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SULTANATE OF OMAN THE STUDY ON A MASTER PLAN FOR AGRICULTURAL DEVELOPMENT

FINAL REPORT  
VOLUME 4 FIRST FIVE YEAR  
AGRICULTURAL DEVELOPMENT PLAN

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**FINAL REPORT**

**VOLUME 4  
FIRST FIVE YEAR AGRICULTURAL  
DEVELOPMENT PLAN**

**NOVEMBER 1990**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

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# VOLUME 4 FIRST FIVE YEAR AGRICULTURAL DEVELOPMENT PLAN

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*CHAPTER 1*

*FUTURE SOCIO-ECONOMIC*

*CHARACTERISTICS*



## CHAPTER 1 FUTURE SOCIO-ECONOMIC CHARACTERISTICS

Since His Majesty Sultan Qaboos assumed power in 1970, basic social infrastructures, such as road networks, transportation, electrification, and broadcasting were developed using funds provided by national oil revenues during the First, Second, and Third Five-year Development Plans. As a result, the framework of the infrastructural layout was completed. Consequently, an efficient exchange of products, personnel and information took place within the country. The social structure of Oman is shifting from a closed tribal community system to a new open society, as the people watch their nation expand.

This tendency, in addition to being an improvement allowing the development of an information-oriented society, is expected to continue as long as the social situation and economy of the country continue to develop.

It is believed that in the future, the national economy will be greatly influenced by the price tendencies of oil. Since oil reserves are estimated at 20 years, the government is making an effort to depend less on oil and to diversify sources of national income.

With regard to oil supply, dependence on OPEC is expected to increase. Future oil prices, therefore, may follow a constantly increasing trend, as long as oil prices are competitive with the prices of alternative energy sources. It is very important for the Fourth Five-year Development Plan to come up with industries other than oil and to make an effective attempt at the diversification of national income sources, using the stable oil revenues to do so.

The population growth rate in Oman is expected to be 3.5 % per annum. This is one of the factors which limits the growth of the national income per capita. However, symbolized by the first graduation ceremony of the Qaboos University in 1990, the investment made by the Omani government for development of human resources through education is expected to pay off in the 1990's and Omanization will be promoted. Qualitative improvement of education, which will provide engineering specialists with higher

technical knowledge, will be required in order to respond to technical innovations, as will the improvement of the overall standards of education.

The purpose of the 10-year Agricultural Development Plan is to present a realistic, but promising picture of Omani agriculture, which will contribute to the constant development of the economy and society of Oman under these circumstances.



*CHAPTER 2*

*ESTABLISHMENT OF DEVELOPMENT TARGETS*



## CHAPTER 2 ESTABLISHMENT OF DEVELOPMENT TARGETS

Taking into account tendencies of the socio-economy of the Sultanate of Oman and the present situation of agriculture, the overall targets of this 10-year Agricultural Development Plan are as follows:

- (1) Increase in self-sufficiency rate of food from 44 % to 55 %
- (2) Enhancement of agricultural productivity
- (3) Conservation and effective use of water resources
- (4) Improvement of agricultural structure
- (5) Activation of the rural areas through the promotion of agriculture
- (6) Human Resources Development
- (7) Achievement of a 6.3 % annual average growth rate in the GDP for the agricultural sector from 1990 to 2000 at constant prices in 1989.

### (1) Increase in Food Self-Sufficiency

#### (a) Necessity

Any country with land and water resources, that can produce agricultural produce at a reasonable cost and with little burden to the people of the country, should make an effort to increase the level of food self-sufficiency from the viewpoint of national security for food, and also for maximum use of the country's resources.

It is, however, difficult for the Sultanate of Oman to attain self-sufficiency with regard to all the food it may need, as the natural and physical conditions are severely restricted. Selective

expansion of agricultural production, therefore, is required to promote self-sufficiency.

(b) Direction of agricultural production

The caloric supply per capita per day in Oman was estimated at 2,830 kcal in 1988, which is less than the figures for Saudi Arabia (2,940 kcal), UAE (3,224 kcal), and Kuwait (3,344 kcal) for the years 1979-1981. However, it is expected to be about 3,000 kcal by the year 2000.

The Omani diet is characterized by a more appropriate PFC balance (the caloric proportions of the supply of protein, fat and carbohydrate) compared to that in many other countries. Therefore, the expansion of agricultural production should be promoted, maintaining 'the Omani type of diet'.

Considering the natural conditions in Oman, such as limited water resources and specific cropping periods, it is not practical to expect full attainment of self-sufficiency in the entire agricultural production spectrum.

It is not realistic to attempt to enhance the self-sufficiency rate in agricultural produce, by disregarding production costs, and productivity.

Therefore, it is essential to draw up a future plan for agricultural production with regard to various conditions such as the importance of each item of agricultural produce in terms of nutrition and agricultural production.

Below are the principal staples to be produced (refer to the details in volume 5, chapter 2) :

(i) Rice & Wheat

Taking into consideration natural conditions and the low

profitability of rice production, it is most realistic to import all rice that is to be consumed in Oman. Wheat is usually imported although some is produced in the country. It is necessary for the Omani government to arrange a reservation system against emergencies, and to diversify its overseas suppliers. More rice and wheat are needed in the country, as the population is increasing. Rice and wheat are ranked as the principal food. It is suggested that the per capita consumption volume be maintained at the same level as at present to maintain the typical Omani's diet, which is one of the most ideal diets from a nutritional standpoint. This would also save on foreign currency.

(ii) Vegetables

The country cannot depend on a sufficient supply of vegetables from overseas countries as vegetables must always be green and fresh. Enough vegetables are produced within Oman to meet the domestic demand, therefore, a forecasted self-sufficiency rate is expected to be at least higher than at present.

(iii) Fruit

Fruit consumption has been increasing recently. The self-sufficiency rate of dates will be maintained at the present level, as they are the crop traditionally cultivated in Oman. Any kind of fruit other than dates will be completely self-sufficient or kept at the present level of production. The export volume of dry limes, primarily to Iraq, is expected to decline now that the Iran-Iraq war has ended. Iraq will start its own dry lime production again.

(iv) Livestock

The self-sufficiency rate for all livestock products should be increased from the present rate of 57 % of the entire demand

to 65 % by the year 2000, as livestock is an important source of protein and plays a vital role in the enhancement of living standards of livestock holders. Fresh milk, eggs and chicken should also be completely self-sufficient in the country.

(v) Feed Crops

Better quality roughage is required for the future to keep livestock production costs down. This is also important from the physiological point of view. Feed crops such as grass should be produced within the country as much as possible.

(vi) Tuber Crops

Production of tuber crops is economically sound but its self-sufficiency rate is quite low, approximately 20 %. The rate should be increased by enlarging the planting area.

(vii) Production of Soya Beans and Seeds

Oman depends greatly on the import of soya beans and seeds. Therefore, it is essential for the country to aim at more practical use of soya beans, and to develop seed production through experiments and research.

For the realization of these basic approaches, it is necessary that encouraging policies for production and promotion be established by the government and that agricultural productivity be enhanced.

As a result, the goal for self-sufficiency is set at a rate of 55 % for the year 2000 up 11 % from the level of 44 % achieved in 1988.

(2) Promotion of Agricultural Productivity

(a) Necessity

The population in the country in the year 2000 is estimated at 2.2 million. This corresponds to a 46 % increase against 1.5 million in 1989, at an increase rate of 3.5 % per annum. Consequently, more agricultural crops will be required to feed the population if the level of self-sufficiency is to be maintained up to and beyond the year 2000. However, as the potential water resources are restricted, the volume of water required for this may not be sufficient even if the crop planting area is enlarged horizontally. Therefore, vertical expansion, that is, the elevation of agricultural productivity, will be required.

The unit crop yields in Oman are low compared to those of the GCC and other advanced countries. Considerable potential is left for future expansion of productivity. It is imperative for the projects to achieve more efficient productivity in this 10-year Agricultural Development Plan, as this is the way the production volume may be increased without requiring water resources.

(b) Basic Direction of Agricultural Development

The basic policy required to realize an increase in agricultural development productivity is as follows:

- (i) To develop better varieties of crops and to promote experiments and research for cultivation techniques.
- (ii) To make a great effort to establish more productive techniques through the promotion of extension services.
- (iii) To save manpower by employing suitable machinery in accordance with the crops to encourage cultivation. For efficient mechanization, such infrastructure arrangements as land readjustments, gravel removal and soil-dressing are prerequisites.

### (3) Securing Water Resources and Efficient Utilization

#### (a) Necessity

Water is indispensable for agricultural production. Especially in arid areas like Oman, where rainfall is insufficient, the usable volume of water is an important limiting factor in agricultural production, as well as in the lives of the Omani people.

Since irrigated water consumes 90 % of the total water supply in the country, it plays a vital role in the water resource policy. As His Majesty Sultan Qaboos declared, water resources should be considered national property and should be shared among the people of the country. Therefore, it is imperative that water resources be developed, managed and preserved from a national point of view.

#### (b) Basic Direction for Securing Water Resources and Water Utilization

Comprehensive efforts should be made to secure water resources and to use them effectively. Regional adaptability of water resources must be taken into account, and the following should be considered:

- (i) Water conservation,
- (ii) Reinforcement of already-exploited aquifers,
- (iii) Exploitation of untapped aquifers, and
- (iv) Legal control

The promotion of (iii) and (iv) above is essential for an immediate effect, while (i) and (ii) are required for medium and long term improvements. In the future, the importance of investment in "water conservation" will be further stressed to utilize the limited water resources more effectively.

This shall be promoted through the combination of the following:

- Strengthening of the ground water storage capacity by



constructing a recharge dam and an underground dam, etc.

- Rationalization of water system using modern irrigation techniques. and
- Strengthening the juridical regulations for water use.

(4) Improvement and Strengthening of the Farm Management and Marketing Structures of the Agricultural Sector

(a) Necessity

In the agricultural sector in Oman, the management structure and the marketing structure are especially important. The agricultural management in the country can be roughly classified into the following three types:

- Large-scale commercial-type management.
- Medium-scale management on new farms, etc. where mainly vegetables, etc. are cultivated on farms which are about 10 feddan. and
- Small-scale traditional management.

Productivity is the highest in large-scale commercial management, followed by medium-scale management, with traditional management showing the lowest productivity level. Accordingly, upgrading large-scale commercial-type management would be most advantageous provided that increasing the self-sufficiency ratio is the aim. However, from the viewpoint of the number of workers employed on the farms, the medium-scale (new farm) and small-scale (traditional) management farms are significantly superior to the large-scale management farms.

Therefore, special emphasis should be placed on improved management of medium- and small-scale farms through the extension

services. The following will be taken into account:

- Increasing per capita income.
- Ensuring employment opportunities.
- Upgrading agricultural productivity throughout the country.

However, the acceptance of the above management improvement program depends mainly on the farmers' abilities and natures. Since the government has placed high priority on education, in the near future, farmers' abilities are expected to be supplemented by the participation of many younger, better-educated farmers.

Marketing structure improvements for agricultural produce should consider the present marketing situation.

- Expansion of the physical distribution areas according to population increases and infrastructure improvements such as roads.
- Transition period to improve the marketing channels, which are evolving out of direct transactions between producers and retailers into indirect deals between producers, brokers, and retailers.

With the population increase and transportation network development, the above tendencies will be more conspicuous. Moreover, there has been a marked loss in domestic agricultural produce in the marketing process, in addition to losses at the farm level.

Therefore, measures which contribute to increasing the self-sufficiency rate for agricultural produce are required to decrease losses in the marketing process.

(b) Basic Approach to Improvement of the Agricultural Structure

It is essential to determine which agricultural management type should have the highest priority in the future among the three management types described above.

From the viewpoints of higher productivity and production increases, large-scale commercial-type management should be recommended. On the contrary, from the viewpoint of creating new employment opportunities and increasing the living standard of the nation, priority should be placed on medium and small-scale management, even though they are less productive than large-scale.

Based on the present agricultural situation in the country, an appropriate combination of all of the above would be the most realistic approach. In this Master Plan, first priority is placed on management improvement of medium- and small-scale farms with an aim to create employment opportunities and to increase the income of the Omani farmer. However, this approach will not increase self-sufficiency effectively by a stable supply of agricultural produce in Oman. Therefore, large-scale commercial management should also be promoted in areas where the natural, social and economic conditions are suitable.

Full-time engagement in agricultural management ensures sufficient economic results for commercial or medium-scale (new farm) farms. However, special attention must be paid to the small-scale traditional farms where date palms are usually cultivated, because they may be required to maintain their living, not only with agricultural income, but also with non-agricultural income. There are, however, possibilities which could improve their present management such as expanding their farm management scale and so forth, as detailed in volume 5, section 4.2.

The other improvements needed are in the marketing structure. Although every effort is made to improve quality and to increase yield in the production stages, economic loss is significant if the marketing process is inefficient from producers to consumers.

Furthermore, if there is no market to set appropriate prices, the producers usually receive little while the distributor enjoys a profit.

Therefore, the following measures are indispensable:

- To establish appropriate and functional price formulation systems in order to consistently supply high-quality produce to consumers, as well as to ensure a profit for producers.
- To improve the collection and distribution systems in order to increase the commercialization ratio of the produce.
- To improve the marketing structure so as to upgrade the marketing technology.

#### (5) Activation of the Rural Area through Promotion of Agriculture

##### (a) Necessity

Rural areas play a vital role, not only as the source of produce, but as the center of Omani culture, as well as providing a place of relaxation for the public. However, the rapid economic growth of Oman has increased urban-rural economic disparity, and the younger generation is drifting towards the urban areas. Such phenomena are frequently observed, particularly in the course of rapid development of the secondary and tertiary industries. The population drift may increase unless countermeasures are instituted.

The creation of employment opportunities and the enhancement of living standards are indispensable in the rural areas for the well-balanced development of the country and the orderly development of resources. Since there is no notable industry in the rural area except agriculture, it plays a vital role in activating the rural economy.

Thus, promotion of agriculture definitely contributes to activating the rural area and to alleviating rural-urban disparity.

(b) Basic Approach to Promotion of Agriculture for the Activation of Rural Areas

In line with the nation-wide agricultural development scheme, the investment in agricultural development in rural areas will be based on regional characteristics. As in the 'Basic Approach to Improvement of Agricultural Structure', the investment differs in terms of the type of agricultural management. Accordingly, the regional development impact derived also differs according to the major agricultural management type in the region.

Furthermore, although agriculture plays a vital role in activating rural areas, it must be understood that there are certain limits to the development effect depending on the regional characteristics.

The following measures are required for areas where it is difficult to maintain a livelihood because they depend on agricultural income only, particularly in such areas where date palms are mainly cultivated and small-scale management techniques are used:

- Expansion of farm management scale.
- Promotion of agriculture-related industries.
- Ensure income opportunities in non-agricultural business.

Because tradition and culture is preserved in the rural areas, it is essential to make every effort to maintain the rural society by means of implementing comprehensive measures focused especially on the promotion of agriculture, and in this way, to activate regional economies.

(6) Human Resources Development

Given the inherent nature of agriculture, wherein the farmer must struggle with the constraints imposed by the national environment, the level of farmer technical skill will be a determining factor in any attempt to improve agricultural productivity.

In order to achieve the targets under the 10-year Agricultural Development Plan, human resources development to train and expand the number of extension and research staff necessary to bring new and practical farm technologies to the farmer will be of highest priority.

Also, a vigorous program of Omanization should be pursued under the 10-year Agricultural Development Plan to fill the new jobs to be created with Omani personnel to the greatest extent possible.

(7) Achievement of a 6.3 % Annual Average Growth Rate in the GDP for the Agricultural Sector at Constant Prices from 1989

The average annual growth rate in the GDP for the agricultural sector from 1989 to 2000 is at 6.3% at constant prices from 1988. It will be achieved as a result of integrated implementation of those measures mentioned above in sub-sections (1) to (6).

