Land settlement projects and agricultural development: An analysis of development factors and processes based on four case studies in Ghana, Libya and Saudi Arabia.

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LAND SETTLEMENT PROJECTS AND AGRICULTURAL DEVELOPMENT

An Analysis of Development Factors and Processes based on four Case Studies in Ghana, Libya and Saudi Arabia

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A B S T R A C T

Agriculture, in all its different forms, is the basis for the livelihood of most of the people living in economically underdeveloped countries. In recent years an improvement in the living conditions of many of these people was seen to be an urgent necessity. Many possible means of achieving this improvement are extant, but in this thesis only the impact of irrigation projects based on a family labour force is investigated. The four examples of such projects considered here differ greatly from each other, involving respectively:

1. Settlement of nomads on virgin soil.
2. Redevelopment of a decaying oasis through the introduction of a new irrigation and drainage system.
3. Reclamation of land which at present is exposed to regular floods.
4. Resettlement of a settled agricultural population on virgin soil.

Each project is described in detail and the economic potential of the new family farms investigated. In addition, the suitability of the production factors and their interdependences are evaluated, as is the hypothetical future economic development of the farm units.

The investigation of the four projects has revealed many findings of a general validity. In particular a "circle of development" was identified in the light of which the viability of the four projects is re-examined.

A C K N O W L E D G E M E N T

I wish to record here my deep gratitude to my immediate supervisor, Professor H. Bowen-Jones, whose consistent patience and encouragement, and valuable advice facilitated the preparation of this thesis. I also wish to thank Professor W. Fisher for accepting me as a Post-graduate Student at Durham.

I am grateful to Mr. and Mrs. K.E. Gall, Mr. E. Buch and Professor Dr. D. Uhlig of WAKUTI, without whose understanding and generous help this thesis would have been impossible to complete.

I wish to thank my former colleagues Mr. R. Sacher of the University of Hohenheim, Germany, for his explanation of several economic concepts, and Dr H. v.d. Decken for his very thorough criticism of the final draught.

My thanks go particularly to my fellow student, Mr A.R. George, who spent endless hours reading over and discussing this thesis and suggested many improvements.

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INTRODUCTION

During the 1960s, the West German engineering consultants WAKUTI, was engaged in extensive development work in the Third World. In April 1969 the author joined the firm as an agricultural expert and, after one month at the firm's headquarters at Siegen, West Germany, was sent to Haradh, Saudi Arabia, where WAKUTI was involved in the planning and construction of an irrigation and Bedouin settlement project. At Haradh, the author's assignment was to supervise a 40 ha pilot demonstration and training farm, established to provide information for the projected large-scale project itself. He was concerned with the overall management of this farm, and with planning for the projected settlement project. This involved detailed research in the economics of agriculture in such conditions, including time measurements for labour input, the establishment, and evaluation of irrigation and soil permeability trials, and the supervision of the introduction of new techniques and agricultural specialisations, in particular the assessment of the performance of the local Nejdi sheep under conditions of intensive feeding. In addition, he was directly responsible for the management of the local labour force. Furthermore, he prepared reports on soil erosion in the surrounding wadis, on the possibilities of recycling sewage water for irrigation, and on the potential for meat and milk production based on Friesians in the projected project. The latter report was based on the author's experience in Tunisia working in the Medjerda Valley Project.

Apart from this work related to the Haradh project, the author investigated the impact of the new irrigation and drainage scheme undertaken by WAKUTI in the Al Hassa Oasis, and studied the traditional water use in the Wadi Jizzan, in Asir province, with a view to a projected irrigation scheme there.

In the course of his two and a half years in Saudi Arabia, the author travelled extensively in the country, and formed a broad picture of the current agricultural situation.

In 1968, WAKUTI was engaged by the Ghanaian Government to undertake a feasibility study for an irrigation, drainage and resettlement scheme at Avu Keta on the Volta mouth. The author was not directly involved in this, and has relied heavily on the company's field data.

In 1965 WAKUTI had been engaged by the Libyan Government to make a similar feasibility study for the Tauorga Oasis in Tripolitania. Again, the author was not directly involved, but has used WAKUTI's field data as the basis for his investigation into this project. However, in March 1973, the author was awarded the Society for Libyan Studies' Fellowship for 1973 and during 1974 the author was able to carry out additional field work in the Tauorga region.

In September 1971, the author entered Durham University Geography Department to work for an MSc and in April 1972 this was transferred to a Ph.D. At Durham, he investigated the above-mentioned agricultural schemes in greater depth, paying particular attention to family income of the settlers, and the feasibility of self-sustained development.

It is hoped that this work will be of value - particularly to those engaged in agricultural development. As U.N. noted:[1]

> "Our knowledge in relation to the problems of agrarian structure is far from being complete. Of specific importance would be an increase of our knowledge about factual tenure situations and of experience with the implementation of agrarian reform programs on a world-wide scale."

Hopefully this work fills at least some of the gaps in our knowledge.

Well established methods are available to assess the profitability of agricultural production units. However, these methods have been developed from conditions in developed countries, and in order to use them the availability of data of the highest quality is essential.

But the developing countries have no long history of data collection and the need for reliable data is not generally recognized. This applies especially to the rural population which has no understanding at all of this need. Thus it is not surprising that hardly any data is available, and the little which is, is not reliable. To illustrate this, in Hofuf it was impossible to find any written records of land ownership. Only after days of unsuccessful investigation was somebody found who claimed to have the necessary knowledge of farm sizes and owners' names. His claims were later supported by officials in the Agricultural Centre in Al Jafer and by Hadj Ali, one of the traditional leaders.

Even the most sophisticated methodology cannot improve poor basic material, and even when the sources seem to be excellent their data are sometimes rather dubious. For instance, the Bedouin tribe Al Murrah in Saudi Arabia numbers either 14,000[2] or 125,000[3] persons, depending on which source is believed. The source for the 14,000 figure is an American anthropologist who spent about two years with the tribe, and thus one could expect his figure to be reliable. However, the source for the 125,000 figure is an oil company belonging to the ARAMCO group, and since this group has done a great deal of research work, one could expect this figure also to be correct. Thus, even with much data from good sources one must still rely upon speculation.

Under such circumstances it is not advisable to use very sophisticated methods of data manipulation. The necessary high degree of reliability of the basic data is absent and thus the use of such methods would lead to misinformation and give a false impression of reliability to persons unfamiliar with the conditions in developing countries.

Consequently, the use of such methods has been avoided and a much simpler one has been adopted for this thesis. Nevertheless, the simpler method has always proved adequate in the author's previous work, and it is noteworthy that it has recently been described independently elsewhere[4].

Before considering a development project it should be recognized that the achievements at which the project is aimed are often strongly influenced by factors which have nothing to do with development or agricultural production per se. For example in the Avu Keta project in Ghana foreign capital will be involved, and thus the political or economic wishes of the donors are a strong influencing factor. Even when the capital is provided by the home countries it is not always those areas with the greatest need for development who benefit first. Internal political reasons, prestige, etc. are often regarded as more important problems and thus can influence the location of projects. Should the project be in a socialist country, the solution of ownership will certainly differ from the solution a capitalist country would prefer.

Furthermore, the planner, builder and the supervisory body may influence the nature of the development, according to their ability, priorities, attitudes, motives to mention just a few. Thus as Reining said:[5]

> " ... the technological officials and experts be as much part of the research as the people being developed."

However, the four projects dealt with in this study have been designed by the same consultant and no foreign capital is involved. The projects in Saudi Arabia and Libya are paid for by these countries and no capital is yet involved in the Ghanaian project as it is still in the planning stage, while the former three projects have either been completed or are under construction. Thus, all four projects have basically similar characteristics in this respect.

The projects considered in this thesis might be described as "Land Reform" projects since they conform exactly with the two basic definitions of land reform:[6]

1. Traditional definition of land reform

   Redistribution of land for the benefit of small farmers and agricultural labourers.

2. The definition originating from the USA

   Any improvement in agricultural economic institutions.

However, it is perhaps more accurate to describe them as "irrigation" projects since all four have agriculture under irrigation as the basis for the farmers' income, and anyway, land reform alone is not necessarily a decisive factor for development. In Western Europe and Japan[7] agricultural development has been achieved in the main by involving land reform in the American sense, but not in the sense of the traditional definition. Japanese and Spanish land reform programmes between 1949 and 1951 only affected small sections of agriculture, and even the Italian land reform programme started in 1951 has been of less significance than normal growth development.

In no nomadic agricultural system, in spite of attempts to introduce technical improvements - conforming to the American definition of a land reform - has any development compatible with the essential features of nomadism been achieved, and the traditional definition has no application at all.

Although the four projects have many important factors in common they differ considerably from each other as the following brief descriptions show.

The Faisal Settlement Project, Haradh, Saudi Arabia

Only two per cent of the 2.2 million sq. km. of Saudi Arabia, that is, about 400,000 ha., is under cultivation, and of this 80 per cent must be irrigated.[8]

The 4,000 ha. of the Faisal Settlement Project could increase the agricultural area of Saudi Arabia by one per cent and thus could lead to a considerably larger output of agricultural produce.

This project is a Bedouin settlement scheme on virgin soil based on (1) the availability of water, (2) adequate soil conditions and (3) a source of power in the nearby Gas-Oil Separator Plant.

It has already been proved on a 40 ha. research station that agricultural production is technically possible in the area and, as a result, on June 7 1966, WAKUTI was given a contract to establish an irrigation and drainage scheme.[9]

After completion of the project in 1971 the Saudi authorities undertook to start agricultural production, but this failed. At present the project has been more or less abandoned and it is doubtful whether it will ever be used according to the original plans. Nevertheless, in this study the project will be considered according to these plans.

The Al Hassa Oasis, Saudi Arabia

The Al Hassa Oasis is one of the oldest settlements in the Middle East, and was already inhabited at the time of Moses.[10]

By means of the agricultural project it is intended to redevelop the remaining 8,000 ha. of the oasis by an irrigation and drainage scheme and a sand dune stabilization programme and to increase the agricultural area to 20,000 ha. This expansion by 12,000 ha. represents an increase of three per cent in the agricultural area of Saudi Arabia. The expansion was favoured as it would only require an increase of eight per cent in the present water output[11] of the springs and wells. However, successful utilisation of the additional area will only be possible when the water is used efficiently.

On April 1 1963 WAKUTI started the investigations and the project was completed in 1972.[12]

The objectives of the project were to assure the farmers of a more reliable source of income thus preventing complete decay in the oasis.

The technical part has been completed and the follow up measures must now be introduced.

The Avu Keta Project, Ghana

In the rainy season of 1968, because of the high water level in the Keta lagoon, the Keta bay-mouth bar had to be pierced in order to drain the excess water into the sea. Consequently, the 50,000 people living on the Keta bay-mouth bar had to be supplied by boat.[13] This event helped considerably to establish the desire for action, and, since flood control was overdue, and the soil and topographical conditions were favourable for agricultural production[14], a development project with the aim of improving the diet and providing an adequate family income was planned.[15]

Therefore, an area of 30,000 ha., at present unusable due to floods, will be made available for agricultural production by means of an irrigation and drainage scheme in the overcrowded Avu Keta area. This will also create employment and thus discourage migration of the inhabitants to the urban centres.

However, apart from these plans, nothing has been done.

The Tauorga Oasis, Libya

The 1972-75 three year plan for agricultural development in Libya was drawn up to reverse the deteriorating agricultural situation. The proportion of agriculture in the gross domestic product dropped from 9.7 per cent in 1962 to 2.4 per cent in 1969 and the value of exports of agricultural goods at market prices dropped from LD four million in 1955 to LD 0.5 million in 1969. This decline in agriculture occurred when about half of the population depended upon agriculture and related activities. Now, as a result of the new plan, an increase in the annual growth rate of agriculture from one per cent to 10.7 per cent is expected.[16]

According to this plan LD 165 million are provided for agricultural development.[17] The Tauorga project will benefit to a large extent from this money since many activities in the project are covered by the plan.

The Tauorga oasis is supplied by the largest springs in the country and these have already been used by Romans, Phoenicians and Arabs to irrigate about 5,000 ha. of date palms. However, the salination of the soil is now so advanced that even dates cannot grow.[18]

Therefore, in June 1965 the Water and Soil Conservation Department, Tripoli, decided to undertake the redevelopment of the oasis, based on an Interim Report of WAKUTI of May 1965.[19] According to this report, the old decayed oasis will be abandoned and nearby 3,000 ha. of new land will be developed to give the inhabitants a better source of income.

The feasibility study had been completed by 1965, but it was not before 1972 that construction started.

The four projects could be examined from many different points of view, but the aim of this thesis is to show the influence of the planned innovations through specific implementation measures, e.g. irrigation and drainage systems, on agricultural production and thus on family income, and its contribution to self-sustained development.

A project which not only aims at agricultural exploitation, but also, simultaneously, at the development of people, can have the following effects:[20]

Economic Effects

a. Increase in the direct and indirect creation of wealth and acceleration of total economic growth:

   i. by activation of idle resources and land reclamation;

   ii. by introduction and amelioration of agricultural processes;

   iii. by promotion of the creation of capital;

   iv. by improving the trade balance (saving of foreign exchange).

b. Promotion of economic stability:

   i. by introduction of high yielding crops and animals;

   ii. by diversifying and commercializing production.

Social Effects

a. distribution of income;

b. improvement of living conditions (health, residence, and education);

c. occupation of the unemployed and underemployed;

d. modification of the rural population's and tribes' way of living.

Cultural Effects

a. removal of illiteracy;

b. training of a critical mass of local expertise;

c. introduction of cultural change.

Political Effects

a. national independence in the supply of the local people, and thus political independence;

b. internal effects - removal of regional disparities.

The next chapters deal with these effects in greater detail.

As noted earlier in the introduction, the author's analyses, re-evaluations and conclusions are based on his own field research and on other documentary sources. The latter include WAKUTI reports from which field data have frequently been taken; where such data and other material have been utilised ascription is given in the chapter references. All other is the result of the author's own investigations, and much of the WAKUTI report data is also the product of the author's survey research.

Much of the detailed data - statistical and cartographic - will not be available through normal sources. These are therefore presented as a set of appendices in Volume II of the thesis and may be used as supporting evidence for the arguments adduced in Volume I.

The main objective of the projects described in this study is to enable the people living in the areas to achieve an adequate family income. In each of the countries concerned the chosen method of achieving this was through creating suitably profitable individual farm holdings. Therefore a farm will be provided for each family, this varying in size according to specific local conditions and to give an income sufficient to maintain in being a rural population.

In the FSP, Haradh, the farm size will be four hectares for each family, however, there are additional plans to create farms of different sizes based on the needs of the families involved.

In general, in the old part of the Al Hassa oasis the farms are too small to assure an adequate income, and for the newly developed land (12,000 ha.) as yet no decision about the size is made. Therefore, farms of an adequate size, that is, not smaller than five hectares should be created there.

Two farm sizes are envisaged for the Avu Keta project, i.e. either 2.5 ha. or 2.8 ha., each farm type having a separate cropping pattern.

In the Tauorga project all farms will be about 10 ha.

The following calculations are based on the assumption that all farms will be run on a family basis and only in exceptional cases, when labourers must be brought in from outside will part of the families' income be spent on wages. Thus, in general, there will be no labour costs.

In order to achieve a clear picture of the economical potential of the farms it is assumed that the farmers are free from debt and do not have to pay any tenure on the newly created farms, i.e. the capital costs of the project are neglected. For the same reason crop failure and extremely high death rate of the livestock, although they sometimes destroy entire agricultural schemes, are not considered in the calculations.

Knowledge of the ex-farm prices of the products is essential for the calculation of the family income. But as there are no ex-farm prices known for the four projects the wholesale prices minus the transport costs have been taken instead. When using this method the marketing has to be done entirely by a co-operative, thus avoiding further reduction of the price the farmer gets. There are many other systems available used as substitutes for ex-farm prices, for instance, (whole-sale price minus transport costs) ÷ 2, all of which are equally questionable since they all involve specific assumptions of farm and non-farm products' values and cannot be used except where the products' range is known and limited within one marketing system and where agricultural activity is dominated by market and monetary considerations. For comparative purposes the simpler price less transport cost is less dangerous to use.

Much of the thesis consists of lengthy numerical calculations; these being essential for the clarification of the impact of all the factors which influence the success or failure of agricultural projects.

The figures presented below are often given to three decimal places. However, it is not intended to imply that the calculations are so exact that such precision is realistic. On the contrary, the author believes that because of the questionable nature of much of the basic material the figures must be accepted with a certain amount of doubt.

Nevertheless, a calculation of the economic feasibility of the projects is necessary, since many important decisions, for example the number of families to be settled, farm size, cropping pattern, the necessity or otherwise of subsidies and, most important, whether a project should be realized or not, depend to a large extent on the future economic success of the production units.

The success of a project does not depend only on its economic feasibility, but the other deciding factors, for instance the human one, make it even more difficult to make any valid predictions, and this fact also decreases still further the value of economic predictions.

However, when planning under conditions described in chapters one to four, one should make fullest possible use of what information is available, whatever one's reservations about it. As long as they are treated with appropriate caution, economic calculations are a valuable guideline in planning.

The layout of this thesis was determined by the necessity to present the four projects in a way which makes a lucid comparison of them possible. The thesis consists of five chapters, of which the first four have exactly the same structure. Each involves a consideration of one of the projects under the major headings of: the project area; the population of the area; circumstances which necessitate the project; and the probable economic outcome. The farm units which have to be established and which will supply the family income have been thoroughly investigated.

The final chapter contains an evaluation of the development implications of the four projects. For this the suitability of the production factors has been investigated, the interdependences of these and other factors analysed, and the pattern of expenditure of the projects emphasized.

Finally, the conclusion deals with the projected improvements of the four projects as well as with more general findings, such as those concerning the "development circle" and the attitude of tradition-bound people towards full-time engagement in farm work.

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CHAPTER ONE

FAISAL SETTLEMENT PROJECT, HARADH, SAUDI ARABIA

Location of the project (see Map No. 1)

The Faisal Settlement Project originated as a bedouin settlement and agricultural scheme of 4,000 ha.

The location was chosen for the following reasons:[1]

1. Availability of underground water resources.
2. Favourable soil and topographical conditions.
3. Existence of a nearby gas-oil separator plant.
4. Good communications (a nearby railway line).

The project area lies in the Eastern Province of Saudi Arabia and is between approximately 23rd. and 25th. parallel North and 48° 30' and 50" East.

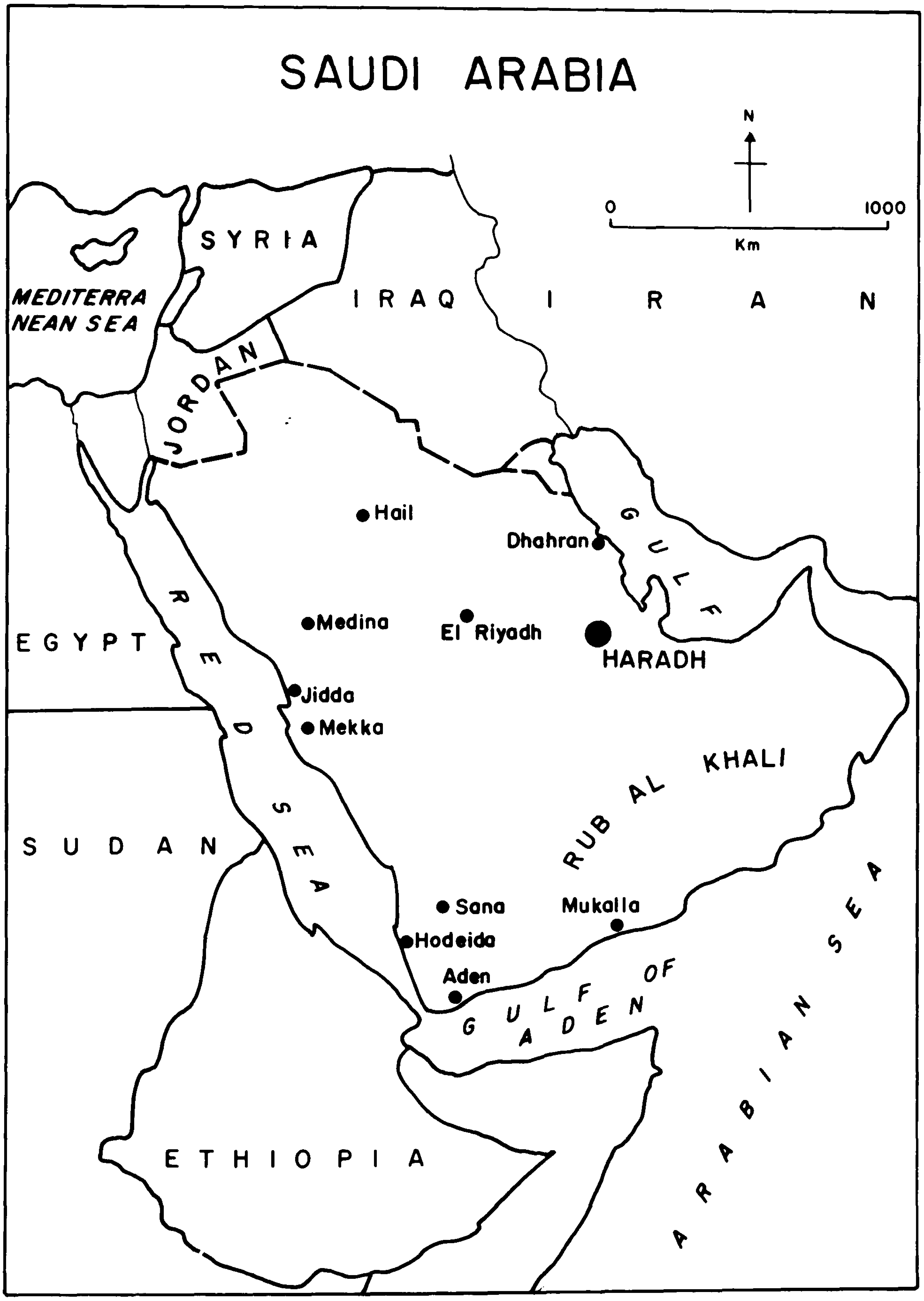
It lies 10 km. east of the Ain Haradh railway station and stretches for 40 km. along the bed of the wadi As Sabha, an average of one kilometre in width.[2]

Present land use

Before the project was established the wadi was used by the Al Jaber subtribe of the Al Murrah for grazing camels. At that time the wadi supported the following plants:[3]

Lasiurus hirsutus (Forssk.)	- grass
Lycium barbarum (L)	- shrub
Ochradenus baccatus (Del.)	- shrub
Haloxylon salicornicum	- shrub
Acacia flava (Schweinf.)	- small tree
Neurada procumbens (L)	- herb
Anabasis setifera	- shrublet
Arnebia decubens (Coss. et Kral.)	- flower

Map No. 1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Jidda
Mekka
RUB AL KHALI
SUDAN
Sana
Mukalla
Hodeida
Aden
GULF OF ADEN
ARABIAN SEA
ETHIOPIA

Plantago ciliata (Desf.) - grass

Senecio coronopifolius (Desf.) - shrublet

Koelpinia linearis (Pall) - weed

Astragalus sp. cf. tribuloides (Del.) - vetch

Diplotaxis harra - cress

Anastatica hierochuntica (L) - flower

The table below shows the basic Arabian range capacity evaluation which has been used for indicating the yields of the Haradh Range.

Table No. 1

Percentage of composition of Range plants in the different Range condition classes

(Animal unit month per acre)*

AVERAGE ANNUAL RAINFALL (ins.)	EXCELLENT 75 to 100	GOOD 50 to 74	FAIR 25 to 49	POOR 0 to 24
2- 4	.1	.08	.05	.025
5- 9	.2	.15	.1	.05
10-14	.4	.3	.2	.1
15-19	.6	.45	.3	.15
20-24	.8	.6	.4	.2
25-29	1.0	.75	.5	.25

Considering the Haradh condition as "good" and with an annual rainfall of two to four inches for the area, one needs one hectare for one sheep every 30 days, and this gives a reasonable estimate of the unaltered pastoral situation.

* One mature cow, camel, horse or five sheep or goats for 30 days grazing.

Research station

Since 1965 a 40 ha. farm has been used to carry out the research necessary for the settlement project, and it is there that the first trials were carried out, including irrigation, fertilizer, variety, planting time and seed requirement trials. With regard to the future main product, 20 sheep were also kept so as to test the suitability of Nejdi sheep for zero-grazing and when reared in sheds.[5]

Three different farm sizes (dealt with later) have been investigated on this experimental area. For each size a pilot plot was established and research on these plots is the basis of the calculations of the project economy. For the new settlers arriving, whether inhabitants of the area or not, the farm was planned to serve also as an education centre, which would continue to provide training in irrigation cultivation for a long period.

Population

The original plan for the settlement scheme assumed that 1,000 families living in a rather indeterminate area south of Al Hassa, i.e. 8,000 persons, would be settled. In fact 7,559 persons living in 1,191 families and inhabiting this area were enumerated in 1969; among them the following age groups were noted.

Table No. 2 Age structure[7]

AGE	MALE NUMBER	%	FEMALE NUMBER	%	TOTAL NUMBER	%
Under 5 years	537	13.3	629	17.8	1,166	15.4
5 to 10 years	774	19.2	700	19.8	1,474	19.5
10 to 15 years	446	11.1	359	10.2	805	10.7
15 to 20 years	328	8.2	264	7.5	592	7.8
20 to 25 years	281	6.7	225	6.4	496	6.6
25 to 30 years	268	6.7	270	7.6	538	7.1
30 to 35 years	269	6.7	263	7.4	532	7.0
35 to 40 years	216	5.3	156	4.4	369	4.9
40 to 50 years	344	8.5	282	8.0	626	8.3
50 to 60 years	255	6.3	183	5.2	483	5.8
60 and above	320	8.0	203	5.7	523	6.9
Total	4,025	100.0	3,523	100.0	7,559	100.0

These people belong to several tribes as shown in the following table:[8]

Table No. 3

NAME OF TRIBE	No. OF FAMILIES	%
Al Murrah	1,080	90.7
Al Ajman	56	4.7
Al Dawaser	35	2.9
Al Kaktan	14	1.2
Other	6	0.5
Total	1.191	100.0

The present population has a male:female ratio of 100 to 88.

Their family status is shown below.

Table No. 4

Family status - over 15 years of age[9]

STATUS	MALE NUMBER	%	FEMALE NUMBER	%	TOTAL NUMBER	%
Single	935	40.6	383	19.8	1,318	31.1
Married	1,242	53.9	1,309	67.5	2,551	60.1
Divorced	37	1.6	37	1.9	74	1.7
Widowed	90	3.9	209	10.8	299	7.1
Total	2,304	100.0	1,938	100.0	4,242	100.0

Of these people 25.2 per cent, i.e. 1,902 persons, had full-time employment. Their professions are shown below:[10]

Table No. 5

PROFESSION	NUMBER	PERCENTAGE
Shepherds	1,178	61.8
Drivers	102	5.4
Labourers	291	15.3
Others	333	17.5
Total	1,902	100.0

These professions show that the first step to permanent settlement was already completed. In fact 1,405 persons, i.e. 18.5 per cent, were already settled in the whole area and 6,154 persons, i.e. 81.4 per cent, are still nomadic.[11]

The following table shows the type of housing used in the area.[12]

Table No. 6

KIND OF ACCOMMODATION	No. OF PEOPLE	PERCENTAGE
Tent	6,210	82.2
Mud cottages	350	4.6
Wood houses (shanty)	999	13.2
Total	7,559	100.0

Before the project was established the average annual income was per head 550.-SR[13] coming from different sources. (See Table No. 7)

Of 6,393 persons over five years of age it was found that 6,123 of them could neither read nor write, 115 persons attended the school and 155 were able to read and write.[15]

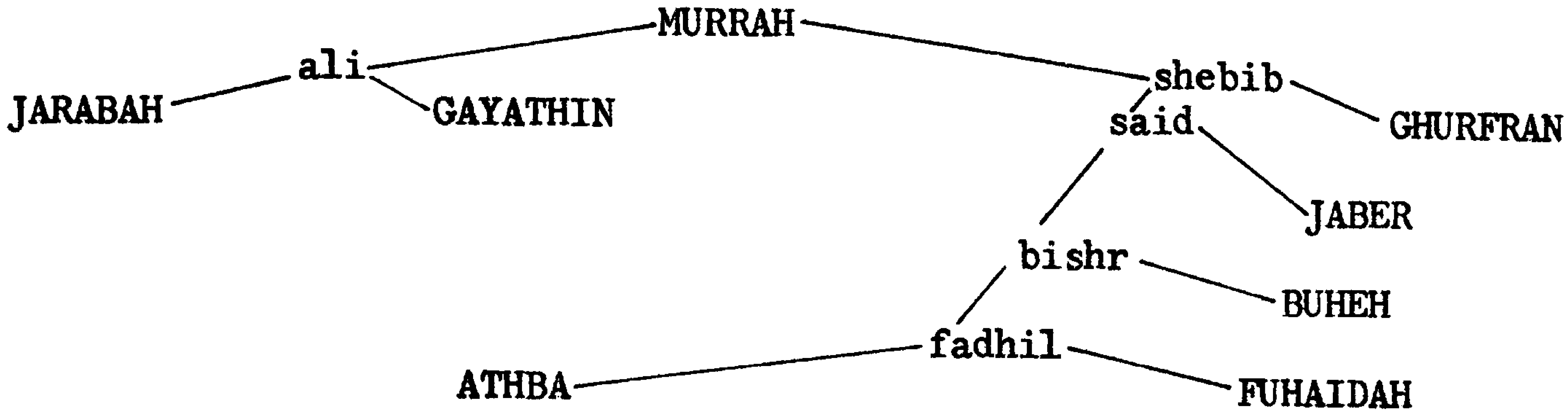
When asked whether they would like to be settled permanently, 6,284 persons, i.e. 90.3 per cent, answered "yes" and 735 persons, i.e. 9.7 per cent, "no". Of those who would like to be settled 6,521, i.e. 95.6 per cent, were willing to become farmers (but see page 25); the rest, i.e. 303 persons or 4.4 per cent, refused. When asked what kind of dwellings they would like, 6,755 persons, i.e. 99 per cent, said "cement cottages", 48 persons, i.e. 0.7 per cent, "mud cottages" and 21 persons, i.e. 0.3 per cent, were undecided.[16]

Since about 90 per cent of the inhabitants of the area are of the Al Murrah tribe, all settlers may be considered as belonging to this tribe. Nevertheless, it is not certain that the people investigated (nearly all of them were of the Al Jaber and Al Ghurfan subtribes) would be the future settlers, because as experience gained from other projects[17] shows, if possible, all subtribes of a tribe to be settled should be numerically and proportionately represented in order to avoid jealousies. The tribal grouping of the Al Murrah may be illustrated as follows:

Table No. 7 — Sources of income[14]

SOURCE OF INCOME	SR TOTAL	PERCENTAGE	AVERAGE ANNUAL FAMILY INCOME IN SR	AVERAGE ANNUAL PER CAPITA INCOME IN SR
Animal sales	2,758,000	66.0	2,320	360
Permanent income from cash donations	1,112,000	26.2	930	150
Other sources	311,000	7.4	260	40
Total	4,181,000	100.0	3,510	550

<u>The tribal grouping of the Al Murrah</u>[18]



"The groups designated by lower case letters express genealogical links and are not operative as everyday groupings. They become operative only when two groups want to act together. Each group designated by capital letters is an actual subtribal descent group which exists "on the ground" and is operative in everyday social relations."

The Al Murrah are patrilocal[19] and partilineal[20] and one of the most highly nomadic tribes of the Arabian Peninsula[21] numbering about 14,000 at present.[22]

The following quotation by Cole[23] indicates the problems the Al Murrah will face in the future:

"The point to be stressed, however, is that the Al Murrah do not identify themselves as primarily herders or nomads or according to any other kind of economic classification. The criterion that distinguishes them from others is a social one. They are <u>tribesmen</u>, and so long as they can maintain their <u>tribal</u> way of life then they have no basic preferences for nomadism over sedentarism. That they can readily maintain their segmentary tribal organisation after large scale sedentarisation has yet to be proved and the current processes of sedentarisation in Saudi Arabia suggests the general breakdown of a tightly knit exclusive tribal organisation although this phenomenon has yet to be studied. If sedentarisation does mean a major breakdown of tribalism and unless there are major proven economic incentives (which have yet to be shown even on a modest scale), then most of the Al Murrah are likely to opt for continuation of their pastoral economy and tribal social organisation."

The land inhabited by the tribe extends from Najran across the Empty Quarter to Hofuf and the Dahna, but they also graze their camels outside this area, i.e. in Oman, Qatar, Abu Dhabi, Kuwait and in the south of Iraq, and if necessary they use the whole Arabian Peninsula as grazing grounds. The wells within their tribal area are solely owned and used by them and only wells at the border of their area are shared with other tribes.[24]

Hofuf is the legal, medical, administrative, trade and religious centre for the tribe. The members of the National Guard receive their monthly payment of 450.-SR there. This is always a social occasion and takes four to five days per month including travelling time.[25]

The oil industry is influencing the life of the tribal members in several ways: (1) through employment, (2) improved infrastructure, (3) wells drilled by the oil companies and (4) now through the Faisal Settlement Project. Whereas points (1) to (3) improve the present standard of living without any major impact, point (4) will, if accepted, completely change the way of life of all participants.

However, according to Cole,[26] a change towards settled agriculture does not necessarily create any serious problems:

"The Al Murrah do not categorically look down on either agriculture or agriculturists, per se. That they have no affiliated sections primarily engaged in settled agriculture is a phenomenon of the physical nature of their territory rather than some unique aspect of their social structure. In the Najran region for example, they claim relationship to a number of settled agricultural tribes and intermarriage does occur, particularly with the Al Jaber subtribe. Likewise, no onus is placed on those Al Murrah who now engage in agricultural wage-labour at the Faisal Settlement Project Farm at Haradh. All maintain that no prejudice of any kind would result towards any family or section that decided to settle and become involved in agriculture so long as he continued to adhere to tribal social etiquette and to lead an upstanding life."

