasing price for PAMAP) is lower than that for imported products (purchase price by wholesalers) according to government statistics. However, an interview survey by the JICA team in the field indicated a reverse situation for prices for imported and domestically produced agricultural products.

(5) Development Potential

The salient problems of distribution in Oman are as follows.

(a) Domestic agricultural produce is at a disadvantage compared with imported produce in aspects of price and stable supply, because of

Table 2.5.19 Production Costs and Purchasing Prices in 1988

No.	Produce	PRODUCTION COST	MINI. PRICE	PURCHASE IN PAMAP		PURCHASING LESS THAN PRODCTION COST			
			IN PAMAP	QUANTITY	VALUE	QUANTITY		VALUE	
		R.O./TON	R.O./TON	TON	R.O.	KG		R.O.	
1	Banana	132	140	3943	539,641	0	0.0%		
2	Cabbage	55	51	835	82,561	264,753	31.7%	13,603	16.5%
3	Carrot	59	147	65	10,961	0	0.0%	0	0.0%
4	Cauliflower	141	73	152	18,424	131,605	86.7%	12,827	69.6%
5	Chilli Pepper	173	195	270	61,259	0	0.0%	0	0.0%
6	Coconut	88	125	41	6,815	0	0.0%	0	0.0%
7	Cucumber	77	232	469	109,497	0	0.0%	0	0.0%
8	Eggplant	84	31	625	36,108	546,580	87.5%	25,206	69.8%
9	Frannkinconse			12	25,568	0	0.0%	0	0.0%
10	Garlic	163	327	68	31,089	0	0.0%	0	0.0%
11	Lettuce	88	207	142	37,873	0	0.0%	0	0.0%
12	Lime	149	114	843	182,439	365	0.0%	365	0.2%
13	Mango	821	98	35	5,476	34,521	100.0%	5,476	100.0%
14	Onion	102	66	174	14,057	173,735	99.8%	14,015	99.7%
15	Papaya	125	98	299	41,149	85,182	28.5%	9,211	22.4%
16	Potato	51	75	1434	191,019	0	0.0%	0	0.0%
17	Pumpkin			469	30,770	0	0.0%	0	0.0%
18	Squash	70	65	379	41,124	111,428	29.4%	6,591	16.0%
19	Sweet Melon	117	157	720	170,824	0	0.0%	0	0.0%
20	Sweet Pepper			180	26,821	0	0.0%	0	0.0%
21	Sweet Potato	59	143	147	25,332	0	0.0%	0	0.0%
22	Tomato	69	68	2561	348,448	488,418	19.1%	33,394	9.6%
23	Water Melon	83	30	1500	181,867	0	0.0%	0	0.0%
24	total			15363	2,219,114	1,836,587	12.0%	120,688	5.4%
25	other local			2306	531,570				
26	imported			1923	513,017				
27	GRAND TOTAL			19592	3,263,701	1,836,587	9.4%	120,688	3.6%

SOURCE : MAF PAMAP

low productivity, high production costs, and large seasonal fluctuation of supply;

(b) The quality of domestic agricultural products is no better than that of the imported, because of Omani farmers' poor knowledge about marketing and how to set prices in line with quality. The lack of incentives for farmers causes them to be satisfied with the poor quality of their produce;

(c) The market for produce is concentrated in the capital area, while production areas are dispersed widely over the whole country, and the production capacity of each area is small. This is the main reason why the handling costs for domestic produce tend to be high; and

(d) Though PAMAP was established in order to market domestic agricultural produce more smoothly, and has been operating for four years, effective performance has still not been accomplished in terms of collection, selection, packing, storing, transporting, and selling.

As a solution to these problems, the following items, classified according to the levels of producer, PAMAP, and MAF, can be considered.

(a) Producer

(i) Increase productivity by improving cropping techniques, introducing new varieties and new kinds of produce, etc.
(ii) Reduce production cost by rationalizing farm management.
(iii) Promote the organization of farmers and establish cooperative selling systems on each production unit (community or village).

(b) PAMAP

(i) Construct and install necessary facilities to cover areas more effectively.
(ii) Promote the discrimination of products on the basis of quality

and give farmers incentives to raise quality, by applying inspection standards severely when purchasing the produce from farmers.

(iii) Rationalize operations by improving the operation methods and system, enhancing the capacities of staff through on-the-job training, etc.

(iv) Soften the competition of domestic produce against the imported by imposing appropriate control on importation.