*CHAPTER 3*

*OUTLINE OF DEVELOPMENT STRATEGY*





## CHAPTER 3 OUTLINE OF DEVELOPMENT STRATEGY

### 3.1 Principles of Development Strategy

In order to attain the objectives of the agricultural development program described in the preceding chapter, development strategies are formulated for each sector. In the formation of such a sectional development strategy, particular attention has been paid to the preparation of effective plans which are consistent with each other, as well as to the following basic principles:

- (1) to maintain consistency throughout the Third Five-year Development Plan,
- (2) to provide maximum effect with minimum expense,
- (3) to use, to the fullest extent possible, the presently available resources,
- (4) to respect Omani society, culture, customs and lifestyle, and
- (5) to focus on farmers' self-reliance.

### 3.2 Basic Framework of Development Strategy

#### (1) General

An agricultural policy in Oman must accept extremely difficult task under severe natural conditions. The policy must achieve maximum production through efficient utilization of the limited water and human resources. Because of prosperous achievements in the petroleum industry, the economic share of the agricultural sector has declined significantly compared with its share before 1970. However, agriculture still remains the most essential industry in the country, except in large urban areas such as Muscat. Furthermore, there is great potential for improvement in agricultural management in Oman because there are still many farmers who manage agriculture at the same level of productivity as before 1970, and

there are many problems to be overcome.

It is important to predict the pattern of the future agricultural and rural society in Oman to formulate the Master Plan for ten-year agricultural development; although, obviously it is difficult to forecast thus accurately due to various uncertain components.

The outline of the sectional development strategy, as well as policies for production, structure, price, distribution and subsidies for the agricultural development plan are discussed below to clarify the relationship between the targets and the strategy.

## (2) Production policy

The vital role of the production policy is to establish the measures for achieving a production increase in agriculture through more efficient use of the limited water resources. Water resources are to be developed through exploitation of already-confirmed new water resources and by recharging the groundwater by constructing recharge dams, etc. New agricultural land development can be promoted by the newly developed water resources. The increasing of land-use efficiency and crop intensity is also proposed through the introduction of modern irrigation methods for water conservation. However, since the resources are limited, expansion of the agricultural land alone will not be able to meet the increasing food demand accompanied by a population increase with a growth rate of 3.5% per annum.

As a result, productivity must increase on the existing agricultural land through various comprehensive measures such as education of farmers, farm mechanization (appropriate to management scale), and extension of the new farming techniques endorsed by research on high-yielding varieties of crops. The expansion of selective crops is proposed for future agricultural production and detailed in chapter 2 "Prospects for demand and supply of agricultural products", volume 5.

Among various agricultural products, special emphasis must be placed on dates which are important partly because of the significant role they

play in Omani society. Unfortunately, they are less profitable than many other crops. Speaking economically, the cropped area for date palms should be converted to other, more profitable crops. In this Master Plan, however, the proposed area for date palm cultivation is estimated as being the same as at present on the assumption that the area converted from date palms to more profitable crops will be balanced by the area newly cultivated for date palms.

### (3) Structural policy

Structural policy includes the most difficult issues in formulating the agricultural development plan for Oman. In particular, the small-scale farmer, who cultivates less than 1 hectare, presents problems. According to the agriculture census conducted in 1978-79, small farmers made up about 70% of the entire population of farm families, and therefore, their social impact was considerable. On the other hand, their total farm land was only 20% of the entire cultivated area in the country. Therefore, their contribution to agricultural production was generally small. More than 3,000 new farms are estimated to have been established since 1970. Considering this fact, it is still believed that small farmers comprise 60 to 70% of the farm families, and only 15% of the entire cultivated land. Small farmers generally employ a cropping pattern which consists primarily of date palm cultivation.

As is discussed in section 4.2, volume 5, the commercial farms and the new farms, the management scale of which is large and medium-size, respectively, are expected to increase productivity significantly. A small-scale farmer may increase productivity, but still be unable to live on the profits from agriculture alone.

Provided that these conditions remain the same in the future, the increasing income disparity between agriculture and other industries or even between different scale farmers may cause social problems. Stability in rural society is imperative for balanced prosperity of the nation; therefore, income generation for the small-scale farmer will be an essential subject in the future. The following can be considered the major generators of increased income for small-scale farmers:

- (a) creation of employment opportunities in part-time and non-agriculture-based industries,
- (b) expansion of farm management scale, and
- (c) promotion of agriculture-based livestock management.

The following measures can be further considered, particularly for (a):

- (i) to reinforce rural industries such as agro-industry,
- (ii) to create employment opportunities in other industrial sectors in urban areas, and
- (iii) to secure employment opportunities in the government-related organizations.

Under these conditions, however, small farmers may only maintain their present situation. The agricultural policy may only be able to make a limited contribution to improvements.

With respect to (b), scale expansion does not mean a real expansion but expansion of management scale through procurement, by lease or purchase, of existing farmland.

As can be seen by the development of secondary and tertiary industries, the younger generation tends to drift towards urban areas. Accordingly, the aging of farmers, as well as the absence of successors may be anticipated on some farms in the near future. Such farmland should be freely circulated to expand management scale and to increase the number of full-time farmers. This aims to transform small-scale management into medium-scale management. It means that the number of small farmers will decrease as the management scale is expanded. Accordingly, the employment in other industries should be available, e.g., if the management scale of each farm increases to two times the present scale, then employment opportunities for about 23,000 farmers must be found in other industries.

Agriculture-based livestock management (c), has prevailed for a long time in Oman, and is readily accepted by the farmers. However, as is discussed in volume 5, section 4.2, livestock management should also be improved in connection with the expansion of the management scale.

This measure (c) is the intermediate measure of measures (a) and (b). Marked emphasis is placed on it in this Master Plan while also, of course, considering (a) and (b).

#### (4) Price policy

The price policy should cover only the temporary declination of the farmer's income, which sometimes occurs as a result of excess production. According to the 1988 price data for imported & exported agricultural products, and for domestic products, a price sustenance policy is not needed for most crops. However, since the data are not adequate to propose a final conclusion, such information should first be collected and processed. Accordingly, the price policy should be examined from time to time, according to the price in question under a distribution policy which proposes to institute a policy by which the price is determined on the basis of free market principles.

#### (5) Distribution policy

The distribution policy should be formulated so as to guarantee benefits for both producers and consumers, considering the relationship between PAMAP and the commercial trader who supplement each other's role in the distribution process. For this purpose, a wholesale market should be established to determine the fairest price, based on supply and demand of agricultural products. In addition, the collection and distribution system (particularly at the terminal end) should be improved for smoother delivery to the wholesale market. Furthermore, the improvement of the distribution management techniques in PAMAP is imperative to reduce the losses incurred in the distribution process.

(6) Subsidy policy

Agricultural input materials (fertilizer, seed insecticide, etc.) are subsidized under the present subsidy policy, in order to maintain a suitable production cost. Since in Oman the producer's price is apt to be determined on the initiative of the wholesaler, the subsidy system should be continued in order to ensure the farmer's profit. On the other hand, in order to strengthen the producer's situation and to influence price decisions, it is strongly recommended that a farmer's association be organized and wholesale markets instituted. Furthermore, which crops are to be subsidized should be determined under a policy referring to the forecast for supply and demand.

Consequently, the present Master Plan is to be formulated in a manner that integrates these policies. Its accompanying measures should be implemented cooperatively, so as to bring about the best results.

The details of each policy are discussed in chapter 4.

*CHAPTER 4*

*DEVELOPMENT TARGET AND STRATEGY*

*BY SECTOR*





## CHAPTER 4 DEVELOPMENT TARGET AND STRATEGY BY SECTOR

### 4.1 Water Resources and Irrigation

#### 4.1.1 Development Target

Traditional irrigation facilities in Oman consist of the well organized aflaj and the hand-dug wells, which in former times were operated by man or animal power. The volume of groundwater resources utilized in such a manner never exceeded the recharging capacity of the groundwater. However, because of the recent excessive use of diesel pumps, there is an unbalanced relationship between the groundwater recharging capacity and water use in some major agricultural areas such as the Batinah coast.

The major water resource in the country is groundwater, which is a most precious resource not only for agricultural production but also for domestic use, as well as for the promotion of industries other than agriculture. Because it is important to the entire nation, groundwater development is of high priority, as well as conservation of water resources as prescribed by Royal Decree in 1988.

Since it is estimated that 90% of the water used in this country is for irrigation, appropriate development and use of irrigation water will affect the entire policy for water resources.

Based on the situation described above, the following targets for the water resources and irrigation sector are set under the Master Plan to improve the economic profitability of agricultural production and increase agricultural productivity through the efficient and effective use of water resources.

- 1) Ensure water resources for a stable agricultural water supply
- 2) Introduce modern irrigation methods to increase agricultural productivity and the efficient use of water resources

- 3) Maintain aflaj for the conservation of the traditional agricultural society
- 4) Control floods to protect agricultural land
- 5) Conduct investigations and observations for the efficient implementation of projects.

#### 4.1.2 Development Strategy

##### (1) Basic Concept of Development Strategy

The basic development strategy under the Master Plan assumes that project formations under previous Five-year Development Plans are essentially sound, and are to be incorporated into the Master Plan with minimal modification. However, projects will be integrated to reinforce development effect. For new projects as well, including those proposed by the JICA team and others expected to emerge in the course of the 10-year Master Plan, it is recommended that they be thoroughly studied and integrated when appropriate into the existing body of projects formulated under the Master Plan study.

Under the Master Plan, development strategies are classified into short-, medium- and long-term depending on the time period required to achieve project effect, and attention is paid to development effect which contributes to improving agricultural productivity and maintaining rural society. Balanced allocation of projects is important to address disparities between regions in level of development.

##### (2) Development Strategy

Stage-wise development of water resources for agriculture can be categorized as follows according to the period for realizing development benefits:

- short-term strategy:

legal restriction on water use and new agricultural development

- medium-term strategy:  
construction of recharge dams and underground dams
  
- long-term strategy:  
water-saving irrigation

On the other hand, there are special features in water use which affect agricultural production and social life in each region. For instance:

- Batinah coast:  
Irrigation by well-water
  
- Dakhaliya and southern Batinah Plain near the mountains:  
Society structured around traditional aflaj
  
- Salalah Plain under monsoon climate:  
Irrigation by well and spring water

Such regional features are considered in the development strategy proposed below. On the whole, new irrigation projects to conserve irrigation water and recharge dam schemes to replenish groundwater will be given relatively high priority although the other projects are considered important as well. A combination of such projects will also be emphasized so as to provide a comprehensive effect.

- (a) New agricultural development program and legal restriction on water use

Agricultural development projects are to be implemented in areas where the development potential of new water resources has already been confirmed; about 500 ha in Nejd and other regions. The agricultural development plan in promising water-resources development areas is to be formulated and prepared based on results from the on-going nation-wide soil survey and water resources survey

conducted by FAO and MWR, respectively. If the soil survey is completed prior to the water resources survey, priority for the water resources survey to be conducted by MWR should be in areas that were deemed suitable by the soil survey. It is necessary for MAF and MWR to maintain close dialogue to ensure the smooth implementation of water resources survey.

Legal restrictions on water use are being studied by MWR and the practical irrigation method is being examined by MAF. The establishment of appropriate measures for legal restrictions suitable to the actual conditions of Oman is urgently required, not only for water resources policy but for agricultural policy as well. In the initial stage in particular, it will be necessary to study temporary legal restrictions to be applied to areas where urgent countermeasures are required, like the Batinah coast.

(b) Construction of recharge dams

As a major medium-term strategy for increasing agricultural production and groundwater resources, the construction of recharge dams is to be implemented under the 10-year Agricultural Development Plan. Many previously conducted studies were closely examined in planning the existing recharge dams. More extensive studies will be required for the future in formulating the plan so as to better reflect beneficiary demands, and to select the best construction methods for the natural conditions at the proposed sites.

The construction of a recharge dam requires the largest budgetary allocation of any single project implemented by MAF, and affects the project area in various direct and indirect ways. Therefore, concentration of similar projects within a specific region should be avoided from the viewpoint of a well balanced promotion of rural area development. In planning the allocation of projects, particular attention must be paid to the population in the region, potential agricultural productivity and urgency, focusing on the alleviation of regional disparities in development. Recharge dam projects are proposed in all regions under the full Master Plan,

which targets the construction of 42 recharge dams. Expected new land using additional recharged water is estimated at more than 1,850 ha based on the results of the preliminary and feasibility studies conducted by MAF.

Following the completion of recharge dams, their appropriate operation and maintenance are required. A certain volume of sediment is deposited upstream during every flood. Proper gate operation of discharge culverts is necessary to facilitate water recharge downstream of the dams. Accordingly, operation and maintenance programs in close connection with construction are indispensable for the recharge dams.

Generally, irrigation projects which utilize recharged water must be implemented in conjunction with the construction of recharge dams. One of the main objectives of the construction of a recharge dam is to supply necessary water for agricultural development. Therefore, the benefits of the recharge dam may not be realized unless the irrigation system has been developed. The promotion of irrigation projects is discussed in item (d).

(c) Construction of underground dams

While the recharge dams aim to increase agricultural production and groundwater resources by means of recharging, the underground dams achieve the same by means of restriction of the discharge. Therefore, the combination of both, in addition to the rationalization of irrigation water management, can be regarded as the most ideal way to improve agricultural production and preserve groundwater resources. In Oman, recharge dams have already been completed and are functioning. Studies on the rationalization of the irrigation methods have also been done although feasibility studies for underground dams have not yet been conducted in detail. The underground dam is regarded as a significantly promising measure for increasing agricultural production and the groundwater resources and may be more effective than the recharge dam if aided by site conditions such as geological structure.

The area for the construction of the underground dam, however, is not only limited by geological conditions but also requires a longer period of investigation before the commencement of construction. Therefore, a pilot project should be proposed for a site selection study to evaluate the technical viability of construction and for an economic feasibility study. Such a pilot project should be proposed on a small scale for the coastal line like the Batinah coast and the basin between Muscat and Sur or the inland area in a wadi.

(d) Introduction of modern irrigation facilities

While the measures discussed from (a) to (c) above can be executed under MAF initiative, the introduction of modern irrigation facilities largely depends on farmers' consensus and cooperation. It takes a long time for farmers to accustom themselves to such new facilities and for them to realize the water-saving effects, even though such effects have the greatest impact on farming. On the other hand, with respect to the aflaj, it may be difficult to introduce these new facilities unless the existing water distribution system is improved.

Accordingly, the introduction of modern irrigation facilities is proposed for areas where the major water sources are wells, such as the Batinah coast, for gradual implementation. The target area to be developed in such a manner, over 10 years, is about 30,000 ha. If modern irrigation systems are introduced into 30,000 ha and 20 or 40 percent of the present total water consumption is saved, irrigation water equivalent to a total amount of water to be consumed in 7,500 ha or 20,000 ha with modern irrigation facilities will be conserved. Part of the conserved water would be kept for the replenishment of groundwater-balance deficit and the rest would be utilized for agricultural development.

The investment cost for this development may be financed by OBAF or it may be subsidized by the government. According to the results

of the economic survey of the model farm (see section 4.2 in volume 5), the large- and medium-scale farmers who mainly cultivate vegetables and who are expected to increase their agricultural production, will be able to repay the loan to OBAF, while the government subsidy shall be extended to those farmers who, on a small scale, mainly cultivate date palms and who are unable to repay the loan with agricultural income. Although these two financial arrangements are ultimately determined by government policy, the JICA team proposes that a portion of the facilities, cost be subsidized by the government and the remaining investment cost be financed by the bank in order to provide farmers with incentives for the promotion of modern irrigation schemes. The size of the subsidy will depend on the farm management scale, cultivated crops, etc.