But animal husbandry in irrigation projects requires exactly the kind of work which does not suit the social customs of the Al Murrah. For example, for the care of 20 sheep kept on the Demonstration and Training Farm of the project in 1970, a farmer from Al Hassa had to be engaged because the Al Murrah refused the handling of manure and the cutting of hoofs. Both jobs are unavoidable when raising sheep in sheds.

Also, the 30 turkeys kept on the farm in 1969-70 had not been taken care of by a Marri, because according to them this is not a job for a man; the first man in charge of the turkeys, a man from the north, was sneered at until he resigned.

In addition, as shown later, the agricultural production will demand a permanent labour input. The Al Murrah were not aware of this when they were asked their views on agriculture. Therefore, the author doubts whether they had a complete grasp of the meaning of agriculture, especially members of subtribes who were not personally involved in farm work, and thus the value of their opinions is severely limited.

Nutrition

Dates, camel milk, rice, coffee and the occasional sheep, poultry or game such as waran lizards, hare and gazelle are the main items of the diet. However, the farm workers and their families vary their diet with vegetables and fruit they receive free from the farm.

Land-ownership

As the king is the supreme chief of all tribes he has ultimate power over all "Dira" land, including the project area. The land in question gained its present value mainly because of the newly discovered water.

Nevertheless, the distribution of land would as far as possible be determined according to the old tribal law;[27] that is, only Al Murrah and members of befriended tribes would receive land units.

The farmers would own the farms privately after a probation period of three to five years.[28]

Soil

Soils in the project area vary from light loam to very gravelly loamy sands. (See Map No. 2). These soil types and their proportions of the total agricultural area are as shown below.

Map No. 2

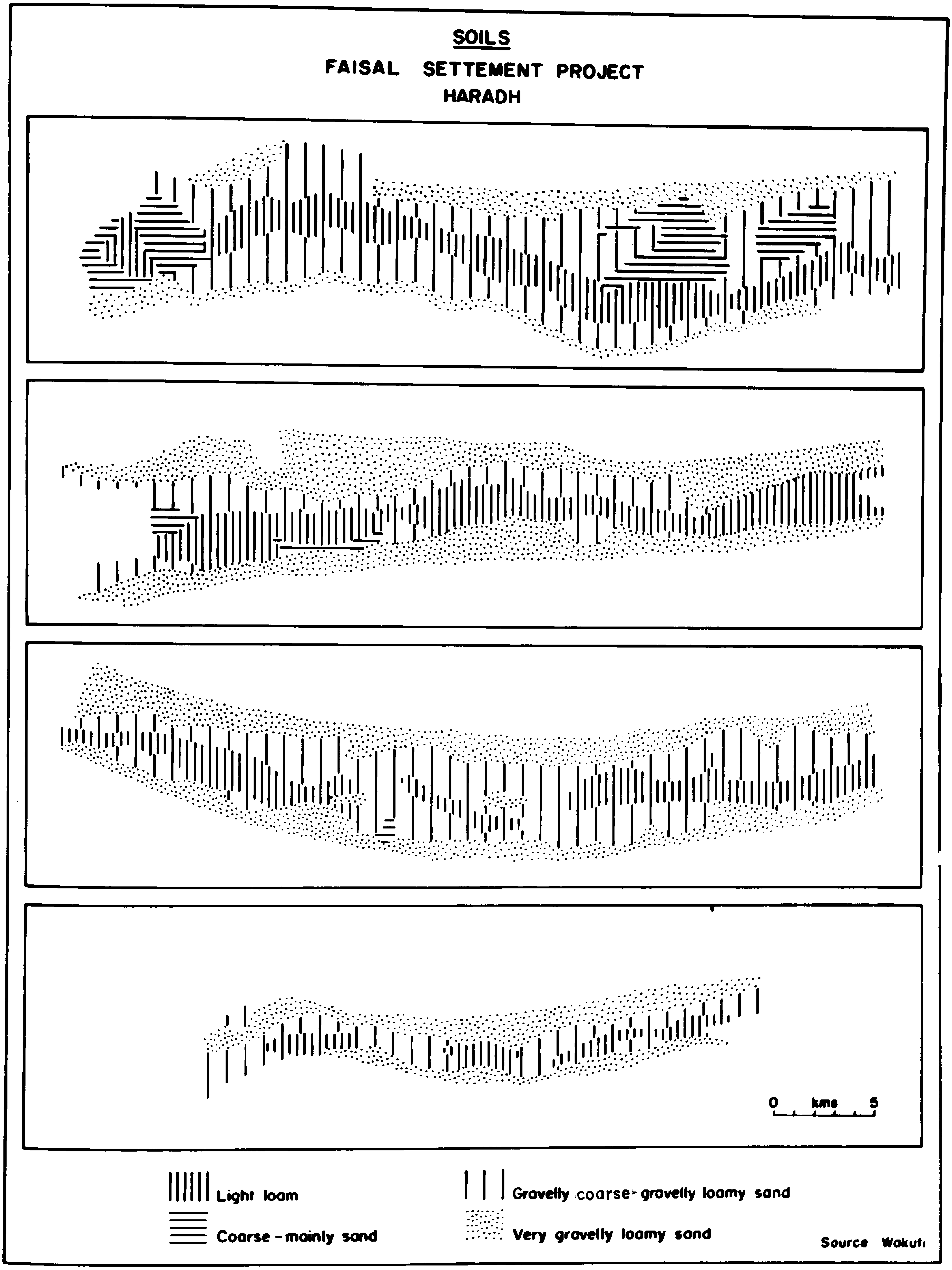

SOILS
FAISAL SETTEMENT PROJECT
HARADH
0 kms 5
Light loam
Coarse - mainly sand
Gravelly coarse- gravelly loamy sand
Very gravelly loamy sand
Source Wakuti

Table No. 8

Soil types in the Faisal Settlement Project[29]

TYPE OF SOIL	ABBREVIATION ON THE MAP	AREA IN ha.	PERCENTAGE OF TOTAL AREA
Light loam	l	939.1	22.13
Coarse - mainly sand	C	227.7	5.37
Gravelly coarse - gravelly loamy sand	gC	1,780.2	41.99
Very gravelly loamy sands	vgC	1,294.4	30.51
Total		4,241.4	100.0

The above table shows that only about one third of the project area has soils of the loamy (L) and (C) soil types. This area is very good for agriculture and no problems will occur when cultivating. When measured one hour after irrigation the water had infiltrated to a depth of up to 0.26 m. of the loamy soil type.

Typical profiles of sandy loam and loamy sand are shown below:[30]

Sandy loam

0- 25 cm.: fine sandy loam, yellowish-brown (dry), darker when moist. Weak structure, soft when dry, slightly sticky when wet, pH 7.5.

Loamy sand

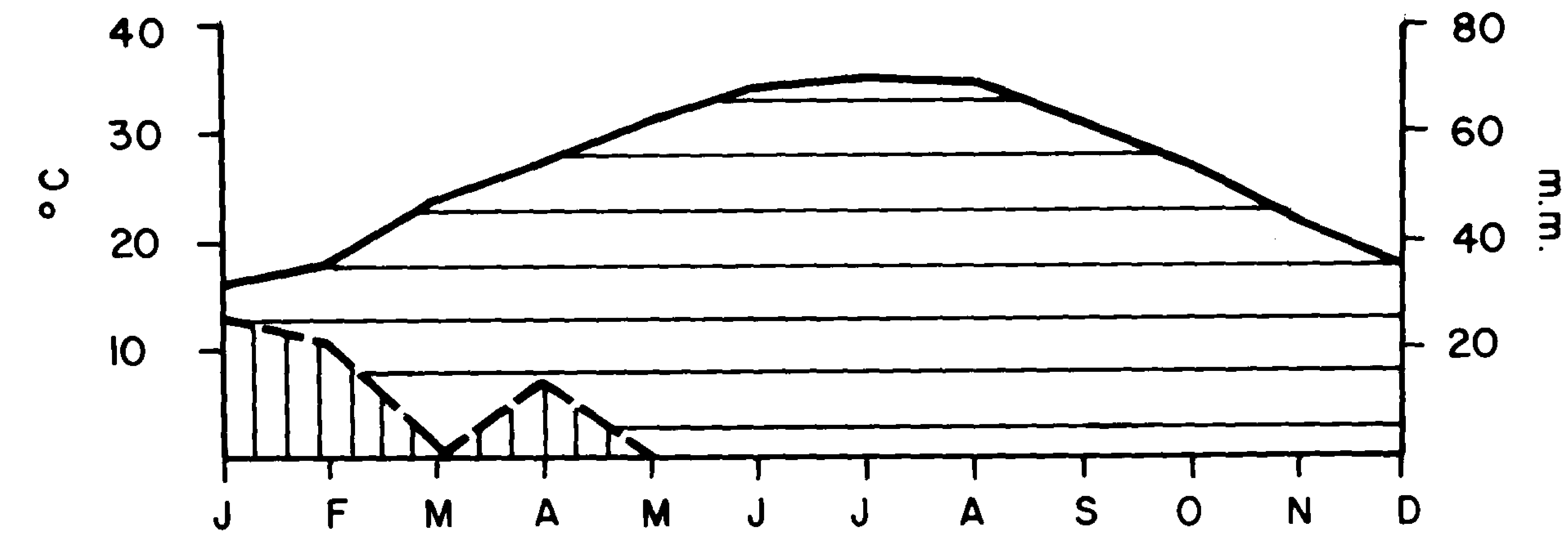
0- 40 cm.: loamy sand, light yellowish-brown when dry, darker when moist. Weak structure, loose when dry, not sticky when wet, pH 7.0 -7.3.

40-100 cm.: loamy sand, yellowish-brown when dry, darker when moist. Very loose when dry, not sticky when wet, pH above 7.5.

The remaining soils in the project area are very permeable. One hour after irrigation, the water had infiltrated them to a depth of up

Diagram No. 1

CLIMATIC DIAGRAM FAISAL SETTLEMENT PROJECT, HARADH



	J	F	M	A	M	J	J	A	S	O	N	D
TEMP. °C	16·0	17·5	23·5	27·0	31·0	34·0	35·0	34·5	31·0	27·0	21·5	17·5
m.m.	26·0	21·0	1·0	14·0	0·9					1·5	1·5	0·1

THIS DIAGRAM IS BASED ON DATA COLLECTED BY ITALCONSULT
THE VALUE OF THE DIAGRAM IS VERY PROBLEMATIC, BECAUSE OF THE SHORT PERIOD OF MEASUREMENT AND DIFFERENT PERIODS. THE READINGS WERE TAKEN FOR TEMPERATURE FROM AUGUST 1968 UNTIL JULY 1970 AND FOR PRECIPITATION FROM JANUARY 1967 UNTIL DECEMBER 1969

---- RAINFALL —— TEMPERATURE

DRY SEASON HUMID SEASON

to 1.14 m. It is most likely that the soils of these types (gC and vgC) will require much more water than necessary to cover the demand of the plants, the leaching requirements and the normal distribution losses because of their high permeability.

There are neither rocks nor hard-pans in the wadi. However, concentrations of salt are found in some places. But these layers are easily dissolved in water and will be eliminated soon after cultivation has started.

Generally the project area soils are lacking N and are poor in P_2O_5 but relatively rich in trace elements.[31] There is no organic matter in the soils and their pH-value is between 7.0 and 8.4.

Climate

The area has a typical desert climate with high temperatures and little and uncertain rainfall. When rain does fall a sparse vegetation grows quickly but is short-lived, although bushes, small trees and some grasses grow where there is underground water.

Diagram No. 1 illustrates some basic characteristics of the climate.

The Saudi Arabian meteorological service has only recently been established and thus no earlier data are available. The data mentioned here were collected mainly during the author's stay in Haradh.

During years with a total rainfall of 125 mm. and more the daily rainfall may reach 25 mm., whereas in other years the total rainfall amounts only to 25 mm.[32] The relative humidity is between 10 and 35 per cent depending upon the time of day. The evaporation from a free water surface is about 3,000 mm. and the annual average evapotranspiration found by ITALCONSULT[33] was 2,760 mm. between 1965 and 1969. The temperatures in the area are shown in the following tables.

Table No. 9

Temperatures - Minimum - Maximum - monthly average - in centigrade[34]

1 April 1969 - 31 March 1970

MONTH	MIN.	MAX.	MEAN MONTHLY
January	4.7	22.1	11.8
February	7.6	27.9	16.6
March	10.4	29.9	19.0
April	19.5	37.1	27.5
May	23.5	45.3	32.1
June	25.4	50.1	37.9
July	24.8	46.9	35.5
August	24.4	47.3	35.6
September	20.8	44.3	35.0
October	15.5	40.8	21.2
November	11.4	28.4	19.1
December	5.9	26.3	14.1

Table No. 10

Mean monthly temperatures - taking the readings at 01-07-13-19 hrs.
1 April 1969 to 30 November 1970[35]

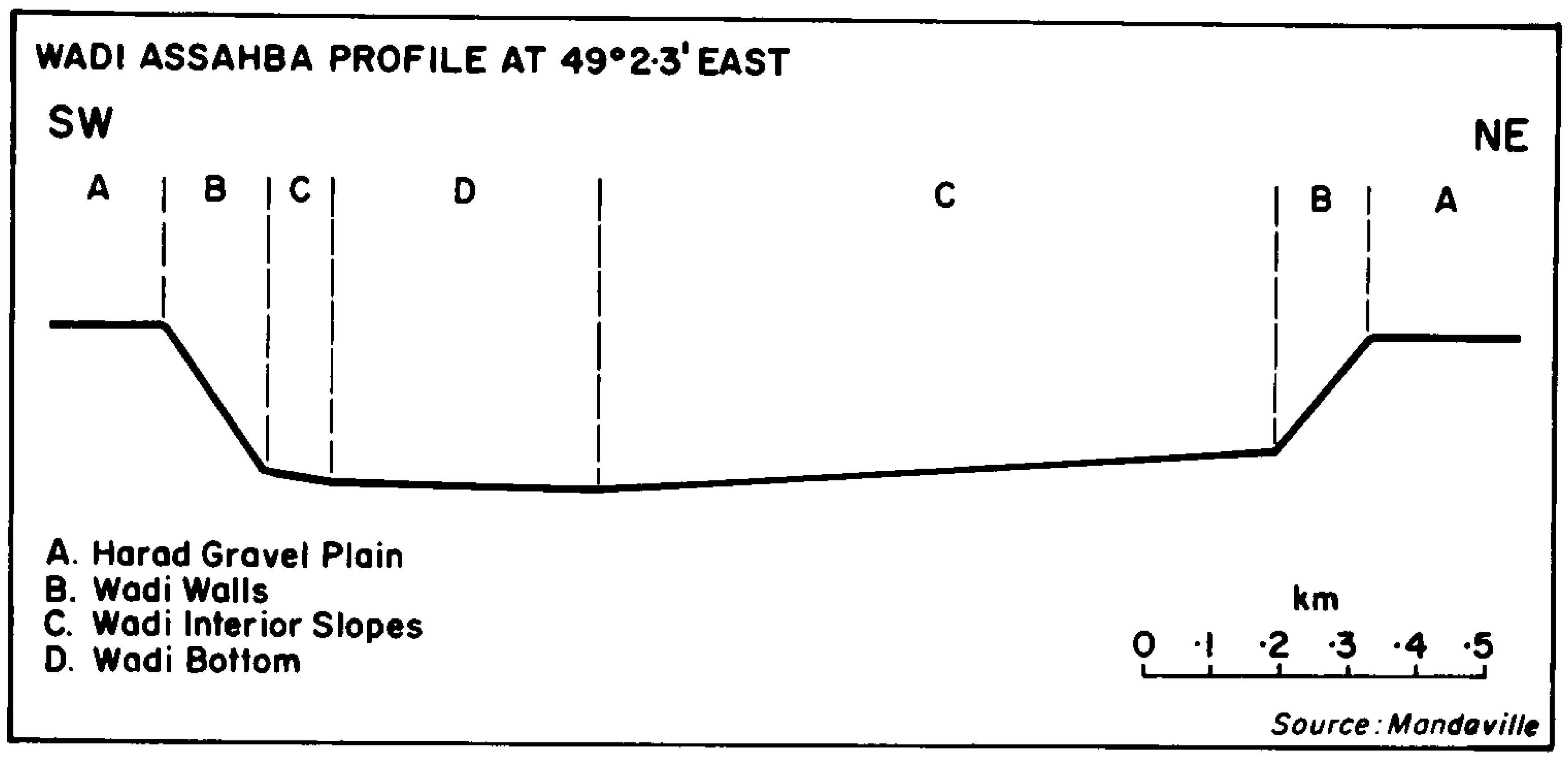
YEAR	MONTH	TEMPERATUES IN CENTIGRADE
1969	April	27.5
	May	32.1
	June	37.9
	July	35.5
	August	32.0
	September	32.0
	October	21.2
	November	19.1
	December	14.6
1970	January	11.8
	February	16.6
	March	19.9
	April	26.1
	May	32.3
	June	37.1
	July	36.9
	August	35.7
	September	31.6
	October	-
	November	19.8

Although the period during which the data were collected was not long, these data give a fairly reliable picture of the restricting influence of the climate.

Topography

The design of the project was strongly influenced by the topography of the wadi. Although there is hardly any restriction to the length of the project, the width of the wadi - only one kilometre on average - is a restricting factor. A typical cross-section of the wadi is shown in the diagram below:

Diagram No. 2



Flood water issuing from the side wadis would endanger the future agricultural production in the scheme, but one way to avoid any damage would be to cultivate the side wadis. If planted with drought resistant grasses this would require only the initial effort of planting, after which the grass would survive through natural precipitation only.

Irrigation

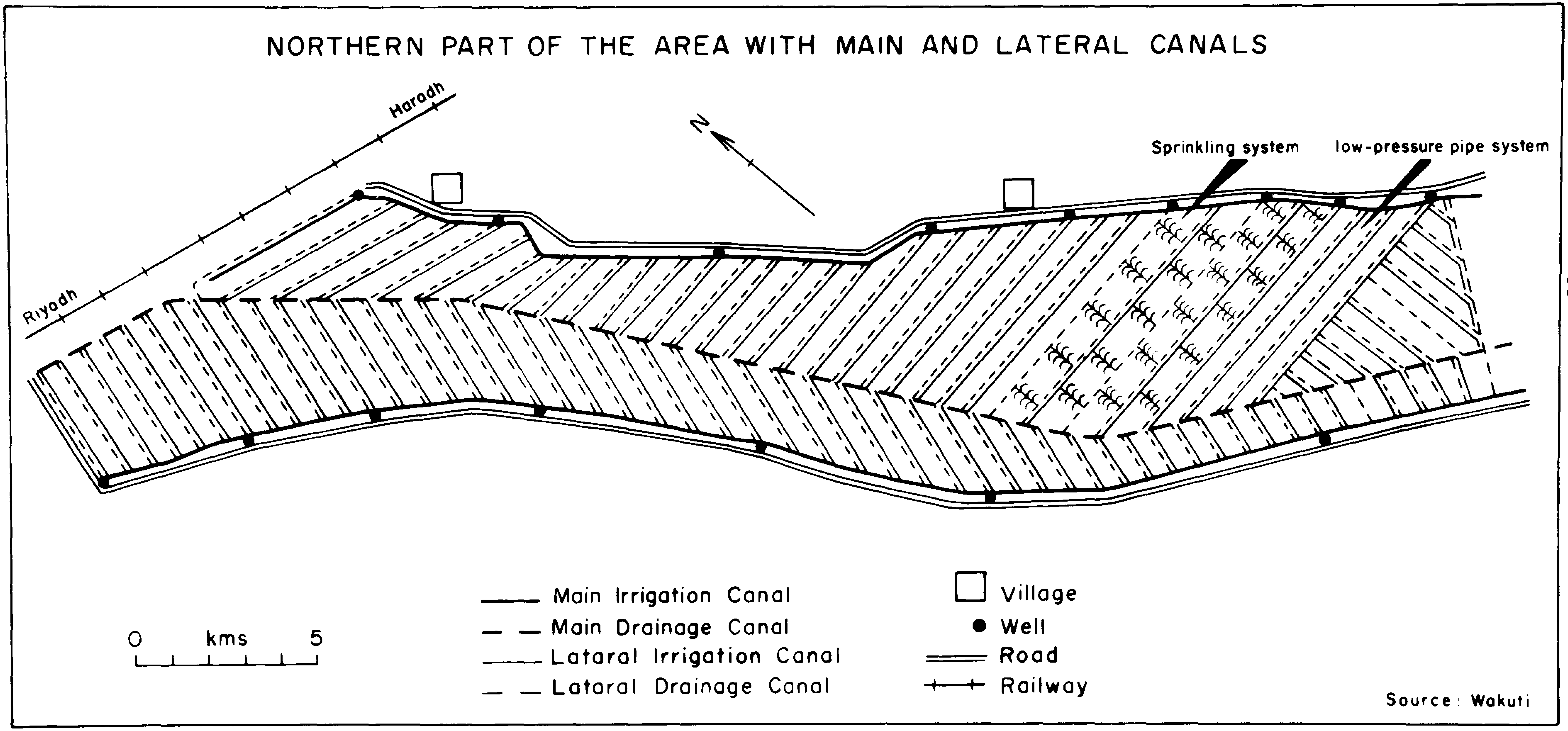
Irrigation system

Map No. 3 shows only 10 km. of the total length of the project of 40 km., however, the pattern shown is typical and continues over the whole project. Thus a section of 10 km. is sufficient to illustrate the features of the irrigation and drainage system.

As the project area has mostly sandy soils it needs a dense canal network; the maximum distance between the canals is 150 m.

Three thousand, seven hundred hectares of the whole cultivation area of 4,000 ha. are irrigated by open canals which provide the most economical system, so far as construction and irrigation are concerned.

Map No. 3


NORTHERN PART OF THE AREA WITH MAIN AND LATERAL CANALS
Riyadh
Haradh
N
Sprinkling system
low-pressure pipe system
0 kms 5
Main Irrigation Canal
Main Drainage Canal
Lataral Irrigation Canal
Lataral Drainage Canal
Village
Well
Road
Railway
Source : Wakuti

A further area of 150 ha. is equipped with a low pressure pipe system which requires higher construction costs and on a second area of 150 ha. sprinkling irrigation under extreme climatic conditions will be tested.[36]

Open concrete canals

The main irrigation canals run along both sides of the wadi and connect the wells; if a well becomes inoperative another well further up the wadi can act as a temporary substitute.

The irrigation canals are made of prefabricated reinforced concrete with parabolic profiles. Main canals have profiles of 66 and 55 cm. and the lateral canals have profiles of 55 and 42 cm. The lateral canals branch off the main canals. The slope of the lateral canal ranges from 0.5 to 3 per thousand. The velocity of flow for all canals ranges from 0.4 to 1.0 m./sec.[37]

The freeboard for the main irrigation canals must be at least 8.5 to 9.0 cm. and for the lateral canals not less than 5.5 cm.[38]

The table below shows the characteristics of the canals.[39]

Table No. 11

GRADIENT PER THOUSAND	CONCRETE PROFILE cm.	WATER DEPTH cm.	FREEBOARD cm.	VELOCITY m./sec.
Main canals				
0.2	1/2 ∅ 85	34	8.5	0.33
0.6	1/2 ∅ 85	25	17.5	0.51
0.7	1/2 ∅ 70	26.5	8.5	0.52
2.0	1/2 ∅ 70	20	15.0	0.77
Lateral canals				
0.5	1/2 ∅ 70	29	6.0	0.46
1.8	1/2 ∅ 70	21	14.0	0.73
2.0	1/2 ∅ 55	22	5.5	0.78
3.0	1/2 ∅ 55	20	7.5	0.90

The longitudinal slope has a gradient of two to four per thousand.

Field tests have shown that for border strip and furrow irrigation with a maximum length of 150 m. this gradient is sufficient.

To bring the water from the lateral canals to the fields, hose-syphons will be used.[40]

Low pressure pipe system

Wells B14 and B15 supply water to an area of 156 ha. by means of a low pressure pipe system. As the pipes are underground heavy machinery can be used. The pipes used are of concrete with diameters of 30 to 40 cm. and can accommodate a rate of flow of 36 and 71 ltr./sec. respectively. There is a distance of 150 m. between the pipelines, and stand pipes of 125 mm. diameter have been located at intervals of 12 m.

Since the area will be irrigated in strips, each outlet will supply two of the strips, each of which is six metres wide and 150 m. long.

This 156 ha. area was established to find out whether the high construction costs for such a system are economically justified.[41]

Sprinkler system

The planned sprinkler system, supplied by wells B12 and B13 would irrigate an area of 161 ha. Two pumps with a combined discharge capacity of 155 cu.m./h. pump water into underground pipelines, 100 to 250 mm. in diameter, portable pipelines being attached to hydrants at intervals of 96 m., each being 70 mm. in diameter and 200 m. long and having 11 sprinklers. Total sprinkler output is 2.14 cu.m./h. and the distance between the sprinklers would be 18 m. As the sprinklers to be installed have a discharge rate of 6.6 mm./h., they could be operated in three six-hourly shifts.[42]

When "border strip" or "furrow" irrigation is used 65 per cent of the total water is used whereas with "sprinkler irrigation" the proportion is 70 to 75 per cent.

A daily average requirement of 7.0 mm., which covers leaching and all losses, is needed during winter. To irrigate every six days the required application is 42 mm.[43]

Approximately 11.6 mm. daily is required during the peak of summer when the monthly evapotranspiration reaches 250 mm. To irrigate every four days the required application is 46.3 mm.

The sprinkler used would discharge 1.61 cu.m./h. over an area of 18 x 24 m., which is equivalent to a precipitation of 3.75 mm./h. Thus the irrigation time during summer would be 12.3 hours daily, (46.3 ÷ 3.75) and the total operating time 14 hours daily.[44]

Water demand and supply

Fifty wells have been drilled on either side of the wadi and there were also two wells at the Demonstration and Training Farm, thus 52 wells provide water for the whole project of 4,000 ha., i.e. each well supplies 80 ha.

Since rainfall is too little and too irregular, the project depends entirely on water supplied by the wells. Water from these wells originates from the 300 m. thick Umm er Radhuma stratum which consists of dolomite limestone of the Paleocene period. Its surface, lying 150 to 200 m. below ground level, is covered by a clay stratum, several metres thick, from which the artesian tension results. Above it lies a stratum of Eocene clay-stone and dolomite-limestone, 80 to 120 m. thick, and this is superimposed by a stratum of lime-sandstone, 40 to 60 m. thick, of Miopliocene age. The wadi surface layer, 20 to 30 m. thick, consists of quartenary sands and gravels.

The hydrostatic level of the semi-artesian aquifer is 75 m. below surface at the southern end of the wadi and 100 m. below surface at the northern end. Only in the areas around wells B34 and B35 does an uplift appear in the Umm er Radhuma stratum at about 65 m. below the surface, so that the water in this area is no longer under artesian pressure.

Three test wells, B6, B26 and B48, were drilled in the middle, at the northern end and the southern end of the project area. Even when pumping continuously for a period of nine days with outputs up to 150 ltr./sec. at times, the water-level only dropped to five metres below the hydrostatic level. During later pump tests, four wells showed a greater drop in the water-level of up to 15 m.

The distance between the wells varies between 450 and 2,500 m.

Calculations regarding the presence of ground water showed that, even if ground water recharge is discounted, it would still be possible to use the existing reserves without danger of exhaustion for a period of 100 years.[45]

The quantity of water discharged annually by each well is: $71 \times 3.6 \times 24 \times 365 = 2.25 \times 10^6$ cu.m.

The annual discharge for the 50 wells, i.e. all the wells except the two in the Demonstration and Training Farm, is: $2.25 \times 10^6 \times 50 = 1.125 \times 10^8$ cu.m.

The water quantity of the Umm er Radhuma available for the Faisal Settlement Project is estimated to be 2.3×10^9 cu.m.

The average annual ground water recharge is estimated to be at least 4.8×10^8 cu.m.[46], provided by precipitation falling over a large catchment area of 2,600 sq.km.

The temperature of the water ranges from 29° to 32°C.

The total salinity of the water reaches 900 or even 1,200 ppm, corresponding to a conductivity of 1.4 to 1.9 mm. hos/cm. The chemical analysis shows:

380 mg./ltr. chlorine

240 mg./ltr. sulphate

150 mg./ltr. calcium

196 mg./ltr. sodium

As the small SAR value of 3.38 shows, sodium presents no danger. For irrigation purposes the water can be classified according to the Riverside Classification of group C3-S1, that is: high salinity - low proportion of sodium. This water can be used for irrigation if sufficient drainage and leaching are guaranteed.[47]

Therefore, it will be necessary to have a surplus of irrigation water for constant leaching. With a leaching proportion of 23 per cent the salt content of the soil water will not exceed 5,100 ppm. All crops, excepting those sensitive to salt, can be cultivated.

Including the leaching requirement, the losses in the feeder canals and the terrain, and percolation in the field, the maximum calculated efficiency for irrigation is 65 per cent.[48]

Water demand in detail[49]

The yearly potential evaporation is 2,500 mm.

Peak demand in summer

Monthly peak evapotranspiration	250 mm.
Monthly leaching requirement incl. losses	135 mm.
Monthly peak irrigation requirement	385 mm.
Monthly peak irrigation requirement per ha.	3,850 cu.m./ha.
Efficiency (250 ÷ 385)	65%
Daily peak requirement (385 ÷ 30)	12.8 mm.
Daily peak requirement per ha.	1.41 ltr./sec.
Daily usable peak requirement (12.8 x 0.65)	8.3 mm.
Daily peak rate of evapotranspiration	8.3 mm.

Average demand in winter

Monthly evaporation	150 mm.
Monthly leaching requirement incl. losses	80 mm.
Monthly irrigation requirement	230 mm.
Monthly irrigation requirement per ha.	2,300 cu.m./ha.

Efficiency	65%
Daily requirement	7.7 mm.
Requirement per ha.	0.89 ltr./sec.
Daily usable requirement	5.0 mm.

Meeting the water demand[50]

Meeting peak demand in summer

60% of the total area is to be cultivated in summer, i.e. of the 80 ha. plot supplied by each well	48 ha.
Water demand per second for 48 ha.	70 ltr./sec.
Discharge of each well	about 70 to 75 ltr./sec.
Max. frequency	6 days
Application every 6 days	77 mm.
Max. application time (77 mm. ÷ 10 mm./h.)	7.7 hours
Application every 4 days	51 mm.
Application time (51 mm. ÷ 10 mm./h.)	5.1 hours

Meeting demand in winter

Size of plot supplied by each well	80 ha.
Water demand per second for 80 ha.	71 ltr./sec.
Discharge of each well	about 70 to 75 ltr./sec.
Application every 6 days	46.2 mm.
Application time	4.6 hours

Drainage[51]

Drainage system (see Map No. 3)

The average annual precipitation is low, but it varies considerably in quantity from year to year. In normal conditions it is mainly water from the irrigation canals which must be drained. Since the efficiency for irrigation water is 65 per cent, 35 per cent will be the maximum for leaching and losses. The dry weather discharge is as follows:

24.8 ltr./sec. from 80 ha., or 0.31 ltr./sec. from one hectare, or 1,240 ltr./sec. from the whole project.

Flood discharge

Wadi as Sabha starts in the Dhana Sands not far from the Dammam-Riyadh railway. The wadi Ashawi touches the project area at the northernmost point of the wadi as Sabha. The Jaffura Sands lie 25 km. to the south-east of the wadi as Sabha and the project area. Thus the flood catchment area is:

Upper end	870 sq.km.
Lower end	1,263 sq.km.

High flood discharge

Maximum daily rainfall		25 mm.
Evaporation	7 mm.	
Infiltration	7 mm.	
Retention in depressions	3 mm.	17 mm.
Maximum flood discharge		8 mm.

Low flood discharge

Average daily rainfall		10 mm.
Evaporation	4 mm.	
Infiltration	3 mm.	
Retention in depressions	2 mm.	9 mm.
Daily discharge		1 mm.

When rainfall lasts 48 hours the quantity drained will be 5.25 cu.m./sec. at km. 0+00 of the main drainage canal.

Main drainage canal

The maximum discharge rate is 104 cu.m./sec.

Since not all catchment areas lie at the same distance from the project area, the water which would pass km. 0+00 during high flood discharge is 42 cu.m./sec., at km. 5+355 plot 14, 4.77 cu.m./sec. and at km. 9+255 plot 17, 5.40 cu.m./sec.

The peak discharge from plots 1-7 passes km. 9+255 at a velocity of 5.0 km./h. 43 hours after rain has started. The relatively low discharge of plot 17 is ignored as it is assumed that high flood discharge may occur only at intervals of 15 to 30 years.

It is assumed that the lowest discharge of 5.25 cu.m./sec. may occur every three to five years, and the dry weather discharge of 1.24 cu.m./sec. will only occur after saturation due to leaching.

The main drainage canals will be designed for a flow of 42 cu.m./sec.

Dimension of the main drainage canal

For effective discharge a main drainage canal, 38.85 km. long, is needed. In addition, another main drainage canal, 3.4 km. long, is needed to drain the water out of the wadi into the desert. Their dimensions are as follows:

Depth: 2.00 m.
Bottom width: 4.00 m.
Slope: 1:2

Table No. 12

DISCHARGE cu.m./sec.	GRADIENT PER THOUSAND	WATER DEPTH-m.	VELOCITY m./sec.
2.00	0.6	3.20	1.26
	0.8	3.00	1.40
5.25	0.6	1.15	0.73
	0.8	1.05	0.82
1.24	0.6	0.52	0.47
	0.8	0.48	0.52

Velocity of flow

The design of the canal is based on the velocity of the water to flow through it. The lowest velocity of flow should be 0.35 to 0.38 m./sec. in order to avoid sand deposits in the canals and the highest is determined by the soil type, that is 0.5 to 0.6 m./sec. in light loamy sands and 0.7 to 0.9 m./sec. in gravelly coarse sands.