(v) Examine the possibility of establishing an agro-industry for produce which is seasonally over-produced.

(vi) Advertise nation-wide the necessity for increased consumption of domestic agricultural produce through appropriate information activities.

(c) MAF

(i) Give incentive to farmers to increase productivity and quality through introducing an output price supporting system, strengthening input subsidies, etc.

(ii) Enlighten farmers as to the importance of modern marketing for agricultural produce using experts in regional extension centers and other extension services.

(iii) Establish necessary regulation and subsidy systems, including assistance for construction of facilities such as storage in order to promote farmers' organization.

2.5.8.2 Agricultural Produce Processing

(1) Historical Development

The government's initiative in policy formulation and investment to develop local industries started around 1970, when there was virtually no industry in Oman. Since then it has been strengthened. In doing so, the government has naturally put emphasis on the oil sector which was seen as most promising in terms of revenue generation for the future development of the country.

Table 2.5.20 Number of Registered Industries from 1975-1988 by Industrial Activity

Industial Activities	1975	First Five Year Plan (1976 - 80)	Second Five Year Plan (1981 - 85)	Third Five Year Plan				Grand Total
				1986	1987	1988	Total	
Food and Beverage	-	14	39	23	18	20	61	114 < 4>
Textile Wearing Apparel	-	1	1	1	-	3	4	6 < 0>
Wood & Wood Productions	2	104	428	101	41	33	175	709 <22>
Paper & Paper Products	1	7	14	1	3	2	6	28 < 1>
Chemical and Chemical Products	-	9	16	9	6	5	20	45 < 1>
Non-metallic Mineral Products	4	204	1,150	228	98	88	414	1,772 <56>
Basic Metal Industries	-	-	-	1	1	-	2	2 < 0>
Fabricated Metal Products	3	54	283	80	43	37	160	500 <16>
Other Manufacturing Industries	-	-	-	1	1	1	3	3 < 0>
Total	10 < 0>	393 <12>	1,931 <61>	445	211	189	845 <27>	3,179 % <100>

Table 2.5.21 Investment in Registered Industries From 1975-1988 by Industrial Activity

(RQ thousand)

Industial Activities	1975	First Five Year Plan (1976 - 80)	Second Five Year Plan (1981 - 85)	Third Five Year Plan				Grand Total
				1986	1987	1988	Total	
Food and Beverage	-	<32> 10,402 (34)	<29> 9,589 (5)	<11> 3,790 (3)	<22> 7,195 (22)	< 6> 2,047 (15)	13,032 < 4>	33,023 < 9>
Textile Wearing Apparel	-	941	105	40	-	249	289 < 0>	1,335 < 0>
Wood & Wood Productions	32	1,864	4,842	1,503	718	869	3,090 < 1>	9,828 < 3>
Paper & Paper Products	44	1,539	2,397	130	577	2,727	3,434 < 1>	7,414 < 2>
Chemical and Chemical Products	-	1,678	53,979	8,541	5,214	2,767	16,522 < 5>	72,179 <20>
Non-metallic Mineral Products	369	11,762	97,857	6,211	8,261	3,131	17,603 < 5>	127,591 <36>
Basic Metal Industries	-	-	-	83,000	6,200	-	89,200 <25>	89,200 <25>
Fabricated Metal Products	26	2,389	7,479	2,474	4,006	1,484	7,964 < 2>	17,858 < 5>
Other Manufacturing Industries	-	-	-	35	255	12	302 < 0>	302 < 0>
Total	471 < 0>	30,575 < 9>	176,248 <49>	105,724	32,426	13,286	151,436 <42>	358,730 % <100>

Tables 2.5.20 - 2.5.21 show the number of companies and their aggregate capital in the manufacturing industry. Among these, the agricultural processing industry accounts merely for 4 % (114 companies) and 9% (R.O. 33 million). Major factories include meat processing, dairy products, canning of vegetables and fruits, milling and animal feed, etc. During the 1986 - 1988 period, various types of agricultural processing plants were established, making the total 61. The industrial sector's share of Oman's GDP has rapidly expanded in the past thirteen years since 1976. Among the four major sectors of industry, mining, fisheries, and agriculture in Oman, industry has made the most sizable contribution to the growth of the GDP every year from 1985 to 1988, in the Third Five-year Development Plan period. The amount of production from agricultural processing in the industrial sector is steadily increasing mainly due to the opening of new plants.

Costs for establishing industrial plants in Oman are estimated to be higher than in other GCC countries, in spite of the existence of favorable government subsidies in Oman.