However, the subsidy needs to be provided on condition that the farmer accepts the proposed water management method, which they implement by themselves, with guidance provided by extension workers.

Flow meters would be affixed to irrigation facilities, and farmers would be expected to report the amount of water used to the relevant extension office, which better enable extension officers to provide effective water management guidance. Also, integrated irrigation facilities from the water source to the field would be established to increase irrigation efficiency and conserve water resources.

(e) Maintenance and rehabilitation of aflaj

Aflaj are part of the indispensable infrastructure which maintains rural society in Oman, and must be maintained in good condition. Accordingly, the aflaj maintenance and rehabilitation program shall be continued. On the other hand, lack of labor for maintenance of aflaj is a serious problem. If no steps are taken, the amount of rehabilitation required in order to reduce maintenance cost will increase year by year. Therefore as an initial step, a project aimed at permanent rehabilitation of major aflaj will be launched under the Master Plan. In this report, a pilot survey

should be done to evaluate the possibilities of an enhancement of irrigation efficiency in oases through improvement of the existing distribution systems.

(f) Repair and construction of wells

A constant effort should be made to maintain the hand-dug wells, which, together with the aflaj, are vital facilities for maintaining the rural society of Oman. Accordingly, following the intentions of the Third Five-year Development Plan, the implementation of a well maintenance and rehabilitation project is incorporated into the Master Plan. In the future, the inter-connection of this project with modern irrigation projects should be considered at the implementation stage.

(g) Erosion control and protection of agricultural land against floods

It is important for agriculture and farmer's property to control erosion caused by floods. Construction work for protection against floods is planned for four areas where the necessity for such work was confirmed under the Third Five-year Development Plan. Further surveys and construction work will be implemented within the scope of "the Master Plan for Erosion Control and the Protection of Agricultural Land and Villages against Floods" to be formulated by MAF.

(h) Investigation and Observation

The continuous activities of surveying and observing in order to collect basic data is essential because these provide vital information for planning. Such activities should, therefore, continue in the future, following the Third Five-year Development Plan. Aerial photography and mapping projects, whose results are used for aflaj maintenance and rehabilitation programs, should continue to be implemented step by step now that the first of four stages is completed. However, the survey components need to be strengthened during the second step so as to extend the survey



results to future projects. Such survey components, not only include information on falaj structures, but also information on the irrigated cropping areas, major crops and location of the irrigation facilities with respect to related structures such as wells to supplement the water shortage in aflaj. Of course, effort should be made to use the existing aerial photographs as much as possible so as to minimize the expense of the survey.

Observation of the existing recharge dams is particularly important for evaluation of their effects which provide precious data for the planning of future projects. Records of observations of wells established around the constructed recharge dams have been kept continuously and that should be continued in the future as well, in order to accumulate data for periodical analysis. Moreover, observations are also required for the proposed dams and should be initiated prior to construction. This is important because the comparison of the long-term observation records before and after construction of a recharge dam enables more accurate analysis of its effects.

## 4.2 Agriculture

### 4.2.1 Development Target

#### 4.2.1.1 Overall Target

Currently, with respect to agriculture in Oman, resources such as land, water, etc., are not used to their full potential, and therefore production and economic efficiency are low. In order to achieve the development targets under this Master Plan for Agricultural Development, which are the improvement of the self-sufficiency rate of food, the improvement of agricultural productivity, and the efficient utilization of water resources for the next 10 years, it is necessary to utilize the full potential of production. This can be done by improving the technology of the farmer, and also by encouraging cooperation among the farmers who perform the actual agricultural production, the research organizations which carry out technical development, and the extension services which are the link between technical development and agricultural production.

In order to achieve the targets of the Master Plan for Agricultural Development, focus should be given to the following;

- (1) Improvement of unit yield and improvement of produce quality.
- (2) Improvement of farmer management methods.
- (3) Control of agricultural production according to demand.

#### 4.2.1.2 Targeted Yield per Unit Area for Major Crops

- (1) Selection of major crops

An overall evaluation of the level of importance of agricultural crops presently cultivated in Oman for promotion of the 10-year Master Plan for Agricultural Development was done after investigating, through assigning grade and weight on the basis of various conditions such as

major production region, production area, total yield, unit yield, unit price, net profit, import or export-ton, PAMAP sales-ton, recommendations by MAF, tolerance to drought, tolerance to salinity, self-sufficiency rate, net profit, benefits per cubic meter water consumption.

The results of evaluation are as indicated in Table 4.2.1. The fifteen most important major crops under the 10-year Master Plan are ranked. These are potatoes, tomatoes, Rhodes grass, citrus fruits such as oranges, grapes, wheat, alfalfa, sweet potatoes, chilli peppers, carrots, date palms, watermelons, sweet-melons, cucumbers and mangoes. Furthermore, though the ranking in the grading table is lower than the major crops mentioned above, some crops necessary for making farming improvement models in different regions, have been ranked as sub-main crops. The sub-main crops have characteristics as indicated below. Bananas, coconuts and papayas are extensively cultivated, particularly in the Salalah Region, and these have outstanding merits of resisting drought and salinity, and excellent profitability. Barley, sorghum and onions are mostly cultivated in the Interior Region, they have either low self-sufficiency rates or excellent profitability. Also eggplants, cabbage and okra are extensively cultivated, particularly in the Batinah Region. These crops are characterized by either a low self-sufficiency rate, or the fact that since the cultivation is easy and production can be realized in a short period of time, they are cultivated by many farmers.

## (2) Targeted Yield per Unit Area

The present yield per unit area for Oman is at a low level and there is considerable scope for improvement in the future. After considering the present yield per unit area in Oman and other countries and the scope of technological improvements, the target yields to be achieved by the end of the 10-year Master Plan for Agricultural Development have been determined (Table 4.2.2).

According to data collected (Annual Updates of Important Statistical Series of the Department of Agricultural Statistics of MAF), the present yield per hectare (ton/ha) is as indicated in Table 4.2.2. Based on the results of investigations conducted by the JICA team and other concerned

Table 4.2.1 Selection Criteria and Prioritization of the Major Crops Proposed in the Master Plan for the Agricultural Development in the Sultanate of Oman

Crop	Major production region		Production		Price RO/ton	Net profit RO/ha	Import or Export ton (1988)	PAMAP Sales ton (1988)	Benefits per cubic meter of water (RO)	Recommendation by ministry	Tolerance		Self-sufficiency rate (%)	Total	Order
	Ba	In	Area ha	Product 1,000 ton							Unit yield ton/ha	Drought			
Dates	⊙	⊙	5	4	2	0	4	0	1	1	5	5	0	41	11
Mango	⊙	⊙	3	2	1	0	3	1	3	1	3	1	(3)	40	15
Citrus(Lime)	⊙	⊙	3	3	2	0	4	3	2	1	3	1	0~(5)	32-47	4-26
Banana	⊙	⊙	2	3	2	2	3	5	2	1	1	1	1	36	19
Coconut	⊙	⊙	1	2	2	2	2	1	2	1	5	5	1	35	21
Papaya	⊙	⊙	1	1	2	3	2	2	(3)	1	1	1	1	31	29
Pomegranate	⊙	⊙	(0)	(0)	(2)	0	(1)	(0)	(2)	1	3	3	(3)	27	31
Guava	⊙	⊙	(0)	(0)	2	0	1	(0)	(2)	1	3	3	(3)	26	32
Grape	⊙	⊙	1	0	2	4	4	(0)	2	1	3	3	5	47	5
Wheat	⊙	⊙	2	0	1	0	5	0	(1)	5	3	1	5	46	6
Barley	⊙	⊙	1	0	1	0	5	0	(1)	1	3	1	5	35	22
Rhodes grass	⊙	⊙	(1)	(3)	4	3	(1)	0	(4)	5	5	5	(1)	48	3
Alfalfa	⊙	⊙	4	5	3	3	(1)	0	(4)	1	3	1	(1)	44	7
Sorghum	⊙	⊙	2	1	4	3	(2)	0	(3)	1	4	1	(1)	35	23
Tobacco	⊙	⊙	1	1	2	5	1	0	(5)	-5	3	1	2	32	27
Frankincense	⊙	⊙	(0)	(0)	(0)	?	(0)	0	(5)	3	5	1	(0)	12	33
Tomato	⊙	⊙	2	3	3	4	5	4	4	1	1	1	2	49	2
Chili pepper	⊙	⊙	2	2	2	3	1	2	(4)	1	1	1	1	43	9
Eggplant	⊙	⊙	1	2	3	0	(2)	3	3	1	1	1	(3)	32	28
Potato	⊙	⊙	1	2	3	4	5	3	1	5	1	1	4	51	1
Onion	⊙	⊙	2	2	2	0	4	2	2	1	1	1	3	34	24
Garlic	⊙	⊙	1	1	2	5	1	1	3	1	1	1	2	38	17
Watermelon	⊙	⊙	2	3	3	3	4	4	3	1	1	1	1	41	12
Sweet-melon	⊙	⊙	2	2	2	4	4	3	3	1	1	1	1	41	13
Cucumber	⊙	⊙	2	2	2	4	2	2	5	1	1	1	1	41	14
Squash	⊙	⊙	1	1	2	3	2	2	3	1	1	1	(3)	37	18
Kaiflower	⊙	⊙	1	1	2	0	3	1	2	1	1	1	(3)	29	30
Cabbage	⊙	⊙	2	3	3	2	3	3	3	1	1	1	1	36	20
Lettuce	⊙	⊙	0	(1)	3	4	1	2	4	1	1	1	(3)	39	16
Carrot	⊙	⊙	1	2	3	5	2	1	3	1	1	1	(3)	42	10
Okra	⊙	⊙	0	1	2	4	(2)	(1)	2	1	1	1	(3)	34	25
Sweet potato	⊙	⊙	1	1	3	4	(1)	2	(4)	1	5	3	(2)	44	8
Note	5	>	10000	20000	1000	3000	8000	3000	2000	Strong	Strong	Strong	< 20		
Ba : Batinah	4	>	5000	5000	500	1500	4000	1500	1000	Medium	Medium	Medium	< 40		
In : Interior	3	>	1700	1250	170	500	1333	500	0.333	Medium	Medium	Medium	< 60		
So : Southern	2	>	430	313	43	125	333	125	0.083	Weak	Weak	Weak	< 80		
Weight	1	~ 3	86	0.78	0.8	25	67	25	0.017	Weak	Weak	Weak	< 100		

Notes: 1. Figures in parenthesis ( ) were estimated by the JICA Study Team.  
 Figures in parenthesis [ ] were obtained from the figures shown in the "Others" column in the Statistics table.

2. Weight: Each factor can be evaluated from all aspects and from 1 to 3 in order of importance.

Table 4.2.2 Determination of Target Yield of Major Crops  
in the Master Plan for Agricultural Development

CROP	Actual unit yield (ton/ha)											Possibility of improvement %	Target unit yield ton/ha
	Oman			Middle East	Israel	Zimba-bwe	Austria	USA	Japan				
	1)	2)	3)	4)(15)	6)	7)	8)	9)	10)	11)			
Date palm	4.1											50	6.0 46
Mango	2.0											50	3.2 60
Lime	10.8											50	15 39
Lemon	15.0								18			50	22 47
Sweet lime	11.0									30-40		50	16 45
Orange	11.0								23			50	16 45
Banana	13.6								6	40-50		50	20 47
Coconut	16.8											50	25 49
Papaya	12.0								10			65	19 58
Grape	15.0			11(15)	15		5.5	15	12			50	19 27
Wheat	1.5			2.4(4.7)	3.1	5.8	4.5	2.5	3.2	2.4-5.5		60	2.4 60
Barley	1.9			2.7	1.4	5.8	4.0	2.8	3.2	2.5-6.0		60	3.0 58
Rhodes grass	57.6 <sup>14)</sup>											40	120 <sup>15)</sup> 33
Alfalfa	38.4 <sup>14)</sup>											90	72 <sup>15)</sup> 20
Sorghum	53.3 <sup>14)</sup>											65	125 <sup>15)</sup> 50
Tomato	22.2	24	48	43	51		28	53	52	50-130		80	40 80
Chill pepper	9.0			17	39		20	12	36	15-25		80	16 78
Eggplant	19.0				33			22	31	30-150		80	32 68
Potato	25.0			20	38	16	26	34	29	30-40		70	30 20
Onion	13.7			18(51)	23	17	35	41	43	40-75		65	18 31
Garlic	8.0			41	13			15		15-20		70	14 75
Watermelon	19.0	22	31	26	16			15	32	30-60		75	26 37
Sweet melon	13.1	16	28	24(57)					19	20-40		80	23 76
Cucumber	14.9			29(121)	29		26	13	43	40-150		70	25 68
Squash	15.8								17	25-40		70	25 58
Cabbage	23.2			31	23		45	20	40	40-80		75	35 51
Lettuce	17.0									26-49		60	20 18
Carrot	23.8			26	49		31	31	27	25-40		65	30 26
Okra	13.2									20-50		80	22 67
Sweet potato	23.8			25	39	24	13	15	23	30-40		40	25 5

Notes:

- 1) These values were obtained in 1989 from "the Annual Update of Important Statistical Series" which has been carried out by the DAS in MAF since 1982.
- 2) Oman Modern Farm. 3) AL Raja Farm.
- 4) The second highest yield from 1985 to 1987 in such countries as Egypt, Iran, Iraq, Jordan, Kuwait, Qatar, Saudi Arabia and UAE (FAO production year book 1987)
- 5) The highest value among those mentioned above.
- 6) - 10) FAO Production year book 1987.
- 11) Horticultural encyclopedia, Okinawa horticultural encyclopedia, Handbook for facilities horticultural.
- 12) Percentage estimated by JICA Study Team under the condition that growing elements are improved.
- 13) Target yield in the year 2000 and its percentage improved from the current yield.

14) Semi-dried Weight

15) Fresh-matter Weight

documents, it is estimated that the figures are slightly on the higher side for sweet potatoes, lettuce, potatoes, carrots, grapes and onions, while for the rest, the figures are estimated to be rather low for alfalfa. Nevertheless, taking into account the fact that MAF has conducted the investigation for the entire country based on the above mentioned annual program through extension organizations and the number of samples are large, these data are considered to be the most reliable available under the present circumstances. As such they have been used as basic figures. However, because actual unit yields for Rhodes grass and sorghum are indicated as weight in semi-dried matter, their data for selling price should be adjusted when they are applied for fresh matter.

The same table also indicates (a) the present yield per unit area of the Oman Modern Farm and Al Raja Farm, which are commercial farms in Oman, (b) the yield per unit area of Middle East countries included in GCC, Israel, Zimbabwe, Austria, USA and Japan as indicated in the Production Yearbook (1987) of FAO, and (c) the maximum level of yield per unit area or standard yield in main production regions of Japan indicated in professional horticultural handbooks.

The reasons for varying yield per unit area according to the producer or producing country may be attributed to environmental (natural) location and techniques. Since man-made improvements are possible in the latter, the improvement rate for unit yield (%) to be achieved by the end of the 10-year Master Plan for Agricultural Development has been estimated on the basis of the anticipated improvement under each technological item.

In addition to the above, the target yields under the 10-year Master Plan for Agricultural Development have been determined after considering various ways to improve the present yield per unit area ranging from 5 % to 80 % depending on the crop.

#### 4.2.2 Development Strategy

In order to achieve these targets, it is necessary for each farmer to acquire a high level of cultivation and farm management technology. This

should include not only a high level of knowledge, backed by scientific data, but also a thinking ability based on fundamental education, as well as good judgment acquired from previous experience in production. This synthesis will enable agricultural management at a high level of productivity and profit. For this synthesis, it is necessary for the agricultural research organizations to develop appropriate technologies, to be integrated through the close collaboration of research organizations and extension services, and ultimately passed on to the farmer through education and extension programs.