Thus the velocities of 0.47 and 0.52 m./sec. endanger the canal profiles. The velocities of 0.73 and 0.82 m./sec. do not endanger the canals which have gravelly, coarse sand deposits on their bottoms. Where loamy sand is to be found a bottom reinforcement is necessary. Prefabricated concrete beams are laid along the canal at intervals of 150 m. The flood discharge will affect the canal profile. Measures to prevent such erosion have not been provided for. After floods the canal profile must be remade but this is cheaper than taking special measures beforehand. However, these floods are very rare.

Lateral drainage canals

The lateral canals are designed to drain the water quantity necessary for leaching, i.e. a maximum of 0.35 x 71 = 25 ltr./sec. This discharge will not occur during the first years but will infiltrate underground.

The lateral drainage canals from the overflows must be able to drain 71 ltr./sec., i.e. the total output of the well, and the lateral canals serving side wadis must be able to drain all the water from these wadis.

Dimensions of the lateral drainage canals

The lateral canals have the following measurements:

Depth: 1 m.

Bottom width: 0.40 m.

Side slope: 1:1.5

The lateral canals with catchment areas, i.e. side wadis, will have a bottom width of 0.40 m. to 2.00 m. and a side gradient of 1:1.5 to 1:2, depending on the quantity of water they have to discharge.

The velocity of flow will be limited to 0.20 to 0.70 m./sec. which will prevent sediment settling due to low velocity, or erosion due to high velocity of flow.

The lateral canals have only been completed in the northern part of the project as far as the Demonstration and Training Farm. Because sand-storms fill in these canals before they can come into operation, further construction has been postponed.[52]

Resettlement

The Al Murrah never established any permanent settlements, but initiated four settlements of seasonal occupance on their tribal land, that is As-Sikak, An-Nibak, Yabrin and Al Khinn. These places are at present more or less abandoned for most of the year; nevertheless, with the exception of Al Khinn, all of them have primary schools.

The most important traditional settlement in the area is Yabrin, 90 km. south of the Faisal Settlement Project, which is owned by the Al Jaber subtribe in general, the wells being owned individually by the extended families of this subtribe.

During summer several sections of the Al Jaber live there in their own houses, but only the amir ibn Muradhaf and a few families spent the whole year there.

A number of Al Murrah settled spontaneously during the last 10 years near towns and other places of employment. In Haradh, a shanty town, more and more leaders of the Al Ghurfran subtribe are building houses. Thus this rapidly expanding town is becoming the centre of the subtribe.

The general approach of the Al Murrah towards settlement is shown very clearly by Cole:[53]

"The Al Murrah in no way look down on sedentarisation per se, in spite of the fact that they hold most sedentary people in Saudi Arabia in very low esteem. All of them are consciously aware of the present-day trend of many Saudi Bedouins toward settlement or at least partial settlement and most of them are desirous of some kind of participation in this general process. Few of them would like to abandon their camels and give up pastoralism *in toto*, but almost everyone would ideally like to have at least a summer house and a small agricultural plot with some date trees. If the agricultural plot should require the full-time employment of a family member and produce a return worthy of his full-time employment, then every household or herding unit would be very willing to spare a member for such an activity, but none of them would like to abandon his tents and his animals in an abrupt change to settled life."

Furthermore, in Yabrin in summer 1969 some of the leaders of Al Jaber expressed their refusal to give up their way of life and move to a permanent settlement. They also said that Al Jaber would only consider any kind of settlement, if it could be assured that their people would stay together.[54]

Nevertheless, it is very difficult for the Al Murrah to remain full nomads in the present circumstances of Saudi Arabia.

According to Peppelenbosch the features of pastoral nomadism are:[55]

"1. The non-sedentary animal husbandry of nomads in search of pastures,
2. with the entire human group accompanying the flocks and herds,
3. that roam seasonally over winter and summer grazing grounds,
4. following more or less fixed routes on tribal land, but still
5. without being self-sufficient."

For most of the Al Murrah this is still valid, the majority being engaged in camel-nomadism. Nevertheless, during the last 20 years about 20 per cent of the Al Murrah have changed from camel-raising to sheep and goat-raising and thus are more restricted in their movements. They depend upon motor-cars in order to profit from their more market oriented livestock. Thus the first step towards settlement has been made. Since keeping sheep and goats does not require as much manpower as camel-raising, the men are free to look for other jobs, i.e. as drivers, labourers, or they remain unemployed. With the result that the next step to permanent full-time employment outside the tribal society is not far away. In fact in each subtribe men of this type, who had either sold their animals or left them with relatives, could be found. As long as their wives remain with the tribe such men are still considered as members. Only if their wives go with them to the cities do they leave the tribal society.

The new settlers could be recruited from this group, because they are not only willing, but also more able, to settle than the others since they have already abandoned nomadism.

The old sources of nomads' income in Saudi Arabia are declining or disappearing. These were (1) selling of camels, (2) raiding of villages and caravans, (3) protection and (4) guidance of caravans.[56] The reasons for this decline or disappearance are manifold, but the most significant causes are:[57]

"1. The establishment of order and unity, and security of life and property, specially by Al Saud in the largest component region of the peninsula but also by other rulers in smaller realms.

2. The development, for the first time in history, of a firm economic basis of life, for Government and for the population.

3. The growth of material and other improvements in living, mainly made possible, directly or indirectly, by the economic progress mentioned above.

4. The ending of Arabia's long condition of at least relative isolation, with its entry into the modern world, and the entry into it, at the same time, of many new influences from other societies."

Of all the subtribes of the Al Murrah only the Al Jaber and the Al Ghurfran are represented in the labour force of the Demonstration and Training Farm, but when selecting the settlers all the subtribes of the Al Murrah must be considered. The best solution would be to recruit members from all extended families. Thus all members of the Al Murrah could participate, and acceptance of the project, and the new way of life would be easier.

For the future farmers there are plans to build seven small villages with 120 dwelling units each and one larger village with about 200 dwelling units along the eastern side of the wadi, i.e. outside the wadi so as to avoid building houses on arable land. The location of the settlements has been chosen with the aim of allowing the farmers to reach their fields in the shortest time possible.

Each village will have a mosque, a school and some shops. Besides this, the central village will have all facilities necessary for the entire settlement project; that is a market place with storage halls, processing plant for the co-operative, administrative buildings, police station, hospital and a hotel.[58] But the construction of these villages has been postponed, although the actual planning is completed. A basic housing unit of 5.00 x 6.50 m., with two rooms, surrounded by a compound wall of 40 x 40 m. is recommended. This unit could be enlarged by the inhabitants if necessary.[59]

Figure No. 1 shows the pattern of several houses and Figure No. 2 shows the layout for the planned villages.

According to Dequin[60] 180.-SR should be invested by each settler for a 90 sheep enclosure, but, since the houses have been postponed for the moment, and even if the houses were built it is rather doubtful whether the farmer would invest this money as sheep and goats are allowed to run loose in the compound in similar houses in Haradh, this sum has been disregarded in the calculation of the profitability of sheep keeping.

Power supply

A central gas turbine station at a gas-oil separator 10 km. from the central village will generate energy for the entire project. As this gas costs nothing as it would normally be flared, gas turbines have been given preference over other sources of power.[61]

Transport

Communication within the project is assured by a bituminized road, 40 km. long and seven metres wide, built along the left side of the main

Figure No. 1

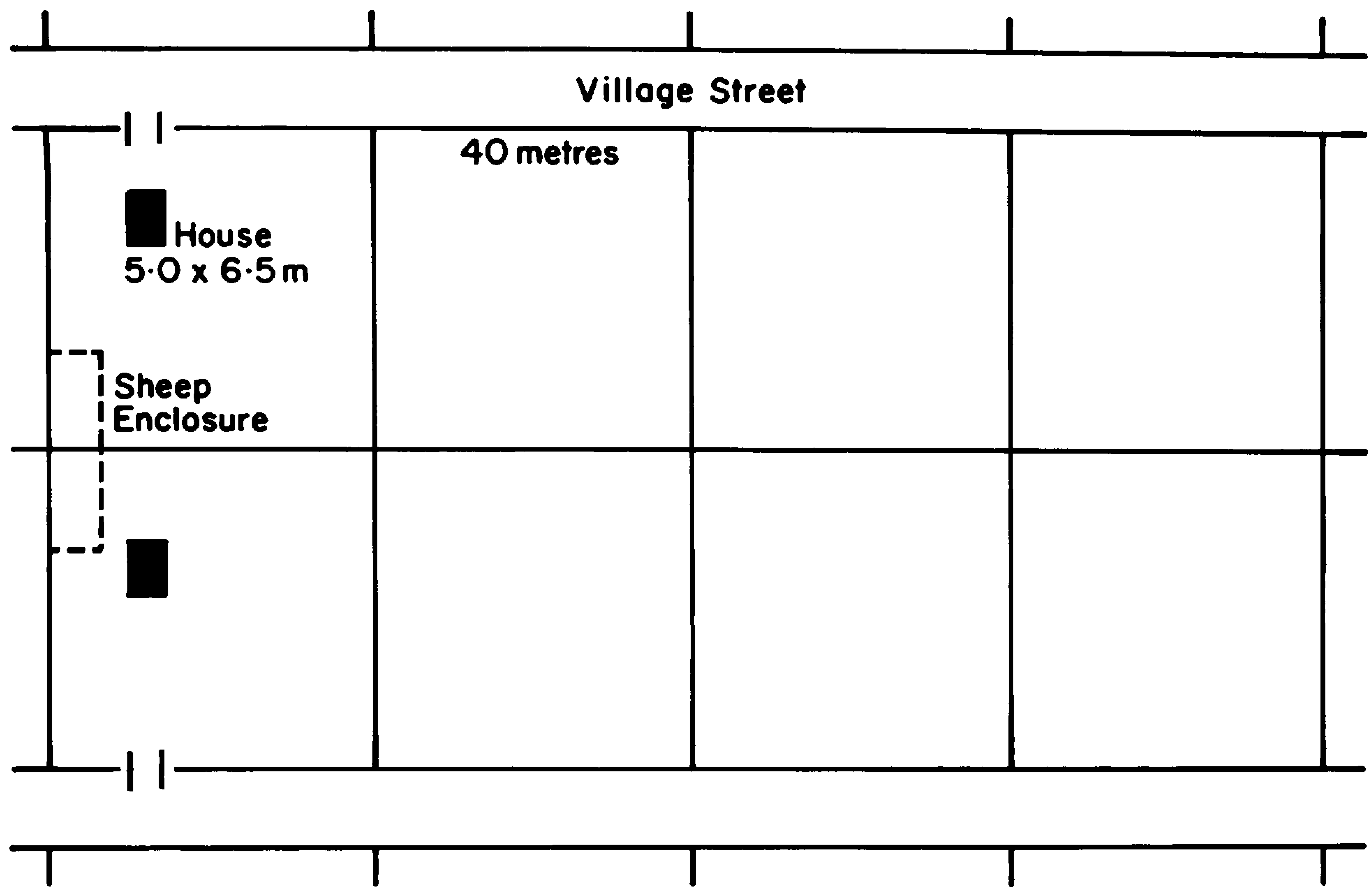
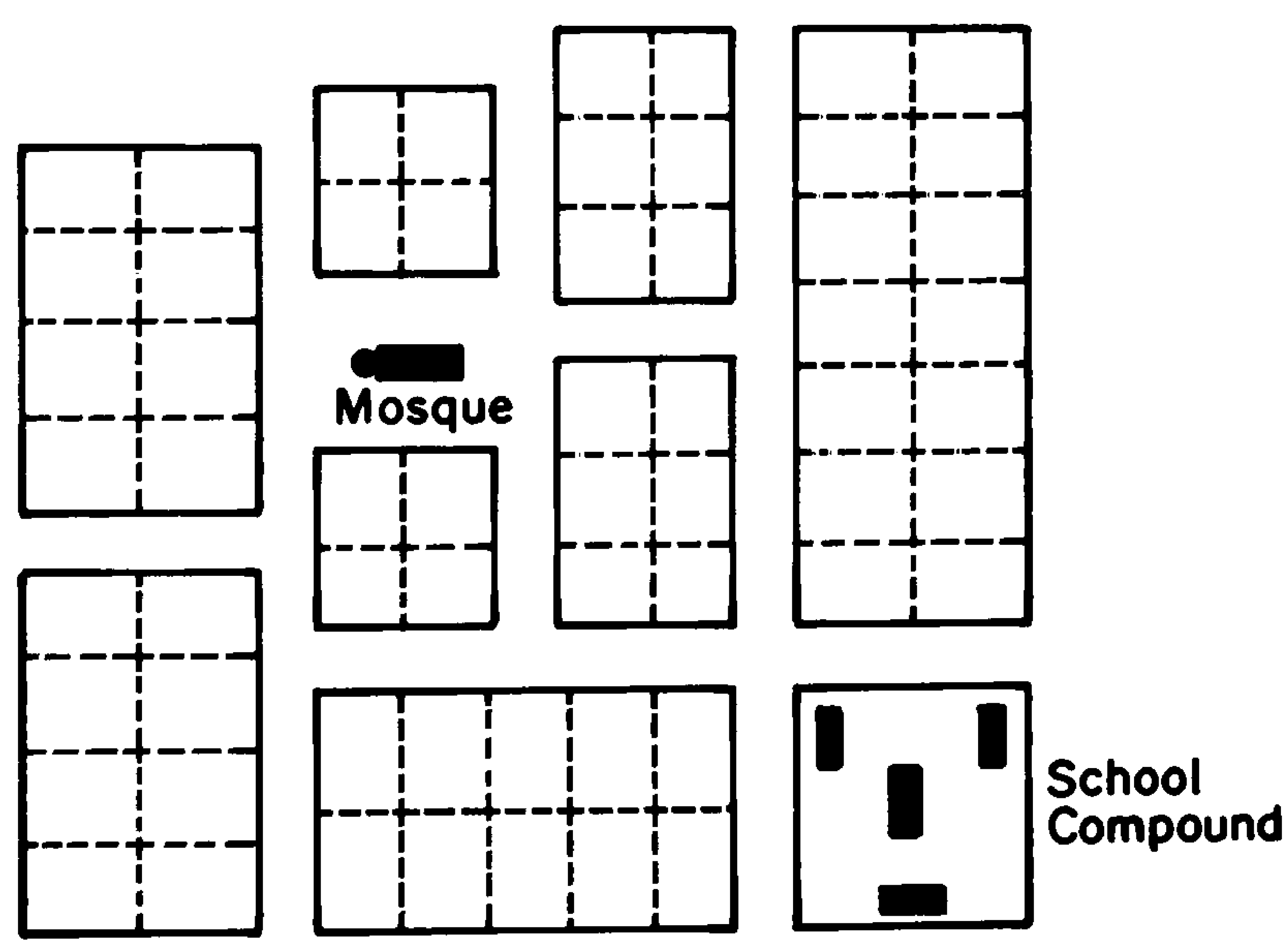


Figure No. 2



Source: Wakuti

irrigation canal.

The village centre and Haradh station will be connected by a bituminized road, 10 km. long.

Secondary roads run along both sides of the main drainage canal and along the western main irrigation canal, crossing the main drainage canal in 14 places where there are bridges. These roads are about 150 km. long and four metres wide.[62]

Unpaved field paths, four metres wide, which run along each lateral drainage canal provide access to the fields. Where the field paths cross the main irrigation canal, the latter is covered.

The wadi is crossed by one strip running north of the Demonstration and Training Farm and another running 15 km. south of the farm, both 200 m. wide and having their own "right of way". These provide for the possibility of the future laying of oil lines across the irrigation area.[63]

From outside, the area can be reached by air, by rail and by road. But at present transport by road is rather difficult since 140 km. of the road, i.e. between Haradh and Udhaliya, are unpaved. The distances from Haradh to important Saudi Arabian towns is shown in the table below.

Table No. 13

TOWNS	DISTANCE IN km.
Hofuf	180[64] (the route used nowadays is about 200 km.)
Riyadh	260[65]
Yabrin	100[66]
Mecca	1,295[67]
Taif	1,225[68]
Jeddah	1,365[69]
Medihnah	1,235[70]

Planned agricultural development

The Bedouins to be settled will live on farms of four hectares each. One thousand farms will thus be established, all of which will have a standard cropping pattern.

Only sheep will be reared during the first 10 to 15 years. A continuous supply of fodder for cattle cannot be assured as the new inexperienced farmers will not be able to supply the correct quantity of fodder at the crucial times. Thus calculations of the farm economy are based on the assumption that on each farm 59 ewes will bekept giving a net increment of 118 lambs to be fattened for sale each year.

Ploughing, levelling, digging of ditches and furrows, ridging, harrowing and harvesting of cereals will be performed by machines. All the other necessary work will be done manually by the farmers and their families. One tractor of 50 to 60 HP is required for every 80 ha., and will be used for 1,500 to 1,700 hours per year. One tractor per 100 ha. will be sufficient during the initial period, but will only be needed for 1,200 to 1,400 hours per year, because a simpler crop rotation will be applied.[71] This crop rotation is shown in Diagram No. 3 . During the initial stage one machinery pool, as shown in the table below, will be required for each 1,000 ha.

Diagram No. 3

PROPOSED CROP ROTATION DURING FIRST YEARS OF CONTRACTOR'S OPERATION
(Faisal Settlement Project Al Haradh, Saudi Arabia)

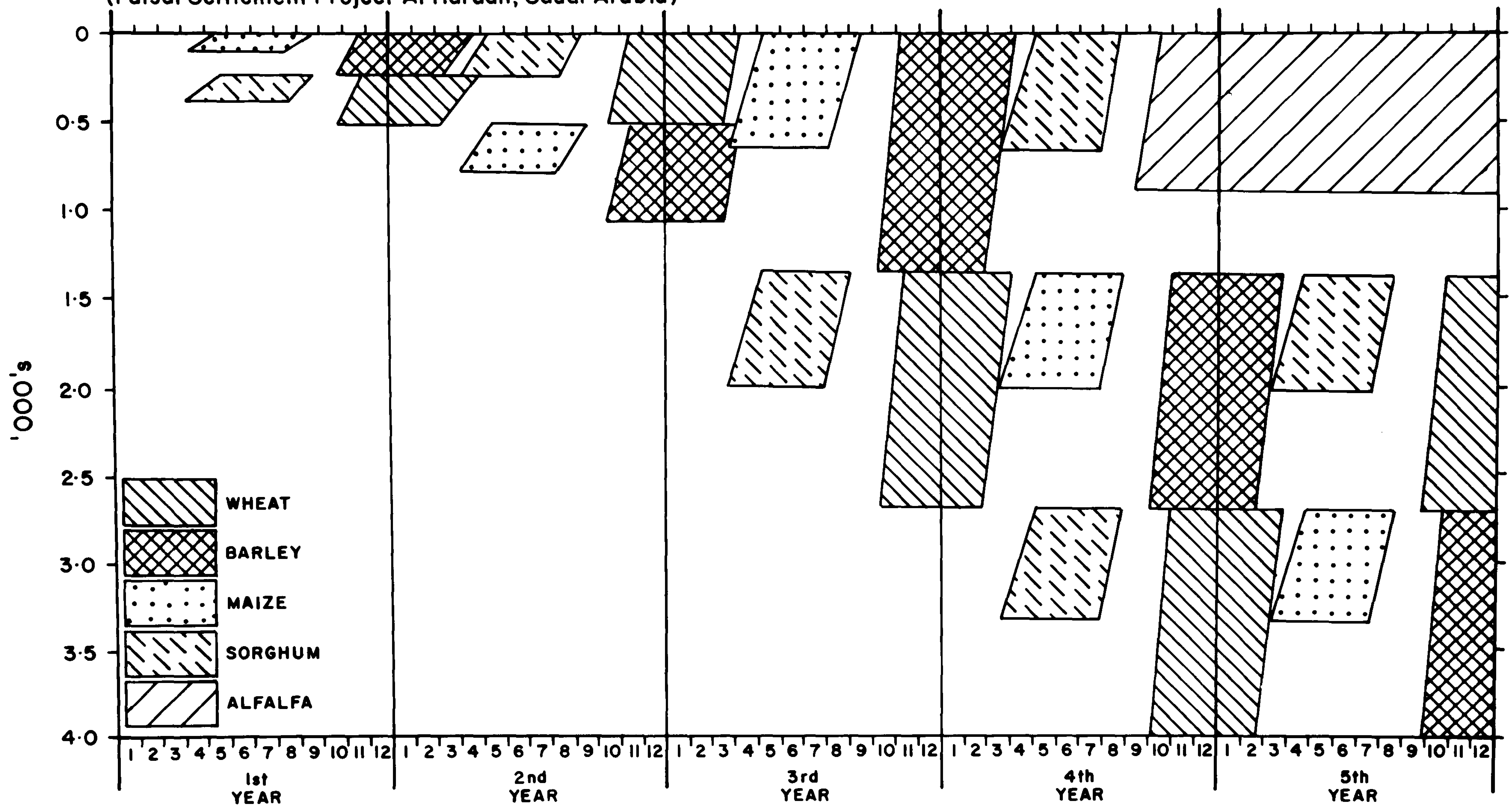


Table No. 14

Machinery pool for 1,000 ha. during the first four to five years[72]

MACHINE	NUMBER	REMARKS
Tractors	10	50 to 60 HP
Ploughs	14	10 disc - 4 moldboard
Harrows	12	8 disc - 4 spike tooth
Ditchers	4	Overman type
Rollers	4	Cambridge or rubber flexi
Seed drills	3	Mounted
Boom spray	2	15 to 20 feet
Rotary slasher	2	
Moving bars	10	
Combines	2	With equipment for maize
Trailers	8	4-wheeled
Workshop cars	2	With servicing equipment
Hay baler	1	

When the total area is cultivated according to the cropping pattern shown in Diagram No. 3 the size of the machinery pool will have to be increased by about 20 per cent.

Wind-break rows will be located on either side of the main drainage canal, beside the main irrigation canals and between the lateral irrigation and lateral drainage canals. The 150,000 plants required for this are already in a nursery. Tamarisks and eucalyptus trees will be used in the wind-breaks along the main irrigation and main drainage canals, while tamarisks and casuarine will form the wind-breaks along the lateral canals.

Economy of four hectare farms

The proposed four hectare farm will have the following cropping pattern: (See Diagram No. 4)

1.6 ha. alfalfa	0.2 ha. vegetables
0.2 ha. maize	0.6 ha. onions
0.4 ha. sorghum	0.3 ha. garlic
0.7 ha. cereals	0.2 ha. cucumber and melons
0.4 ha. potatoes	0.2 ha. okra

The alfalfa, maize and sorghum will be used to feed the 59 ewes and the 118 lambs noted on page 56 . The ewes will be fed 365 days per year and the lambs will be fed for 80 days before sale. (See Volume II, Part one, p. 1)

The daily fodder ration for each ewe will be:

Table No. 15

Daily fodder ration for one ewe (average for dry and lambing ewe)

FODDER	AMOUNT IN kg.
Alfalfa hay	0.6
Alfalfa green	2.0
Silage (maize and sorghum)	0.5
Barley	0.25
Straw	for satiation

This ration has the following content of nutritive substances:

Diagram No. 4

CROPPING PATTERN 4·0 ha FARM

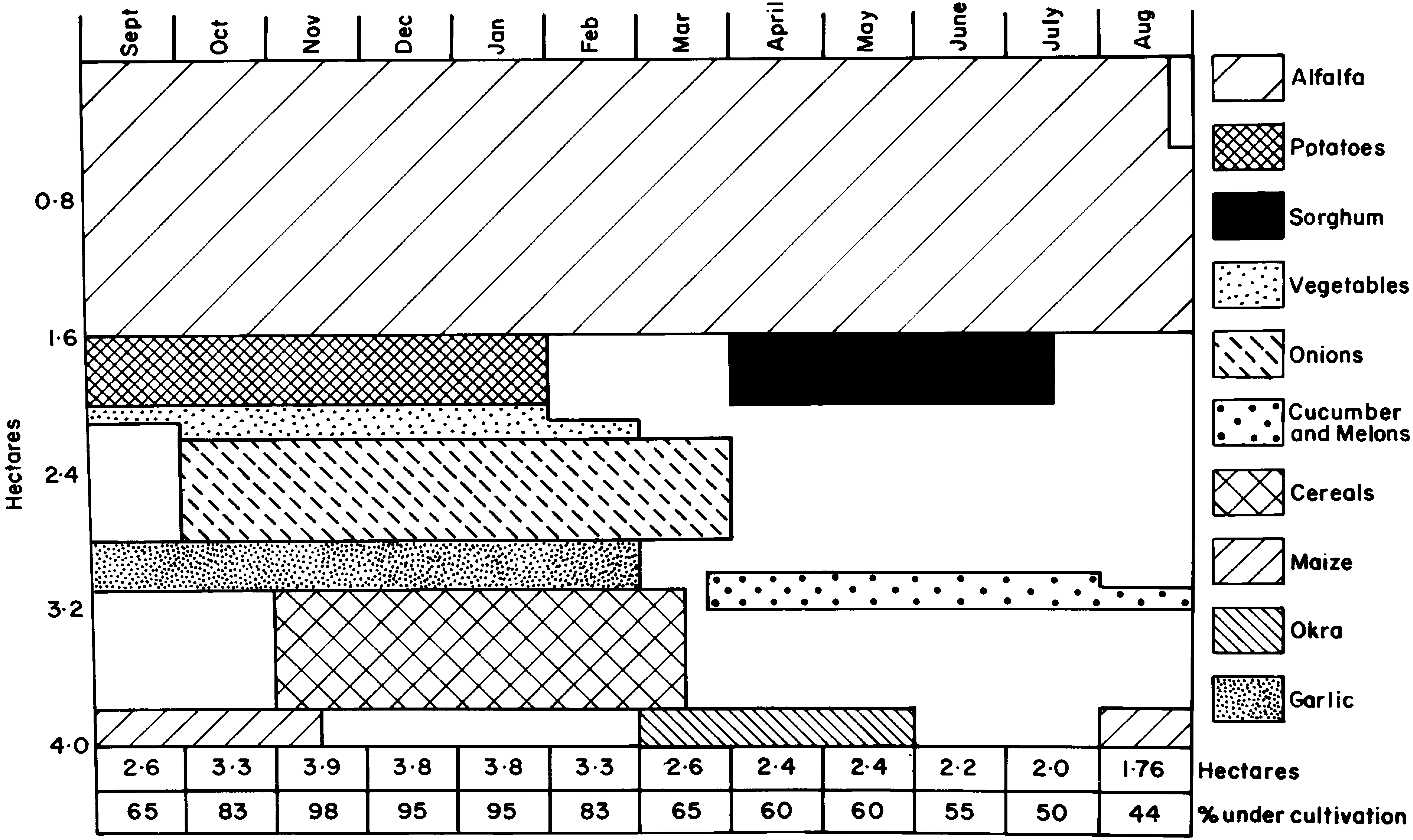


Table No. 16

Nutritive substances in fodder ration[73]

FODDER	DRY MATTER kg.	DIGESTIBLE PROTEIN - gr.	STARCH UNITS
Alfalfa hay	0.510	67.8	171.0
Alfalfa green	0.478	62.0	206.0
Silage	0.090	6.0	54.0
Barley (grain)	0.215	19.0	172.0
Total	1.293	154.8	603.0

Given a maize and sorghum yield of 40 tons per hectare, 24 tons would be produced from the 0.6 ha. Assuming a 30 per cent wastage due to decay, 16.8 tons of silage would finally be available.

One hundred and sixty tons of alfalfa would be produced from the 1.6 ha. each year similarly given reasonable yield of 100 tons per hectare.

The barley ration is bought in for reasons given on page 58.

The pattern of expenditure for sheep raising given the inputs noted above is detailed below.

Table No. 17

Pattern of expenditure for fodder crops

HECTARES	CROP	AMOUNT/ha.	SR UNIT	SR/AREA
	Alfalfa			
0.54*	Seeds	50 kg.	13.00	351.00
1.60	Fertilizer	400 kg.	0.52	332.80
1.60	Plant protection	120 SR	-	192.00
1.60	Machine costs**	87 SR	-	139.20
1.60	Water***	60,308 cu.m.	0.10****	6,030.80
				7,055.80
0.40	Sorghum			
	Seeds	15 kg.	0.80	4.80
	Fertilizer	500 kg.	0.52	104.00
	Plant protection	20 SR	-	8.00
	Machine costs	87 SR	-	34.80
	Water	3,496 cu.m.	0.10	349.60
				501.20
0.20	Maize			
	Seeds	15 kg.	0.60	1.80
	Fertilizer	500 kg.	0.52	52.00
	Plant protection	20 SR	-	4.00
	Machine costs	87 SR	-	17.40
	Water	2,205 cu.m.	0.10	220.50
				295.70

* The seeded area is only 0.54 ha. per annum because alfalfa lasts for three years.

** The cost of mechanical work is assumed to be the same on all farms. The average machine cost per hectare is 87.00 SR, regardless of crop.

*** In all cases the amount of water is given not per hectare but per cropped are

**** 0.10 SR is the assumed price of water for all crops.

Lump sum for the ram, 10.-SR per lamb	1,180.00 SR
Costs for the vet, 5.-SR per lamb	590.00 SR
Purchase of barley (7,744.35 x 0.35 SR)	2,710.50 SR

Table No. 18 Total expenditure

ITEM	COST IN SR
Alfalfa	7,055.80
Sorghum	501.20
Maize	295.70
Ram	1,180.00
Vet	590.00
Barley	2,710.50
Total	12,333.20 SR

Cash return from sheep

The calculation of the return from sheep is based on the procedure for replacing old ewes and the proceeds from fattened lambs. For replacement of the old ewes the farmers have to take female lambs from their own stock. It is assumed that the old ewes will fetch the same price as if sold as lambs and consequently the replacement stock will not be considered separately.

Every year 118 fattened lambs will be sold. These lambs, sold for 140.-SR each, will bring a return of 16,520.00 SR. The annual expenditure on these lambs will have been 12,333.20 SR, yielding a return of 4,186.80 SR.

In the Riyadh region, the per annum average consumption per person of vegetables is 60 to 75 kg. and of meat 50 to 56 kg.*[74] The inhabitants

* The consumption figures given above are in fact figures for urban markets. The figures for rural markets are smaller (20 to 40 kg. for vegetables and 30 to 40 kg. for meat)[75] The higher figures have been chosen in order to cover the increase in consumption which will occur in the future.

of the project region will probably reach this level very soon.

The families living on the four hectare farms will have an average of six members and thus each average family will consume about 400 kg. of vegetables and 300 kg. of meat per annum, which is the equivalent of one lamb per head.

It is therefore necessary here to deduct the cost of family consumption from the value of the sheep.

Value of sheep	4,186.80 SR
Consumption of 300 kg. of meat = 6 lambs*; each valued at 140.00 SR	840.00 SR
Remaining value	3,346.80 SR

Cash crops

The pattern of expenditure for each of the cash crops is shown below: that for wheat is given in detail in order to illustrate the system used. For other crops only the totals are given here.

Table No. 19

Pattern of expenditure for cash crops

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.4	Wheat			
	Seeds	120 kg.	1.00	48.00
	Fertilizer	500 kg.	0.52	104.00
	Plant protection	24 SR	-	9.60
	Machine costs	87 SR	-	34.80
	Water	2,444 cu.m.	0.10	244.40
				500.20

* It is assumed that the lambs will have a final weight of 50 kg. This weight is higher than that achieved in the research station in Hofuf. There, the average final weight after a fattening period of 5.8 months was 45.5 kg. However, the author believes that by selection it is possible to improve the stock to be kept in Haradh and thus achieve a higher final weight.

Table No. 20

Total expenditure for cash crops (see Volume II, Part one, pp. 2-4)

CROP	TOTAL EXPENDITURE IN SR
Barley	319.80
Potatoes	1,268.20
Onions	1,414.20
Garlic	1,541.00
Vegetables	305.50
Cucumber and melons	306.90
Okra	291.10

The total value of the cash crops is as shown in the following table.

Table No. 21 Total value of the cash crops

HECTARES	CROP	YIELD kg./ha.	YIELD kg./area	PRICE SR/kg.	INCOME/SR/ CROP AREA
0.4	Wheat	3,000	1,200	0.75	900.00
0.3	Barley	2,800	840	0.45*	378.00
0.4	Potatoes	12,500	5,000	0.70	3,500.00
0.6	Onions	14,000	8,400	0.42	3,528.00
0.3	Garlic	6,000	1,800	2.98	5,364.00
0.2	Vegetables**	10,000	2,000	0.65	1,300.00
0.2	Cucumber and melons	10,000	2,000	0.40	800.00
0.2	Okra	8,500	1,700	2.00	3,400.00
	Total value of the cash crops:				19,170.00 SR

* The price of domestically produced barley is 0.45 SR. The price of imported barley is 0.35 SR, which includes transport costs to Haradh. Thus, it is more economic to sell the barley produced in the project and buy imported barley for feed.

** The yield per hectare and the price per kilogramme are average values.

From the value of the crops the expenditure will have to be deducted in order to arrive at the net value.