(2) Major Agricultural Products for Processing

(a) Dates

Although dates have long been one of the major agricultural products, recently date growing has been declining due to unfavorable environmental and social conditions, a shortage of skilled workers, rising growing costs, and low product prices. At present, there are six main outlets for harvested dates:

(i) Fresh dates consumed by growers or marketed locally for human consumption
(ii) Fresh dates export
(iii) Animal feed
(iv) Production of date syrup by traditional means for home consumption or local markets
(v) Production of dried dates ("Busr") for export under a scheme

administered by the Ministry of Commerce and Industry (MCI)

(vi) Processing and packing for local sales and export at MAF's date factories in Nizwa and Rustaq

Among the above, with respect to (v) and (vi), volumes of 2,300 tons and 1,300 tons per annum are processed, respectively. Current farmgate prices of dates are not enough to compensate for average production costs of dates. Farmgate prices, at present, are even higher than prices of imported dates from Iran, etc.

(b) Limes

Limes also have a long tradition in Oman, and are consumed either fresh or sun-dried. Dried lime is currently exported at a volume of 2,000 tons per annum, which makes it one of the major export items. In order to promote the export of dried lime that is produced in traditional natural drying processes, further research and development of new products will be required, an example of which is the "lime-bag" (like a "tea-bag") presently produced by PAMAP.

(c) Bananas

Bananas are an important cash crop in the Salalah Region in southern Oman. Most of the bananas in Oman are produced in this region, and sold in the Muscat capital area or exported. Currently, the volume of exports is around 300 tons annually. PAMAP ripening facilities are located inside the collection facilities in Muscat and Salalah with reasonable care given to the ripening process to match the marketing schedule, bananas have the potential to become a major export.

(d) Pickles of Vegetables/Fruits

A pilot scheme to produce and sell pickles from seasonal vegetables and fruits during the harvesting period has been started by PAMAP.

(e) Coffee/Tea

Coffee and tea are imported in the raw form for local consumption or re-export since they are not grown locally.

(3) Processing Facilities

(a) MAF

The processing and packing of dates by MAF is conducted at two date-packing plants located in Nizwa and Rustaq, both of which started operation in 1976. Their current status is described below. In order to improve the productivity of these plants, measures including diversified modes of production need to studied.

(i) The production machines and their attached equipment are obsolete.
(ii) The cost of products is high due to manually-operated equipment and high percentage of losses of raw materials during processing (10 - 15 %).
(iii) The designed capacity of the two plants is 2,000 tons per annum. But the actual utilized capacity did not exceed 700 tons.
(iv) The lack of packing and processing equipment for various packing lines minimizes the new marketing outlets of the products.
(v) The conditions of the date collecting centers are not efficient due in part to the lack of pallets.

(b) MCI

MCI purchases dried dates ("Busr") from farmers, stores them for some time, and then exports most of the product to India. Processing of dates after harvest, and transportation to the MCI collection ground at Muscat, are done by farmers themselves. The facility owned by MCI at Muscat is merely a dried dates storage which was erected in 1986.

(c) PAMAP

PAMAP is ripening bananas and grading and packing pickles and dried lime at three agricultural produce processing centers. The size of these operations is generally small, basically pilot schemes, except for banana ripening. There are banana-ripening facilities located at Muscat and Salalah, which started operation in 1986 and 1982, respectively. At Salalah, PAMAP took over management at the end of 1985 from MAF, which started the facility. The capacity of ripening facilities is almost fully utilized by normal storage needs. Shortages of storage have been experienced during certain times of the year. It is necessary to build additional ripening facilities to deal with the growth of banana production. They may be more efficiently managed by using them in a multi-product fashion.

The development of the processing industry for locally available agricultural products is in line with the above-stated policy orientations. While the importance of increasing production, productivity, and quality standards of agricultural products cannot be overstressed, it is also highly advisable to add more value to the products by developing the processing industry. The processing industry is justified in light of enhancing regional development, settlement in rural areas, and "Omanization" of the economy, because it will provide employment as well as utilize products available locally.

In promoting the agricultural produce processing industry, the following factors should be fully taken into consideration, based on the present status of agricultural and industrial production in the country.

(a) Stable and economical supply of agricultural products.
(b) Measures for ensuring high utilization of plant capacity-combined agricultural processing.
(c) Training of engineers and workers in order to involve new technologies and facilities.
(d) Government support for the start-up period in terms of financial, institutional, and staffing requirements.