Based on this, the strategies for development are as follows:

- (1) Increase in unit yield and quality improvement.
  - (a) Introduction of suitable crops on a regional basis.
  - (b) Introduction, selection, breeding and extension of superior varieties.
  - (c) Improvement of cropping technology, including irrigation, fertilizer use, pest control, etc., and extension of same.
- (2) Improvement of Farm Management.
  - (a) Introduction of optimum cropping pattern and farm-management model.
  - (b) Implementation of farm-management research.
  - (c) Appropriate level of farm mechanization to reduce farm-labor requirement.
- (3) Establishment of an agricultural production structure well suited to demand requirements.
  - (a) Selection and introduction of crops most responsive to demand.
  - (b) Establishment and extension of optimum cropping pattern and cropping technology.
  - (c) Timely dissemination of pertinent information to farmers.

In order to implement the above strategy, a well-emphasized farmer education program is essential. Such a program would stress farmer

independence, and function to stimulate enthusiasm in agriculture at the farmer level.

Strengthening of the agricultural research and extension structure would be the basis for implementation of farmer education. In order to achieve this, training of adequate numbers of research and extension staff will be necessary. The government will also need to actively support the activities of such personnel through the establishment of required facilities and provision of necessary equipment.

In addressing the issue of farmer education, attention must be given to the fact that the gap between current levels of farmer technology and that required to achieve targets under the Master Plan is large. Consequently, it will be necessary to carefully prepare an effective extension program relying on the latest extension methods such as audio-visual technology for presentation.

#### 4.2.2.1 Cultivation

To achieve expansion in production to meet the targets of agricultural development, plans are necessary for expansion of production quantity mainly in the already existing cultivated areas.

The improvement of the following should be considered in order to achieve a higher unit yield.

- (1) Selection of kinds of crops.
- (2) Variety selection.
- (3) Investigation of ploughing and land preparation methods.
- (4) Improvement of cropping systems.
- (5) Dispersion of cropping season.
- (6) Improvement in cultivation methods.
- (7) Improvement of methods for control of crop pests.
- (8) Development of new cultivation methods.
- (9) Introduction of modern irrigation methods.



The details regarding the above are described in volume 5, chapter 4 "Improvement Plan for Cultivation and Farming".

#### 4.2.2.2 Farming

There are more than 83,000 farms in Oman. The national average farming scale is low at about 1 ha; although it is rather bigger in the region along the Batinah coast (approximately 1.6 ha), but much smaller in the Salalah Region.

In the first phase, the study team selected representative examples totaling eight new farms, four traditional farms, and one commercial farm from the five main agricultural regions, and studied current conditions of agriculture in Oman.

In order to estimate a realistic farming index at the end of the 10-year Agricultural Development Plan, the knowledge and information gained from this study and results of analysis of the information available before the study were used to draw up farming improvement models, which were then utilized to estimate projected farmers' income.

Details of the above are described in volume 5, chapter 4 "Improvement Plan for Cultivation and Farming". Outlines of them are as follows:

##### (1) Formation of farming improvement models

Improved present farming models were first formulated on the assumption of the introduction of modern irrigation methods, major crops, and slight modifications of the ratio of area under cultivation between the different crops. Taking into account potential for technological improvement in the future, final farming improvement models were worked out on the basis of the improved present models.

Technical improvements introduced for the improved models are as follows:

Improvement of crop selection, introduction of superior varieties and modern irrigation methods, improvement of cropping patterns, fertilization improvement, and more effective pest control.

Expected production increase through these improvements is shown in table 4.2.3.

Farming improvement models were formulated as follows: three types of new farms in Batinah, the Interior and Salalah Regions, two types of traditional farms in northern Oman and the Salalah Region, and, in addition, two combined crop production and livestock improvement models were formulated for new farms and traditional farms, respectively. Parts of these models are explained below.

(a) Farming improvement models for new farms

(i) Farming improvement model for new farms in Batinah Region

Preconditions for Farming Improvement Model in Batinah Region

Target area	South and North Batinah
Farming scale	4.2 ha, total annual cultivation area: 4.9 ha (land utilization rate of 119.5%)
Cropping pattern	Multiple farming; vegetables as a main crop, combined feed crops and fruit trees. 4 vegetables and 3 feed crops grown in rotation.
Labor capacity	Basic labor capacity: 3 workers. Machines are owned by individuals, or extension center machinery is used.
Main technology, others	Improving cropping area rates: making best use of advantages of site conditions like being close to large markets, increase of cultivation of sweet

Table 4.2.3 Technology Improvement Methods and Expected Production Increases in Farming Improvement Models

Parameter	Technological Improvement Methods	Expected production increase
Improvement of crop selection and ratio of area under cultivation between crops	Following the govt's agriculture policy selecting comparatively profitable crops, and increasing their proportion of area under cultivation	At least several % (there are examples of improvements from about -300RO to about 500 RO on 0.5 ha)
Introduction of superior varieties	Introduction of good quality varieties that can be easily cultivated for high yield and to promote replacement of low yield varieties	several %
Introduction of modern irrigation methods	Fruit trees: bubbler method; semiperennial feed crops: sprinkler method. veget. and field crops: drip method. The fertilizer is dissolved in the irrigation water for application	several %
Improvement of cropping pattern	New farms: improving annual cropping rates. Traditional farms: in addition to the above, introducing as much inter-cropping and mixed cropping as possible	13% on traditional farms to 19% on new farms in Northern Oman  several %
Introduction of crop rotation system	The same family of crop is to be cultivated more than two years apart on the same land.	Avoiding increase of pest and soil exhaustion.
Fertilization improvement	Complete compliance with fertilization standards prepared by MAF. The current fertilization rate is 50% or less and it should be increased 100%	Depending on the kind of crops, about 30% increase in yield can be expected for feed crops, field crops and vegetables.
Thorough pest control	Appropriate selection and application of agricultural chemicals and increase of expenditure on chemicals by 50%	The reduction of income and the quality deterioration rates will be improved, at least several percent.
Increasing of unit yield (ton/ha.)	To target overall increases in income from the above improvements in technology	See Table 4.2.2

melons, other vegetables, and Rhodes grass, which yield good income. Reduce date palms, and introduce grapes which bring better profit.

(ii) Farming improvement model for new farms in Salalah Region

Preconditions for Farming Improvement Model for New Farms in Salalah Region

Target area	Salalah Plain in Southern Region
Farming scale	2.0 ha; total cultivation area: 3.10 ha (land utilization rate of 155%)
Cropping pattern	Fruit trees, feed crops and vegetables in well-balanced combined cultivation. For all crops, other than fruit trees, cultivated in rotation.
Labor capacity	Basic labor capacity: 2 workers, extension center machinery is used.
Main technology, others	In improving cropping area rates, deficiencies in feed result because of the large number of livestock. Therefore, the proportion of land being cultivated for feed crops should be increased. The number of fruit trees should be decreased somewhat to make more room for growing relatively profitable vegetables. The planting period for vegetables should be adjusted to allow for transporting to conform to the lean time between harvests in northern Oman. Good use could be made of the comparatively mild climate in this region to establish a system of rotating crop cultivation combining vegetables and feed crops, with cultivation continuing throughout the year, and not allowing the land to lie fallow. Inter-cropping and mixed cropping can be done in the orchards to maximize land surface

utilization.

(b) Farming improvement models of traditional farms

(i) Farming improvement model for traditional farms in northern Oman

Preconditions for Farming Improvement Model for Traditional Farms in Batinah Region

Target area	Northern Oman (including the Batinah, the Interior, the Dhahira, and the Sharqiya Regions)
Farming scale	0.5ha, total annual cultivation area: 0.57 ha (land utilization rate of 114%)
Cropping pattern	Mainly fruit trees combined with feed crops and vegetables; all crops other than fruit trees are cultivated in rotation.
Labor capacity	Basic labor capacity: 1 worker. Extension center machinery is used for ploughing. Pest control is accomplished with manually operated sprayer.
Main technology, others	Improving cropping area rates. The land devoted to cultivation of date palms should be slightly reduced to allow for introduction of highly profitable grapes. The proportion of land devoted to vegetables in the Batinah Region, and for field crops in the Interior Region, should be increased. Land time and space utilization rates should also be increased. Inter-cropping and mixed cropping should also be conducted within the orchards.

(ii) Farming improvement model of traditional farms in the Salalah Region

Preconditions for Farming Improvement Model for Traditional Farms in Salalah Region

Target area	Salalah Plain in Southern Region
Farming scale	0.5 ha; total cultivation area: 0.68 ha (land utilization rate of 137%)
Cropping pattern	Mainly fruit trees combined with feed crops and vegetables, all crops other than fruit trees cultivated in rotation.
Labor capacity	Basic labor capacity: 1 worker. The extension center machinery is used for ploughing. Pest control is done with manually operated sprayers.
Main technology, others	Improving cropping area rates: The land devoted to the cultivation of bananas should be slightly reduced, and highly profitable grapes should be introduced. Many head of livestock should be kept, and because they cause a deficiency in feed, profitable Rhodes grass should be introduced. Coconuts, bananas and papayas should be planted separately and mixed to increase land utilization. Vegetables and field crops should be inter-cropped inside the grape orchard, which should also increase land utilization. The cropping period for vegetables needs to be adjusted to enable shipment in the lean time between harvests in northern Oman. The comparatively mild climatic conditions need to be taken advantage of to develop a cropping pattern and rotation system of vegetables and field crops for continuous cultivation throughout the year without allowing the land to lie fallow.

(2) Estimate of farm profit for farming improvement models

The Annual Updates of Important Statistics Series from the Department

of Agriculture and Statistics of MAF contains data such as yields, selling prices and production costs per hectare (not including depreciation costs on initial investment and machines, etc.).

These data are used for estimating present farming profits. As for the farming improvement model, it was estimated by using expected yields and present selling prices. Costs for new irrigation, seed, fertilizers and pesticides were included in production costs.

(a) Estimate of farm profits for new farms

(i) Batinah Region

Present farming profit:	R.O.	2,700
Improved present farming profit:	R.O.	5,300
Improved model farming profit:	R.O.	10,800
(2000)	(livestock combined model, breeding goats 40 head, R.O.	11,300 )

(ii) Salalah Region

Present farming profit:	R.O.	1,300
Improved present farming profit:	R.O.	3,300
Improved model farming profit:	R.O.	6,600
(2000)		

(b) Estimate of farm profits for traditional farms

(i) Northern Oman

Present farming profit:	R.O.	- 230
Improved present farming profit:	R.O.	280
Improved mode farming profit:	R.O.	650
(2000)	(livestock combined model, breeding goats 8 head and egg-laying chickens 750, R.O.	2,600 )

(ii) Salalah Region

Present farming profit:	R.O.	460
Improved present farming profit:	R.O.	680
Improved model farming profit:	R.O.	1,240

(2000)

(3) Farming scale

Results of the estimation indicate that new farms are profitable, however, traditional farms cannot support themselves on agricultural income alone. Assuming that one family's annual living cost is about R.O. 2,500, and they earn their living by agricultural income only, an increase in their farming land to 2.0 ha is needed in northern Oman, and an increase to 1.0 ha is needed in the Salalah Region.



#### 4.2.2.3 Agricultural Research

##### (1) Research Targets

Agricultural research, like agricultural extension, is one of the most important factors to improve agricultural productivity. Agricultural research will be heavily counted on to solve many of the technological difficulties facing Omani agriculture. It is consequently one of the most important issues under this agricultural development plan.

Agricultural research is carried out with the aim to develop appropriate farm technology ultimately applicable in the field. In order to effectively achieve this, research targets and subjects must be carefully formulated on the basis of accurate information about needs and requirements at the farmer level.

Consequently the challenge confronting agricultural research in Oman at present is to conduct research pertinent to each individual region, and establish a mechanism whereby developed results are promptly reflected in agricultural policy and technical guidance at the farmer level.

Since often long periods of time elapse from the commencement of research to the actual attainment of tangible results, the inherently long-term targets must dovetail smoothly with long term government agricultural policy.

In this regard, the agricultural research targets must be determined on the basis of a consensus between all of the parties concerned. This includes not only the actual staff at the agricultural research institutions, but also concerned officials in the formulation of government agricultural policy, academics involved in basic research at Sultan Qaboos University, representatives of extension workers in the field, etc.

Currently, a study on a "Framework for Research" is being carried out at the Rumais Agricultural Research Center towards the establishment of agricultural research targets for the coming 10-year period, and it is

anticipated that this will help set an effective orientation for long-term agricultural research proposed under the 10-year Master Plan.

In order to maximize the benefits to be obtained from long-term research and realize the greatest return on investment, continuity of research efforts should be emphasized, and modifications to research targets and subjects should only be made where absolutely necessary.

On the basis of study findings, the JICA team proposed the following research targets:

- (a) Integrated improvement of agricultural production.
  - (i) Region-wise introduction and selection of appropriate crops.
  - (ii) Region-wise introduction, selection and breeding of superior varieties.
  - (iii) Establishment of stable high yield, high quality crop production techniques responsive to demand requirements (cropping season, fertilizer application method, etc.).
  - (iv) Establishment of an integrated program for pest and weed control.
  - (v) Mechanized farming technology.
  
- (b) Conservation and effective use of water resources.
  - (i) Development and improvement of irrigation techniques.
  - (ii) Development of irrigation techniques using brackish water.
  
- (c) Development of arid farming technology.
  - (i) Study on salinization problem and salt tolerant crops and varieties.
  - (ii) Study on cultivation techniques for the high temperature, summer season.
  
- (d) Agricultural economic research towards maximized reduction of production cost and increased farm profit.

- (e) Research on regionally specialized agricultural products (honey, perfume, etc.).
- (f) Study on afforestation and preservation/promotion of the same for the public good.
  - (i) Selection and preservation of drought-tolerant tree species suitable to Oman's conditions.
  - (ii) Development of afforestation technology.
- (g) Training of agricultural researchers and technical staff.

In addition to the above, it is recommended that research be carried out on date palms concerning the improvement of production quality, replacement of old trees with superior seedlings, processing of main and by-products, etc. Date palms account for 40 % of all cropped area in the Sultanate and are a traditional crop of special importance to the Omani culture. Dates are also important as a caloric source, and may become more valuable in the future.

## (2) Establishment of a Research Structure

### (a) Research Management

#### (i) General

Research management assumes the function of determining operating policy and overseeing the day to day direction of research. In recent years, with the need for highly specialized or region-oriented research, it is assumed that such will be carried out at separate research entities of different responsibility for specific areas of experiment and study, with care taken to avoid the overlapping of efforts. And within each separate research institution, it is essential that an atmosphere be established which allows maximum range to the independence for the creative talents of each researcher while still maintaining the integrity and orientation of an organized

entity.

Management functions include arranging the research structure, hiring and deployment of personnel, procurement of equipment and materials, allocation of funds, supervision of internal affairs at the institution, and other such duties affecting the shaping of the research environment, as well as decisions on research subjects, and collating, publishing and extending findings.

(ii) Monitoring and Evaluation of Research Progress

In monitoring the progress of research, evaluation should be carried out at each stage. Such monitoring and evaluation would serve as a means to ensure accurate, efficient and effective execution of research activities, and would cover the entire research process including creating the specific subject from the farmers' problems warranting research, implementation of the research subject, devising practical technologies to realize findings and their extension.

Evaluation of research progress would be performed at the preliminary, intermediate and final stages.

o Preliminary evaluation

Preliminary evaluation will be made before implementation of the research, and would assess the appropriateness of items as research subjects, and their implementation, from the standpoint of the current technical levels and performance of the institution and the researcher, and also whether the research target is realistic.