Table No. 22

Value of cash crops after deduction of the expenditure

CROP	VALUE IN SR	EXPENDITURE IN SR	REMAINING VALUE IN SR
Wheat	900.00	500.20	399.80
Barley	378.00	319.80	58.20
Potatoes	3,500.00	1,268.20	2,232.80
Onions	3,528.00	1,414.20	2,113.80
Garlic	5,364.00	1,541.00	3,823.00
Vegetables	1,300.00	305.50	994.50
Cucumber and melons	800.00	306.90	493.10
Okra	3,400.00	291.10	3,108.90
Total	19,305.00	5,946.90	13,224.10

If we deduct family consumption of crops (see page 56) from this 13,224.10 SR, cash crop of a value of 12,964.10 SR will remain:

Table No. 23

Value of cash crops	13,224.10 SR
Consumption of 400 kg. of vegetables at an average price of 0.70 SR/kg.	280.00 SR
Value of remaining cash crops	12,224.10 SR

On this basis, each farm will produce marketable crop and animal products of a value of 15,570.90 SR. In addition to this each family would earn an average of 2,750.00 SR per year from their other livestock, which is kept on the old pastures in the desert.[77]

Marketing (See Volume II, Part one, p. 5)

Based on the production of four hectare farms the annual output of the Faisal Settlement Project available for external markets would be:

Table No. 24 Products for external markets

CROP	AREA IN ha.	EXPECTED YIELDS IN TONS
Wheat	400	1,200
Barley	300	840
Potatoes	400	5,000
Onions	600	8,400
Garlic	300	1,800
Vegetables	200	1,600
Cucumber and melons	200	2,000
Okra	200	1,700

In addition to this, 112,000 sheep, weighing a total of 5,600 tons, will be brought to market. (The consumption of the settlers and their families has been taken into account in the above calculations.)

Cereals

In 1969, cereals to the value of 188,596,000 SR were imported by Saudi Arabia. In the same year cereals to the value of 14,000 SR were exported by Saudi Arabia. In 1972, imports increased to the value of 242,359,000 SR and exports were completely stopped.[78] This shows that there is an increasing demand for cereals in Saudi Arabia. However, the cereal needs of the Eastern Province will be covered by Al Hassa oasis and the Qatif oasis, and Riyadh will be supplied by Al Karj and the Kasseem, thus the cereals from the project would have to be sold in the Western Province.

Vegetables

The vegetable demand of the Eastern Province will be saturated by the Al Hassa and Qatif oases. The markets in and around Riyadh are supplied by Al Karj and the Kasseem, and this capital area will most probably be self-sufficient by 1978.[79] Thus, only the western market, that is Jeddah, Mecca, Medihah and Taif, is available. In this area only 50 per cent of the demand for agricultural goods is covered, and it is estimated that the shortfall in the supply of vegetables will be 68,300 tons by 1985.[80] Thus the vegetables and the 5,000 tons of potatoes from the project could be sold there.

Lamb

The above-mentioned surplus of 112,000 sheep is most probably an underestimate because the supply of sheep by Bedouins has not been taken into consideration. But this is an uncertain factor, since production by Bedouins depends entirely upon natural conditions which cannot be relied upon to guarantee a continuous flow of products to the markets. Here, too, only markets in the Western Province are open to products from the scheme. Five hundred thousand sheep are needed each year in that province for sacrificial purposes alone during the Hadj.[81] Thus the timing of peak output from the project should be aimed at this period.

Map No. 1, Part one, Volume II, shows the settlement belts of Saudi Arabia. In these belts the most important markets of Saudi Arabia are located.

Transport

Only the truck is recommendable as a means of transport. Air transport is too expensive (1.50 SR/kg.[82]) and the railway needs a large labour force because of transshipment, whilst the relative inflexibility of train schedules necessitates special storage facilities at the markets. In contrast the arrival of trucks at markets can be timed exactly. At the moment, moreover, the transport of animals by the Saudi Railway is forbidden.

It is likely therefore that agricultural products from the project would have to be brought to the western markets via Hofuf and the present road system. The costs entailed in the supply of external markets in this way are detailed below.

Transport from Haradh to Hofuf

Based on the cost of transporting one ton by truck from Haradh to Dammam, 46.00 SR,[83] the price for transport from Haradh to Hofuf is only 23.66 SR. Thus, the transport of each kilogramme will cost 0.024 SR.

Transport from Hofuf to the Western Province

As noted above, the surplus from the Faisal Settlement Project will have to be transported to the western markets. The distance from Hofuf to those markets is as follows:

to Jeddah	1,365 km.[84]
to Mecca	1,295 km.[85]
to Medinah	1,235 km.[86]
to Taif	1,225 km.[87]

The cost of transporting one ton over long distances is about 0.50 to 0.70 SR per kilometre.[88] This means that the cost of transporting one kilogramme from Haradh to Jeddah is 0.85 SR, to Taif 0.77 SR, to Mecca 0.81 SR and to Medinah 0.76 SR.

Taking these transport costs into account, the profit from a four hectare farm of the type described above would be converted into a loss as detailed in the following table.

Table No. 25

Profit from the agricultural production of a four hectare farm (in SR)

	WHEAT	BARLEY	POTATOES	VEGETABLES	LAMB
Value of products	399.80	58.20	2,232.80	10,268.31*	3,428.18
Transport costs to:**					
Taif	231.00	161.70	962.50	2,983.75	1,078.00
Jeddah	255.00	178.50	1,062.50	3,293.75	1,190.00
Mecca	243.00	170.10	1,012.50	3,138.75	1,134.00
Medinah	228.00	156.60	950.00	2,945.00	1,064.00
Total transport costs	957.00	666.90	3,987.50	12,361.25	4,466.00
Profit	-	-	-	-	-
Loss	557.20	608.70	1,754.70	2,092.94	1,047.82

This shows clearly that transport costs eliminate the possibility of any profit. On the contrary the losses are very high: 6,061.36 SR for each farm. This results in a total annual loss for the whole project of 6,061,360.00 SR. In addition the capital costs must be considered.

Since no farmers would be able to supply the enormous amounts of money to cover these losses, the scheme can thus only work with heavy financial support from the Government.

Labour demand of four hectare farms

At the Demonstration and Training farm, it was found that the working

* The home consumption is deducted.

** Since all four markets are almost of the same size, it is assumed that the amount of agricultural produce sold at each market is equal.

ability of the farm labourers who were to be the future settlers differed from that of well established farmers such as those in Al Hassa. The following tables show their performance in greater detail.

Table No. 26 Tractor work

WORK	QUALITY IN % OF POSSIBLE	SPEED IN % OF POSSIBLE
Ploughing	90	70-80
Levelling	60	80
Furrow making	80	80
Ridges for border strip	90	80
Mowing	70	70
Trailer transport	60	-
Maintenance	60	-
Motor sprayers		
Barrow power spraying	70	60
Knapsack power spraying	70	60

Table No. 27 Work with small farm implements

WORK	SPEED IN %
Shovelling	60
Raking (hay)	60
Raking (soil)	50
Weed hoeing in rows	50
Preparing irrigation furrows	50
Planting	90
Mowing with sickle	70
Mowing with scythe	50
Loading hay with forks	50
Tree pruning with secateur	50

Resulting from the figures shown in the tables above the monthly labour input for the different crops is as follows:

Month/crop	Hectares	Work	Man hours per ha.	Man hours per area
September				
Alfalfa	0.64	making hay	10.0	6.40
	1.06	spraying	3.4	3.60
	0.54	sowing	3.0	1.60
	1.06	top dressing	3.1	3.30
Potatoes	0.40	planting	60.0	24.00
Vegetables	0.10	planting	75.0	7.50
Cereals	0.70	preparing seedbed	17.0	11.90
Maize	0.20	top dressing	3.1	0.62
	0.20	spraying	3.4	0.68
	0.20	handhoeing	15.0	3.00
Garlic	0.30	planting	350.0	105.00
				167.60
		Man hours required for irrigation:		99.90
		Total man hours required for cultivation:		267.50
October				
Alfalfa	0.64	making hay	10.0	6.40
	1.60	spraying	3.4	5.40
Potatoes	0.40	handhoeing	82.5	33.00
	0.40	spraying	13.0	5.20
Vegetables	0.10	spraying	13.0	1.30
	0.10	handhoeing	82.5	8.25
	0.10	planting	75.0	7.50
Onions	0.60	planting	480.0	288.00

Month/crop	Hectares	Work	Man hours per ha.	Man hours per area
Garlic	0.30	handhoeing	132.5	39.75
				394.80
		Man hours required for irrigation:		106.99
		Total man hours required for cultivation:		501.79
November				
Alfalfa	0.64	making hay	10.0	6.40
	1.60	spraying	3.4	5.40
Potatoes	0.40	handhoeing	82.5	33.00
	0.40	spraying	13.0	5.20
	0.40	top dressing	22.7	9.00
Vegetables	0.20	handhoeing	82.5	16.50
	0.20	spraying	13.0	2.60
Onions	0.60	handhoeing	132.5	79.50
	0.60	spraying	10.4	6.24
Maize	0.20	harvesting	30.0	6.00
Garlic	0.30	spraying	10.4	3.10
				172.94
		Man hours required for irrigation:		99.45
		Total man hours required for cultivation:		272.39
December				
Alfalfa	0.96	making hay	10.0	9.60
	1.60	spraying	3.4	5.40
Potatoes	0.40	spraying	10.4	4.20
Vegetables	0.20	handhoeing	82.5	16.50

Month/crop	Hectares	Work	Man hours per ha.	Man hours per area
Vegetables	0.20	spraying	10.4	2.10
	0.20	top dressing	21.7	4.30
Maize	0.20	preparing seedbed	17.0	3.40
Garlic	0.30	handhoeing	132.5	39.75
Cereals	0.70	spraying	3.4	2.40
				87.65
		Man hours required for irrigation:		81.80
		Total man hours required for cultivation:		169.45
January				
Alfalfa	0.96	making hay	10.0	9.60
	1.60	spraying	3.4	5.40
Potatoes	0.40	harvesting	200.0	80.00
Vegetables	0.10	harvesting	613.0	61.30
Onions	0.60	top dressing	35.0	21.00
	0.60	spraying	10.4	6.20
	0.60	handhoeing	132.5	79.50
Cereals	0.70	top dressing	3.1	2.20
				265.20
		Man hours required for irrigation:		81.80
		Total man hours required for cultivation:		347.00
February				
Alfalfa	0.96	making hay	10.0	9.60
	1.60	spraying	3.4	5.40
Vegetables	0.10	harvesting	613.0	61.30

Month/crop	Hectares	Work	Man hours per ha.	Man hours per area
Garlic	0.30	harvesting	500.0	150.00
Sorghum	0.40	preparing seedbed	17.0	6.80
				233.10
		Man hours required for irrigation:		81.53
		Total man hours required for cultivation:		314.63
March				
Alfalfa	0.96	making hay	10.0	9.60
	1.60	spraying	3.4	5.40
Okra	0.20	sowing	50.0	10.00
	0.20	spraying	10.4	2.10
Onions	0.60	harvesting	500.0	300.00
Cucumber and melons	0.20	preparing seedbed	23.0	4.60
	0.20	sowing	30.0	6.00
				337.70
		Man hours required for irrigation:		101.65
		Total man hours required for cultivation:		439.35
April				
Alfalfa	0.96	making hay	10.0	9.60
	1.60	spraying	3.4	5.40
	1.60	top dressing	3.1	4.70
Cucumber and melons	0.20	spraying	9.3	1.90
	0.20	handhoeing	87.5	17.50

Month/crop	Hectares	Work	Man hours per ha.	Man hours per area
Okra	0.20	spraying	10.4	2.10
	0.20	handhoeing*	132.5	26.50
				67.70
		Man hours required for irrigation:		93.08
		Total man hours required for cultivation:		160.78
May				
Alfalfa	0.96	making hay	10.0	9.60
	1.60	spraying	3.4	5.40
Sorghum	0.40	handhoeing	15.0	6.00
Cucumber and melons	0.20	spraying	9.3	1.90
Okra	0.20	spraying	10.4	2.10
	0.20	harvesting	750.0	150.00
				175.00
		Man hours required for irrigation:		97.06
		Total man hours required for cultivation:		272.06
June				
Alfalfa	0.96	making hay	10.0	9.60
	1.60	spraying	3.4	5.40
Cucumber and melons	0.20	spraying	9.3	1.90
	0.20	handhoeing	87.5	17.50

* including singling

Month/crop	Hectares	Work	Man hours per ha.	Man hours per area
Maize	0.20	preparing seedbed	17.0	3.40
				37.80
		Man hours required for irrigation:		102.42
		Total man hours required for cultivation:		140.22
July				
Alfalfa	0.96	making hay	10.0	9.60
	1.60	spraying	3.4	5.40
Sorghum	0.40	harvesting	30.0	12.00
Cucumber and melons	0.10	harvesting	350.0	35.00
				62.00
		Man hours required for irrigation:		98.42
		Total man hours required for cultivation:		160.42
August				
Alfalfa	0.96	making hay	10.0	9.60
	1.60	spraying	3.4	5.40
Cucumber and melons	0.10	harvesting	350.0	35.00
Potatoes	0.40	preparing seedbed	23.0	9.20
Vegetables	0.20	preparing seedbed	23.0	4.60
Onions	0.60	preparing seedbed	23.0	13.80
Garlic	0.30	preparing seedbed	23.0	6.90
Alfalfa	0.54	preparing seedbed	17.0	9.20
				93.70
		Man hours required for irrigation:		89.53
		Total man hours required for cultivation:		183.23

In addition the farmer requires 1.9 hours daily for the transport of fodder.

Input of labour for irrigation

Each pump has an output of 71 ltr./sec. and this is enough to cover the 23.6 ltr./sec. demand of three farms simultaneously.

The average distance from the houses to the farms is two kilometres and each farmer will spend about 0.4 hours per working day in travelling to and from work.

The man-hours necessary for irrigation of a four hectare farm are shown below.

Month/crop	Area in ha.	Cu.m. water/ha.	Cu.m.water required
September			
Alfalfa	1.6	3,390	5,424
Potatoes	0.4	2,668	1,067
Vegetables	0.1	2,900 x 0.89*	258
Maize	0.2	2,784	557
Garlic	0.3	2,668	800
			8,106 cu.m.

Man-hours required for irrigation: 95.14

Man-hours of travel time required: 4.76

Total man-hours required for irrigation: 99.90

Month/crop	Area in ha.	Cu.m. water/ha.	Cu.m.water required
October			
Alfalfa	1.6	3,030	4,448
Potatoes	0.4	2,484	994
Vegetables	0.2	2,700 x 0.89*	486
Onions	0.6	2,484	1,490

* Because of the wider spacing of tomatoes.

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Month/crop	Area in ha.	Cu.m. water/ha.	Cu.m. water required
Potatoes	0.4	1,633	653
			6,637 cu.m.
	Man-hours required for irrigation:		77.90
	Man-hours of travel time required:		3.90
	Total man-hours required for irrigation:		81.80
February			
Alfalfa	1.6	2,270	3,632
Vegetables	0.1	2,025 x 0.89*	182
Onions	0.6	1,863	1,118
Garlic	0.3	1,863	559
Cereals	0.7	1,620	1,134
			6,616 cu.m.
	Man-hours required for irrigation:		77.65
	Man-hours of travel time required:		3.88
	Total man-hours required for irrigation:		81.53
March			
Alfalfa	1.6	3,250	5,200
Onions	0.6	2,668	1,601
Cucumber and melons	0.05	3,016 x 0.6*	90
Okra	0.2	2,784	557
			7,448 cu.m.
	Man-hours required for irrigation:		87.42
	Man-hours of travel time required:		4.37
	Total man-hours required for irrigation:		91.79

* Because of the wider spacing of rows.

Month/crop	Area in ha.	Cu.m. water/ha.	Cu.m. water required
April			
Alfalfa	1.6	3,530	5,648
Sorghum	0.4	2,268	907
Cucumber and melons	0.2	3,419 x 0.6*	393
Okra	0.2	3,024	605
			7,553 cu.m.

Man-hours required for irrigation: 88.65

Man-hours of travel time required: 4.43

Total man-hours required for irrigation: 93.08

Month/crop	Area in ha.	Cu.m. water/ha.	Cu.m. water required
May			
Alfalfa	1.6	3,680	5,888
Sorghum	0.4	2,367	947
Cucumber and melons	0.2	3,419 x 0.6*	410
Okra	0.2	3,156	631
			7,876 cu.m.

Man-hours required for irrigation: 92.44

Man-hours of travel time required: 4.62

Total man-hours required for irrigation: 97.06

Month/crop	Area in ha.	Cu.m. water/ha.	Cu.m. water required
June			
Alfalfa	1.6	4,220	6,752
Sorghum	0.4	2,718	1,087

* Because of the wider spacing of rows.

Month/crop	Area in ha.	Cu.m. water/ha.	Cu.m. water required
Cucumber and melons	0.2	3,926 x 0.6*	471
			8,310 cu.m.

Man-hours required for irrigation: 97.54

Man-hours of travel time required: 4.88

Total man-hours required for irrigation: 102.42

July			
Alfalfa	1.6	4,340	6,944
Sorghum	0.2	2,790	558
Cucumber and melons	0.2	4,030 x 0.6*	484
			7,986 cu.m.

Man-hours required for irrigation: 93.73

Man-hours of travel time required: 4.69

Total man-hours required for irrigation: 98.42

August			
Alfalfa	1.47	4,280	6,292
Cucumber and melons	0.1	3,978 x 0.6*	239
Maize	0.2	3,672	734
			7,265 cu.m.

Man-hours required for irrigation: 85.27

Man-hours of travel time required: 4.26

Total man-hours required for irrigation: 89.53

* Because of the wider spacing of rows.

The yearly water demand for a four hectare farm is 91,184 cu.m. The man-hours required for irrigation of a four hectare farm/year is 1,070.23.

The man-hours of travel time required for a four hectare farm/year is 53.51.

The total man-hours required for irrigation of a four hectare farm/year is 1,123.74.

Labour input for sheep (See Table No. 28)

Ewes

Feeding:[89]	0.757 man-minutes per ewe daily.
	44.66 man-minutes for 59 ewes daily.
	271.68 man-hours for 59 ewes yearly.
Litter:[90]	0.16 man-minutes per ewe daily.
	9.44 man-minutes for 59 ewes daily.
	57.43 man-hours for 59 ewes yearly.
Paring:[91]	3.586 man-minutes per ewe yearly.
	3.53 man-hours for 59 ewes yearly.
Dipping[92]	0.26 man-hours per ewe yearly.
	15.34 man-hours for 59 ewes yearly.
Cleaning[93] of fold:	0.27 man-hours per ewe yearly.
	15.93 man-hours for 59 ewes yearly.
Lambing:[94]	0.62 man-hours per ewe yearly.
	36.58 man-hours for 59 ewes yearly.

Total man-hours for 59 ewes: 400.49

On average two lambings with three born and two reared lambs can be expected.[95]

Lambs

Feeding:[96]	0.757 man-minutes per lamb daily.
	89.33 man-minutes for 118 lambs daily.
	119.11 man-hours for 118 lambs yearly.
Litter:[97]	0.16 man-minutes per lamb daily.
	18.88 man-minutes for 118 lambs daily.
	25.17 man-hours for 118 lambs yearly.
Dipping:[98]	0.13 man-hours per lamb yearly.
	15.34 man-hours for 118 lambs yearly.
Cleaning[99] of fold:	0.135 man-hours per lamb yearly.
	15.94 man-hours for 118 lambs yearly.
Loading:	4 man-minutes per lamb.
	7.87 man-hours for 118 lambs yearly.

Total man-hours for 118 lambs: 214.69

Total per annum requirement of man-hours for sheep rearing

Ewes:	400.49 man-hours
Lambs:	214.69 man-hours
Total:	615.18 man-hours

The overall labour input for a four hectare farm in order to assure the maintenance of the sheep and crops is thus as follows:

Table No. 28 Labour input for sheep (man-hours)

	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.
Ewes												
Feeding	22.2	22.94	22.20	22.94	22.94	20.72	22.94	22.20	22.94	22.2	22.94	22.94
Litter	4.80	4.96	4.80	4.96	4.96	4.48	4.96	4.80	4.96	4.80	4.96	4.96
Dipping	7.67							7.67				
Paring								3.53				
Lambing				18.29						18.29		
Cleaning of fold				7.97						7.97		
Total	34.67	27.90	27.90	54.16	27.90	27.90	27.90	38.20	27.90	54.16	27.90	27.90
Lambs												
Feeding	14.8	22.94	22.20				14.8	22.20	22.94			
Litter	3.2	4.96	4.8				3.2	4.80	4.96			
Dipping	7.67							7.67				
Cleaning of fold				7.97						7.97		
Loading			3.94						3.94			
Total	25.67	27.90	58.84	7.97			18.0	34.67	31.84	7.97		
Total sheep	60.34	55.80	86.74	62.13	27.90	27.90	45.90	72.87	59.74	62.13	27.90	27.90

Table No. 29 Total labour input

MONTH	MAN-HOURS CASH CROPS	1.9 HOURS/DAY FOR FODDER	SHEEP MAN-HOURS	TOTAL MAN-HOURS
September	267.50	57.0	60.34	385.74
October	501.79	58.9	55.80	616.49
November	272.39	57.0	86.74	416.13
December	169.45	58.9	62.13	290.48
January	347.00	58.9	27.90	433.80
February	314.63	53.2	27.90	395.73
March	439.35	58.9	45.90	544.15
April	160.78	57.0	72.87	290.65
May	272.06	58.9	59.74	390.70
June	140.22	57.0	62.13	259.35
July	160.42	58.9	27.90	247.22
August	183.23	58.9	27.90	270.03
Total	3,228.82	693.5	617.25	4,540.45

The average working time per full-time labourer (one labour unit) is 2,400 hours per annum, i.e. 200 hours per month or 25 working days of eight hours per month.

Two labour units, i.e. 16 working hours daily, will be supplied by family members on this farm type. This is enough to cover the labour demand as is shown in Table No. 30 and Diagram No. 5.

Diagram No. 5

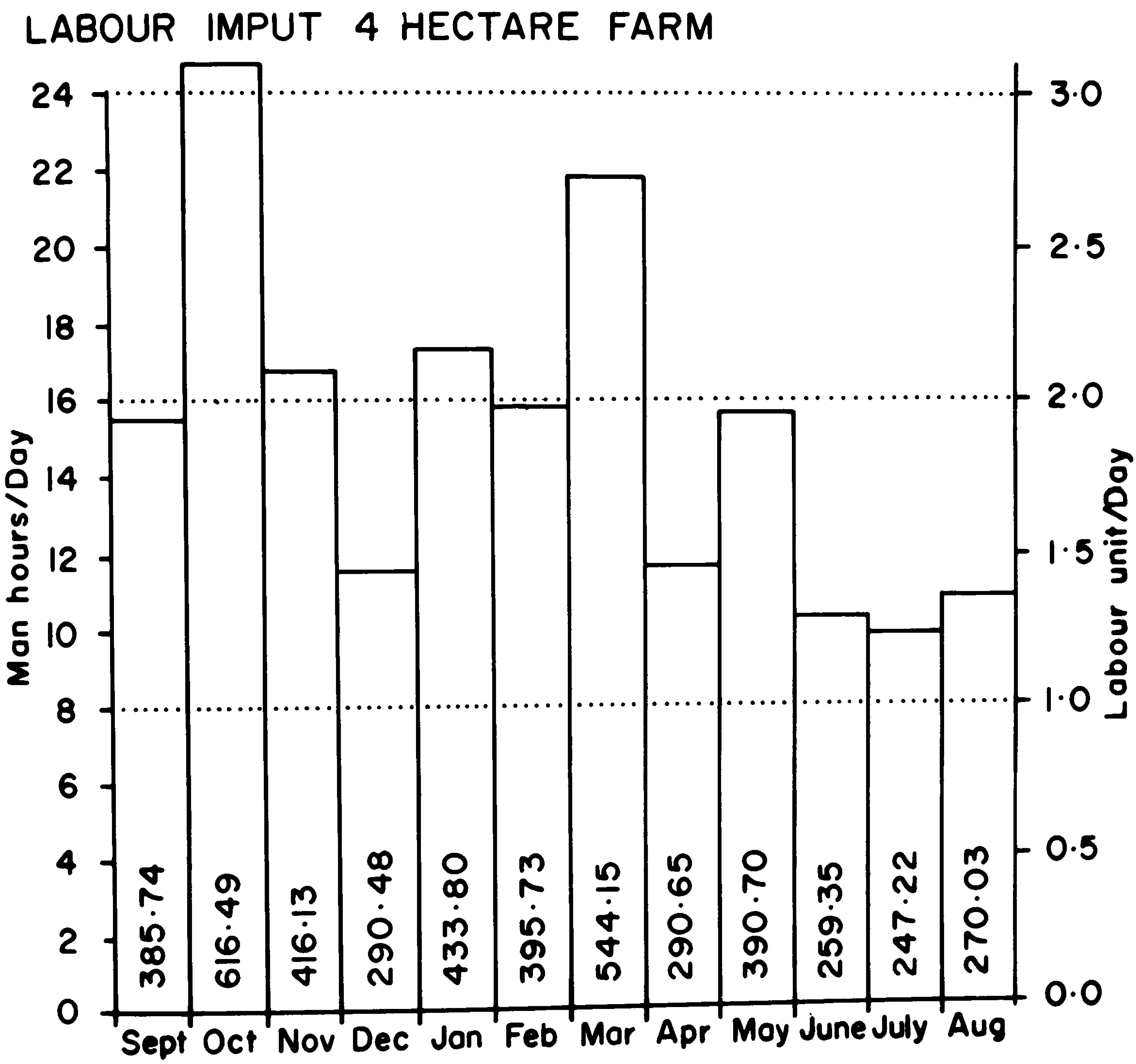

LABOUR IMPUT 4 HECTARE FARM
Man hours/Day
Labour unit/Day
24
22
20
18
16
14
12
10
8
6
4
2
0
3·0
2·5
2·0
1·5
1·0
0·5
0·0
385·74
616·49
416·13
290·48
433·80
395·73
544·15
290·65
390·70
259·35
247·22
270·03
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug

Table No. 30 Labour demand and supply

MONTH	DAILY WORKING HOURS	MONTHLY WORKING HOURS	PERCENTAGE OF 2 LABOUR UNITS
September	15.43	385.74	96.44
October	24.66	616.49	154.13
November	16.65	416.13	104.60
December	11.62	290.48	72.63
January	17.35	433.80	106.47
February	15.83	395.73	99.00
March	21.77	544.15	136.16
April	11.63	290.65	72.63
May	15.63	390.70	97.70
June	10.33	259.35	64.56
July	9.89	247.22	61.81
August	10.80	270.03	67.50

These, then, are the labour inputs demanded by the production systems recommended for the family size farms of four hectare areas.

According to a later plan for the Faisal Settlement Project, the farms could differ in size. Farms of one, four and nine hectares are projected in a proportion of 80:12:8, i.e. 2,960 ha., 440 ha. and 300 ha. respectively.[100] Thus 2,960 farms of one hectare, 110 farms of four hectares and 33 farms of nine hectares would be established in the project area.

Based on this plan the project would have the following output:

Table No. 31

Output of the Faisal Settlement Project

PRODUCT	FROM 1 ha. FARMS	EXPECTED YIELDS IN TONS FROM 4 ha. FARMS	FROM 9 ha. FARMS	TOTAL
Wheat	-	132.00	158.40	290.40
Barley	-	92.40	101.64	194.04
Potatoes	7,400.00	550.00	247.50	8,187.50
Onions	12,432.00	924.00	415.80	13,771.80
Garlic	5,328.00	198.00	89.10	5,615.10
Vegetables	5,920.00	220.00	99.00	6,239.00
Cucumber and melons	8,880.00	220.00	148.50	9,248.50
Okra	5,032.00	187.00	126.23	5,345.23
Lamb	592.00	616.00	419.10	1,627.10

The income from farms of these three sizes is dealt with below.

The income from the four hectare farms is the same as that from the four hectare farms in the original plan.

One hectare farms

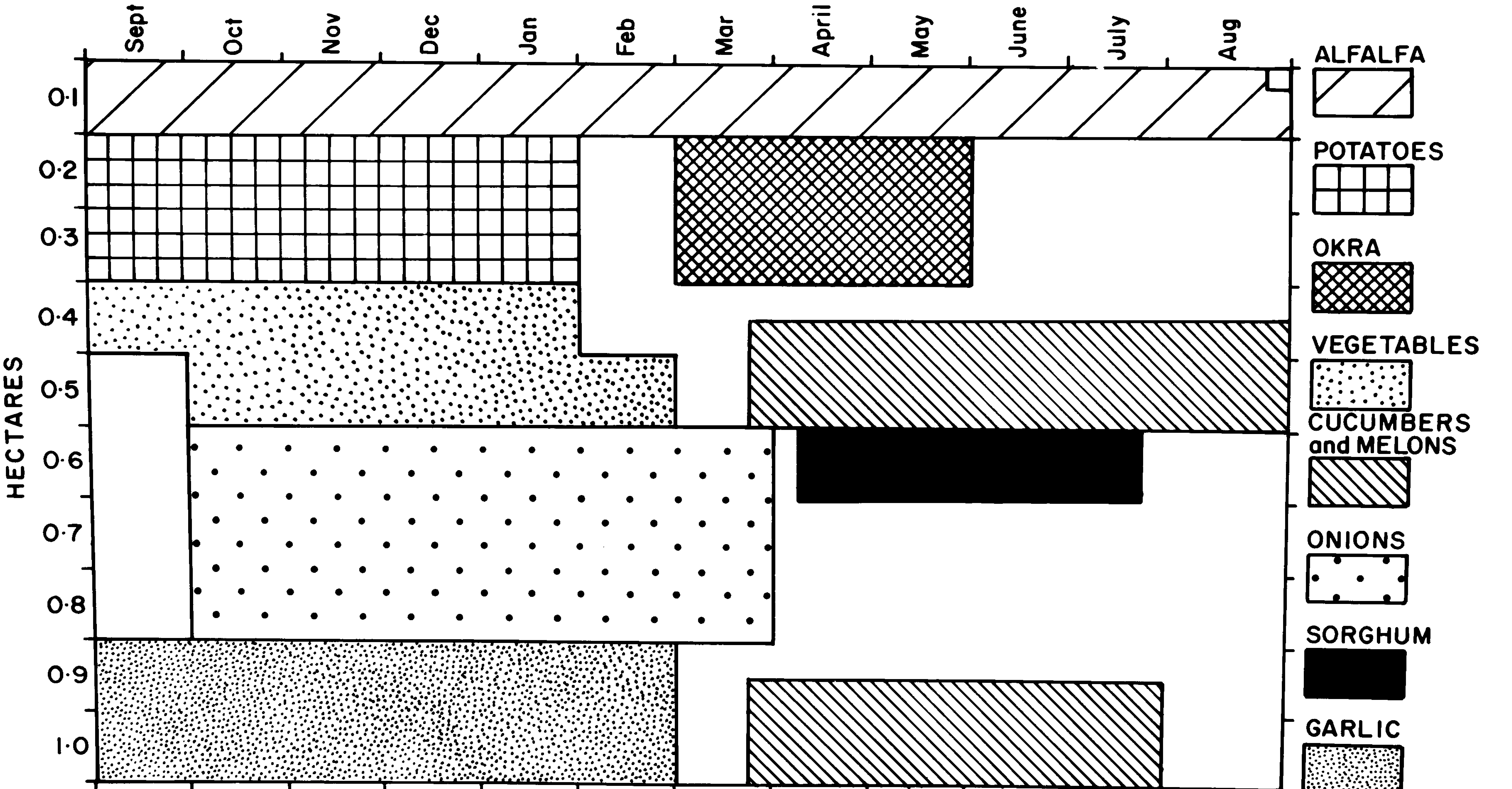
The proposed one hectare farms will have the following cropping pattern: (See Diagram No. 6)

0.1 ha. alfalfa	0.2 ha. okra
0.2 ha. potatoes	0.3 ha. cucumber and melons
0.2 ha. vegetables	0.1 ha. sorghum
0.3 ha. onions	0.2 ha. garlic

These farms are intensive vegetable farms with a small number of lambs for fattening, productng enough to provide an adequate family income. Four ewes and eight lambs will be reared and fattened yearly on farms of this type.

Diagram No. 6

CROPPING PATTERN — I HECTARE FARM



Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	
0·6	1·0	1·0	1·0	1·0	0·7	0·68	0·68	0·70	0·50	0·48	0·25	Hectares
60	100	100	100	100	70	68	68	70	50	48	25	% of cultivated area

Table No. 32

Labour input for cash crops

CROP	AREA IN ha.	MAN-HOURS PER ha. YEARLY	MAN-HOURS PER CROP AREA YEARLY	IRRIGATION MAN-HOURS YEARLY	TOTAL MAN-HOURS YEARLY
Alfalfa	0.1				
Haymaking		1,313.9	131.40		
Daily fodder		0.7 h./day	273.80	47.20	452.40
Potatoes	0.2	522.7	104.54	25.43	130.00
Vegetables	0.2	880.0	176.00	23.64	199.60
Onions	0.3	1,323.8	397.14	45.02	442.30
Garlic	0.2	1,183.4	236.68	30.00	266.70
Okra	0.2	1,111.9	222.38	22.10	244.50
Cucumber and melons	0.3	600.0	180.00	38.69	218.70
Sorghum	0.1	104.1	10.40	11.26	21.70
Total man-hours required for crops:					1,975.90

The monthly number of labour hours required for crop cultivation is very small and thus only the yearly figures are given on Table No. 32.

The total annual labour input required for sheep rearing is 73.82 hours. Thus the annual labour input required for both sheep raising and field work is 2,049.72 man-hours.

The value of crops after deduction of expenditure is as illustrated in the following table.

Table No. 33 Value of cash crops (in SR)

CROP	VALUE BEFORE DEDUCTION	EXPENDITURE	VALUE AFTER DEDUCTION
Potatoes	1,750	634.10	1,115.90
Onions	1,764	707.10	1,056.90
Garlic	3,576	1,027.40	2,548.60
Vegetables	1,300	303.60	996.40
Cucumber and melons	1,200	430.10	769.90
Okra	3,400	291.00	3,108.90
Total	12,990	3,393.40	9,596.60

Each farmer will produce eight fattened lambs of a value of 197.60 SR after deduction of the expenditure. When the family consumption of meat and vegetables for a family with four members is deducted, the total value of the agricultural produce will be 9,045.20 SR.

As the produce from these farms will also have to be sold at markets in the Western Province profit is not possible.

Table No. 34

Income from agricultural production of one hectare farms (in SR)

	POTATOES	VEGETABLES*	LAMB
Value of products	1,115.90	8,281.70	98.80
Transport costs to:*			
Taif	481.25	2,329.25	38.50
Jeddah	531.25	2,571.25	42.50
Mecca	506.25	2,450.25	40.50
Medinah	475.00	2,299.00	38.00
Total transport costs	1,993.75	9,649.75	159.50
Profit	-	-	-
Loss	877.85	1,368.05	60.70

In addition to their engagement in the project each family earns an average of 2,750 SR per year from their livestock, which is kept on the old pastures in the desert.[101]

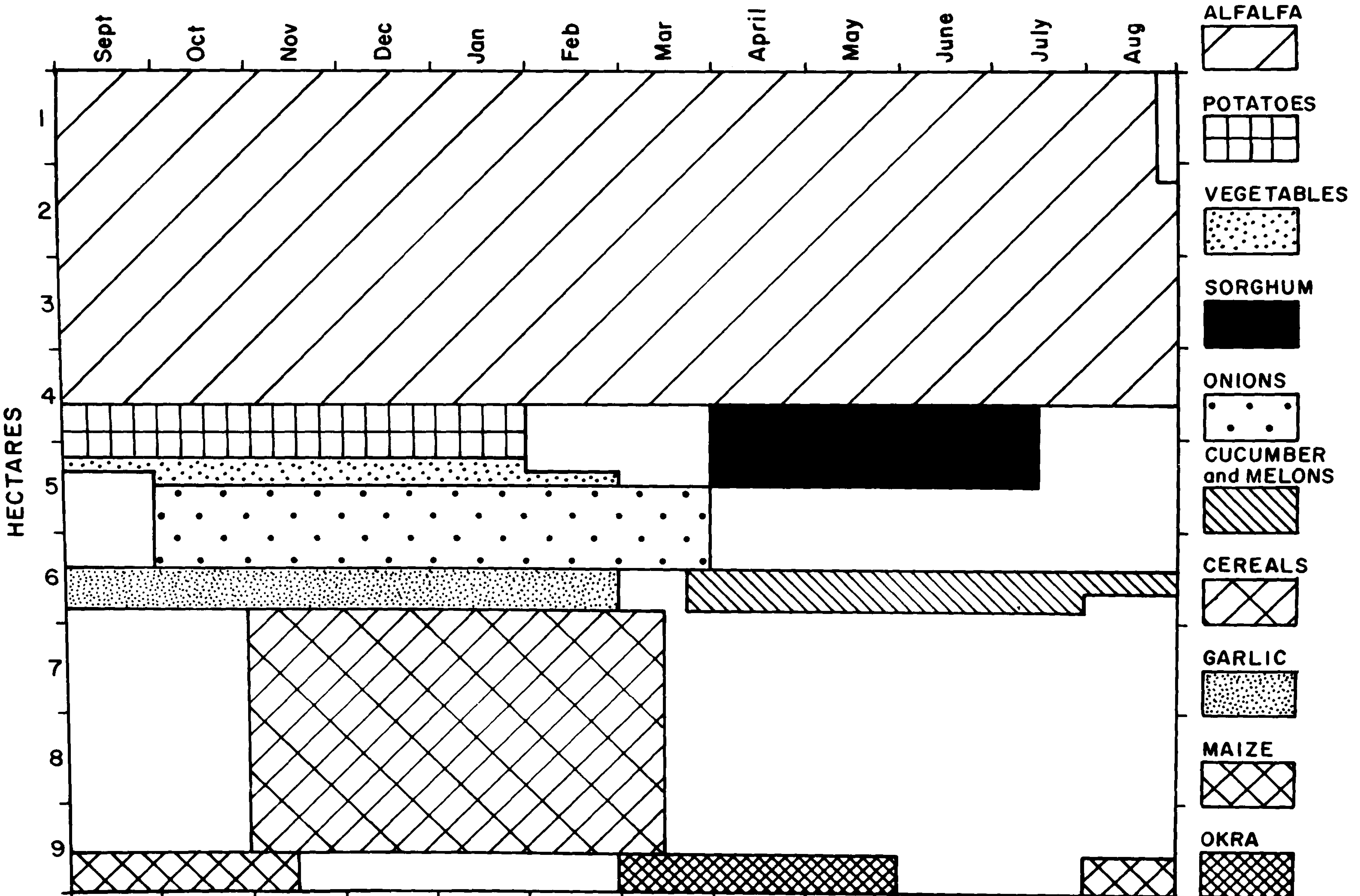
Nine hectare farms

The proposed nine hectare farms will have the following cropping pattern: (See Diagram No. 7)

3.60 ha. alfalfa	0.30 ha. vegetables
0.45 ha. maize	1.60 ha. wheat
0.90 ha. sorghum	1.10 ha. barley
0.60 ha. potatoes	0.45 ha. okra
0.90 ha. onions	0.45 ha. cucumber and melons
0.45 ha. garlic	

* Home consumption has been deducted.
** Since all four markets are almost of the same size, it is assumed that the amount of agricultural produce sold in each market will be the same.

CROPPING PATTERN — 9 HECTARE FARM   Diagram No. 7



	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug
Hectares	5·25	6·3	8·8	8·55	8·55	7·8	5·51	5·4	5·4	4·95	4·5	3·98
% of cultivated area	58	70	98	95	95	87	61	60	60	55	50	44

The farmer will rear 133 ewes which will produce 266 lambs for fattening each year.

Farms of this size, with the above-mentioned cropping pattern and number of sheep, have a labour demand of 8,177.30 man-hours per annum.

Table No. 35

Labour demand of nine hectare farm

MONTH	MAN-HOURS CROPS	2.2 HOURS/DAY FOR FODDER TRANSPORT	MAN-HOURS FOR SHEEP	TOTAL MAN-HOURS
September	499.10	66.0	136.08	701.18
October	818.53	68.2	125.86	1,012.59
November	487.80	66.0	130.67	684.47
December	342.36	68.2	140.08	550.64
January	603.17	68.2	62.93	734.30
February	544.99	61.6	56.84	663.43
March	726.57	68.2	103.53	898.12
April	362.28	66.0	164.33	592.61
May	612.11	68.2	134.73	815.05
June	315.46	66.0	138.05	515.91
July	360.99	68.2	62.93	492.12
August	385.75	68.2	62.93	516.88
Total	5,759.11	803.0	1,318.96	8,177.30

Thirty-two working hours per day (four labour units) will be available from families living on this type of farm. However, the farms do not require that much labour and thus this farm type will lead to disguised unemployment, as shown in the following table and in Diagram No. 8.

Diagram No. 8

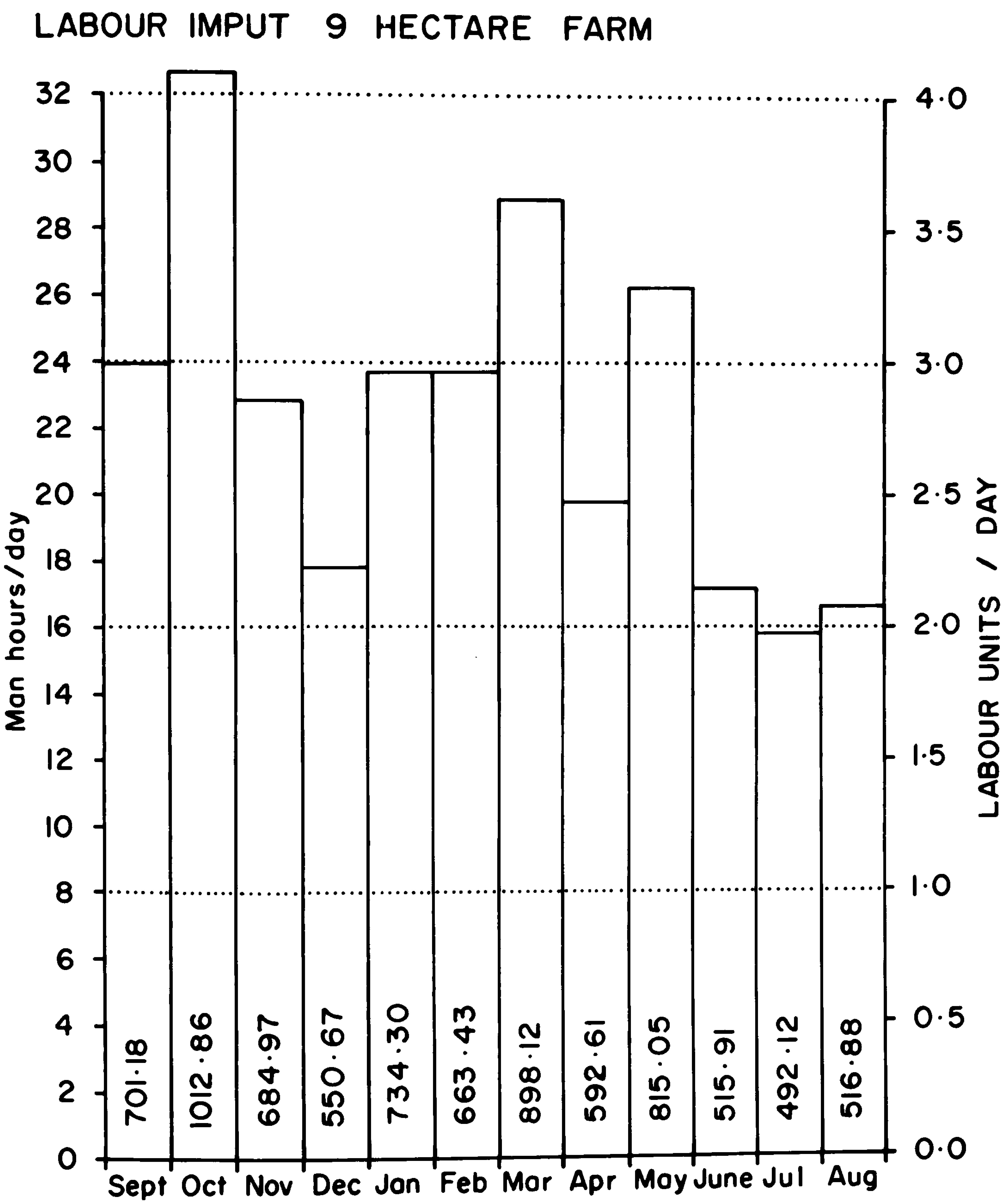

LABOUR IMPUT 9 HECTARE FARM
Man hours/day
LABOUR UNITS / DAY
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
4·0
3·5
3·0
2·5
2·0
1·5
1·0
0·5
0·0
701·18
1012·86
684·97
550·67
734·30
663·43
898·12
592·61
815·05
515·91
492·12
516·88
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
Jul
Aug

Table No. 36 Labour demand and supply

MONTH	DAILY WORKING HOURS	MONTHLY WORKING HOURS	PERCENTAGE OF 4 LABOUR UNITS
September	23.37	701.18	73.03
October	32.66	1,012.86	102.06
November	22.82	684.47	71.31
December	17.76	550.64	55.50
January	23.70	734.30	74.06
February	23.69	663.43	74.03
March	28.97	898.12	90.53
April	19.75	592.61	61.72
May	26.30	815.05	82.19
June	17.18	515.91	53.69
July	15.87	492.12	49.59
August	16.67	516.88	52.09
Total		8,179.57	

The value of the crops grown on each of the nine hectare farms when deducting the expenses works out as follows:

Table No. 37 Value of cash crops (in SR)

CROP	VALUE BEFORE DEDUCTION	EXPENDITURE	VALUE AFTER DEDUCTION
Wheat	3,600.00	1,762.80	1,837.20
Barley	1,386.00	1,172.60	213.40
Potatoes	5,250.00	2,033.20	3,216.80
Onions	5,292.00	2,121.30	3,170.70
Garlic	8,046.00	2,311.65	5,734.35
Vegetables	1,950.00	454.70	1,495.30
Cucumber and melons	1,800.00	690.15	1,109.15
Okra	7,650.00	654.95	6,995.05
Total	34,974.00	11,201.35	23,771.95

Every year 266 fattened lambs will be sold at 140.-SR each, thus having a total value of 37,240.00 SR. When the annual expenditure on raising these lambs of 27,780.30 SR is deducted, their value decreases for the farmer to 9,459.70 SR. The expenditure for raising these lambs are shown below.

Table No. 38 Expenditure for lamb raising

ITEM	COSTS IN SR
Alfalfa	15,930.00
Sorghum	1,128.40
Maize	620.90
Ram	2,660.00
Vet.	1,330.00
Barley	6,111.00
Total	27,780.30

After the family consumption of meat and vegetables for the 12 family members is deducted, products of a value of 30,990.95 SR will remain.

From these farms, too, the products will have to be sold at markets in the Western Province.

The income which can be achieved from nine hectare farms is as illustrated below.

Table No. 39

Income from nine hectare farms (in SR)

	WHEAT	BARLEY	POTATOES	VEGETABLES	LAMB
Net value of products	1,837.20	213.40	3,216.80	18,504.20*	7,779.70
Transport costs to:*					
Taif	924.00	592.90	1,432.75	5,125.31	2,444.75
Jeddah	1,020.00	654.50	1,593.75	5,657.81	2,698.75
Mecca	972.00	623.70	1,518.75	5,391.56	2,571.75
Medinah	912.00	595.20	1,415.00	5,058.75	2,413.00
Total transport costs	3,828.00	2,466.30	5,960.25	21,233.43	8,128.25
Profit	-	-	-	-	-
Loss	1,990.80	2,252.90	2,743.45	2,729.23	348.55

Here, too, each family earns an additional annual average of 2,750 Sr from their livestock which is kept on the old pastures in the desert.

Income from the total project

As in the original plan, these farms do not provide any profit. The losses are considerable.

* Home consumption has been deducted.

** Since all four markets are of almost the same size, it is assumed that the amount of agricultural produce sold in each market will be the same.

Table No. 40

Losses in the Faisal Settlement project

TYPE OF FARM	LOSS IN SR
4 ha. farm	6,061.36
1 ha. farm	2,306.60
9 ha. farm	10,064.93

Thus the annual losses of the total project would be 7,726,428.29 SR, of which 6,727,536.00 SR from one hectare farms, 666,749.60 SR from four hectare farms and 332,142.69 SR from nine hectare farms. The amortisation or repayment of capital costs of the project are not included in this total.

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CHAPTER TWO

THE AL HASSA OASIS, SAUDI ARABIA

Location of the project (see Map No. 1)

Al Hassa Oasis lies between 25° 21' and 25° 37' Latitude North and between 49° 33' and 49° 46' Longitude East, covering an area of about 180 sq.km. It is "L" shaped and extends about 16 km. West-East and about 20 km. North-South.[1] According to Abul Ela[2] it was about 48 km. from north to south and about 34 km. from east to west in 1959. From the difference between these two statements it is evident that recently the oasis has shrunk considerably. (See Volume II, Part two, p. 1)

The boundaries of the oasis are:[3]

To the north-west: Jabal Qarat Er Rukban;
To the south-west: Jabal Bu Ghanimah;
To the south: A line drawn between Jabal Bu Ghanimah and Jabal Arba;
To the east: The Jafurah desert;
To the west: The Ghuwar cliffs.

The capital is Hofuf which lies at the meeting points of the two axes of the "L".[4] The Al Hassa Oasis is one of the largest settlements in Saudi Arabia,[5] and Hofuf is one of the largest towns.

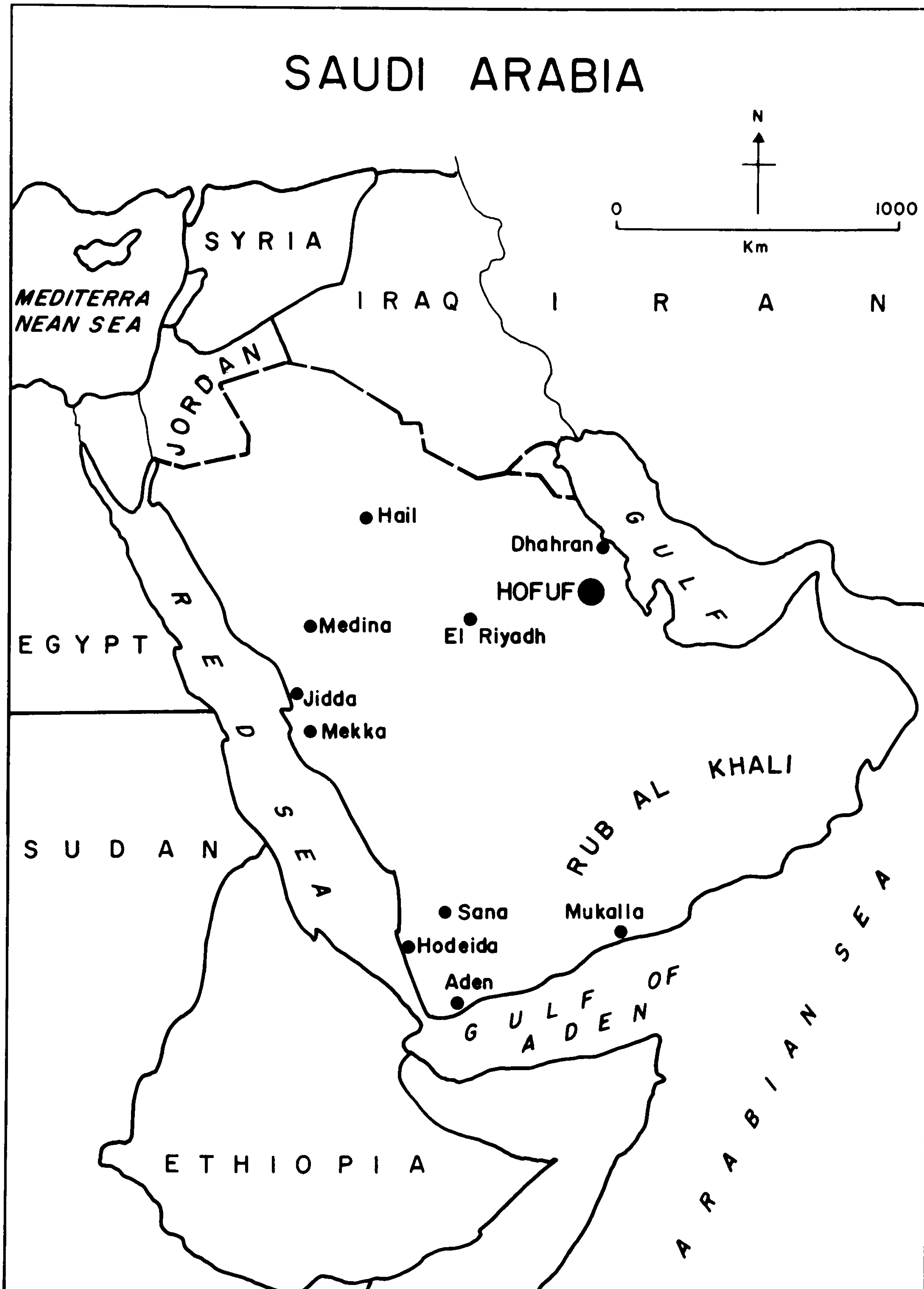
Apart from the towns of Hofuf and Mubarraz there are 52 villages: 44 in the Eastern Oasis, six in the Northern Oasis and two in Al Uyun.[6]

Present land use

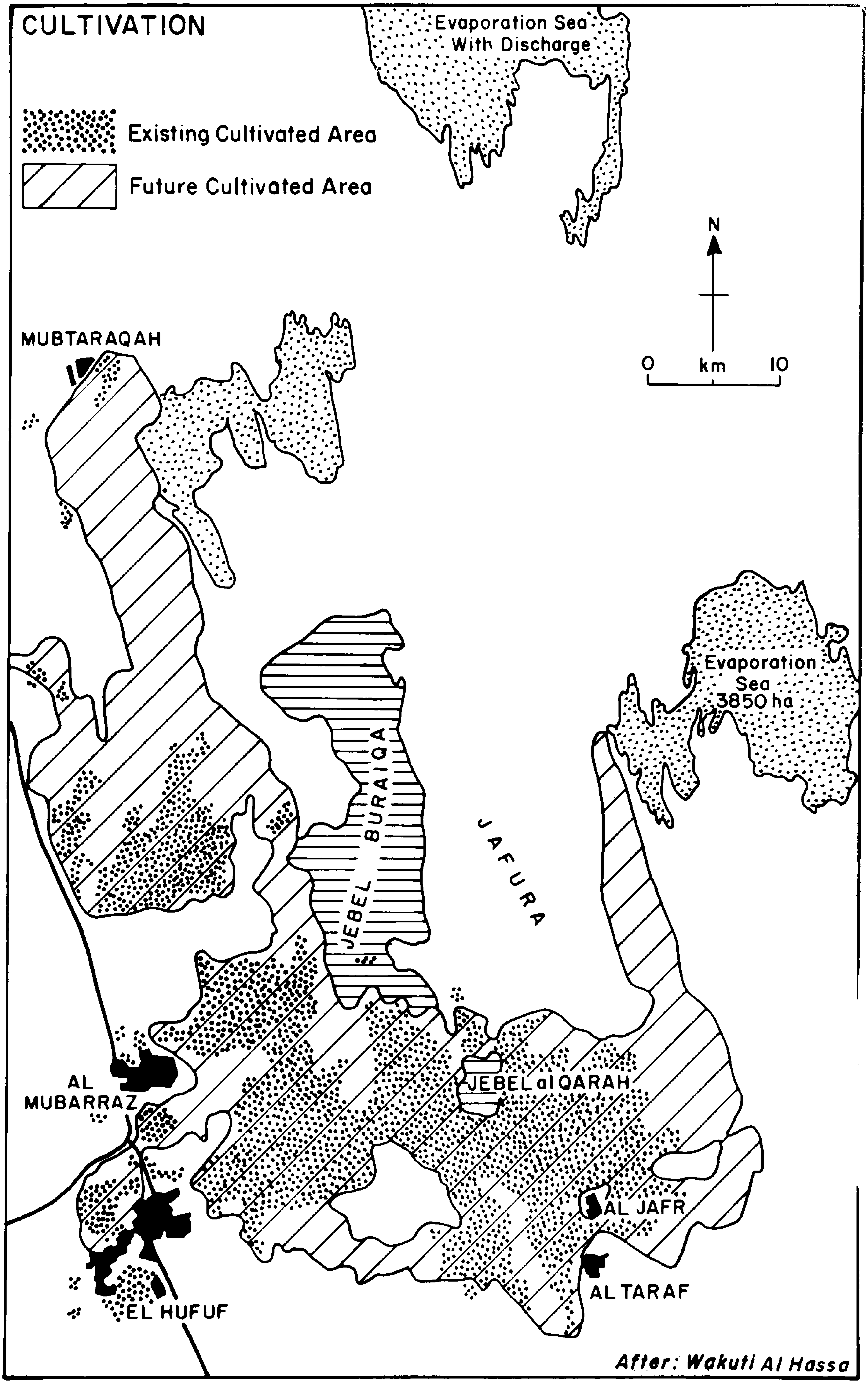
In 1963 10,000 ha. were under cultivation. This area is shown on Map No. 2, but in fact only 8,000 ha. were in good condition, the remaining 2,000 ha. being highly salinated.

The crops shown in the following table were grown:

Map No. 1


SAUDI ARABIA
N
0
1000
Km
SYRIA
IRAQ
IRAN
MEDITERRA
NEAN SEA
JORDAN
EGYPT
SUDAN
ETHIOPIA
RED SEA
GULF
Hail
Dhahran
HOFUF
Medina
El Riyadh
Jidda
Mekka
RUB AL KHALI
Sana
Mukalla
Hodeida
Aden
GULF OF ADEN
ARABIAN SEA

Map No. 2


CULTIVATION
Existing Cultivated Area
Future Cultivated Area
Evaporation Sea With Discharge
N
0 km 10
MUBTARAQAH
Evaporation Sea 3850 ha
JEBEL BURAIQA
JAFURA
AL MUBARRAZ
JEBEL al QARAH
AL JAFR
AL TARAF
EL HUFUF
After: Wakuti Al Hassa

Map No. 3

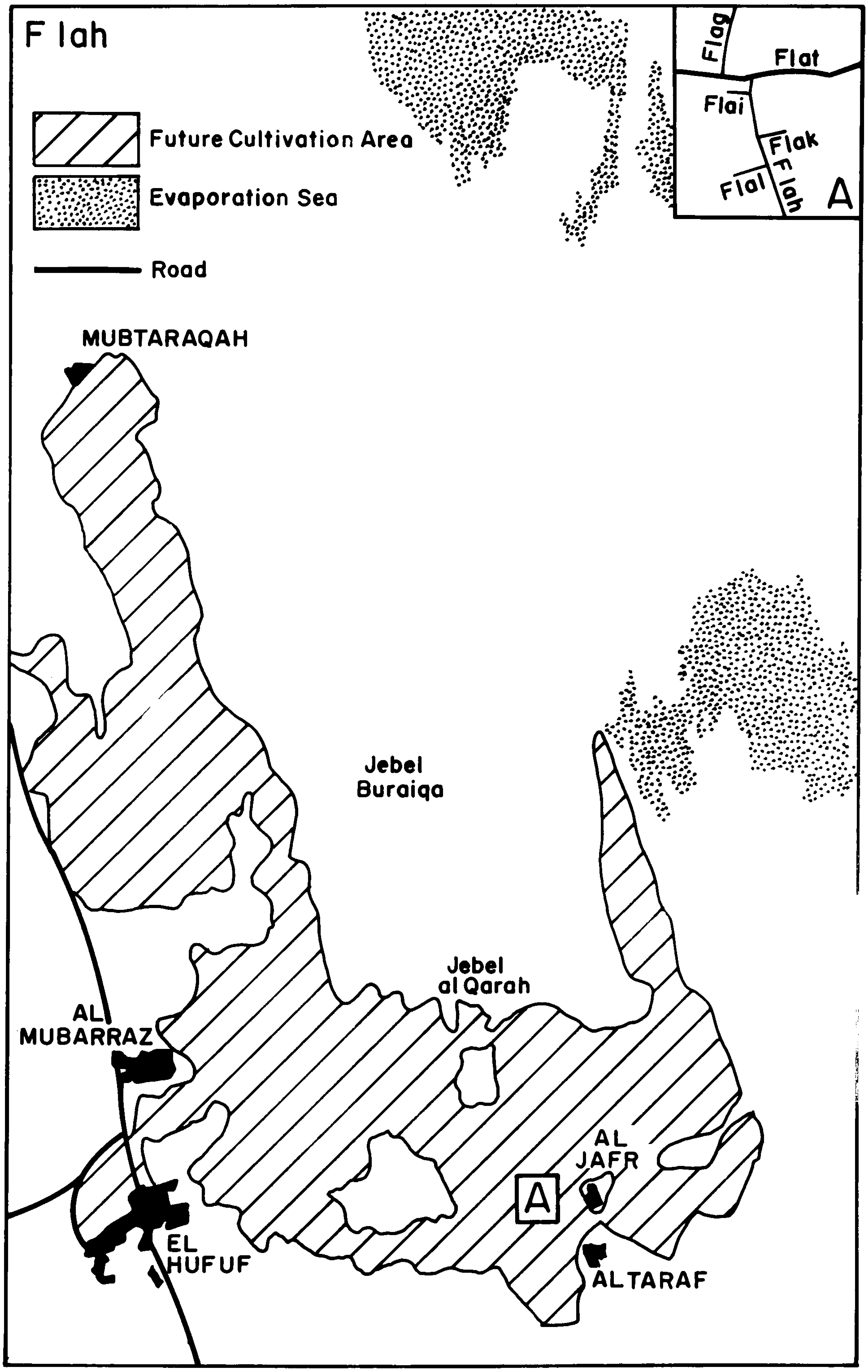

F lah
Future Cultivation Area
Evaporation Sea
Road
Flag
Flat
Flai
Flak
Flal
F lah
A
MUBTARAQAH
Jebel
Buraiqa
Jebel
al Qarah
AL
MUBARRAZ
EL
HUFUF
AL
JAFR
A
ALTARAF

Table No. 1 Cultivated area of Al Hassa[7]

CROP	AREA IN ha.
Date trees (with or without subculture)	4,750
Alfalfa	880
Rice	1,150
Other crops (vegetables, melons, etc.)	1,120
Total	8,000

Thus of the total area under cultivation about 38 per cent - 3,150 ha. - was cultivated with a second crop besides palm trees.

However, in 1971 it was estimated that in fact only 15.79 per cent, i.e. 1,263.2 ha. of the 8,000 ha. are cultivated with a second crop besides date palms.[8]

In April 1971 the situation at Flah (see Map No. 3 and Table No. 2) was as follows. Map No. 4 illustrates the above situation.

The smallest agricultural production unit found in Flah is two palm trees in Flah1, and a plot of 0.015 ha. in Flah3, but such tiny units will be disregarded in this study. The smallest unit recognized is a 0.244 ha. farm, which is the average farm size in Flah. In addition, a calculation based on a farm size of 1.808 ha., the largest farm found in Flah, will be made.

The present cropping pattern in the oasis (based on the Flah study and the author's experience in Al Hassa) is as shown in the table below:

Map No. 4

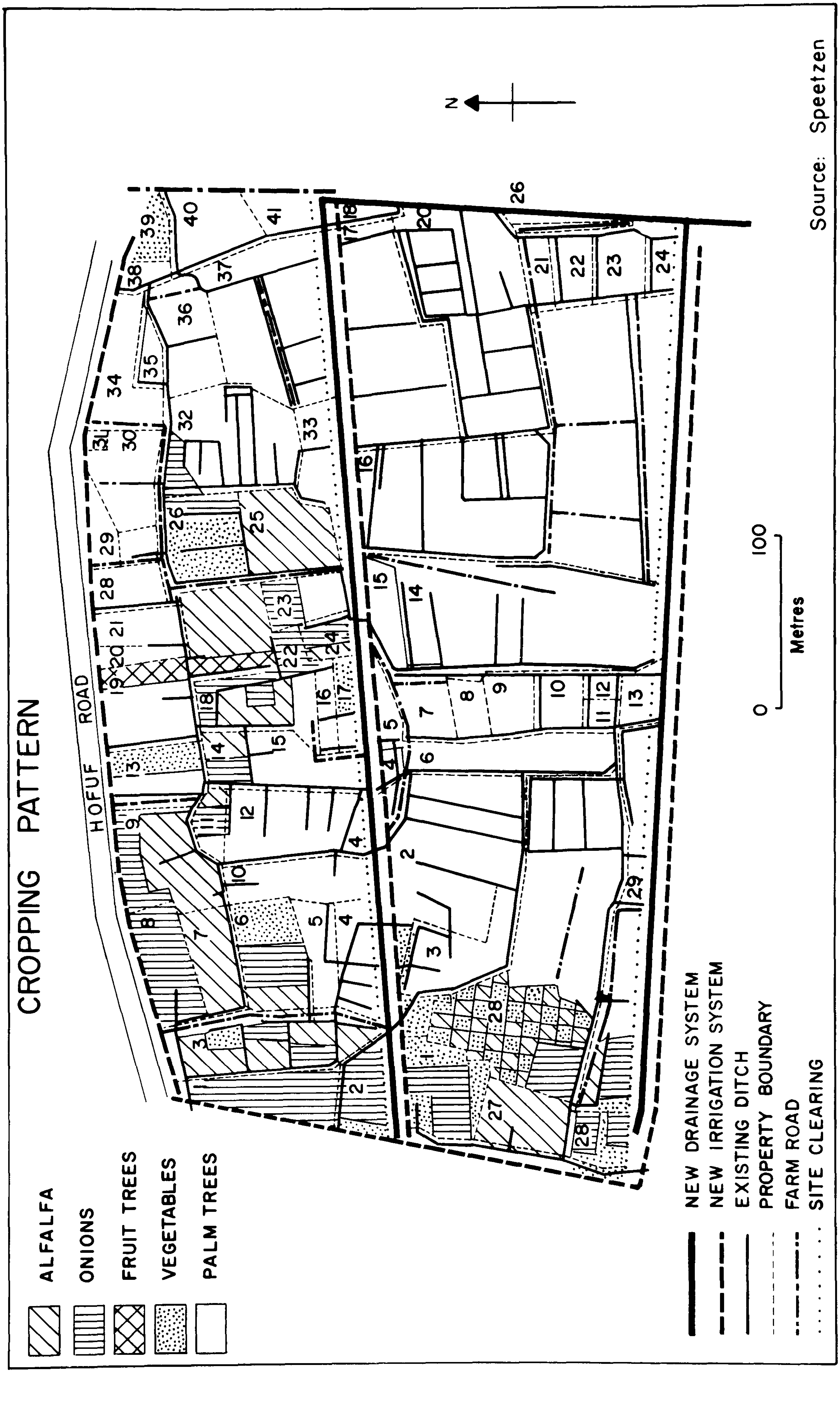

CROPPING PATTERN
HOFUF ROAD
ALFALFA
ONIONS
FRUIT TREES
VEGETABLES
PALM TREES
NEW DRAINAGE SYSTEM
NEW IRRIGATION SYSTEM
EXISTING DITCH
PROPERTY BOUNDARY
FARM ROAD
SITE CLEARING
N
0
100
Metres
Source: Speetzen

Table No. 29 Cropping pattern in Flah

CROP	Flah1 + Flah3 = 17.091 ha.		Flah1 = 7.405 ha.		Flah3 = 9.686 ha.	
	ha.	percentage	ha.	percentage	ha.	percentage
Alfalfa	0.849	4.97	0.589	7.95	0.260	2.68
Onions	1.039	6.08	0.921	12.44	0.118	1.22
Vegetables	0.699	4.09	0.385	5.20	0.314	3.24
Fruit trees	0.122	0.65	0.122	1.51	-	-
Total	2.699	15.79	2.007	27.10	0.692	7.14

Table No. 3 Cropping pattern

CROP	PROPORTION IN PERCENTAGE
Onions green	2.03
Onions dry	2.03
Lettuce	2.03
Alfalfa	4.97
Rice	15.00
Vegetables, melons	4.09
Fruit trees	0.65

In addition, date palms are grown on 50 per cent of the land. Assuming that about 40 trees are grown per Dunnum*,[10] the average farmer (0.244 ha.) owns 48.8 trees and the largest farmer (1.808 ha.) owns 361.6 trees.