Particularly in the case of development research, where the fruits of both basic and applied research must be effectively combined for the development of new technology to increase production, evaluation at the outset, as to whether

goals and the program to attain them are sufficiently specific and realistic, is extremely important.

o Intermediate evaluation

Intermediate evaluation will examine a research program in progress with a view to assessing effectiveness of its implementation and potential problem points. At this stage, steps are formulated to improve, or modify the research program, if necessary.

o Final evaluation

At this stage the outcome of the research activity will be assessed, as will the methodology applied to achieve it.

Evaluation of results should be performed not only from a technical and/or academic point of view but must also reflect the viewpoint of those intended to actually apply and use the technology. The evaluation consensus should thus reflect the assessment of extension workers, farmers and concerned government officials as well.

Such a broad-based evaluation will serve towards improving the efficiency of all aspects of future research activity.

(iii) Evaluation items

(Technical items)

- o Overall technical value (contribution to new knowledge, (development of new or improved methods, etc.)
- o Appropriateness for experimental design (technical feasibility of hypothesis employed and implementation steps, statistical feasibility of the design)

- o Appropriateness of research documents and information used
- o Appropriateness of methodology, equipment and personnel
- o Appropriateness of yearly study implementation plan  
(feasibility of achieving research goal within implementation period)
- o Relation to other research subjects (urgency; contribution to success of other research subjects)
- o Redundancy ( unnecessary overlap with other research)
- o Proportional weight of basic, applied and development research  
(Administrative items)
- o Appropriateness of priority given to research subjects
- o Necessity of the research topic from the standpoint of national policy and technical goals.
- o Cost-benefit evaluation; appropriateness of funding
- o Appropriateness of intended beneficiaries

(iv) Notification and Extension of Research Results

After review of research findings by an evaluation team and/or technical committee (limited not only to experts from within the subject research body, but possibly including as well experts from other institutions), the details of research should be distributed as soon as possible to all concerned parties.

Research results should be compiled at each institution in an annual report or some other periodical form for publication

in order to prevent redundancy of research at other research bodies and to serve as a reference in the formulation of future research planning.

In the case of research results which take the form of practical technologies, the same should be introduced immediately to the governmental personnel concerned and steps taken to pass the technology along to extension agencies through the establishment of training programs, etc.

(b) Securing and nurturing researchers

(i) Securing researchers

At research organizations, while going ahead with research activities, it is necessary to employ available skilled researchers, and also to endeavor to train researchers who will become key researchers in the near future. These activities are part of the the vital aspects of research management. Training and expanding the number of skilled researchers is a very important factor for maintaining and upgrading the level of research at the institution.

In Oman, the first graduating class at Qaboos University will be in 1990. To intensify the activities of research organizations, these graduates should be taken on by the research department of MAF and trained as skilled researchers. These trainees should be instructed in the methods of research planning and implementation by on-the-job training. For the time being, it is recommended that this training should be executed with the support of expatriate experts inside and outside of Oman. Also, in addition to instilling trainees with a high level of professional and academic knowledge covering a wide range of subjects, it is also important for them to have practical experience at the agricultural production site. Trainees should learn that communication with farmers and extension experts will provide the basis for accurate

understanding of the problems facing agriculture in Oman. They will then be prepared to reflect this in their research activities.

In addition, it should also be stressed that where feasible and practical, research staff and trainees should be sent to research institutions, universities, etc., outside Oman for wider exposure to advanced techniques.

(ii) Establishment of Training Centers for Research Staff and Extension Staff

For systematic training of research staff and extension officers, training centers should be established at the Rumais Agricultural Research Center and in the Southern Region. For more information about training centers, see section 4.2.2.4, "Extension Services".

(3) Expansion of Research Facilities

Due to a present shortage in Oman of trained research management staff and research experts, further aggravated by insufficient facilities and equipment, the agricultural research sector in general although achieving some partial success in the development of practical innovations, has not been able to achieve results commensurate with requirements and expectations at the farmer level.

In the case of the Rumais Agricultural Research Center, the main research building has been completed but the annex wing and procurement of research equipment and materials remain to be completed. In the future, it is expected that this institution will continue to carry out broad, basic research which will cover the entire country. In addition to providing the latest, most sophisticated equipment to the center, it will also be necessary to support its activities in the initial stages with expatriate experts.

Only the field workshop has been completed at the Jimmah Agricultural



Research Station. A research building, and research equipment are still required. These should be provided as promptly as possible given the importance of the Interior Region for Omani agriculture, as well as the uniquely wide range of natural conditions the Interior Region encompasses from Jabal to the arid Interior plain.

At the Salalah Agricultural Research Station, the research and administration building and equipment should be urgently strengthened to keep pace with research requirements which have rapidly increased in recent years. Particularly in response to the special nature of the Southern Region, necessary facilities and equipment should be provided for expanded research in coconuts, coffee, bee-keeping, perfumes, etc. as well as irrigation technology.

The Rumais Agricultural Research Center is not capable of completely meeting the research requirements of the Batinah Region important for the fact that the region accounts for over half of Omani agricultural production as well as its weather and soil conditions differing from those in the north and south. Accordingly, the present Sohar Experimental Farm in North Batinah should be upgraded to research station status, particularly with a view to accelerating research in vegetable and fruit cultivation important to the area.

At a future date, establishment of agricultural research stations at Sharqiya and Dhahira, which exhibit unique regional conditions as well would make an effective contribution to improving Omani agricultural technology.

In order to support the above research activities, it will be necessary to also establish training facilities for research and extension personnel.

Establishment of a library and documentation center for collection, compilation and collation of documents relevant to agricultural research is recommended. The library would have a two fold function of (a) pooling information from outside Oman yet relevant to its conditions which would help in avoiding redundancy of research effort inside the country as well

as serve as a database for development of new technologies practical for Oman, and (b) raising the academic standards of and providing intellectual stimulus to research staff. It would be effective to equip the library with a computerized information processing system, connected on-line with databases outside Oman for ready transfer of information.

#### (4) Future Research Subjects

##### (a) Crop-wise Research Subjects

##### (i) Vegetables

Availability of high quality vegetables throughout the year is very important. Also, along with the rise in living standards, the demand for agricultural products will diversify, and in response to that, diversification of vegetable production and development of corresponding cultivation techniques will be necessary. Furthermore, quality-control, which has not been an issue before, will definitely be reflected in the price of products in the future. In particular, quality-control technology for produce export will be necessary. Therefore, research for dispersing the planting period which has up to now been concentrated around a particular time, introduction and breeding of new varieties, and improvement of quality should be pursued.

Research subjects with regard to shifting planting periods include sheltered cultivation utilizing the shade of date palms, as well as film mulching and film tunnel cultivation for hastening the growth of transplanted crops. Furthermore, research in vernalization to hasten the flowering process, particularly applicable to the introduction of strawberries, is also necessary.

In recent years, attention has been focused on the usage of greenhouses in Oman. However, the costs of these facilities vary depending on purpose and materials used. Research in the

future into effective usage of greenhouses is anticipated.

#### (ii) Field Crops

Wheat is one of the most important foods in Oman. However, at present almost all wheat is being imported. The main wheat producing regions are Dhahira and the Interior Region, but recently wheat is also beginning to be grown in other regions, too. The government is taking various measures to promote wheat production, and at the same time is developing new varieties to improve quality, increasing yield and expanding the area for cultivation. In the future, further research on the selection and breeding of high yield varieties with resistance to diseases, development of irrigation methods and economical mechanization is essential.

Only a small portion of the consumption quantity of pulses is being produced and this has possibilities for expansion in the future. In the case of soybeans, since photoperiod and temperature influences the blooming and fructification of this crop, variety selection is very important. Also research on shifting the sowing season, rational fertilization techniques for nitrogen according to the working of root nodule bacteria, etc. is also necessary.

#### (iii) Date Palms

Most of the fruit trees in Oman are date palms. The important research subjects concerning date palms are utilization of space under date palms and thinning and replacing of old date palms. When the old trees, the productivity of which has become relatively low, gradually thin out, there are two possibilities; one is replacing these with superior new varieties by application of tissue culture, etc. and the other is utilization of the space under these trees through modern agricultural production techniques. These subjects need to be investigated in the future, from the viewpoint of farm economy

and from the viewpoint of crop science. Also, it is important to develop technology for processing date by-products.

In relation to the above, the following subjects will have to be studied in the future: improvement of irrigation systems for date cultivation; development of an inter-cropping system under date palms which includes mechanization; crop cultivation under the shelter of trees in summer; development of simple tunnel cultivation methods using plastic material; and development of processed foodstuffs which have added value and will serve to stimulate demand for dates, etc.

#### (iv) Fruits

An overproduction of limes is predicted in the future, and research on cultivation techniques of fruit trees such as orange trees, to replace limes, will thus become necessary. Also, grapes, the self-sufficiency rate of which is low at present, are expected to have a high demand in the future. Therefore, testing and research for selection of superior grape varieties and improvement in cultivation techniques is essential for promoting cultivation. Also, selection of superior varieties of other fruits of high quality and marketing value is necessary.

#### (b) Factor-wise Research Subjects

##### (i) Irrigation Technology

Effective use of limited water resources is the most critical issue in terms of increasing agricultural productivity in the Sultanate. Efforts to alleviate this heaviest of constraints will require research on individual crop water requirements, appropriate irrigation methods, and feasibility of irrigation using brackish water.

##### (ii) Pest and Weed Control

The main pest control method is the chemical control method, but to conserve the environment and to produce safer foods, not only dependence on agricultural chemicals but concepts of integrated pest control methods will be needed. These methods combine the usage of varieties which have resistance against pests, natural enemies, and other control methods. Integrated pest control does not mean complete elimination of insects or pests from ecosystems, but reduction of concentration of these to bring down the damage to crops below the permissible level. It is technology for control of pests utilizing the ecosystems.

Research related to diagnosis of crop disease is particularly important for crop production. Diagnostic methods for pathogenic organisms and techniques for forecasting disease and pest occurrence are also necessary.

Crop diseases are mainly caused by fungi, bacteria or viruses. With progress in the development of pesticides, the importance of research on viral disease has been increasing, because disease caused by viruses cannot be controlled by pesticides. At present, research on resistant varieties is progressing and this will become an increasingly important research subject.

In recent years, the types of agricultural chemicals have increased and methods of application have become more complicated. Also, most of the conventional plant diseases have become possible to control, but on the other hand, plant diseases which had not been a problem until now are occurring more frequently and causing problems.

Regarding research on classification and identification of crop pests, development of detection, classification and identification techniques has been progressing at both the Rumais Research Center and Salalah Research Station. Such research will continue to be very important.

Research on physiology and ecology of harmful insects is the first step to forecasting a system of harmful insect occurrence in the future. In addition, research on biological control methods such as usage of sex pheromon for forecasting occurrence and communication disturbance, usage of natural enemies etc. is particularly needed in the future.

Importance must also be attributed to studies on toxicity and residual duration of agricultural chemicals from the standpoint of the environmental and health impact on human beings.

Also studies on desert locust occurrence, monitoring and countermeasures for control is essential. The research structure is expected to play a leading role in effectively addressing this problem.

Weeds compete with crops for usage of fertilizer and various other components for growth. But, they have other advantages, such as prevention of soil erosion and prevention of an excessive rise in soil temperature. Therefore, their ecology should be studied, and research on rational and efficient control methods are necessary.

### (iii) Soil and Plant Nutrition

As with pest, disease and weed control, fertilizer application technology in Oman is at a low level of development. For this reason improvement and expanded application of fertilizer would be expected to greatly increase agricultural productivity. Along with research on plant physiology, research towards development and improvement of fertilizer application technology responsive to plant type, planting season, and cropping method is important.

Also, in line with the above, the establishment of

facilities properly equipped for soil analysis, including systematic data processing, are necessary to identify soil characteristics in areas already under cultivation as a basis for developing fertilizer application methods most suited to such soil conditions.

Furthermore, given that the horizontal expansion of cultivation area is possible, an increase in agricultural produce in the short term is possible. However, to achieve such, it is necessary to select the most suitable land for such expansion. Upon completion of the Soil Survey Project now in progress with cooperation from FAO, follow-up soil surveys in areas ranked according to highest development potential should be continued in order to identify the full extent to which increase in cultivation area is possible.

#### (iv) Arid Region Agriculture

In order to maintain long-term, stable agriculture in an arid region such as Oman, comprehensive research on prevention and countermeasures for salinization of soil, salt tolerant crops and varieties, etc. is necessary. These subjects relate to a wide spectrum of technical fields including agricultural engineering, horticulture, plant breeding, pedology, plant physiology, etc.

Similarly, research related to horticulture, plant breeding and plant physiology would be required to formulate countermeasures for high temperature damage to crops, particularly in the summer time.

#### (v) Agricultural Machinery

MAF considers farm mechanization to be a central issue to the improvement of farm management. Unfortunately, there has been little study on this in Oman to date. Accordingly, various experiments are considered necessary for selection and

improvement of type, model and size of agricultural machinery best suited to the crops, natural conditions and cropping methods present in Oman. Such experiments would also explore the durability and maintenance problems affecting candidate equipment. Studies on the "soft" aspect of farm mechanization, including economical methods for machinery use would also be carried out.

(vi) Breeding and Seed Production

Research of this would include introduction and selection of existing varieties bred in countries outside Oman where conditions are similar, collection and selection of traditional Omani varieties, cross-breeding of genetically superior foreign and domestic varieties, and bio-technological breeding. Considering that the gestation period is long in case of biotechnological breeding methods other than tissue culture, these would, for the time being, be excluded from consideration. But well-organized combination should be made among the above methods.

Maximum application of existing traditional Omani varieties of fruit trees, feed crops, etc., which have been confirmed as having superior genetic characteristics well-suited to the Omani environment, would be emphasized.

Seed production requires a higher technological ability than general cultivation, and the development and transfer to Omani farmers of appropriate techniques would be pursued. Crops to be considered for seed production would include vegetables (carrots, onions, chilli peppers), wheat and barley in the Interior, and potatoes in the Southern Region and Jabal Akhdar. Seed production of such other vegetables as radish, gourds, spinach and okra should be considered in the future.

(vii) Agricultural Economy



It can be expected that the importance of research on agricultural economy will continue to increase. Such research should be conducted on a broad sociological basis, aimed at the formulation of agricultural policy to upgrade farm-management practices, and improve productivity and income. Improved farm income in turn is a foundation for enhanced rural living standards and farmer welfare.

Research is also necessary in the area of most effective allocation of water and other limited agricultural resources under proper farm management towards maximized farm productivity.

Also, measures to improve the traditional falaj-water-management system must be carefully analyzed under this item due to the central importance of this system to village society.

(viii) Afforestation

Due to the public impact both economically and culturally (and in terms of impressing upon the younger generation the importance of conserving precious natural resources) of forest conservation and afforestation, research in this area should be addressed from an integrated governmental approach including all concerned agencies in addition to MAF.

The following impact would be expected from afforestation:

- o Conservation of existing tree species in Oman (genetic resources).
- o Preservation of the natural environment and its beauty.
- o Flood and soil erosion control.
- o Groundwater recharge.
- o Protection and nurturing of honey bee resources.
- o Control of sand dune drift and desertification.
- o Creation of recreation sites.

Although all the components involved in this project are not necessarily pure research work, careful research in particular with regards to selection and conservation of tree types suited to Oman as well as pilot afforestation methods should be on the agenda. Careful attention would also have to be given to the degree that afforestation would compete with agriculture in terms of water consumption.

#### 4.2.2.4 Extension Services

An increase in agricultural productivity is essential to meeting the demand for food which is expected to increase rapidly in the future. To this end, new and highly productive techniques which have been developed at the experimental stations should be introduced to the farmers along with policies ensuring effective application of these techniques. The most basic activity for increasing agricultural productivity in the future in Oman is extension services for the farmers.

The extension-service plans under the Master Plan are one of the most important sectors and are described below.