The cropping pattern of an average farm and the largest farm is as detailed below:

Table No. 4 Cropping pattern of average and largest farm

CROP	FARM OF 0.244 ha.	FARM OF 1.808 ha.	PROPORTION IN PERCENTAGE
Onions green	0.005	0.036	2
Onions dry	0.005	0.036	2
Lettuce	0.005	0.036	2
Alfalfa	0.012	0.090	5
Rice	0.036	0.270	15
Vegetables	0.005	0.036	2
Cucumber and melons	0.005	0.036	2
Fruit trees	0.002	0.018	1
Total	0.075	0.550	31

* Ten dunnum = one hectare

This cropping pattern is portrayed graphically in diagrams Nos. 1 and 2.

Livestock

The numbers and type of livestock kept in the oasis is shown in the table below:

Table No. 5 Livestock in Al Hassa

TYPE	NUMBER 1959[11]	1968[12]
Cattle	10,000	6,036
Sheep and goats	45,000	11,414
Donkeys	9,000	?

This table apparently shows that the number of animals has recently decreased.

The cattle in Al Hassa are mostly of zebu type and are kept for milking purposes only.

Most of the donkeys in the area are of the white Al Hassa type which are used to pull two-wheeled carts and for riding. This donkey is very valuable and is exported to other countries of the Middle East.[13] Also a brown species is used to carry goods within towns and villages.

Most of the sheep, which are of the Najdi breed, are kept by settled nomads as for example in Al Uyun.

Besides the above-mentioned animals, fowl are raised in large numbers in Al Hassa, but since this activity has no relation to the settlement project it has not been included in this study. However, it is a very successful source of income and could be practised by farmers who are not able to enlarge their farms but do want to increase their income.

The number of horses kept in the oasis is very small and they are bred only by enthusiasts.

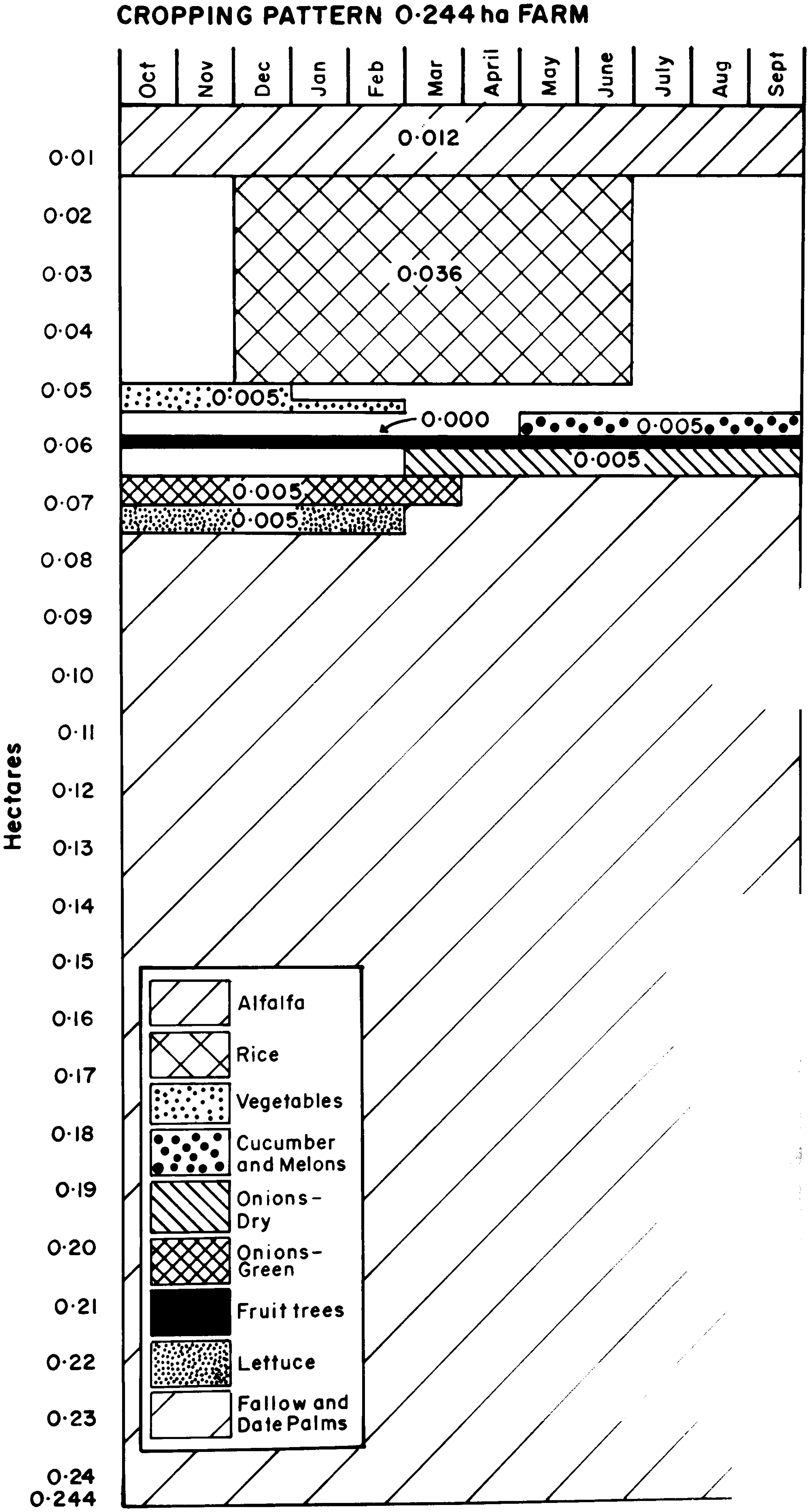
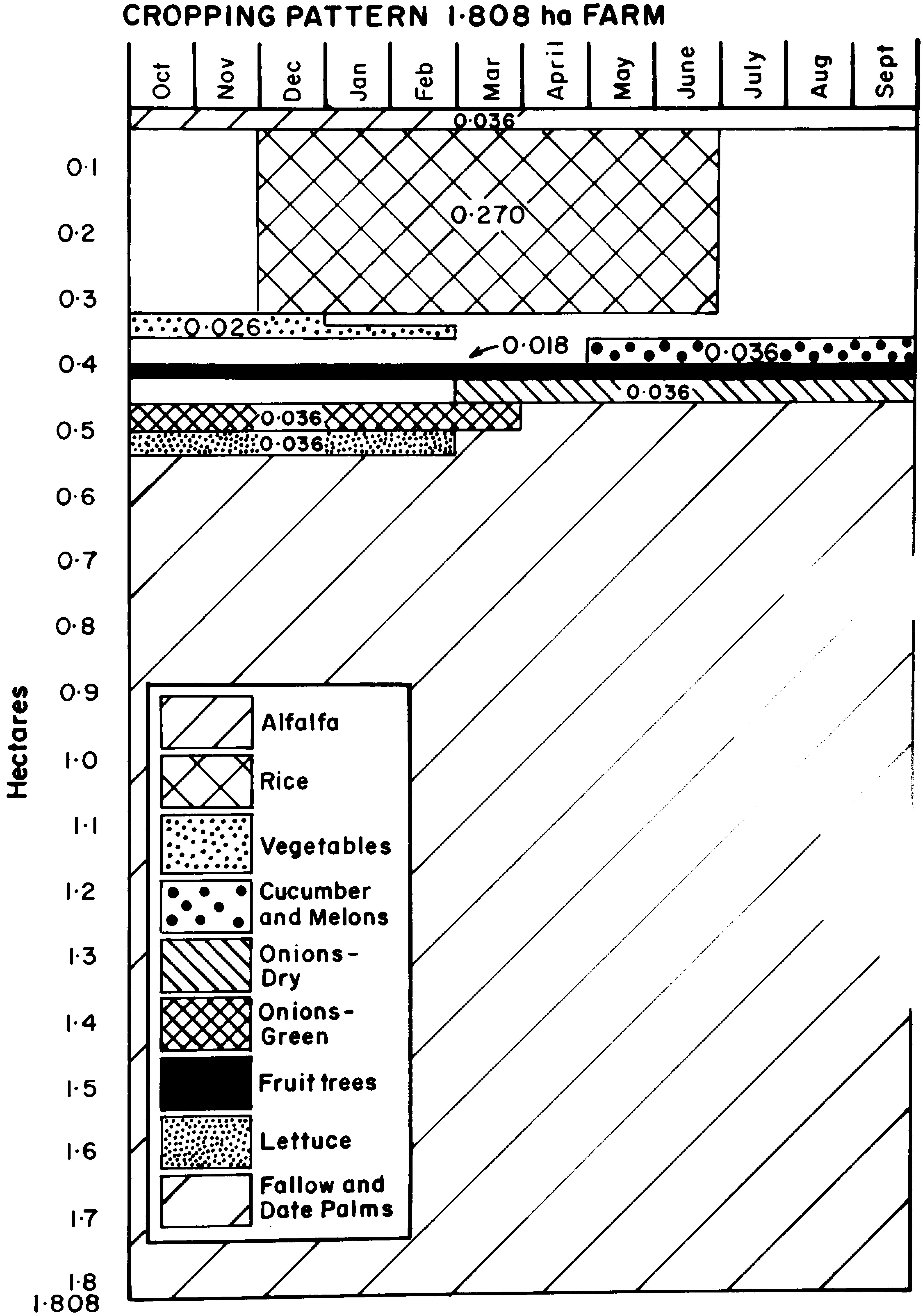

CROPPING PATTERN 0·244 ha FARM
Oct
Nov
Dec
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Hectares
0·01
0·02
0·03
0·04
0·05
0·06
0·07
0·08
0·09
0·10
0·11
0·12
0·13
0·14
0·15
0·16
0·17
0·18
0·19
0·20
0·21
0·22
0·23
0·24
0·244
0·012
0·036
0·005
0·000
0·005
0·005
0·005
0·005
Alfalfa
Rice
Vegetables
Cucumber and Melons
Onions-Dry
Onions-Green
Fruit trees
Lettuce
Fallow and Date Palms

Diagram No. 1



CROPPING PATTERN 1·808 ha FARM
Oct
Nov
Dec
Jan
Feb
Mar
April
May
June
July
Aug
Sept
0·036
0·270
0·026
0·018
0·036
0·036
0·036
0·036
Hectares
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
1·1
1·2
1·3
1·4
1·5
1·6
1·7
1·8
1·808
Alfalfa
Rice
Vegetables
Cucumber and Melons
Onions - Dry
Onions - Green
Fruit trees
Lettuce
Fallow and Date Palms

Diagram No. 2

Without any doubt the production of milk, meat and eggs could be increased as the marketing situation is promising, and there is a ready supply of farm produced fodder.

Research Station

A 60 ha. experimental farm is located near Mubarraz on the road to Ab Qaiq. On this farm, the Leichtweiss Institute, Braunschweig, is working on research into irrigation and drainage and the University of Wales is carrying out research into animal and forage production.

Fifty Jersey cattle imported in 1964, and 250 sheep of the Black Najdi, White Najdi and Awassi breeds are kept, most of their daily fodder ration being supplied from a seven hectare alfalfa field.

These animals form the basis of an important part of the research programme which includes problems of animal husbandry, i.e. stock conservation, fertilizer and variety trials, demonstration of new techniques, better use of the old oasis land and new land, and extension service.[14]

The activities of this station could be extended to encompass the training of the farmers.

Population

When talking about the inhabitants of Al Hassa one must distinguish between two groups: the old society, including the settlers, the semi-nomads and the nomads, and the new community, made up of the people settled recently because of the oil industry.[15] The new community will not be considered here, as it is not engaged in agriculture. Emphasis will be placed on the old society which includes the groups shown below:[16]

1. Al Baharina
2. Hawalah
3. Negroid people
4. The newly settled parts of tribes

Al Baharina

This means "the people who work at sea, or seafarers", to which half of the population of the oasis belongs. In spite of the fact that this name refers to people working at sea, most of them are engaged in agriculture.[17]

Hawalah

The people of this group have settled mainly in Hofuf and Mubarraz and the majority of them belong to the Bani Tanim. Their group name "Hawalah" means "Transference", because they have been settled on the Persian coast of the Gulf for several centuries. During that time the people remaining in Al Hassa became Shiites, but since the Hawalah were absent they remained Sunniites. They prefer to be craftsmen.[18]

Negroid people

These are the remainder of those brought during the slave trade, now abolished. They are now free and fully integrated in the society and work in all professions.[19]

The newly settled parts of tribes

This group lives on the edges of the oasis near the surrounding desert, because when they first came to the oasis they still lived in tents and reared animals. They have now given up their tents and animals and live partly from agriculture. Included in this group is part of Bani Khalid, Al Ojman and Bani Yas.[20]

Bani Khalid

During the 17th. and 18th. century the Bani Khalid reigned over the whole area.[21] Even today, in spite of the fact that the oasis has been occupied by many different powers and is now part of Saudi Arabia, "the Bani Khalid still consider themselves as the rightful masters of the area".[22] The following sections and subsections have been settled in the region.[23]

Section	Subsection
Al Humaid	
Al Jabur	
Al Miqdam	
Al Subaih	Al Katab

Until their power was broken by the Wahabis, the Bani Khalid was the paramount tribe of Eastern Arabia.[24] They are Maliki and not Hanbali Sunnis, most probably because of their hereditary antagonism towards the Wahabis.[25]

A few clans of the Al Ojman are settling in Al Uyun. This is at present the most powerful tribe of the Eastern Province.[26]

In addition to the above-mentioned tribes some clans of Bani Hasir live in the oasis.[27]

Vidal[28] believes that the proportion of Shiites to Sunnites is 55 to 45. However, the proportion of Sunnites will increase, because more and more Bedouins are settling in Al Hassa,[29] especially in Hofuf and Mubarraz. Although the overwhelming majority of the Sunnites are Hanbalis, all four orthodox schools are present.[30]

Apart from their respective religious characteristics, the difference between Shiites and Sunnites can also be seen in their education and occupations: the Sunnite children go to state schools whereas the Shiites prefer to send their children to unofficial schools run by Shiites. The Shiites are usually craftsmen while the Sunnites tend to be merchants, but only in Hofuf and Mubarraz these are full-time jobs, and in the villages they work part-time as farmers and farm labourers.[31]

With a density of 22 people per hectare[32] 130,950 people live in the oasis,[33] i.e. in Hofuf and Mubarraz 80,000 and in the 52 villages 50,950.[34] But estimates of the number of inhabitants vary, as shown in Table No. 6.

Table No. 6 Estimates of Al Hassa population according to different sources[35]

SOURCE	EASTERN OASIS	HOFUF	MUBARRAZ	ALL VILLAGES	TRANSIT. OR NOM.	TOTAL
Hogarth, 1905, p. 234		20,000	20,000			
Dickson, 1949, maps		25,000 or 30,000	10,000			15,000
von Wissmann, n.d. (1937), pp. 192; 204-205		30,000				150,000
Philby, 1923, I, 22-32	7,500					
Crary, 1951, p. 379						150,000
Fuad Hamzah, 1933, p. 78		100,000			200,000	300,000
Hafiz Wahbah, 1935, pp. 71-72		62,500			187,500	250,000
Harrison, 1924, p. 43		30,000				100,000
Handbook of Arabia		25,000	8,500			
al-Bilad al Saudiyah, XV, No. 1108, 2 Dec. 1951		150,000 or 200,000				500,000
Lorimer, 1908, p. 644		25,000	8,500	33,500		67,000
Mackie, 1924, pp. 194-195		30,000	20,000	30,000	15,000	95,000
Dowson, 1952, p. 51						250,000
Vidal		60,000	28,000	50,000	20,000	158,000
Local estimates: a. most conservative		60,000	30,000	40,000	30,000	160,000
b. most exaggerated		175,000	50,000	55,000		280,000

Vidal[36] believes "that 160,000 is probably a reliable figure for the total population of Al Hasa". WAKUTI estimated 200,000 inhabitants. Of these about 60,000 live in Hofuf and about 28,000 in Mubarraz.[37] The others live in the 52 villages spread over the whole oasis. In 1951 there were more than 35,000 inhabitants living in the East Oasis and 15,000 in the North Oasis.[38]

The average annual increase in the population of Hofuf and Mubarraz during the 1960s, according to Abul Ela, was 2.77 per cent which can be traced to the migration within the oasis towards these two towns and to the governmental policy of encouraging people from Central Arabia to move to Hofuf and Mubarraz in order to increase the Sunnite population. At the same time many Shiites moved to the Qatif oasis or to Iraq and Iran, thus the Shiite proportion increased only slightly.[39]

The increase in several parts of the oasis can be seen from the following table:

Table No. 7 Increase of population in Al Hassa[40]

NAME OF LOCATION	YEAR 1908	1956	ANNUAL INCREASE IN PERCENTAGE
Hofuf and Mubarraz	33,500	80,000	2.77
Al Sabat	500	500	no change
Al Markaz	1,625	1,000	decline
Bani Nahu	100	-	vanished
Al Taraf	2,250	4,000	1.55
Al Shuqaiq	500	2,000	6.00
All villages	33,500	50,950	1.04

On average the male-female ratio is 51:49 in the Eastern Province.[41] The ratio for a Sunnite village in the oasis is shown below.

Table No. 8

The proportion male to female in Jishshah[42]

Houses		500
Rooms per house		6
Population		2,470
AGE STRUCTURE	**MALES**	**FEMALES**
-10	600	555
11-17	150	?
18-25	100	?
26-40	250	?
41-50	150	?
51-	50	?
Total	1,300	1,170

In this case the male:female ratio is 52.7:47.3.[43]

After deducting the young male people under 17 and the old and disabled people, which amounts to 30.7 per cent,[44] and the female population, 47.3 per cent, the proportion of the total population constituting the working population is reduced to 22 per cent. The females of the settled population are not considered to form part of the labour force as they are solely concerned with the household.[45]

One of the main reasons for the decline in agriculture is the shortage of labour, as much of the working population is employed in the oilfields. The farmers will stay on their farms, and others will be attracted to agriculture, only when farm work is equally profitable for both owners and farm labourers.

In general the age of marriage for the male is between 18 and 25, depending on his economic situation; very seldom does he marry younger or older.[46] The marriage age for females is between 13 and 19.[47] The number of children is from 1 to 11 but the average is 3.[48]

The marital status of Al Jishshah village is shown in the following table:

Table No. 9

Marital status in Al Jishshah in percentage[49]

AGE	MARRIED	SINGLE
18-25	94	6
Total	100	

On average the Sunnite's family is larger than the Shiite's, because it is more common among Sunnites to have more than one wife.[50]

The life expectancy in the area is about 35 years,[51] and the average growth of the population is 1.02 per cent per annum, which represents a doubling in 100 years.[52] The birth-rate and the mortality-rate is shown in the table below:

Table No. 10

Birth-rate and mortality-rate in Jishshah[53]

No. OF BIRTHS	BIRTHS PER THOUSAND	No. OF DEATHS	DEATHS PER THOUSAND
129	52.2	101	40.8

The Sunnites are mainly engaged in trade, whereas the Shiites are usually craftsmen, their traditions accounting for this. The Sunnites are former nomads who reject manual labour, whilst the Shiites, due to their contact with other people, such as Iraqis and Persians, gained the necessary skill for craftsmanship.[54] Whenever possible the Shiites live in villages exclusively inhabited by their own people. This is illustrated by the fact that out of the 55 villages in the oasis only 11 are inhabited by a mixed population. The Shiites are even prepared to leave their homes in order to avoid living with Sunnites, thus some Shiite families left Al Jafer and founded Al Sabat for this reason. In mixed villages, such as Al Jishshah, Al Jafer, Al Taraf and Al Fadhul, Shiites live on the side of the village which is closest to the cultivated land. The two sects are also strictly separated in Hofuf and Mubarraz.

Since most of the Shiites are farmers or farm labourers the new scheme will mainly help the Shiites.[55]

Migration of labour

There are three different types of migration in the Eastern Province:[56]

"1. From villages in Hofuf to other villages in the same oasis.
2. From the Hofuf oasis to the Qatif oasis.
3. From both Hofuf and Qatif and other parts of the region to the oilfields and commercial towns."

The types described in (1) and (2) are well established traditional movements, which have little influence on the total number of inhabitants. The third type, on the other hand, has an enormous influence on the size and quality of the labour force of the oasis and has partly caused the decline of agricultural production.[57]

Out of a total of 8,355 men working in the oilfields of the Eastern Province, 3,827 men, i.e. 45.8 per cent, came from Hofuf oasis, as shown in the table below:

Missing pages are unavailable

This table shows that members of the traditional elites, such as landlords, earn much less than someone who owns a car to rent to other people.

The average annual income of the labourers in the oilfields is 2,500 SR. Some of them already own houses, livestock, cultivated land or motor-cars.[60] That it is not surprising that the farm labourers move to the oilfields. The following table shows the problems created for the farmers by the movement of their labourers to the oilfields; only the young and the disabled stay on the famrs.

Table No. 13

Age structure of the workers in the oilfields[61]

AGE GROUP	NUMBER	PERCENTAGE
16-20	2,314	17.1
21-25	4,187	30.9
26-30	3,843	28.4
31-35	1,668	12.3

In the Eastern Province contractors make the highest profit as they normally invest in cars, trucks or buses. In 1956 their average income was 330,259.25 SR.[62]

However, it is not only in the oilfields that the salaries are tempting: the labour force employed in the non-agricultural sector (both in and outside the oasis) by, for example, traders and contractors, amounts to two thirds of the number of Hassawi employed by ARAMCO.[63]

Nutrition

Only rich merchants and land-owners can afford to eat meat, milk, vegetables, bread, fruit and canned foods daily. Farm labourers cannot afford this, but they do eat meat or fish occasionally. The daily diet of the nomads is milk and dates, and their animals are kept for milk supply and transport. A sheep, goat or camel is sometimes slaughtered on special occasions.

However, their diet is enriched by hunting wild animals. These are: dhabb, jeraboo, fox, gazelle, weasel, hedgehog and locust.

Before the nomads and farm labourers can participate in a modern working process their diet has to be improved considerably, because as was proved in the oilfields, the nomads are not strong enough and tire easily. But, through better agricultural techniques and higher production, salaries can be increased and the diet would be improved.

Land-ownership

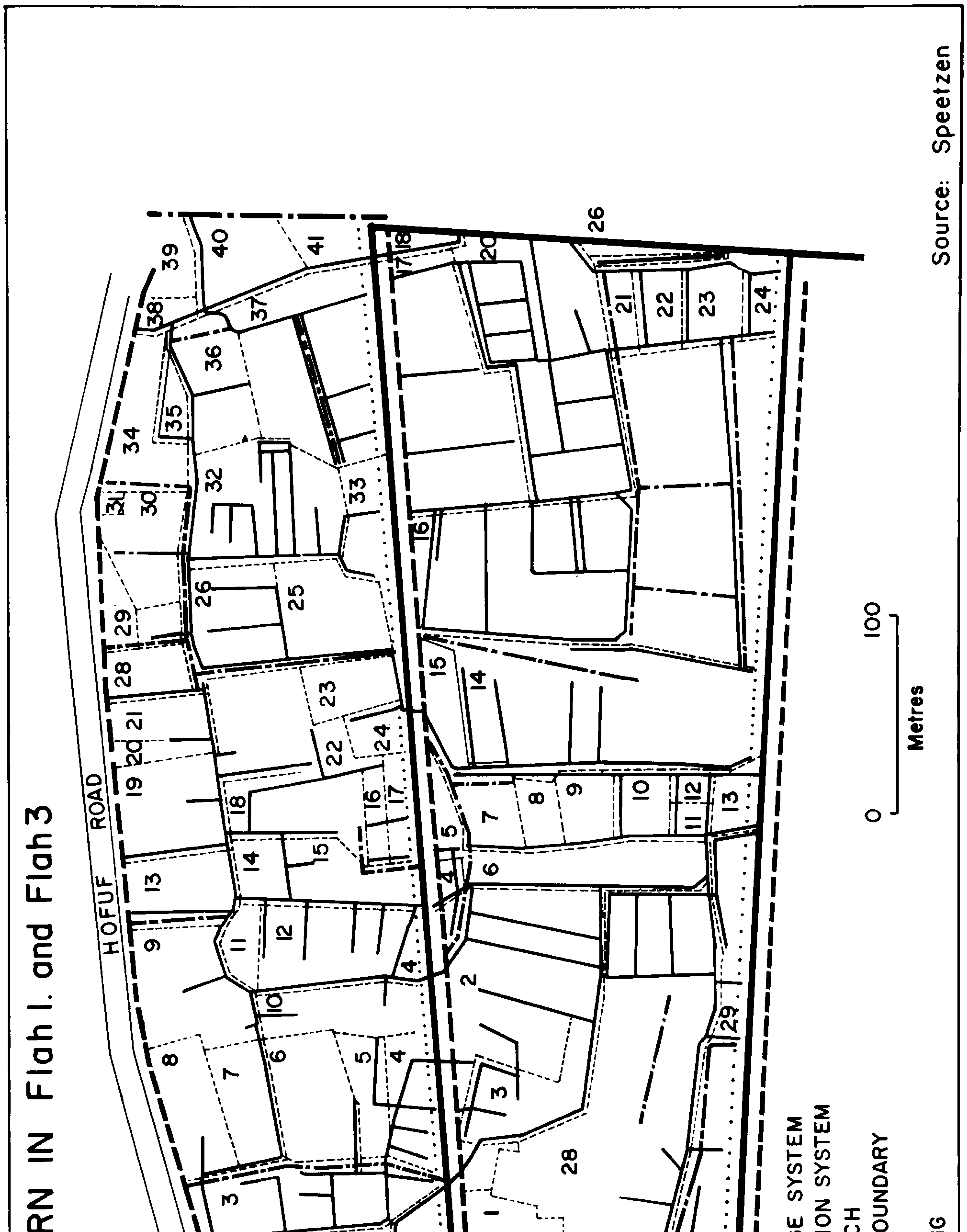
During the author's stay in Hofuf the farms at the irrigation canal Flah in the East Oasis were investigated.

The farms at Flah1 and Flah3 in particular were surveyed. Unfortunately, this area only amounts to 200 ha., or 2.5 per cent of the present cultivated area and one per cent of the future cultivated area. But no other information was available and, furthermore, the author was informed that this was a typical area of the Al Hassa Oasis. Thus, information referring to "Al Hassa Oasis" is in fact based on the situation in Flah1 and Flah3. Altogether the surveyed areas amounted to 17.091 ha., that is, in Flah1 7.405 ha. and in Flah3 9.686 ha.

The average farm size in the area is 0.244 ha., i.e. 0.181 ha. in Flah1 and 0.334 ha. in Flah3. The farm size varies in Flah1 between 0.016 ha. and 0.592 ha., and in Flah3 between two palm trees and 1.808 ha. In this study, the farm size of 0.244 ha. will be used as the overage for the whole area.

The owners' names and the farm sizes can be seen in Map No. 5 and in Tables Nos. 1 and 2 in Part 2 of Volume II. The name number represents the number of the property on the map. Thus, in Flah1 there are 41 farms and in Flah3 29.[64]

Map No. 5


PROPERTY PATTERN IN Flah I. and Flah 3
HOFUF ROAD
N
NEW DRAINAGE SYSTEM
NEW IRRIGATION SYSTEM
EXISTING DITCH
PROPERTY BOUNDARY
FARM ROAD
SITE CLEARING
0
100
Metres
Source: Speetzen

The name given as the owner's in Tables Nos. 1 and 2 of Part 2 in Volume II is not necessarily that of the present owner, but may be of a previous one. At present the farm could in fact be owned by a group, by the Government, by the Mosque or by individuals. If land-ownership is considered in greater detail it can be divided into five types:

1. HUKUMAK land, which is owned by high officials in the Saudi Government.[65]
2. Bait Al-Mal Land, which is owned by the Government itself.[66]

The land belonging to the above-mentioned categories was formerly Turkish and covers a quarter of the cultivated land.[67] Land owned by the Mosque (WAKF land) would also appear to belong to this group, although it was not mentioned by Vidal or by Abul Ela. The table below shows the situation in Flah.[68]

Table No. 14 Government land

	Flah1 + Flah3 17.091 ha.	Flah1 7.405 ha.	Flah3 9.686 ha.
Proportion in ha.	2.083	0.275	1.808
Proportion (%)	12.19	3.71	18.67
WAKF land			
Proportion in ha.	1.536*	1.292	0.244*
Proportion (%)	8.99	17.45	2.52

3. Individual independent ownership.[69] Of those people who own this land, 140, i.e. 0.1 per cent of the total, are rich merchants or members of the royal family who own large estates.[70] The rest is divided into small farms.
4. Multiple ownership, in which individuals own precisely defined and separate plots which share the same irrigation, but are harvested and worked separately.[71] This type of ownership covers 10 per cent

* + two palm trees.

of the land.[72]

5. Joint ownership: This land belongs to a group of people, who work, irrigate and harvest together. The share of the harvest depends on the size of each owner's holding.[73] This type of ownership covers 20 per cent of the land.[74]

Two thirds of the land is owned jointly by the Government and small local groups.[75]

Land tenancy

In this case an agreement between the tenant and the landowner exists, in which a fixed proportion of the harvest is awarded to the landowner as rent. Since the proportion is based on the best yield ever obtained, the tenant, because of his lack of money to buy fertilizer and other production means and the increasing salinity of the soil, is not able to fulfil his contract and becomes more and more indebted.[76]

Soil[77] (See Map No. 6)

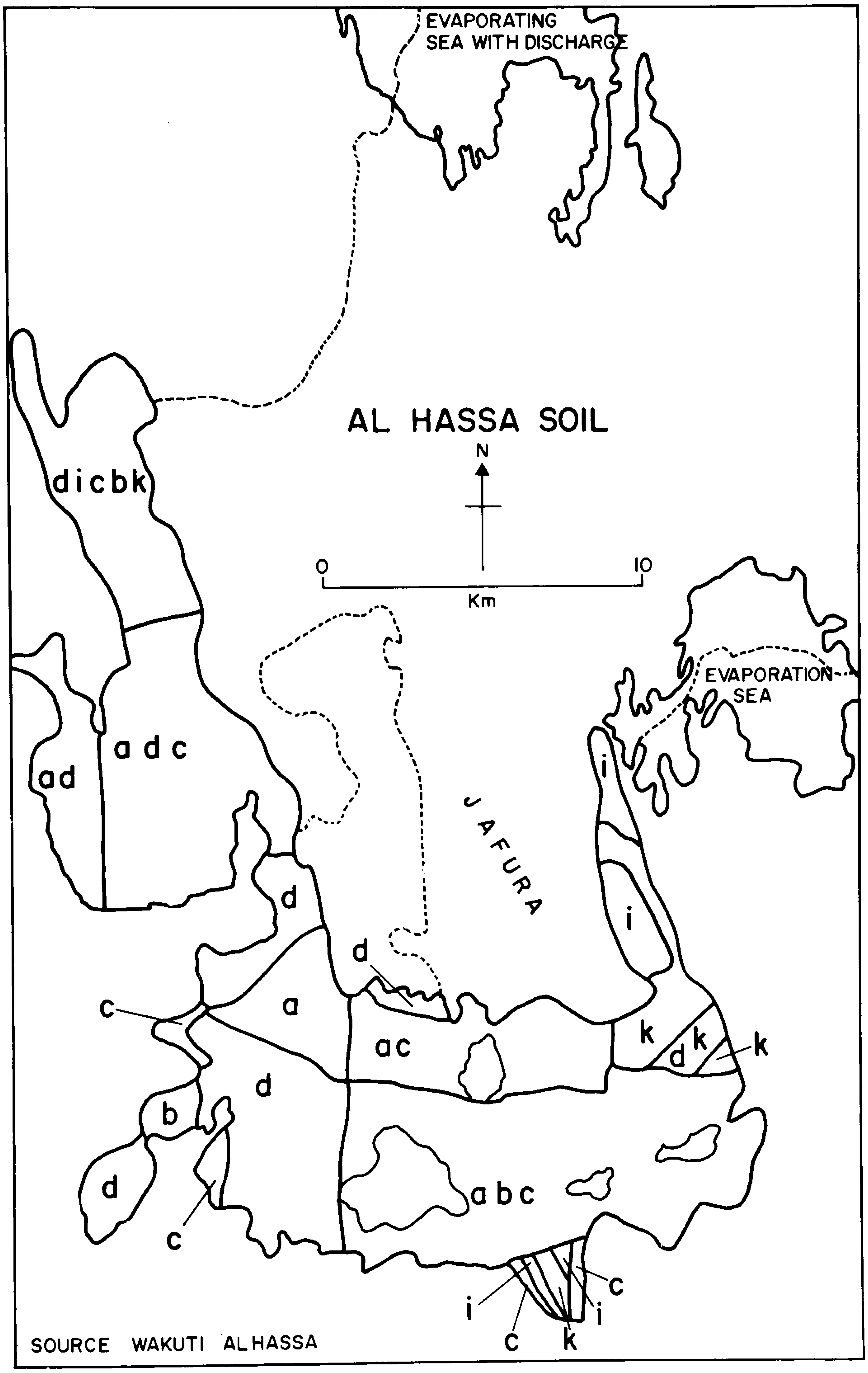
Over a total area of 35,300 ha. the soil can be classified into six categories. These categories and their sizes are as follows:

Table No. 15 Soil catagories

MAPPING UNIT	SIZE IN ha.
a	5,385.3
b	2,642.5
c	6,416.6
d	8,551.7
i	3,347.4
k	2,130.4
Total	28,474.0

The characteristics of the different areas are detailed below:

Map No. 6


EVAPORATING
SEA WITH DISCHARGE
AL HASSA SOIL
N
0
10
Km
EVAPORATION
SEA
JAFURA
dicbk
adc
ad
d
d
a
c
ac
d
b
d
c
abc
i
i
k
d
k
k
i
c
c
k
i
SOURCE WAKUTI AL HASSA

Unit a: deep soils, 70 to 120 cm., loamy sands, sandy loams, humic, low salt content;

Unit b: middle to deep soils, 60 to 150 cm., loamy sands, sandy loams, poor humic, low salt content;

These units, i.e. (a) and (b), cover an area of 8,027 ha. This is the area which is still under cultivation.

Unit c: medium deep soils, 60 to 130 cm., initially loamy sands, sandy loams, poor humus, crusted saline soils, no vegetation;

These soils require improvement before they can be used for agriculture. They cover an area of 6,400 ha.

Unit d: medium deep soils, 90 to 130 cm., loamy sands, sandy loams, no vegetation;

Unit i: shallow soils, 40 to 80 cm., loamy sands, sandy loams, silty, very high salt content, vegetated with rushes, poor humus, Sabkah border areas;

Unit k: shallow soils, 40 cm., loam and heavy loam, humic, with rushes or no vegetation, deeper lying Sabkah areas.

The areas (d), (i) and (k) must also be considered in planning in order to meet the projected cultivation area of 20,000 ha. But only areas with a suitable soil depth, permeability, and structure and a flat surface will be considered. Since 6,000 ha. will be needed at the most, in addition to the 14,400 ha. gained from units (a), (b) and (c), it will be possible to find areas with the necessary characteristics from the 14,000 ha. of this unit.

Sand-dune problem[78]

1,000 years ago Juhwasa was the capital of Al Hassa but today it is more than 3 km. away from the northern border of the East Oasis buried beneath sand dunes. These dunes cover an area of 269 ha., 35 km. long and up to 8.5 km. wide in the north of the East Oasis. This dune field, with dunes of between 2-3 m. and 11-12 m. is still moving at a speed of 10 m. per year for a dune with an average height of 10 m. This means that sand masses of 255,000 cu.m. are moving into gardens and villages of the East Oasis. If no measures are taken against these dunes, within 600 years two thirds of the East Oasis will be covered by sand. Fortunately, a project to protect the oasis against sand-dunes was started in 1962[79] by the Saudi Government. This has already saved the village of Ashshimalyah in Al Umran, which otherwise would have been covered with sand by 1968.

The measures against the shifting sand are as follows:

1. Palm branch fences.
2. Tamarisk hedges.
3. Terraces grown with grass.

These measures, as shown at the northern border of the East Oasis, appear to be sufficient.

Salination

Large parts of the oasis are not under cultivation because of soil salination. This is the result of artesian irrigation water which is very saline and high evaporation due to climatic conditions. Furthermore, the irrigation methods of the farmers are not conducive to the prevention of salination in the future.

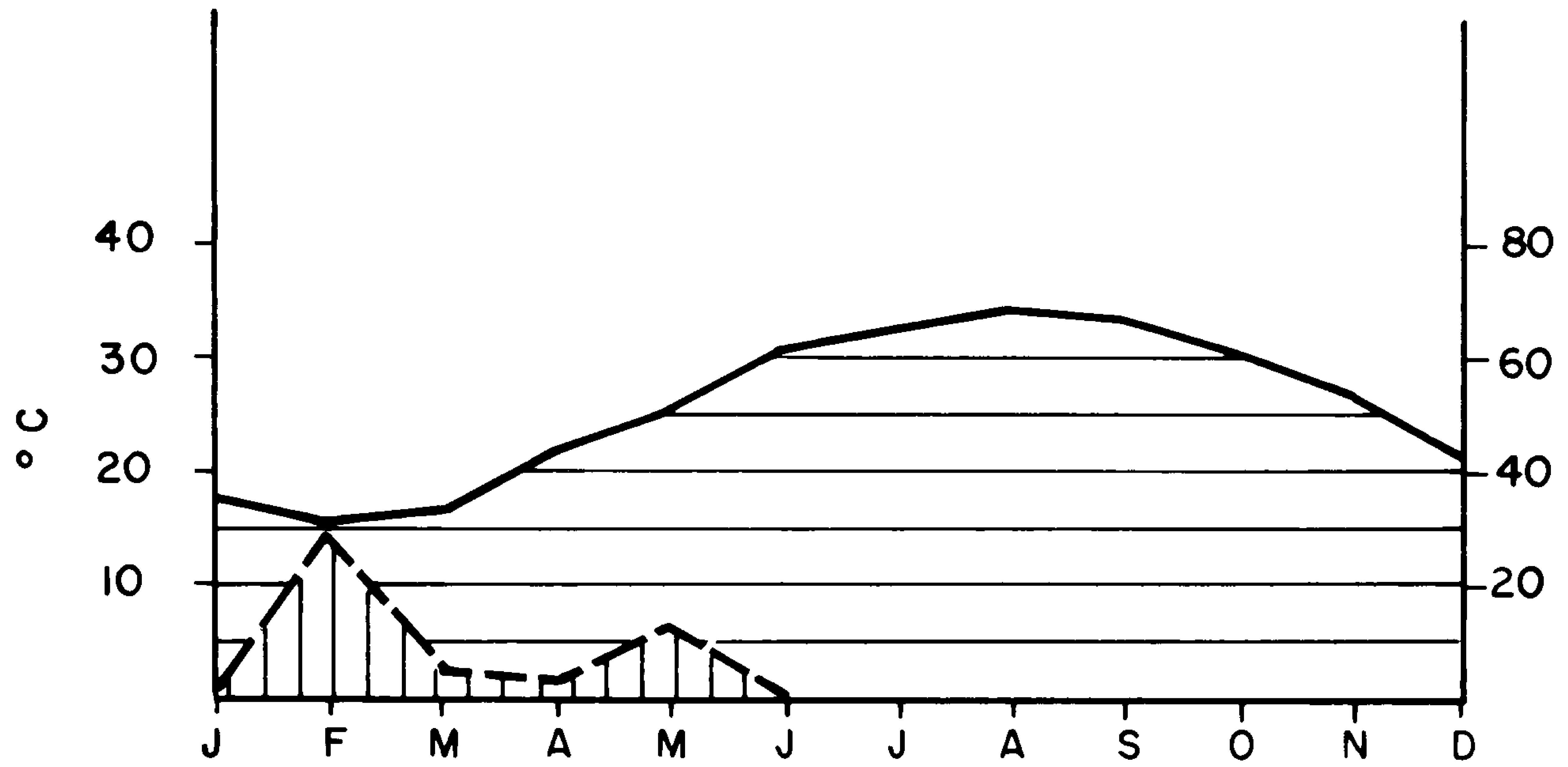
To make the soil productive, effective irrigation and drainage are essential.

Climate (See Diagram No. 3)

As meteorological records started only recently, it is very difficult to obtain reliable figures concerning the climate in Al Hassa. Most of the data are based on von Wissmann's studies in 1937, but these data are based on an inadequate number of observations.[80] However, these figures are worth mentioning because they are similar to more recent figures.

Diagram No. 3

CLIMATIC DIAGRAM AL HASSA



	J	F	M	A	M	J	J	A	S	O	N	D
TEMP °C	17·33	15·33	16·47	22·1	25·2	30·53	32·43	34·17	33·57	30·65	26·93	21·5
m.m.	1·1	29·0	5·7	3·63	12·73	0·13			0·3		0·4	0·3

THIS DIAGRAM IS BASED ON DATA COLLECTED FROM NOV. 1968 TO SEPT 1971 BY LEICHTWEISS INSTITUTE OF THE UNIVERSITY OF BRAUNSCHWEIG. BECAUSE OF THE SHORT STUDY PERIOD THE VALUE OF THIS DIAGRAM IS LIMITED. UNFORTUNATELY NO OTHER DATA IS AVAILABLE.

---- RAINFALL ——— TEMPERATURE

DRY SEASON HUMID SEASON

Von Wissmann recorded an average annual temperature between 27°C and 31°C, a relative humidity of 70-75 per cent and an annual precipitation of 100 mm.[81]

The description of the climate of the Al Hassa Oasis in this chapter is based on research done by the Leichtweiss Institute in Mubarraz.

The following data was collected:[82]

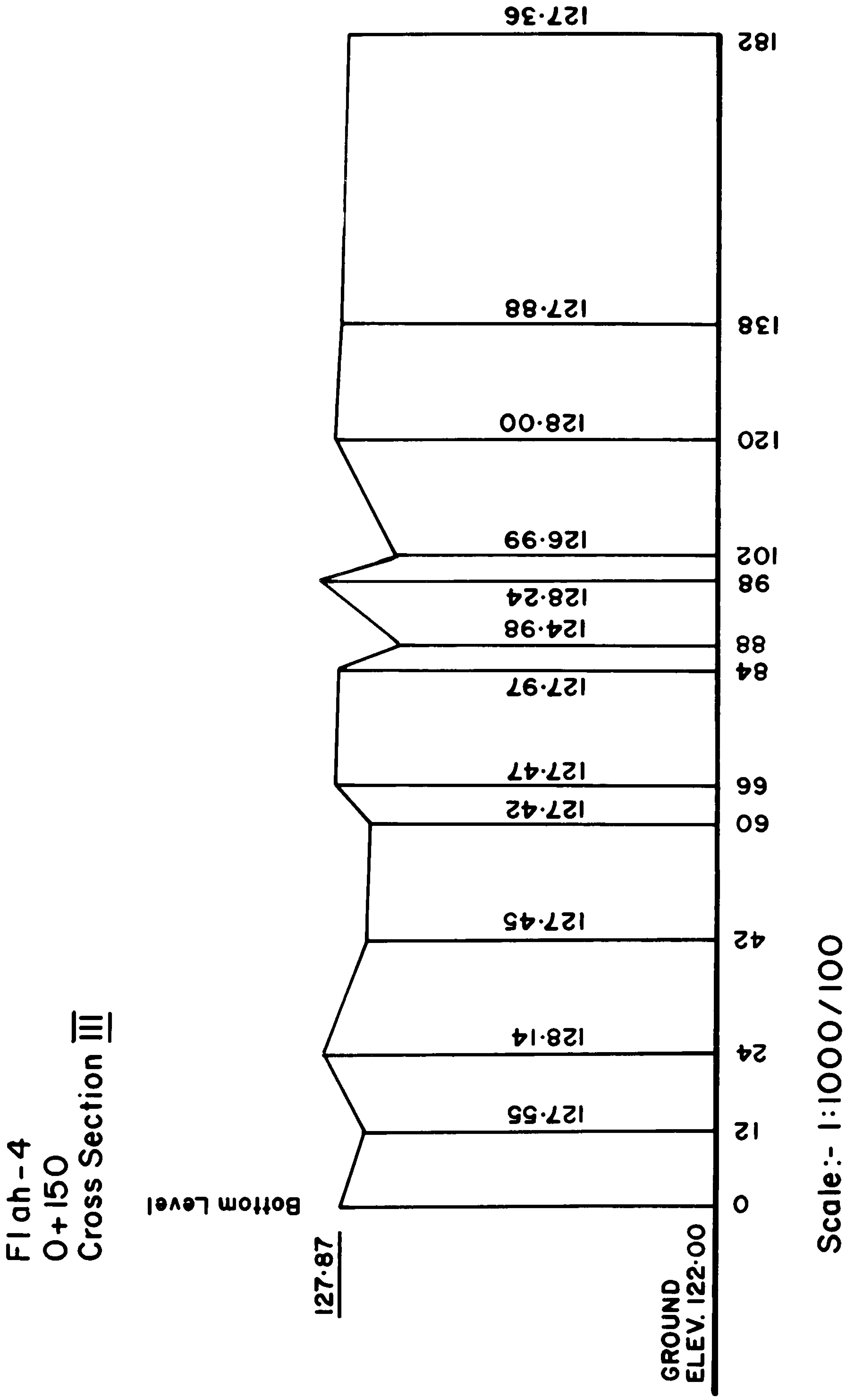
Annual average temperature	20°C
Mean maximum temperature in July	44.7°C
Maximum temperature in July	51°C
Solar radiation in June	725 cal./cu.m./day
Maximum temperature variations, May-Sept.	35°-51°C
Air humidity, mean daily maximum in June	9%
Air humidity, mean daily maximum in December	33%
Minimum winter temperature	above zero
Once every 15 years frost occurs	
Evaporation of free water surface	3,500 mm.
Calculated evapotranspiration	2,450 mm.
Monthly value of evapotranspiration - summer	300 mm.
Monthly value of evapotranspiration - winter	90 mm.
Rainfall	60 to 70 mm.

Topography

Hofuf lies about 150 m. above sea-level but within the oasis a number of hills, the most important of which are Djebel Buraiqa and Djebel Qarah in the East Oasis, rise 50 to 100 m. above the general surface. At the western end of the oasis lies the Summan plateau.[83]

The future agricultural area is nearly level, although there is a slope from the Hofuf area to the region of Al Jisha and Al Umran in the east, the difference in height being about 15 m. in 15 km., i.e. one per thousand. There is a similar slope from Mubarraz to Al Uyun, the

Diagram No. 4


Fl ah-4
0+150
Cross Section III
Bottom Level
127·87
GROUND ELEV. 122·00
0
12
24
42
60
66
84
88
98
102
120
138
182
127·55
128·14
127·45
127·42
127·47
127·97
124·98
128·24
126·99
128·00
127·88
127·36
Scale:- 1:1000/100

difference in height being approximately 30 m. in 20 km., i.e. a slope of 1.5 per thousand.[84]

Whereas the general slope of the project area is favourable for irrigation there are problems in some places between the irrigation canals due to the uneven surface. The necessary levelling cannot be done by machines because of the palm trees; thus an enormous amount of manual work is required, but this exceeds the capability of the farmers, and Governmental help is necessary. A typical cross-section of one of these areas is shown in the drawing below.

Present irrigation system

According to an unwritten law, adjoining owners are allowed to irrigate their crops from the canals, no restriction being imposed on irrigation time and water quantity. Thus water exploitation was always greater by day than by night.[85] The surplus water and the draining water are led to the next garden, and so on to the end of the oasis where the water flows into the desert or Sabkahs.[86]

Before the establishment of the new irrigation and drainage system, two kinds of irrigation were found in the oasis, i.e. the Saih irrigation and the Mugharraf irrigation.

Saih irrigation. Gravity flow from the artesian well.[87]

Mugharraf irrigation. The water had to be lifted from the water ditches by means of a Shaduf; thus man or animal power had to be used.[88] This more expensive method necessitated the cultivation of higher return crops, such as vegetables and alfalfa.[89]

The Saih irrigation is used in palm gardens where mainly date-trees and rice are grown. The Mugharraf irrigation is applied to alfalfa and vegetable areas.[90]

When the old system was in operation, the existing ditches were used for both irrigation and drainage. Thus the level of salinity rose continuously from one farm to the next. This was the cause of salination of large parts of the oasis and the decrease of the agricultural production.

This stepwise increase in salinity is shown in Table No. 16.

Under these conditions agriculture could only be effective when:

1. the soil is free from salt and
2. the irrigation water does not contain any salt.

But the irrigation water of the oasis is very saline and the salt concentration in the soil is high. The high ground-water level and the inadequate water supply increase the salinity still further.

Since the farmers knew no other solution, they abandoned the salinated land and moved to virgin soil.

The salination also led to date-tree monoculture, which is most marked in areas further away from the springs.

<u>The existing water reserves</u>

The only sources of irrigation water are the wells and springs which are either artesian or with pumps installed.[92]

<u>Wells</u>

Wells are spread over the whole oasis area, most of them in small gardens which have no connection with the irrigation system. Most of these wells were drilled by rich landowners who became independent from the irrigation system with its salinated water. 1972 estimates are that their output does not exceed 10 ltr./sec. but according to earlier work the maximum was 5 ltr./sec.[93] The total output of all 336 wells is 1.7 cu.m./sec. and they serve for irrigation purposes only. In general those in the North Oasis are equipped with pumps while those in the East Oasis are artesian. They vary in depth between 100 and 180 m. or 250 m. depending on the ground-water level which in turn depends on the occurrence of the Neocene Stratum or the Khobar Stratum. These two strata are separated by a thick impermeable layer. All these wells will be closed

Table No. 16 [91]

Increase in salinity

ION	SALINITY INCREASE FROM SOURCE TO AL DALWAH ppm	appr. %	SALINITY INCREASE FROM AL DALWAH TO ABU THAUR ppm	appr. %	TOTAL INCREASE ppm	appr. %
Sodium Na	48 (plus)	24.6	525 (plus)	312.0	573 (plus)	389
Calcium Ca	49 (plus)	25.5	357 (plus)	248.0	406 (plus)	312
Magnesium Mg	3 (minus)	15.7	-	-	3 (minus)	157
Sulphate SO_4	44 (plus)	14.3	657 (plus)	248.0	701 (plus)	308
Chloride CO_2	95.5 (plus)	26.9	852 (plus)	349.0	947.5 (plus)	274
Carbonate	-	-	-	-	-	-
Bicarbonate HCO_2	43 (plus)	22.0	177 (plus)	70.5	220 (plus)	213
Total salinity	276.5 (plus)	21.7	2,568 (plus)	264.5	2,844 (plus)	323

after the new scheme is established.[94]

Springs

These springs are artesian. Where the pressure is high enough the water flows out naturally, otherwise, a pump or shaduf must be installed.

There are two main groups of springs:

1. Approximately three kilometres west of Hofuf.
2. In the North Oasis near Al Mutairfi.

Most of the water comes from the Neocene Stratum. In total there are 162 springs with an output varying from 0.001 cu.m./sec. to 1.7 cu.m./sec. But only 34, i.e. those with the larger output will be used for the new scheme. According to another source 37 will be used.[95] The output of the others does not justify any investment.[96] The actual water delivery of these springs amounts to 364,000 cu.m./year.[97] The 34 springs are lined with a wall of reinforced concrete which is always 0.50 m. higher than the hydrostatic water-level.[98] Table No. 3 in Part 2 of Volume II shows these springs with their output and their adjacent irrigation areas.

Irrigation areas

According to the decision of the Ministry of Agriculture and Water the final design is based on 24 hours irrigation, despite the fact that, according to tradition, the farmers irrigate in the daytime only.

The new scheme will have a total area of 202.498 sq. km. (see Map No. 2). Over an area of 39.884 sq.km. the water must be pumped into elevated reservoirs and from there it will flow through the canals into the fields. The other 162.614 sq.km. can be irrigated by gravity.[100]

Table No. 17

Water consumption of crops in the Al Hassa Oasis (in cu. m.)

The water demand and a leaching requirement of 35 per cent, based on the Blaney and Criddle[99] method, is as shown below:

CROP	OCT.	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL
Alfalfa	1,917	1,701	1,431	1,296	1,289	1,404	1,674	1,836	2,187	2,241	2,214	2,106	21,286
Rice	-	-	1,004	1,814	1,777	1,966	2,344	2,570	3,062	1,568	-	-	16,105
Wheat	-	1,446	1,216	1,102	504	-	-	-	-	-	-	-	4,268
Barley	-	1,446	1,216	1,102	504	-	-	-	-	-	-	-	4,268
Potatoes	1,629	1,446	1,216	-	-	-	-	-	-	-	1,882	1,790	7,963
Sorghum	-	-	-	-	-	-	1,256	1,377	1,640	1,671	-	-	5,944
Maize	1,821	708	-	-	-	-	-	-	-	-	2,103	2,001	6,633
Sunflower	1,821	708	-	-	-	-	-	-	-	-	2,103	2,001	6,633
Lettuce	-	-	1,132	1,026	1,004	1,111	663	-	-	-	-	-	5,136
Onions	758	-	-	-	502	1,111	1,325	1,453	1,731	1,774	1,752	1,652	12,058
Vegetables	1,517	1,346	1,132	1,026	502	-	-	-	-	-	-	826	6,349

Table No. 18

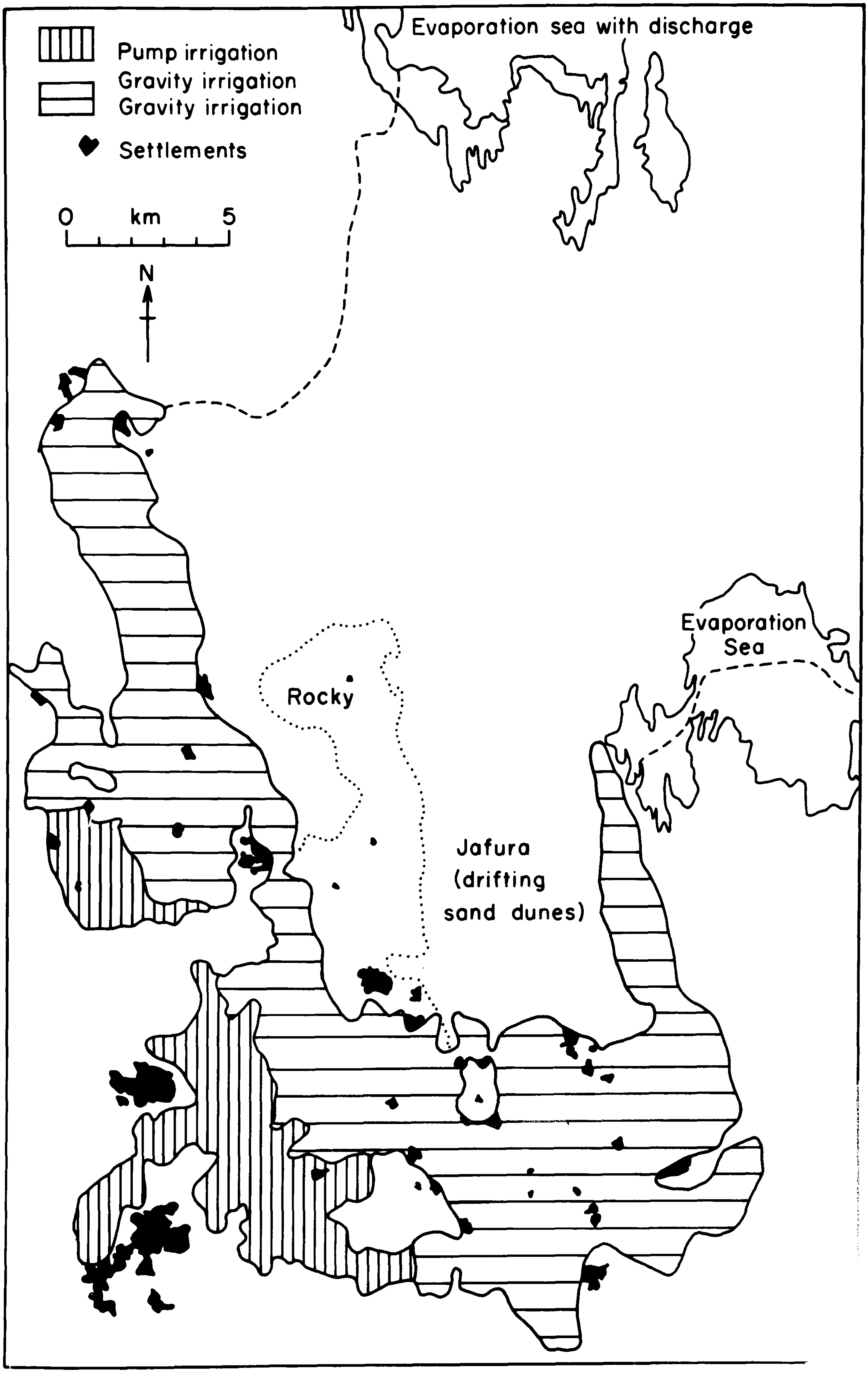
The size of the areas is in particular:

CANAL	SIZE OF AREA IN ha.[101]
F1.1	1,999.4
F1.1.1	562.9
F1.1.2	599.5
Total F1.1	3,161.8
F1.2	1,637.0
F1.3	777.7
F1.4	684.7
F1.5	611.7
F1	2,505.3
Total F1	9,378.2
F2	1,563.5
F3	171.9
F4	738.3
F5.1	565.1
F5	1,950.9
F6.1	139.0
F6	476.1
F7	385.2
Total F1-F7	15,368.2
P1	1,313.8
P2	784.1
P3	-
P4	1,186.3
Total P1-P4	3,284.2

Pump areas[102] (see Map No. 7)

3,284.20 ha. of the new scheme will be irrigated by pumps. Four pump areas were planned but the area P3 was cancelled later. It is proposed to establish the pump stations next to the springs from which water will be pumped into the adjacent elevated reservoirs. From these

IRRIGATED AREAS



Map No. 7

it will be led through sub and lateral canals into the fields.

All calculations below are based on an irrigation time of 20 hours. P1 (Ain Luwaimi) and P4 (Ain Al Harrah) have the same number of pumps and thus the same output and P2 (Ain Huweirrah) has three pump units. From the springs the water is led to the elevated reservoirs by pipelines 800 mm. in diameter.

The pump stations are equipped as follows:

P1

Four pumps with an output of 360 ltr./sec. each	1,295 cu.m./h.
In total 1,440 ltr./sec.	5,180 cu.m./h.

P2

Two pumps with an output of 395 ltr./sec. each	1,422.5 cu.m./h.
In total 790 ltr./sec.	2,845.0 cu.m./h.

P4

Four pumps with an output of 385 ltr./sec. each	1,386 cu.m./h.
In total 1,540 ltr./sec.	5,540 cu.m./h.

The storage capacity of the different reservoirs is:

Table No. 19 Reservoir storage capacity

No. OF RESERVOIR	CAPACITY IN cu.m.
ER 1	15,150
ER 2	8,000
ER 4	15,150

Feeder canals

These are the canals between the springs and the main canals. They have a rectangular profile and a bottom width between 1.00 m. and 3.50 m. Normally they are open canals and only in high lying terrain and when they are very deep are they closed.

The canals are:

<u>Open</u>: Z1.5 - Z1.6 - Z1.6.1 - Z6.1 - Z6.1.1 and Z6.12

<u>Closed</u>: Z1.1 - Z1.2 - Z1.3 - Z1.4 - Z1.4.1 and Z4

The closed canals are equipped with man-holes at intervals of up to 150 m.[103] Their total length is 5.812 km. In Table No. 4, Part 2, Volume II, more detailed information is given.

<u>Main canals</u>

The normal depth of the main canals is 1,50 m., and the bottom width varies from 2 m. to 11 m.[104]

From km. 0+290 to km. 2+350 canal F3, because of its great depth, is a closed canal.[105] Their total length is 151.588 km. In Table No. 5, Part 2, Volume II, more detailed information is given.

An overflow is installed on all main canals before the last branching sub-canal.

At the inlet to the sub-canals ground joists varying in height between 0.10 m. and 0.20 m. are installed to assure the required water quantity.

To raise the water-level and to ensure the required flow to the sub-canals, hand operated gates are installed.

In the "pump area" the water is led through pipes into the elevated reservoir and from there sub-canals lead the water into the irrigation system. Here again the water-flow is controlled by hand operated gates.

With the exception of the sub-canals F1.2ag, P4a and P4g, which are 1.50 m. deep, all other canals are one metre deep. The bottom width, depending on incline and volume of flow, varies from 0.50 m. to 1.00 m., only P4c and P4g having a bottom width of 2.00 m. These canals number 233 and their total length is 208.393 km. More detailed information is shown in Map No. 6, Part 2, Volume II.

All main and sub-canals are built of reinforced concrete.

Lateral and farm canals

The length of a single canal can be between 600 m. and 1,000 m. and the distance between the canals 150 m.,[106] which is adequate under these conditions.

The lay-out of the farm canals depends upon the topographic and land-ownership conditions.

The lateral canals are built of concrete, have a bottom width of 0.50 m. and a depth of 0.50 m. to 1.00 m. The farm canals are earth canals with no specific size.

From the sub-canals the water flows into the lateral canals through pipes 0.25 m. in diameter, which is sufficient for the amount of water needed to irrigated eight hectares. If the adjacent area is larger, two or more outlets are installed.[107]

The lengths of the lateral canals according to their different profiles are:

Table No. 20 [108] Lengths of profiles

PROFILE	LENGTH IN km.
1a	625.007
1b	376.890
1c	75.868
Total	1,077.765

Connection canal F2-5

This canal connects the main irrigation canal F2 and the irrigation canal F5 and is designed for a flow of 0.5 cu.m./sec. It is made of concrete with a bottom width of one metre and a depth of 1.50 m. The inflow and outflow is regulated by hand operated gates.[109]

Bottom falls

Bottom falls with a height of 0.50, 0.80, 1.00 or 1.30 m. are installed in several places. The height depends on the slope of the terrain. These bottom falls are built of concrete.[110]

Weirs

The water-level in the main and sub-canals is regulated by weirs. One hundred and thirty weirs have been installed in the main canals. In places where the canal is wider, i.e. up to 11.0 m., two weirs have been installed. With the exception of the weir 5.1-0, which is 3.40 m. high, all other weirs are 1.30 m. high. The top of the weirs always lies 0.20 m. below the canal crest, in order to avoid overflow from the canals.

The inflow from the main canals to the sub-canals is also regulated by weirs, of which there are 175. They are 1.30 m. high and vary in width from 0.50 m. to 1.50 m.

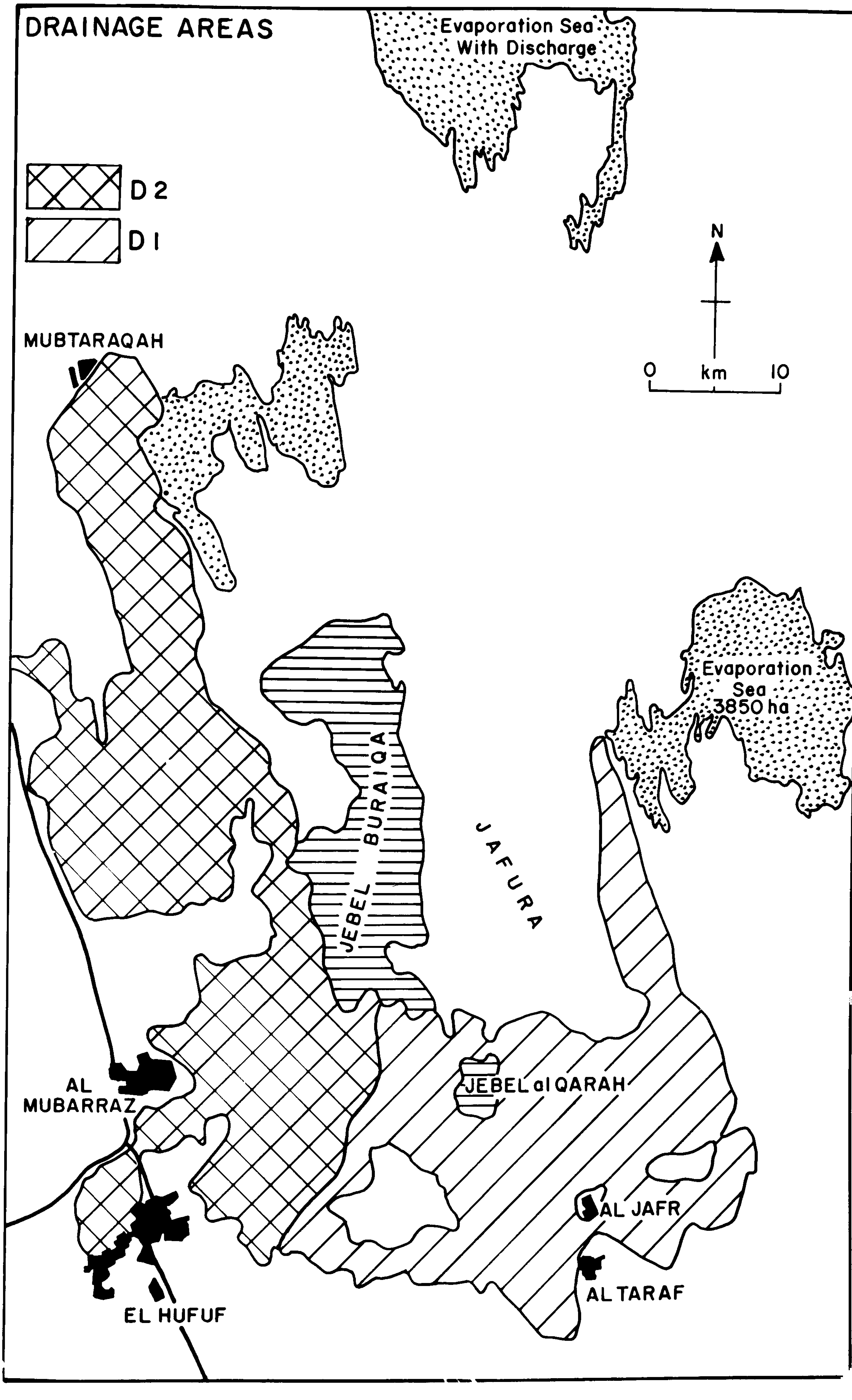
Four hundred and eighty weirs have been installed in the sub-canals at bottom falls and on longer slopes, to assure a sufficient inflow into the lateral canals. They range in width from 0.50 m. to 2.00 m., and from 0.60 m. to 1.10 m. in height.[111]

Drainage (see Map No. 8)

There are two main drainage areas: D1, which drains an area of 108.430 sq.km. of the North Oasis and D2, which drains an area of 94.068 sq.km. of the East Oasis. Together these areas cover 202.498 sq.km.