##### (1) Employment and Training of Extension Staff

###### (a) Subject Matter Specialists (SMS)

At the moment the organization of extension services is based on dividing the country into nine agricultural regions, with 43 extension centers in total. There is one extension supervisor in each regional office who has overall responsibility for integrating extension services in the given region.

An SMS should be assigned for each special field in these regional offices, but at the moment there are only five SMSs. They must supervise the work of personnel of the extension centers in each region, and they are also required to provide technical advice in their special fields.

A particular problem is that despite the fact that there is a serious need for techniques to increase farm productivity in important fields such as modern irrigation and date palm cultivation, there are no SMSs at all. In the areas of vegetables, general fruit trees, and field crop cultivation, as well as plant protection and socio-economics, the number of SMSs need to be increased.

###### (b) Extension Staff

There are only 85 staff working in all 43 extension centers. It is estimated that at the moment each individual extension officer is responsible for about 1000 farms. This is three or four times greater than the number for which one person is responsible in developed countries. Hence, the number of personnel should be increased three or four times, considering the increasing importance of extension services, the currently low technical level of farms in Oman, the fact that farmers are distributed over wide areas, the need to undertake larger new irrigation projects under this Master Plan, and the need for on-the-job training for Omanis who will replace expatriate extension staff.

The number of personnel should be steadily increased along the lines indicated in the training program given below.

#### (c) Training of Extension Staff

Considering both the importance of and the difficulties involved in extension services in Oman, securing a sufficient number of extension officers with sufficient quality is an extremely important issue. It is generally accepted that basic academic qualifications are indices of the quality of extension officers. Many countries in the West require graduation from a junior college or an agriculture college for these positions.

More Omani junior college and university graduates need to be hired to secure high quality Omani extension officers, but it is also important to provide education to develop basic knowledge whenever there is an opportunity to do so for the high-school graduates and persons with less educational training currently working at the extension centers. The wide-range of general knowledge required to respond to needs on the farms, and the ability to make quick, effective decisions there, are forms of practical knowledge needed in addition to basic academic knowledge.

Communication skills, leadership, and other qualities that go

beyond academic achievement can only be developed through appropriate practical training and direct experience.

Three training courses per year are provided in Oman for extension officers, but the content of these courses needs to be developed further.

Replacing expatriates by Omani nationals is currently a particularly important issue, and the following concepts are needed to effectively educate these extension staff.

(i) The training should be well planned.

A clear vision of the standards of qualifications required for extension officers and how many staff need to be trained is necessary based on future planning and phased targets for agricultural development in Oman.

(ii) Training curriculum should be set up.

In line with effective planning of training, it is also necessary to specify the curriculum for training staff. Single course units should be well organized and simple so that it is possible for trainees to grasp it. Collectively, units should form a smooth progression from one level of difficulty to the next.

The support of university professors and researchers at agriculture research institutions should be sought to ensure specialist supervision of the contents of training curriculums.

(iii) Staff needs to develop practical leadership abilities.

It is important to take into account the fact that the extension staff must become capable of providing practical leadership at the farm level.

Toward this end, not only classroom training, but ample practical instruction in the field is also necessary in formulating extension curriculum.

- (iv) Facilities and equipment required for training should be provided.

The training center described in (2)-(a) should be set up and provided with the necessary facilities and equipment for extension staff training.

As already mentioned, the role that the educational system will play in terms of a basic academic foundation will be extremely important in early securing of well trained extension staff.

The first graduating class from Sultan Qaboos University is in 1990. However, it is anticipated that these valuable and limited human resources will be largely absorbed into the planning and research efforts of MAF, with very little leeway for assignment to the extension officer level.

At present, the principal source of personnel for extension staff in Oman is the Nizwa Agricultural Institute. However, three years of study at this institute (high school level) is insufficient for in-depth training in both basic academic skills as well as practical agricultural techniques, both of which are essential for effective extension staff. In developed countries, for example, an institute such as that at Nizwa is rather a training ground for future farmers, with higher junior college or 4-year education provided to prospective extension experts.

With the foregoing in mind, the new construction of an agricultural junior college functioning to train not only extension officers but also middle level agricultural engineers would be expected to contribute greatly to accelerating the pace of agricultural development in the Sultanate. However, the educational program at such junior college would necessitate integrating the

requirements of the academic curriculum of the Ministry of Education and Youth (MEY) and the training goals of MAF regarding extension personnel. Thus a coordinated effort between these two authorities in the establishment and operation of the school would be expected.

## (2) Equipment and Facilities for Extension Services

### (a) Training Centers for Extension Staff

For training of the extension staff and extending the techniques researched and developed, training centers should be established to strengthen the link between research institutions and extension centers.

Such training centers would be established at the Rumais Agricultural Research Center and in the Southern Region. Instructors would be experts from the research institutions, and the training would reflect the results of research in crop cultivation, crop protection, agriculture management, and other research subjects.

Facilities would include classrooms, laboratories, workshops, libraries, meeting rooms, and basic living facilities such as dormitories and cafeterias, etc. Practical learning facilities would include an experimental farm, post harvest facilities, etc.

Teaching aids to support training are also important and would include slides, photographs, exploded diagrams, models, tape recorders, VTRs and other audio-visual educational materials, as well as copiers, printing machines, and other equipment.

This training center is primarily aimed at training of extension staff but it should also undertake the following activities.

- (i) Training in the latest technology and research management methods for current and prospective research staff.
- (ii) The center would function as a forum for exchange between

researchers and extension staff, thereby providing farmer feedback to research institutions, universities, and other entities engaged in agricultural research.

(iii) Audio-visual educational materials considered indispensable to providing effective extension and training services should be developed in cooperation with the Development Support Communication Center (see (c)).

(iv) Outside experts from PAMAP and elsewhere would be invited to assist in providing not only extension officers and researchers, but also farmers and other interested parties with short-term training on agricultural production, gathering and selling crops, marketing, and other specialized areas of concern.

(v) Training in the methodology of agricultural statistical surveys for statistics staff would be provided.

(b) Installation and Strengthening of Extension Center Equipment

Along with installing the equipment needed to increase the extension functions of the extension centers throughout the country, agricultural technology information units would also be established at these centers for distributing agricultural information. An extension center and sub-centers should also be set up in remote areas which are not reached by present extension services to strengthen the country's agricultural extension network.

(i) Equipment

o Mobile A/V Unit

Opportunities for direct contact between extension staff and as many farmers as possible should be increased. At this time it is important to deploy audio-visual material effectively to maximize the benefits of the extension services.



Audio-visual materials would be taken in mobile A/V units to places where farmer groups gather. There, previously agreed upon daily topics would be illustrated with VTRs and other equipment, after which the contents would be discussed with the farmers to ensure their understanding.

Such materials and vehicles would be provided on a regional basis.

#### o Computers

Files are presently being created containing current information on management and cropping patterns for each of the 2,500 farms now covered by the extension programs.

Guidance tailored to the individual farms is being provided on the basis of this data, and as it develops into the strengthening of the training and other support for these key farmers, the quantity of data needing to be processed will surely increase dramatically. Computerized data management will help greatly in providing advice on farm management, crops, cultivation periods, cultivation areas, harvesting periods, pest and disease control, etc.

#### o Simple Analytical Equipment

All samples of soil and water are sent to the Rumais Agricultural Research Center and analyzed. This takes a long time and it is impossible to respond promptly to needs in the field. The work also takes up a disproportionate amount of the work time of the Agricultural Research Center. Analytical equipment should be provided to the extension centers, and simple analysis conducted there.

#### o Reference Books

Reference books, illustrated materials, research manuals published in the Arab countries, and other necessary books and materials should be provided. This is necessary to support extension staff in their daily self-study and education efforts.

(ii) Agricultural Technology Information Units

Agricultural Technology Information Units should be established at the extension centers throughout the country to offer farmers technical information with regards to farming and related sciences. The units provide easy-to-understand introductions to agricultural techniques and farm inputs. These units should be open to farmers and rural housewives alike, with facilities for viewing videotapes and diagrams, and places for meetings. These information units would provide significant information towards improving farm management, including crop market prices, etc.

In addition to improving farm income, general enhancement of daily rural life is important for raising the standard of living in the farming villages. Such aspects include improving health, sanitation, and nutrition. These information units would undertake to provide the training, support, and guidance for activities on promoting ways to address these aspects. In this regard cooperation between the ministries concerned could be pursued.

In carrying out the activities under this item, the DSCC described in (c) below would be effectively utilized.

(iii) Extension Center and Sub-Centers in Remote Areas

It is very difficult for the extension staff to reach remote areas and return in the same day. Extension center and sub-centers should be established in such remote areas where

necessary to provide farmers with access to extension officers and extension center activities.

(c) Development Support Communication Center (DSCC)

The Development Support Communication Center is designed to be a part of the overall agricultural information services and produces video tapes, radio and TV programs for farmers. It also works to integrate the various programs such as that for improving the standard of living in the farming villages operated by the Ministry of Social Affairs (MSA) and other government departments. Materials created for extension services by this communication center are used by the training centers, the agricultural technology information units, and the mobile A/V units. These materials comprise a program in line with the audio-visual farmer training described below in section (3)-(c). Problems and results arising from using these materials are fed back from the farm to the center by the extension staff for reflection in the preparation of subsequent materials.

Toward effective and integrated implementation of the activities under this section, it is recommended that operation of the DSCC be performed under the guidance of a committee comprised of representatives from the concerned ministries chairmanned by the MAF minister.

(3) Farmer Technical Training

(a) Key Farmer Training

Under current extension services, key farmers are the focus of training in cropping techniques, with their fields functioning as demonstration fields for new varieties, new cultivation methods, etc. It is expected that key farmers will disseminate these techniques to colleagues in their villages.

In Oman, an extension program for 2,500 farmers has been in progress since 1987. These farmers are expected to be the mainstays

in the future for Oman's agriculture. Thus, under the Master Plan, it is recommended that this extension program be continued under the Third Five-year Development Plan. The number of people targeted by this extension program will be increased, and they will be trained as key farmers. Referring to the farming improvement model given in volume 5, chapter 4 "Improvement Plan for Cultivation and Farming", guidance in methods to improve farm management would be actively extended to these key farmers. Data pertinent to instruction in farm management would also be collected and collated.

(b) Farmer Education and Training Facilities

As described in (2) (b) above, farmer education and training is to be carried out using mobile A/V units and the agricultural technology information units. In this regard, effective means for utilizing audio-visual materials are discussed below.

(c) Audio-visual Farmers' Training

(i) Educational Techniques using Audio-visual Technology

Various techniques should be used for training farmers, and the appropriateness of those chosen greatly influences the results of extension work.

Extension services are directed at three types of audiences (listed below), with the respective techniques and materials appropriate to them.

- a) Individuals: Farm visitation, training
- b) Groups : Demonstration farms, model farms, demonstrations, video tapes
- c) Unspecified number of farmers:  
Demonstration farms, radio, pamphlets,  
TV programs, video tapes

The breakdown of extension objectives and techniques is as

follows.

- a) Stimulating motivation: Meetings of farmers in groups
- b) Techniques for assisting comprehension in attempts to solve practical problems:
  - \*\* Demonstration and individual contact for individual farmers
  - \*\* For groups, lectures, roundtable discussions, and other types of meetings, as well as use of audio-visual materials
- c) Techniques for strengthening commitment and encouraging practical applications when solving problems:
  - \*\* Training for individuals
  - \*\* Leadership training for groups
  - \*\* Cooperative work demonstrations, and use of demonstration farms for programs aimed at specific regions.

Extension methods are classified according to the medium and shown in Table 4.2.4

Figure 4.2.1 shows that people who understand things through direct experience and concrete methods easily understand with the techniques listed towards the bottom of the cone. People who understand through indirect experience and abstract or symbolic methods rely on the techniques listed higher up in the cone. Thus, in the agricultural communities where the educational level is low, the more concrete and direct techniques involving personal experience seeing and hearing are appropriate.

In general, it is a good idea to combine extension techniques as much as possible. Activities should be targeted at both individuals

Table 4.2.4 Extension Methods

Medium	Extension Methods
LOOKING and DEMONSTRATING	<u>Exhibitions</u> : Actual articles, samples, models, photographs, pictures, blackboard, wall pictures, diagrams and tables, magnetic boards, posters. <u>Visual aids</u> : Movies, slides, overhead projector, TV, skits, demonstrations, demonstration farms, visits to actual installations, exhibition.
LISTENING and TALKING	<u>Interviews</u> : Visiting farms, visiting offices, <u>Telecommunications</u> : Telephone, cable broadcasts, radio, tape recorders <u>Meetings</u> : Roundtable discussions, on-site meeting, lectures, panel discussions, symposiums, report meetings, role playing, seminars, extension vehicles, brainstorming.
READING	Letters, pamphlets, leaflets, wall newspapers, information bulletins from extension centers, notice boards, mail, contact or business cards, notices, display boards.
DIRECT EXPERIENCE	Taking responsibility for demonstration farms, production competitions, technique competitions, cooperative work projects, recreation, training (practical)

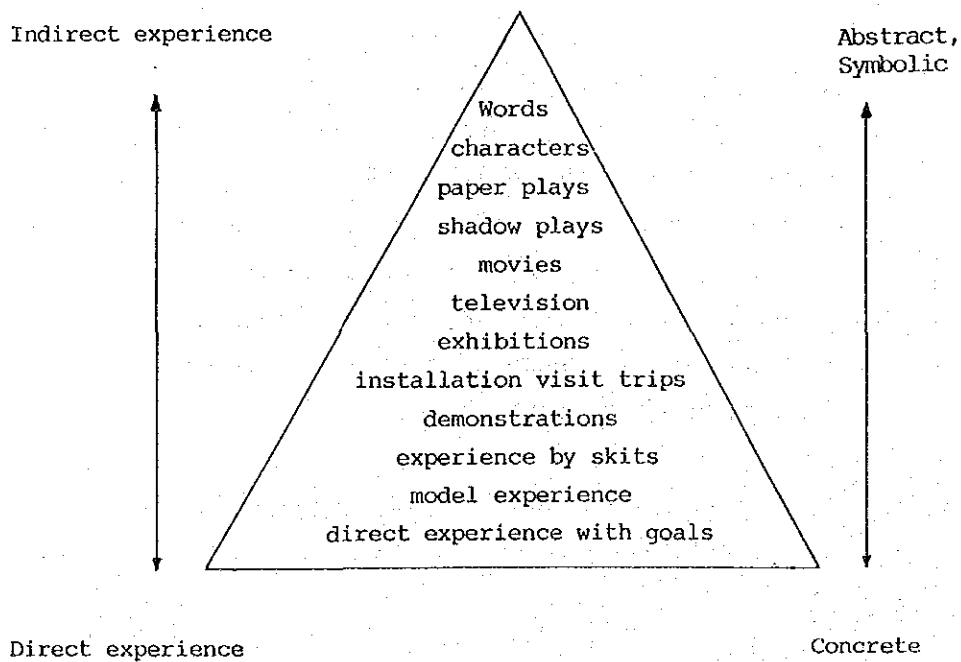


Figure 4.2.1 Cone of Experience

Source: Edgar Dale, Audiovisual Education Techniques

and groups. It is important to establish contacts with the entire regional community as well.

#### (4) Linkage between Extension and Research

The practical aspects of agricultural research take precedence over basic research, and only when the results of research are realized in terms of increased agricultural production in the field, is return on investment in research realized. In this regard, a close link between the research and extension sectors is essential to maximize the cost effectiveness of investment in development of Omani agriculture.

Towards this end, the training center discussed above as well as all other possible opportunities must be effectively utilized as forum for exchange between research and extension personnel. Also, administrative measures will be necessary to provide incentives to farmers to adopt new techniques, as a means of promoting the timely shift of research results to the field.

### 4.3 Livestock

#### 4.3.1 Development Target

Present productivity and profitability of the livestock industry are generally low in Oman. From the viewpoint of national food security, it is essential to increase the self-sufficiency rate which is only 29 and 19 percent for red meat and table eggs, respectively in spite of their importance as the primary diet in the nation. It is possible that a high potential for further development in the livestock sector exists expected because of the present low productivity and profitability.

Present constraints on animal husbandry can be summarized as follows.

- (1) Feed resources are insufficient because they have not yet been effectively used, in spite of the fact that they depend fully on the limited water and land resources.
- (2) Because the program for breeding and improvement of livestock is not in place, productivity remains low.
- (3) Livestock economic losses are large because animal hygiene and epidemic control systems have not yet been well established.
- (4) Efficient breeding management is not practiced mainly due to the low economic awareness of livestock holders in general.
- (5) The distribution system, facilities for marketing livestock, and product processing, etc. have not yet been well developed. Consequently, distribution of products is not smooth, and an enthusiastic increase in animal production has not been stimulated.

In an effort to eliminate the above mentioned constraints which hamper the productivity improvement of the livestock industry, livestock development targets within the development scope of the Master Plan are as follows:



- (1) Securing and developing feed resources
- (2) Improvement of livestock
- (3) Improvement of animal hygiene and elimination of serious epidemic diseases
- (4) Improvement of livestock management and expansion of intensive livestock management
- (5) Improvement of marketing environment

#### 4.3.2 Development Strategy

##### 4.3.2.1 Livestock Development Concept

The development target in this Master Plan is to increase livestock productivity by encouraging the farmers of Oman to use intensive livestock management. The approach which will utilize the full development potential of livestock and realize this goal is as follows:

##### (1) Objective livestock holders

Small- or medium-scale agriculture-based holding types which possess some of their own feed resources, should be highlighted as main objective livestock holders for the following reasons:

- (a) Since most of the livestock holders in the country are small- or medium-scale agriculture-based holding types, priority must be placed on the improvement of productivity in their agriculture and livestock management.
- (b) Within the limited agricultural resources, effective use of agricultural by-products or residue for feedstuff, and livestock manure for fertilizer, are essential for livestock and cultivation, respectively. A mutual supply of feedstuff and fertilizer is quite

possible on agriculture-based holding type farms.

(c) Domestic-type livestock holders seldom possess their own feed resources and mainly engage in non-agricultural occupations. Therefore, development potential here is low due to limited involvement in livestock management.

(d) Most of the commercial livestock farms are already being managed well. Moreover, as far as herbivorous livestock are concerned, further development of new commercial farms is not expected, except in limited areas such as Southern Nejd, due to limited water resources. Nevertheless, on commercial poultry farms which are easily established and operated by the private sector itself, government support is less necessary except in the area of marketing, which requires some improvements.

The nomadic and semi-nomadic holding types are also important for the effective use of feed resources (as are small and medium scale agriculture-based holders) and the preservation of rangeland. These nomadic holding types are gradually beginning to settle down in one place to provide their children with education opportunities. In the future, because their livestock graze on rangeland, further settlement of nomadic and semi-nomadic livestock holders should be promoted, and improvement of their management skills will be included in future livestock development plans.

## (2) Increase self-sufficiency rate of livestock products

Traditionally, livestock products have been the basic diet of the Omani people. Meat particularly has been essential to the maintenance of traditional dietary customs during celebrations immediately after 'Ramadhan' when large quantities are consumed. Since the self-sufficiency rate of livestock products is still low in Oman, improving the ratio is essential for national food security. On the other hand, however, there are serious limitations with the agricultural, water and grass resources, and such resources will allow very little expansion of livestock. In this context, the development of livestock in the target year 2000, shall be

promoted under the concept described below.

- (a) A self-sufficiency rate of 100 percent is targeted for poultry, i.e. broilers and table eggs, because poultry requires neither a large amount of land, nor a large quantity of water, and is competitive in price compared to imports.

It is expected that the establishment and the proliferation of small-scale poultry farms would increase the employment opportunities in rural areas. Moreover, it will promote the permanent settlement of farmers in rural areas due to increased farm income.

- (b) In connection with fresh milk, its freshness is particularly important. Therefore, a self-sufficiency ratio of 100 percent is also targeted. The price of milk is also competitive with imports. A definite self-sufficiency rate for the other dairy products has not yet been targeted but will be set on the basis of future market surveys and feasibility studies, taking into account competitive power against imports.

- (c) With respect to the meat of herbivorous livestock, which depend on extensive water and land resources for grazing, maximum effort will be made to increase the self-sufficiency rate for meat within the available feed resources. Focusing only on the improvement of the self-sufficiency rate, it is possible to increase it by increasing the number of livestock through an excessive supply of mixed feed ingredients which consist of imported material. However, this study does not simply aim at improving the ratio, but recommends a well-balanced supply of both fodder and the feed ingredients, taking into account the physiological characteristics of the herbivorous livestock. It is also possible to increase the ratio by fattening imported young livestock with the mixed feed ingredients. However, this measure is not considered in this study because of its reliance upon imported materials, which are not regarded as contributing to national food security. This is discussed below.

(i) Herbivorous animals require roughage feed even during fattening stages to some extent. If precious domestic grass resources are fed to imported fattening livestock, the domestic grass resources for breeding livestock will be correspondingly reduced. In that case, the development of breeding livestock would be retarded. The development of domestic breeding livestock which can propagate itself is more important than the fattening of imported livestock from the viewpoint of national food security. Therefore precious domestic grass resources should be applied to the development of domestic breeding livestock.

(ii) In the case of feeding animals imported from foreign countries, there is some danger concerning imported epidemic diseases unless a thorough quarantine system is established. Moreover, any resultant epidemics would bring about large economic losses to the animal husbandry. Also, the elimination of epidemic disease is extremely expensive.

### (3) Development concept for livestock

In accordance with the description of (1) Objective livestock holders and (2) Increase self-sufficiency rate of livestock products, the development concept for various types of livestock is discussed below.

#### (a) Poultry

Poultry management only requires a limited area in comparison with other herbivorous livestock breeding. Therefore, it is recommended that holders who possess relatively small areas of farmland establish poultry farms with the support of the government and manage them under the management guidance of the government. In order to attain 100 % self-sufficiency for broilers and table eggs, more highly-productive and large-scale poultry farms shall also be established. However, such large farms will be managed entirely by the private sector except for marketing and supply of superior chicks, which will be supported by the government.

Due to the sensitivity to disease of poultry, strengthening of CVIL and training and expansion of veterinary staff is to be pursued. The production ratio for large-scale to small-scale poultry holders by the project target year is 75:25 for broilers and 70:30 for table eggs (based on the Feasibility Study for Establishment of Poultry Project in Oman, GRM, 1988).

(b) Cattle

(i) Dairy cattle

In the outskirts of the capital area (for example the South Batinah and the Interior), which contain most of the major consumers in the country, and the Southern Region, where dairy cattle breeding prevails, the conditions for establishing dairy product-processing factories are satisfied from the viewpoints of the collection of the fresh milk and its marketing. 100 % self-sufficiency in fresh milk will be attained in Oman through helping farmers to raise cows cross-bred from local species and exotic species. This goal would be attained on the basis of intensive extension service and governmental support such as the artificial insemination service, etc. The superior effects of cross-breeding have almost been confirmed in Oman.

(ii) Beef cattle

As described in the "demand forecast", efforts will be made to improve the productivity and quality of beef, which has the highest domestic demand of any meat. There are several problems with beef production, such as over-grazing in the Southern Region and marketing disadvantages due to price differences between domestic and imported beef. It is difficult for the private sector to solve these problems alone. Accordingly, the problems will be solved systematically, under the guidance of the government.

Specifically a joint government and private sector

corporation will be established to promote integrated development of produce, processing and distribution for cattle products.

In order to overcome the geographical disadvantages in marketing, particularly in the Southern Region, an intensive, as well as large-scale, modern organization for fattening is indispensable for high-quality and low-price beef production. Large-scale fattening will be under the guidance of the Public Corporation, which will be established and operated jointly by the government and private sectors.

At the same time, intensive management of beef cattle fattening by farmers should also be promoted. Generally, with respect to cattle, intensive feeding-management methods should be extended to holders who possess relatively large farmland for the promotion of high quality beef and milk at low prices.

#### (c) Goats

Goats are the most suitable livestock for feeding, especially in light of the fact that they use roughage resources so effectively. Actually, goats account for the largest number of livestock in the country. Moreover, Omani people prefer to eat goat meat. Under these circumstances, the best effort shall be made to expand goat production, focusing particularly on the small- and medium-scale agricultural-based livestock holders who have, to some extent, established their own feed resources. It is recommended that these holders adopt intensive feeding management, expansion of breeding scale, and fattening of young goats by themselves.

#### (d) Sheep

Mutton is not as popular among Omanis as goat meat is. In addition, since there is no production cost difference between mutton and goat meat, the production of sheep is less profitable. Therefore, efforts shall be made to produce high quality mutton in

the future. On the other hand, sheep are better able to subsist on roughage than goats, and can be more dependent on manufactured compound stockfeeds during the fattening stage. In other words, the fattening efficiency of sheep is superior to that of goats. In this context, extension of intensive feeding-management programs for sheep and the production of high quality mutton shall be promoted among medium- and small-scale agricultural-based holders, who have some of their own feed resources. It is further recommended that the fattening be extended to all young lambs except for replacements.

(e) Camels

A camel's diet consists mainly of roughage, and therefore, in terms of effective use of feed resources, it is suitable for breeding in Oman. However, the meat and milk of camels are less marketable than that of other livestock, and what used to be the primary function of camels, i.e. transportation, is no longer necessary. Accordingly, the number of camels needs to be reduced and the surplus of feed resources needs to be allocated to more profitable livestock.

It must be remembered, however, that the breeding of camels is a traditional part of the Omani lifestyle, and its meat and milk are used for domestic consumption. A drastic reduction in camels is not recommended for these reasons. Consequently, a gradual reduction shall be implemented by limiting the replacement of camels, except in the case of camels with superior racing ability or milk productivity.

In addition, special attention must be paid to the limited water and grass resources in the country for future livestock development and supply. The expansion of livestock will not only take place by the area's expansion of feed resources or by an increase in the number of head of livestock, but by increasing the productivity and quality of each live animal through the extension of intensive management programs.

(4) Development concept by region

The country is herein divided into three regions, -- the Batinah, the Interior (including Sharqiya, Dakhliya, Dhahira Region) and the Southern Region. Regional strategies for livestock development are discussed below in terms of the livestock species to be emphasized for each.

(a) Batinah Region

In the Batinah Region, where a considerable number of agricultural-based livestock farmers are concentrated, there is an advantage because of its close proximity to the capital area, which is the largest area for consumption in the country. Based on this, livestock development has been proposed as follows:

- (i) Large-scale farms ..... Dairy cattle (cross-breeds) are recommended  
(cultivated land: more than 5 feddan)

Reasons:

- Geographically advantageous due to close proximity to the consumption area, which will enable them to maintain the freshness of milk.
- Advantageous for collection of milk due to the concentration of farms.
- Advantageous for certain large-scale self-supplying feed resources (i.e. cultivated land) which are required for breeding dairy cows.

- (ii) Medium-scale farms ..... Sheep and goats are recommended.  
(cultivated land: 2 to 5 feddan)

Reasons:

- Effective use of feed resources is feasible due to the combination of cultivation and livestock breeding.



(iii) Small-scale farms ..... Poultry (layers) are recommended.  
(cultivated land: less than 2 feddan)

Reasons:

- Advantageous for maintaining freshness and for transportation due to the close proximity to the consumers.
- Advantageous for the collection of eggs due to concentration of farms.
- Feasible to be managed by small farmers because poultry does not require a large area.

(b) Interior Region

Because the rangeland in this area is vast and farms are scattered, the livestock proposed for development in this region is as follows:

(i) Large-scale farms ..... Dairy cattle (cross-breeds)  
are recommended

(located relatively close to the capital area and with cultivated land of around 5 feddan or more)

Reasons:

- Geographically advantageous due to close proximity to the consumption area, which will enable them to maintain the freshness of milk.
- Advantageous to raise dairy cows in the Interior Region from the standpoint of disease prevention due to relatively low humidity.
- Advantageous for certain large-scale self-supplying feed

resources (i.e. cultivated land) which are required for breeding dairy cows.

- (ii) Large- and medium-scale farms ..... Goats are recommended  
(cultivated land: more than 2 feddan)

Reasons:

- Effective use of feed resources is feasible due to the combination of cultivation and livestock breeding.
- Goats rely mostly on fodder available on the rangeland.

- (iii) Small-scale farm ..... Poultry (broiler) is recommended.  
(cultivated land: about less than 2 feddan)

Reasons:

- Poultry can be fed by the small farmers because it does not require a large area.
- The distance between poultry farms and consumers is not as important as for eggs, which require shorter transportation distances to maintain freshness and to avoid damage.
- The offensive odor of the manure of the poultry is less of a problem in rural areas where the residences are spread out.

(c) Southern Region

The Southern Region can be further divided into three sub-regions -- Jabal, the Salalah plain and the Nejd area -- based on their topographical and feed resource differences. The major livestock to be developed in these areas is as follows:

- (i) Jabal Area ..... Cattle and Poultry are recommended.

Reasons:

- The rangeland which extends over the Jabal plateau is a large, natural pasture land, and has the only and very important supply of high quality natural grass which enables breeding of herbivorous livestock.
- Most cattle in Oman are grazing in this area.
- Cattle grazing here is appropriate not only because of the high quality of the natural feed for cattle, but also because there is less possibility of over-grazing, which destroys natural pasture, as with goats and camels.
- The Jabal area is located at a relatively high elevation with relatively cool summers because of the influence of the monsoon. Therefore, it is advantageous to raise poultry in this region due to the low tolerance of poultry against very hot conditions.

(ii) Salalah Plain

The Salalah Plain can be characterized by its flat land with some residential areas, and by small- and medium-scale farmers mainly engaged in irrigated agriculture. The major livestock proposed for this area is:

- Large-scale farms (5 feddan or more) ..... Dairy cattle (cross breeds) fattening
- Medium-scale farms (2 to 5 feddan) ..... Goat and Sheep
- Small-scale farms (2 feddan or less) ..... Poultry

(iii) Nejd Area ..... Cattle (Feed lot) goats and sheep are recommended.

Reasons:

- In order to increase the commercial value of beef in the Jabal area, it is necessary to produce high quality beef at a low cost by means of large-scale and intensive management of fattening. To this end, a considerable amount of hay will be required. Fortunately in the Nejd area, a development scheme for the agricultural land irrigated by fossil water, is being proposed. Therefore, an increase in hay production is very possible.
- This area is appropriate for large-scale fattening management because of its distance from the existing residential areas, which do not allow the offensive odor associated with large scale fattening management.
- In order to promote the permanent settlement of the nomads traditionally raising goats and camels in this area, it would be effective to pursue intensive husbandry of goats and sheep based on development of the large reserves of fossil water available in the area.

#### 4.3.2.2 Development Target

(1) Potential number of livestock in the target year

In accordance with the study discussed above, the potential number of livestock to be fed by the target year (2000) is estimated in Table 4.3.1. According to this table, the estimated potential number of each type of livestock in the target year corresponds to 150 % for sheep, 126 % for goats, 75 % for cattle and 59 % for camels. It is compared to the present estimated number of each livestock. Details of this calculations are described in volume 5, chapter 2.

(2) Target of farm economy

Based on the discussed premises above, the balance of some types of farm economy has been studied for several livestock breeding models. The economic balance in the target for different feeding models is estimated in the following tables:

Table 4.3.2	Intensive management of 40 head of goats
Table 4.3.3	Nomadic management of 100 head of goats
Table 4.3.4	Intensive management of 10 head of cross-bred cows
Table 4.3.5	Cattle management of 80 head in Southern Jabal
Table 4.3.6	Fattening management of beef cattle in southern Oman
Table 4.3.7	Intensive poultry management
Table 4.3.8	Intensive chicken management

According to these tables, each management type ensures a promising profit. The depreciation cost in intensive management, however, is a large proportion of the management cost. Therefore, an effort shall be made to minimize depreciation costs, particularly in the initial stages of livestock development when the management techniques have still not been well developed.

### (3) Self-sufficiency rate for livestock in the target year

Livestock production and its self-sufficiency rate in the target year (2000) can be estimated on the basis of the previous "potential number of livestock fed in the target year" and is depicted in tables in volume 5, chapter 2. The parameters for estimation of livestock production are also described in volume 5, chapter 2.

As described in volume 5, a 100 % self-sufficiency rate is promising for chicken, eggs, and fresh milk, and a 48 % self-sufficiency rate is viable for red meat. Details of the calculations are described in volume 5.

More concrete development strategies for achieving the above target values are discussed below.

Table 4.3.1

Estimated Livestock Population in 2000

('000)

Region	Cattle	Goats	Sheep	Camel
North	54	909	225	15
South	112	75	4	27
Total	168	984	229	42
Increase Rate From 1989%	75	126	150	59

Table 4.3.2 Intensive Management Plan of 40 Head of Goats

Farm Management Plan (Goats) 40head Intensive Management  
NEW-Local 40head Intensive Management

Rough Revenue	Amount	Unit	Cost	Unit Price	Remark
cull	4.7	head	360	77	
Young	22.9	head	1,466	64	
(Milk)	1,270	L	508	0.40	Home consumption
By-product			508		
Total			1,825		
Operating Cost					
Livestock Purchases			0		
Feed Hay			0		
Feed Concentrate	4.87	ton	382	79	
Feed Mineral	40	unit	14	0.36	
Fertilizer	0.4687	ha			
Seed	0.4687	ha	258	550	
Pesticide	0.4687	ha			
Veterinary	40	head	16	0.4	
Market costs	28	head	14	0.5	
Transport					
Repairs, Maintenance	1	set	87	4325x0.02	
Fuel	1	set	60	12monthx5	
Depreciation	1	set	36	200x0.9/5	cutting machine
Tools	1		10		
Labour	self-support				Working time/day (Hour) feeding-observation 4 cleaning 0.5
Unallocated cost					
Interest payment					
Taxes, Imports					
Contingencies	5%		44		
Total			921		
(Home consumption)			508	Profit-rate	
Profit			904	50 %	

Note: Herds number shows constant existing total heads

Table 4.3.3 Nomadic Management Plan of 100 Head of Goats  
 Farm Management Plan (Goats) 100head Extensive

Rough Revenue	Amount	Unit	Cost	Unit Price	Remark
cull	14.1	head	974	69	
Young	25.2	head	1,610	64	
(Milk) By-product	1,718	L	687	0.40	Home consumption
Total			687		
			2,583		
<b>Operating Cost</b>					
Livestock Purchases			0		
Feed Hay	2.65	ton	186	70	
Feed Concentrate	12.54	ton	984	79	
Feed			0		
Mineral	100	unit	36	0.36	
Fertilizer		ha	0	156	
Seed		ha	0	22.5	
Pesticide		ha	0	35	Herbicides and other
Veterinary	100	head	10	0.1	
Market costs		head	0		
Transport	450	L	54	0.12	
Repairs, Maintenance		set			
Fuel	0	set	0		
Depreciation	0	set	0	450	=If 1Cargo Car Poses
Tools	1	set	10	10	
Labour	self-support				Working time/day (Hour) feeding-observation 7 cleaning 0
Unallocated cost					
Interest payment					
Taxes, Imports					
Contingencies	5%		64		
Total			1,344		
			687		Profit-rate
Profit			1,240	48 %	

Note: Herds number shows constant existing total heads

Table 4.3.5 Cattle Management Plan of 80 Head in Southern Jabal

Farm Management Plan(Cattle) 80head  
Jabal

Rough Revenue	Amount	Cost	Remark
cull	8.9	1,788	200
Young	15.1	904	60
(Milk)	5.6	678	120
By-product	5,883	1,324	0.225 /L Home consumption= 1 Milk 5883L
<b>Total</b>		<b>(1,324)</b> <b>4,693</b>	
<b>Operating Cost</b>			
Livestock Purchases			
Feed Hay	6.27	439	70
Feed Concentrate	21.00	1,680	80
Feed Mineral	80	115	1.44
Fertilizer			
Seed			
Pesticide			
Veterinary	80	112	1.4
Market costs		0	
Transport	1562.5	188	0.12
Repairs, Maintenance			
Fuel	1	36	
Depreciation	1	450	450 = 1Cargo Car
Tools	1	20	20
Labour			working time/day (Hour) feeding-observation 7 cleaning 0
Unallocated cost			
Interest payment			
Taxes, Imports			
Contingencies	5%	152	
<b>Total</b>		<b>3,191</b>	
<b>Profit</b>		<b>(1,324)</b> <b>1,502</b>	<b>Profit-rate</b> <b>32 %</b>

Note: Herds number shows constant existing total heads



Table 4.3.4 Intensive Management Plan of 10 Head of Cross-Bred Cows

Farm Management Plan			(Cow)	10head	Intensive Mngement
	Amount	Unit	Cost		Remark
Rough Revenue					
cull	1.1	head	317	288	
Young	2.0	head	120	60	
(Milk)	0.7	head	84	120	
By-product	7,595	L	1,709	0.225	/L
Total			2,230		
Operating Cost					
Livestock Purchases					
Feed Hay		ton			
Feed Concentrate	9.20	ton	727	79	
Feed Mineral	10	unit	14	1.44	
Fertilizer		ha			
Seed	0.6340	ha	349	550	
Pesticide		ha			
Veterinary	10	head	14	1.4	
Market costs	7,595	L	8	0.001	
Transport		L			
Repairs, Maintenance	1	set	88	4400x0.02	
Fuel	1	set	24	12monthx2R.0	
Depreciation	1	set	162	900x0.9/5years	
Tools	1	set	10		
Labour				Working time/day (Hour)	
				feeding-observation	7
				cleaning	0
Unallocated cost					
Interest payment					
Taxes, Imports					
Contingencies	5%		70		
Total			1,465		
Profit			764	Profit-rate	34 %

Note: Herds number shows constant existing total heads

TABLE 4.3.6 Cattle Fattening Management Plan  
Farm Management Plan(Cattle) Fattening 8,555 Head  
Nejjid

Rough Revenue	Amount	Cost	Remark
cull			
Young	8,043	1,769,460	220
(Milk)	3,013	602,600	200
By-product			
Total		2,372,060	
Operating Cost			
Livestock Purchases	8,467	465,685	55 male calf
Livestock Purchases	3,157	347,270	110 female
Feed Hay	3,185	222,950	70
Feed Concentrate	9,053	724,240	80
Feed Mineral	8,555	12,319	1.44
Fertilizer			
Seed	Accounted	in Feed Purchased	
Pesticide			
Veterinary	8,555	4,278	0.5 Drug
Market costs	8,555	4,278	0.5
Transport			
Repairs, Maintenance	1	21,470	
Water	8,555	86	0.01 Water cost/l
Depreciation	1	77,231	
Tools	8,555	856	0.1
Labour			Working time/day (Hour)
Manager	1	6,912	feeding-observation 7
Veterinarian	1	6,912	cleaning 0
Assistant	2	5616	
Others	19	39,012	
Fuel	110	13,140	120 gasoil etc
Interest payment			
Taxes, Imports			
Contingencies	5%	97,613	
Total		2,049,865	
Profit		322,195	Profit-rate 14 %

Note: Herds number shows constant existing total heads

Repair, Maintenance, Depreciatuon

Item		Repair	Depreciation
Construction Cost	1,285,485	12,855	57,847
Machinery Cost	172,300	8,615	19,384
Total	1,457,785	21,470	77,231

Table 4.3.6 (continued)

Farm Management Plan		(Cattle)	Local Fattening	40 head
Rough Revenue	Amount	Cost	Remark	
cull				
Young	38	8,273	220	
	14	2,818	200	
(Milk)				
By-product				
Total		11,091		
Operating Cost				
Livestock Purchases	40	2,177	55	male calf
Livestock Purchases	15	1,624	110	female
Feed Hay	15	1,042	70	
Feed Concentrate	42	3,386	80	
Feed				
Mineral	40	58	1.44	
Fertilizer				
Seed	Accounted in Feed Purchased			
Pesticide				
Veterinary	40	20	0.5	Drug
Market costs	40	20	0.5	
Transport				
Repairs, Maintenance	1	116		5800x0.02
Water	40	0	0.01	Water cost/1
Depreciation	1	324		1800x0.9/5years
Tools	1	10		
Labour				Working time/day (Hour)
				feeding-observation 7
				cleaning 0
Fuel	1	61		
Interest payment				
Taxes, Imports				
Contingencies	5%	442		
Total		9,281		
Profit		1,810	Profit-rate 16 %	

Note: Herds number shows constant existing total heads

Table 4.3.7 Farm Management Plan (Layer, Small Holder)  
Small Holder Egg Farm Operating Cost

		Model A Producing 75,000 eggs p.a.	Model B Producing 45,000 eggs p.a.
Point of lay pullets @RO 2.3	RO	1,150	690
AV. Feed @24kg layer housed for 300 day Period @RO 95/ton	RO	1,140	685
			(80g/day.layer)
Approx water requirement/layer per day=0.125ltr depending on weather. Water requirement/300 days		18,765L	11,259L
Price of water @RO 0.25/m	RO	4.75	2.25
Labour			
Kerosene	RO	15	10
Repairs/Maintenance/Depreciation (Investment Cost x 0.1)	RO	258	155
Total operating costs	RO	2,568	1,542
Crude income(if @45bz/egg)	RO	3,375	2,025
Plus sale of spent layer @RO 1.0 each(mortality 10%)	RO	450	270
Profit	RO	1,257	753
Initial investment	RO	2,580	1,550

Source: Feasibility Study for Establishment of Poultry Project in Sultanate of Oman (GRM 1988)

\*, MAF and Consultant's estimation

Table 4.3.8 Farm Management Plan (Broiler, Small Holder)  
Small Holder Broiler Farm Operating Cost

		Model A Producing 18,000 Broilers p.a.	Model B Producing 9,000 Broilers p.a.
Day-old Chick costs @RO 0.17	RO	3,060	1,530
AV. Feed @28kg broiler for @RO 105/ton	RO	5,290	2,645
Approx water requirement/broiler per day=3.5ltr depending on weather. Price of water @RO 0.25/m	RO	16	8
Labour			
Kerosene	RO	108	54
Repairs/Maintenance/Depreciation (Investment Cost x 0.1)	RO	930	465
Total operating costs	RO	9,404	4,702
Crude income (if @750bz/one)	RO	13,500	6,750
Profit	RO	4,096	2,048
Initial investment	RO	9,300	4,650

Source: Feasibility Study for Establishment of Poultry Project in Sultanate of Oman (GRM 1988)

\*, MAF and Consultant's estimation

#### 4.3.2.3 Establishment of the Development Strategy

In order to improve the present situation of livestock development and to accomplish the above-mentioned development targets, livestock development will be promoted in accordance with the concrete strategy shown in the Table 4.3.9, in terms of the "Constraints of development" described in section 4.3.1, "Development Target".

The basic concepts for establishing the development strategy are as follows:

- (1) To use existing feed resources effectively and with preservation in mind, as well as to increase the capacity of the feed supply through the development of new feed resources.
- (2) To increase livestock productivity through the promotion of breeding and improving livestock.
- (3) To reduce the economic losses of livestock by establishing systems for animal health and disease control aimed at the eradication of serious epidemics.
- (4) To establish, extend and expand the number of livestock farmers using the intensive breeding management technique by increasing farmers' economic awareness.
- (5) To provide the nation with quality livestock products by encouraging farmers through production incentives and by improving the existing livestock marketing system.

The basic concept for development projects, research/extension, and the subsidiary institution under the above-mentioned development strategies, can be summarized as follows:

##### (1) Development projects

The development projects will be planned with the necessary

government support, in order to extend and promote more modernized and intensive livestock management to the livestock holders in the country.

(2) Research and extension

In the research activities, special emphasis shall be put on the development of feed resources and breeding management techniques, which are directly connected to increasing livestock productivity. While in the extension services, improvement of the livestock holder's economic awareness and prompt communication of research results and development accomplishments to the farmers should be stressed.

(3) Subsidy institution

Farmer encouragement through production incentives is essential for the future expansion of livestock products at the farm level. The government's subsidiary scheme in the proposed development projects basically aims at providing farmers with production incentives. Therefore, the subsidy should be the minimum amount so as not to decrease the farmer's own management efforts. Furthermore, this subsidiary system should focus on expediting the farmer's self-sufficiency, and should not aim to provide the farmer with permanent subsidies.

The following three approaches should be considered for the implementation of the government subsidiary scheme in the proposed development projects. However, the subsidy provided to the farmers in each scheme, shall not be on a permanent basis, but on a temporary basis due to the above reasons.

(1) Subsidies for production inputs

Subsidies for initial capital investments that are necessary to start modernized and intensive livestock management.

(2) Subsidies for running costs

Subsidies for major production related materials, such as medicine and chemicals for upgrading and maintaining livestock management.

(3) Subsidies for production output

Subsidies connected with the price of livestock products to ensure appropriate profits in livestock breeding.



Table 4.3.9 List of Development Strategies

Constraints to Development	Development Projects	Development Strategies Research/Extension	Subsidiary Institution
Shortage of feed resources	<ol style="list-style-type: none"> <li>1 Regeneration of southern rangeland</li> <li>2 Preservation of rangeland through reduction of grazing livestock, i.e. purchase of feeding calves for fattening</li> </ol>	<ol style="list-style-type: none"> <li>1 Development of new feed resources</li> <li>2 Development of effective use of existing feed resources</li> <li>3 Estimation of nutrient requirements of animals and development of effective feed supply methods</li> <li>4 Extension of the above technique and above accomplishments communicated to farmers.</li> </ol>	<ol style="list-style-type: none"> <li>1 Purchase of grazing livestock</li> </ol>
Low livestock productivity	<ol style="list-style-type: none"> <li>1 Implementation of artificial insemination</li> </ol>	<ol style="list-style-type: none"> <li>1 Development of breeding and improvement methods.</li> <li>2 Breeding to superior species and supplying to farmers.</li> <li>3 Extension of the above technique and accomplishments communicated to farmers.</li> </ol>	

Table 4.3.9 (continue) List of Development Strategies

Constraints to Development	Development Strategies		
	Development Projects	Research/Extension	Subsidiary Institution
Insufficient establishment of animal health and disease control system	1 Improvement of animal quarantine system	1 Development of vaccine available for specific disease characteristics	1 Supply of and subsidy for medicine and chemicals for farmers.
	2 Improvement of animal health system		
	3 Implementation of vaccination program (Stage-4)	2 Communication of health control techniques to farmers.	
Low economic awareness of livestock holders, ie. undeveloped breeding management techniques	1 Improvement of extension related facilities and system.	1 Development and extension of effective management techniques.	1 Subsidy for initial investment for commencing intensive livestock management.
Less developed livestock marketing system	1 Improvement of marketing facilities and distribution of livestock products.	1 Development of quality improvement method for livestock products (Research on fattening method, etc.)	Recommendation Dissolution of retailing price differences between domestic products and imported goods.
	2 Production of high quality meat through establishment of fattening management.		
Others: Insufficient basic data for development	Collection and accumulation of basic data for livestock development (to conduct surveys and studies)		