Dry weather discharge

The loss of irrigation water by infiltration amounts to 30 per cent, but this calculation is based on a loss of 36 per cent in order to assure the leaching requirement and cover the losses in the feeder canal. Thus the water quantity to be drained is 36 per cent of the irrigation quantity, i.e. 36 per cent of 1.8 ltr./sec. x ha.


DRAINAGE AREAS
Evaporation Sea
With Discharge
D 2
D I
N
0 km 10
MUBTARAQAH
Evaporation
Sea
3850 ha
JEBEL BURAIQA
JAFURA
AL
MUBARRAZ
JEBEL al QARAH
AL JAFR
AL TARAF
EL HUFUF

Map No. 8

A discharge of 14.6 cu.m./sec. for the total area can thus be expected. That is, 14,600 ÷ 20,249.8 = 0.72 ltr./sec. x sq.km.

Up to 10 sq.km. of alfalfa will be grown in the new scheme during summer. This will result in the following discharge: 0.36 x 1.8 = 0.65 ltr./sec. x sq.km. On the other areas, because of a different cropping pattern, the following discharge will occur: 0.36 x 0.72 = about 0.26 ltr./sec. x sq.km.

All calculated dimensions are multiplied by 1.5 in order to meet the demands of unexpected floods.

Rain-water discharge

This calculation is based on data collected in Dhahran and Abqaiq from 1953 to 1963, in Mubarraz during an unknown period and in the project area during the 1964 investigation.

Because of the surrounding sand-dunes and the incline of the area there will be such a small amount of water from outside the project area to be drained away that no special measures are necessary.

The drainage system is designed for the irrigation requirements, since during summer no additional precipitation occurs and in winter when it is raining irrigation is discontinued.

The soil does not discharge the infiltrated water immediately, and thus, even when the amount of rain-water is higher than the amount of irrigation water, the drainage system is sufficient.[112]

D1-D2-D3

Canal D1 discharges water drained from the North Oasis and leaves the area at Al Uyun. From there the canal flows east to the Sabkah Es Sarrah, then north through the sand-dunes and ends in an evaporation lake in the Sabkah Hammed which lies 20 km. beyond the project area and covers 5,000 ha.[113]

D2 carries water drained from the area east of Hofuf, a part of P1 and the East Oasis, and takes it to the Sabkah Al Asfar, then north-east into an evaporation lake and from there through the sand-dunes into another evaporation lake. This lake is situated about five kilometres beyond the scheme, lies about 10 m. deeper and covers 5,000 ha.[114]

Both lakes, i.e. the evaporation lakes of D1 and D2, are large enough to evaporate the annual amount of drainage water.[115]

Canals D1 and D2 flow through sand-dunes where they are built as closed canals if their bottom is more than 5.00 m. below the surface. Thus, D1 from km. 47+592 to km. 47+936 and from km. 49+750 to km. 50+940, and canal D2 from km. 22+510 to 22+610, are closed canals.

Simultaneously with the construction of the canals a dune stabilisation programme was started.[116]

Because of the sand-dunes problem the planned outflow, D2, had to be relocated, thus necessitating the construction of another canal, i.e. D3 south-east of Jishshah.[117]

Main drainage canals

The two main outflows, that is D1 and D2, are connected to the main drainage canals and lead the drainage water out of the scheme. The total length of the outflows and the main drainage canals is 143.281 km. More details are given in Table No. 7, Part 2, Volume II.

These canals are made of earth and they are between 2 m. and 4 m. deep, depending on the terrain. The bottom width is from 0.50 m. to 6.00 m. and the side incline is 1:1.5. The velocity of flow is between 0.30 and 0.60 m./sec. and thus no deposits or damages to the slope will occur.

In all main canals stone fascines are installed to prevent erosion.[118]

Sub-drainage canals

The sub-canals which will lead the water from the lateral canals to the main canals are also made of earth and are 1.80 m. to 2.20 m. deep with a bottom width of 0.50 m. The side incline is 1:1.5. Their total length is 174.313 km. More detailed information about these canals is given in Table No. 8, Part 2, Volume II.

The velocity of flow, which is between 0.30 and 0.60 m./sec., prevents deposits on the bottom of the canals and damages to their banks. Where the incline, and the resulting velocity of flow is too low the canals are lined with concrete. Stone fascines 0.20 m. in diameter prevent erosion of the banks.[120]

Lateral drainage canals

The lateral drainage canals are approximately 967 km. long[121] and are also made of earth. The canal side incline is 1:1.5 and the bottom width 0.50 m. The longitudinal incline varies between 0.50 and one per cent and the depth between one and two metres. The velocity of flow is within the admissible limits.

These lateral canals and those of the irrigation system run parallel to each other at 150 m. intervals.

The area between the lateral canals is drained by smaller ditches and the old irrigation-drainage system. The optimal spacing of these ditches is 20 m. and their optimal length 100 m. Therefore it is preferable to lay an underground drainage system in order to avoid land losses.[122]

Culverts have been installed under the roads where main and sub-canals and roads cross.

The incline of terrain necessitates bottom falls and, according to the different inclines, three heights are applied, i.e. 0.50 m., 0.80 m. and 1.00 m.[123]

Ground-water discharge

The water to be drained is irrigation water and spring water which does not reach the surface; precipitation is not high enough to be considered.

The water stagnates only in some lower lying areas.

The Sabkahs, i.e. Sabkah Al Arba in the South, Sabkah Al Asfar in the North-east and Birka Musa in the North, and the neighbouring areas of the oasis, have a high ground-water level - up to 20 cm. below surface, even in summer.[124]

Resettlement

To prevent further migration of the villagers to other areas, conditions in the villages must be improved considerably. Firstly the men must be given the opportunity to gain an adequate income from their farms or from their work as farm labourers. There are two possible ways to achieve this:

1. Specialisation in agricultural production which is independent of land, such as chicken or turkey rearing.
2. Enlargement of individual farms to ensure an adequate income.

The first solution requires a highly skilled labour force, and is very susceptible to fluctuations of market prices for both the production means and the finished product. Furthermore, the animals are prone to disease and the farmer could lose not only his profit but also the basis of his income. Thus the first solution is not advisable under the present circumstances. The second solution is more promising. Therefore, this solution will be dealt with thoroughly later in this chapter.

Nearly everyone in the area is settled, and plans exist for the improvement of housing conditions.

Transport

The transport system within the oasis and connections with other parts of the country have been improved due to the development of the oil industry.

Between Hofuf and Riyadh and between Hofuf and the Gulf asphalted roads were built in 1962. In 1951 a railway was built from the Gulf to

Riyadh. In Mubarraz the road and the railway meet.

Within the oasis there are asphalted roads and salt tracks. Donkey carts are used for transport, but they are being replaced by small trucks.

The few camels still remaining in the area mainly belong to the Bedouins who temporarily stay near or in the oasis.[125]

The following table shows the distances by road from Hofuf to several localities in Al Hassa and in Central and Eastern Arabia.

Table No. 21 [126] Distance to Hofuf

LOCALITY	DISTANCE (km.)	LOCALITY	DISTANCE (km.)
Mubarraz	3.7	Muhassin	6.0
Al Fudhul	9.1	Agricultural Station	10.1
Al Jafer	13.0	Al Mutairifi	11.8
Al Taraf	14.4	Ain Sad	16.9
Al Jishshah	16.0	Al Uyun	25.3
Al Dalwah	10.3	Al Jadidah	29.1
Al Tuhaimiyah	11.2	Abqaiq	69.0
Al Qarah	11.9	Al Uqair	73.0
Al Kilabiyah	10.2	Haradh	150.0*
Al Shabah	12.7	Yabrin	280.0
		Riyadh	370.0

The road network within the irrigation area is adapted to the drainage system in order to keep the number of bridges to a minimum.

For this network two types of road have been built:

1. Main roads: six metres wide and with 2 x 0.5 m. curbstone strips, a total width of seven metres.

* The track used nowadays is about 180 km. in length.

2. <u>Subsidiary roads</u>: five metres wide and with 2 x 0.5 m. curbstone strips, a total width of six metres.

Main roads have been built along the main drainage canals and subsidiary roads along the sub-canals.[127]

Trade

Hofuf was famous for the manufacture of coffee-pots and gold and silver ware, but these crafts are dying out as imported goods are better and cheaper. Pottery is declining for the same reason.

Basketry and matting although not highly developed are profitable to a limited extent.

The only remaining economically important activities are the textile industry and tailoring[128] which are practised on a family basis. If these were developed to a higher industrialised level they would become one of the main sources of income in Al Hassa, apart from agriculture.

Many new workshops, run mostly by immigrants from Palestine and Syria, have been established to cater for the increasing number of cars in the oasis.

Planned agricultural development

In order to increase the agricultural area and to introduce intensive crops, the planned water output of the springs has been increased by 1.7 cu.m./sec. to 14.6 cu.m./sec. However, this increased output will only be fully used in May.

The increased supply of 392.286 million cubic metres per year is only 28.326 million cubic metres per year or eight per cent more than the original 363.960 million cubic metres per year. But with this eight per cent increase in water supply, a 150 per cent extension of the agricultural area has been made possible, from 8,000 ha. to 20,250 ha.[129]

On this area the following crops will be grown: dates, alfalfa, rice, barley, wheat, sorghum, maize, sunflower, onions, lettuce and other vegetables. The cultivation time of these crops is shown in Tables Nos. 22 and 23.

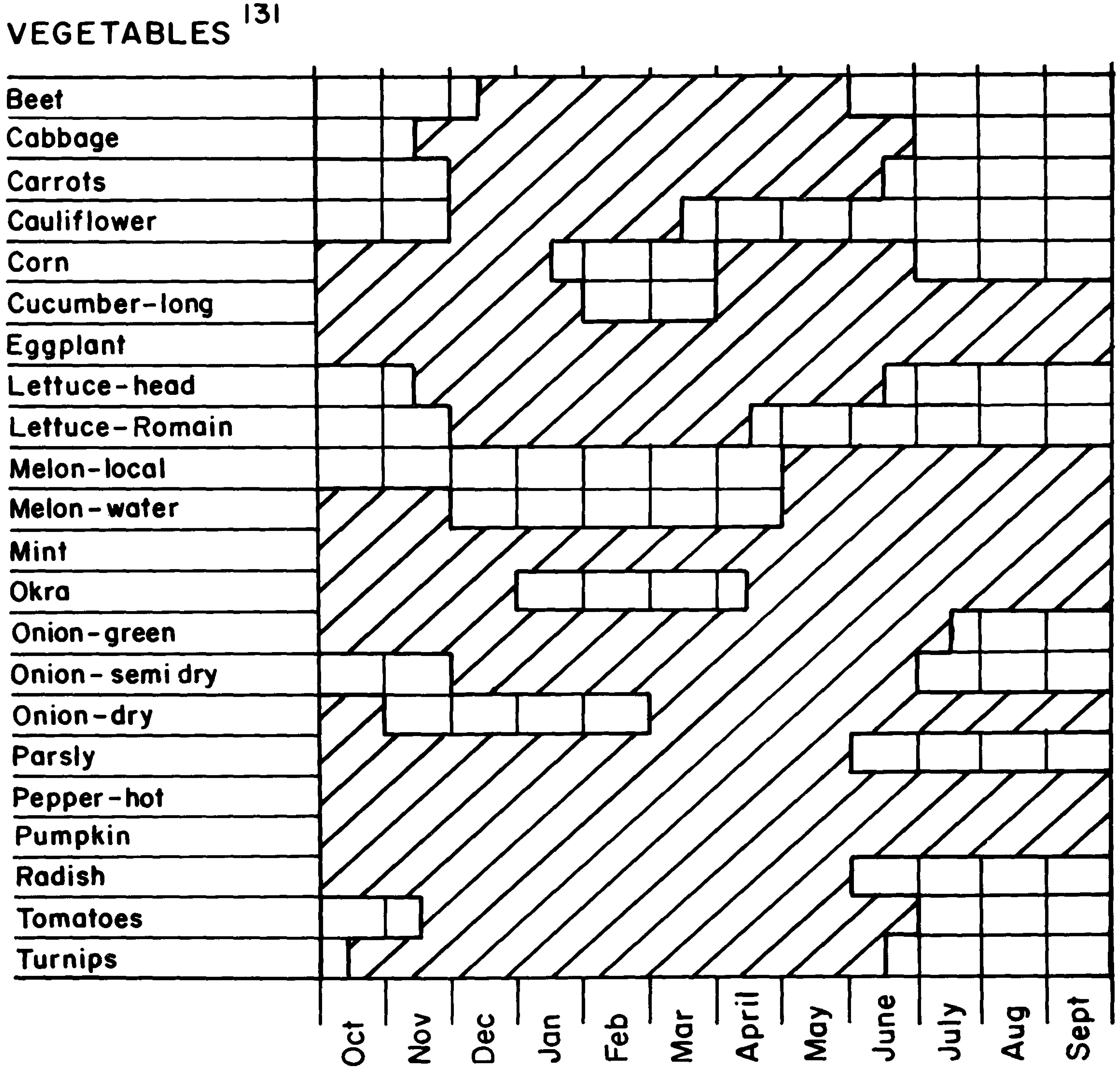
Table No. 22

Selected crops and cultivation time

CROP	TIME[130]
Dates	all year
Alfalfa	all year
Rice	December-July
Cereals	November-March
Potatoes	August-December

Based on a population of 200,000 in the Al Hassa Oasis, and assuming that the per capita consumption of agricultural products equals that of Riyadh in 1963,[132] the annual demand for agricultural products in the producting region would be as follows:

Table No. 23



VEGETABLES [131]
Beet
Cabbage
Carrots
Cauliflower
Corn
Cucumber-long
Eggplant
Lettuce-head
Lettuce-Romain
Melon-local
Melon-water
Mint
Okra
Onion-green
Onion-semi dry
Onion-dry
Parsly
Pepper-hot
Pumpkin
Radish
Tomatoes
Turnips
Oct
Nov
Dec
Jan
Feb
Mar
April
May
June
July
Aug
Sept

Table No. 24

Yearly demand for agricultural products

PRODUCT	DEMAND IN TONS
Dates	9,376
Rice	19,240
Fruit	14,544
Alfalfa	6,191 (for sheep)
	68,207 (for cows)
Vegetables	16,120
Field crops	21,220
Lamb	5,200
Beef	100

This demand would be supplied by agricultural products from the Al Hassa Irrigation project.

According to McMillan the annual agricultural output from the new scheme would be as follows:*

* McMillan's figures are based on two reports prepared by WAKUTI in 1964.[134/135]

Table No. 25

Output of the new scheme according to McMillan[133]

PRODUCT	OUTPUT IN TONS	REMARKS
Dates	59,000	
Rice	4,000	
Fruit	9,000	Pomegranates, citrus, plums, vines, figs, apricots, apples, etc.
Alfalfa	346,000	
Vegetables	122,000	Onions, lettuce, melons, etc.
Field crops	9,600	Wheat, barley
Beef	3,018	
Lamb and goat	571	

However, the following calculations are not based on these figures but on information concerning the cropping pattern, the planned cultivated area and the demand of the markets in Saudi Arabia, obtained during the author's own field study[136] in the Eastern Oasis and from WAKUTI's investigations[137] during the planning and construction period. These figures are more recent and reliable than those dating from before 1964.

The following table shows the demand, output and cultivated area necessary to cover the demand.

Table No. 26 Output and demand

PRODUCT	OUTPUT IN TONS	DEMAND IN TONS IN THE OASIS	WESTERN PROVINCE	AREA REQUIRED IN ha.
Vegetables	87,321	16,120	71,201	6,892
Wheat	7,065	7,065	-	2,355
Barley	7,065	7,065	-	2,523
Potatoes	7,065	7,065	-	565
Lamb (104,000 sheep)	5,200	5,200	-	1,939*
Beef	100	100	-	3,773**
Rice	14,544	14,544	-	2,200***
Total				20,247

* This area includes: 1,410 ha. of alfalfa, 353 ha. of sorghum, and 176 ha. of maize.

** This area is necessary to supply the demand of the 6,036 cattle in the oasis. The 100 tons of beef demanded each year by the population could be taken from this stock. The area includes: 2,414 ha. of barley, 679.1 ha. of alfalfa, 377.25 ha. of sunflowers and 301.8 ha. of maize. These cattle can also supply the demand for milk.

*** The present area of rice cultivation is too small to cover the local demand. If the cropping pattern found in Flah were applied to the whole scheme, the area devoted to rice cultivation would be 9,720 ha., or 48 per cent of the total cropped area. But in spite of the high demand rice cultivation will decrease in future for the following reasons:[138] the high water demand required for rice cultivation, the high labour input required, permanently rising labour costs, and the fact that the markets are supplied with much cheaper imported rice.

Fruit demands a lot of care during transport to the markets, but the farmers of Al Hassa are as yet unable to handle and market fruit properly. Therefore, imported fruit should cover the demand, as the agents are experienced enough to supply the markets with better and cheaper fruit. Thus, no area has been allocated for fruit production.

The farmers of the Al Hassa Oasis produce an annual surplus of 49,624 tons of dates. The privately owned date factory has an annual capacity of 750 tons, but in recent years only 200 tons to 300 tons have been packed, and a further decline can be expected in the future. The reasons for this decline are high labour costs, declining consumer demand and strong competition from Iraqi producers.[139] Thus it is desirable to reduce the area under date cultivation. This reduction is in fact already taking place, since many farmers neglect their date-trees. During the construction period many date-trees had to be cut down. But instead of the expected resistance from farmers it was found that they were very keen to sell their trees to the Government.

But date-trees are important for other reasons than date production: (1) they act as wind-breaks, (2) they impede evaporation and (3) they are an important element in the oasis' microclimate. Thus, if the date-trees were abandoned, wind protection hedges would have to be planted, a higher evaporation rate must be accepted and a change of the microclimate can be expected.[140]

The Al Murrah tribe still has a high consumption of dates but there is no possibility of selling dates to these people because most of them have their own date-trees in Yabrin, an oasis 100 km. south of Haradh.

In the investigation of Flah, two farm sizes were recognized: "the average farm" of 0.244 ha., and the largest farm in the area of 1.808 ha. Before the investigation the author had been told that this was a typical area of Al Hassa and that conditions found there were valid for the entire oasis. However, "being a typical area" presupposes that the conditions in the entire oasis are known, but this condition is not met. The author believes that none of the people involved in planning and construction of the irrigation and drainage system had enough knowledge to speak about "typical" or "untypical" conditions.

The area Flah is only a small part of the oasis and it may well be that conditions in other parts of the oasis are completely different.

Although the average farm size of 0.244 ha. was identified as a common feature of present land use, its economic importance is negligible as the incomes which can be achieved on farms of this size are insignificant.

The 1.808 ha. farm was the largest unit found, but even this is too small to assure an adequate family income. However, it does assure at least a small income to part-time farmers.

Therefore, all farms smaller than 1.808 ha. will be ignored in this study as they are of no economic importance. In the following calculations farms in the oasis will be assumed solely to be of 1.808 ha. in size.

1.808 ha. farms

In order to increase the output of agricultural production the cropping pattern on each farm will be changed so that the cultivated proportion of each farm will be increased from 31 per cent to 100 per cent. Thus the cropping pattern and the area under cultivation for farms with a size of 1.808 ha. would be as follows: (see Diagram No. 5).

CROPPING PATTERN- 1·808 Hectare Farm

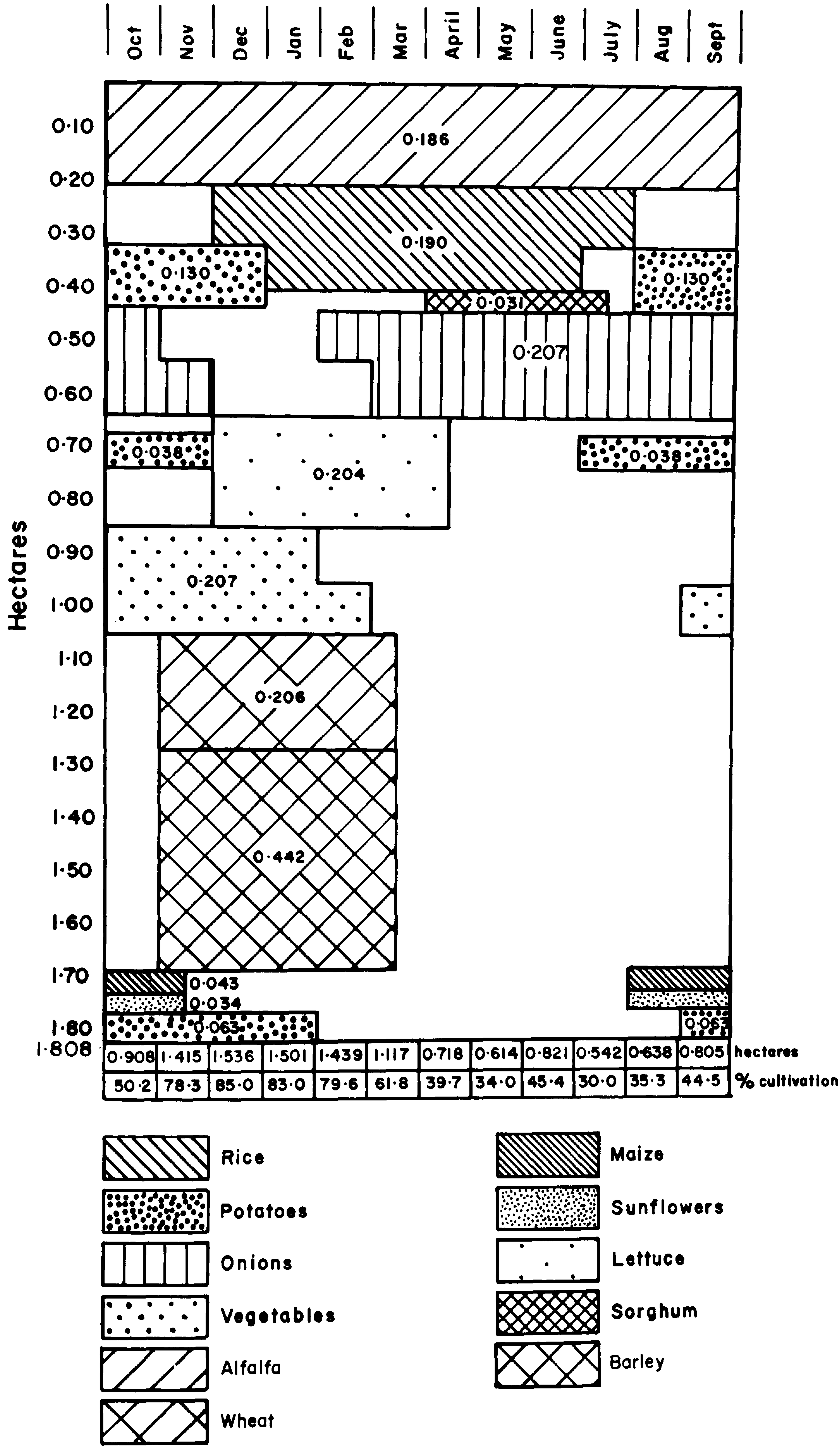


Diagram No. 5

Table No. 27

Cultivated area on 1.808 ha. farms

CROP	CULTIVATED AREA IN ha.
Vegetables	0.620
Wheat	0.206
Barley	0.447
Potatoes	0.231
Rice	0.197
Alfalfa	0.186
Sorghum	0.031
Maize	0.043
Sunflower	0.034
Total	1.995

Expenditure for cash crops

The pattern of expenditure is detailed in the tables below.

The production inputs for the project at Haradh as well as those for the project in Al Hassa are bought in Hofuf and in the towns along the Gulf. Therefore, the prices on which the calculations of the expenditure for the Faisal Settlement Project in Haradh are based can also be taken as the basis for calculations for the Al Hassa Project.

Since on the 8,000 ha. of the Old Oasis no mechanisation is possible because of the palm-trees, machine costs do not appear in the calculations. But instead, the labour input required of the family members will be considerably higher.

Table No. 28 Required expenditure for crops

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.207	Vegetables			
	Seeds	100.00 SR*	-	20.70
	Fertilizer	600 kg.	0.52	64.58
	Plant protection	60 SR	-	12.42
	Water**	1,314.42 cu.m.	0.10***	131.44
				229.14
0.207	Onions (dry)			
	Seeds	5 kg.	140.00	144.90
	Fertilizer	600 kg.	0.52	64.58
	Plant protection	40 SR	-	8.28
	Water	2,496.01 cu.m.	0.10	249.60
				467.36
0.207	Lettuce			
	Seeds	5 kg.	140.00	144.90
	Fertilizer	600 kg.	0.52	64.58
	Plant protection	40 SR	-	8.28
	Water	1,063.15 cu.m.	0.10	106.32
				324.08

* The 100.00 SR is an average price.

** The price of 0.10 SR for water is assumed. This is valid throughout the entire project.

*** The amount of water is not per hectare but per area in all of the calculations.

Table No. 28 (continued)

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.206	Wheat			
	Seeds	120 kg.	1.00	24.72
	Fertilizer	500 kg.	0.52	53.56
	Plant protection	24 SR	-	4.94
	Water	879.01 cu.m.	0.10	87.90
				171.12
0.232	Barley			
	Seeds	120 kg.	0.70	19.49
	Fertilizer	500 kg.	0.52	60.32
	Plant protection	24 SR	-	5.57
	Water	990.18 cu.m.	0.10	99.02
				184.40
0.231	Potatoes			
	Seeds	1,200 kg.	1.40	388.08
	Fertilizer	600 kg.	0.52	72.07
	Plant protection	60 SR	-	13.86
	Water	1,839.45 cu.m.	0.10	183.95
				657.96

Table No. 28 (continued)

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.197	Rice			
	Seeds	135 kg.	1.00	26.60
	Fertilizer	1,000 kg.	0.52	102.44
	Plant protection	60 SR	-	11.82
	Water	3,172.69 cu.m.	0.10	317.27
				458.13
361.6*	Dates			
	With a yield of 30 kg. of dates per tree[141] the total yield is 10,848 kg. per farm. Based on a price of 0.37 SR,[142] required to produce one kilogramme of good quality dates, the production costs for dates are 4,024.61 SR.			

At present in the Al Hassa Oasis, an average of five sheep (5.13) and 0.3 cattle (0.298) are kept per hectare. Based on this, for each 1.808 ha. farm an area for the production of enough fodder for 9.28 sheep and 0.539 cattle must be included. The necessary fodder crop areas are shown below.

* Average number of trees per farm.

Table No. 29 Fodder crop area

CROP	AREA IN ha. FOR SHEEP	AREA IN ha. FOR CATTLE
Alfalfa	0.125	0.061
Maize	0.016	0.027
Sunflower	-	0.034
Sorghum	0.031	-
Barley	-	0.215
Total	0.172	0.337

The expenditure for these crops are detailed below.

Table No. 30

Expenditure for fodder crops for sheep

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.125	Alfalfa			
	Seeds	ignored	-	-
	Fertilizer	400 kg.	0.52	26.00
	Plant protection	120 SR	-	15.00
	Water	2,660.75 cu.m.	0.10	266.08
				307.08
0.016	Maize			
	Seeds	15 kg.	0.60	0.14
	Fertilizer	500 kg.	0.52	4.16
	Plant protection	20 SR	-	0.32
	Water	106.13 cu.m.	0.10	10.61
				15.23

Table No. 30 (continued)

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.031	Sorghum			
	Seeds	15 kg.	0.80	0.37
	Fertilizer	500 kg.	0.52	8.06
	Plant protection	20 SR	-	0.62
	Water	184.26 cu.m.	0.10	18.48
				27.48

This results in a total expenditure of 349.79 SR.

Table No. 31

Expenditure for fodder crops for cattle

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.061	Alfalfa			
	Seeds	ignored	-	-
	Fertilizer	400 kg.	0.52	12.69
	Plant protection	120 SR	-	7.32
	Water	1,298.45 cu.m.	0.10	129.85
				149.86
0.027	Maize			
	Seeds	15 kg.	0.60	0.24
	Fertilizer	500 kg.	0.52	7.02
	Plant protection	20 SR	-	0.54
	Water	179.09 cu.m.	0.10	17.91
				25.71

Table No. 31 (continued)

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.034	Sunflowers			
	Seeds	15 kg.	0.90	0.46
	Fertilizer	500 kg.	0.52	8.84
	Plant protection	20 SR	-	0.68
	Water	225.52 cu.m.	0.10	22.55
				32.53
0.215	Barley			
	Seeds	120 kg.	0.70	18.06
	Fertilizer	500 kg.	0.52	55.90
	Plant protection	24 SR	-	5.16
	Water	917.62 cu.m.	0.10	91.76
				170.88

From the area planted with barley 602 kg. of barley will be harvested. As there is a difference between the prices of local barley (0.45 SR) and imported barley (0.35 SR), the barley produced on the farm for fodder should be sold and imported barley used for fodder instead. If the farmer shold his barley in the local market, he would receive 270.90 SR whereas for imported barley he would spend 210.70 SR. That is, he would earn 60.20 SR net, which he could deduct from the expenditure for cattle rearing. This expenditure will thus be 318.08 SR instead of 379.08 SR.

Assuming that the average family has about seven members, all of the products of animal husbandry would be consumed by the farm and therefore does not reach the markets. These products therefore have no recognized cash value for the farmers.

Cash crops

The cash crops grown on this farm type have a total value of 15,314.74 SR as detailed in Table No. 32.

Since the vegetables will have to be sold in the Eastern as well as in the Western Province, the price given above is the average price of vegetables in both provinces as derived in Chapter 1.

The price for barley is the minimum price for Hofuf. In general a higher price will probably be achieved.

The price of locally produced potatoes is unknown. Local wholesale prices are known only for Buraydah, Medinah and Abha and these prices have been taken as the basis for that in Hofuf.

From the value of the crops the expenditures have to be deducted, thus leaving a net value of 8,069.07 SR.

Table No. 32 Total value of cash crops

HECTARES	CROP	YIELD kg./ha.	YIELD IN kg. PER AREA [143]	PRICE [144] SR/kg.	VALUE OF CROPS IN SR
0.207	Vegetables	10,000	2,070.00	0.65	1,345.50
0.207	Onions	14,000	2,898.00	0.72	2,086.56
0.207	Lettuce	14,000	2,898.00	0.72	2,086.56
0.206	Wheat	3,000	618.00	0.86	531.48
0.232	Barley	2,800	649.60	0.45	292.32
0.231	Potatoes	12,500	2,887.50	0.88	2,541.00
0.197	Rice	2,360	464.92	1.00	464.92
361.6*	Dates	-	10,848.00	0.55	5,966.40
Total					15,314.74

* This is the average number of date-trees per farm.

Table No. 33

Net value of agricultural products

PRODUCT	VALUE	EXPENDITURE	NET VALUE	LOSS
Vegetables	1,345.50	229.14	1,116.36	-
Onions	2,086.56	467.36	1,619.20	-
Lettuce	2,086.56	324.08	1,762.48	-
Wheat	531.48	171.12	360.36	-
Barley	292.32	184.40	107.92	-
Potatoes	2,541.00	657.96	1,883.04	-
Rice	464.92	458.13	6.79	-
Dates	5,966.40	4,024.61	1,941.79	-
Sheep	-	349.79	-	349.79
Cattle	-	379.08	-	318.88
Total	15,314.74	7,245.67	8,797.94	668.67

The products from animal husbandry have no recognized cash value for the farmers. Thus they appear here as losses in spite of the fact that the farmers could obtain profit when selling these animals or their products.

Marketing

With the exception of a proportion of the vegetables, all the agricultural products from the scheme can be marketed within the oasis. Thus for these products transport costs need not be considered.

For the vegetables which must be sold in the western markets the transport costs per kilogramme for truck transport are: from Hofuf to Tai'f 0.74 SR, to Jeddah 0.82 SR, to Mecca 0.78 SR and to Medinah 0.73 SR. This results in an average price of 0.77 SR per kilogramme of goods to be transported from Hofuf to the markets in the Western Province.

Of the total annual vegetable production of the Al Hassa Oasis of 87,321 tons, 71,201 tons will have to be sold in the Western Province. That is, of the 7.866 tons of vegetables produced on a 1.808 ha. farm annually*, 1.458 tons can be sold within the Oasis and 6.408 tons must be sold in the western markets. Thus, from the net value of the agricultural products of 8,129.27 SR, the transport costs of 4,934.16 SR must be deducted. Furthermore, the family consumption must be considered. Based on a home consumption of 67.5 kg. of vegetables (60 to 75 kg.) per person per annum, a seven member family consumes 0.473 tons each year. This means a further deduction of 329.50 SR. Thus the actual annual cash family income is 2,866.61 SR. This implies:

Monthly family income of:	238.88 SR
Income per head per annum:	409.46 SR
Monthly income per labour unit:	119.44 SR
Hourly wage:	0.60 SR

Labour input

No investigation of the labour input required for agricultural production has yet been made in the Al Hassa Oasis. Therefore, these calculations are based on data obtained in Haradh, slightly altered to suit the circumstances in Al Hassa. In particular the speed and quality of work are low in the Faisal Settlement Project, Haradh, because the Bedouins to be settled are inexperienced in agriculture,whereas the farmers and farm workers in Al Hassa are very experienced and skilled. Therefore, from these men the best possible performance of labour, both in speed and in quality can be expected.

* The output of vegetables of 1.808 ha. farms is 7.886 tons per annum. However, based on the output calculated for the entire project on page No 152 the output should be 7.797 tons. This difference is caused by rounding of decimals in the calculation.

As stated above, mechanisation is not possible on the 8,000 ha. of the Old Oasis. This implies an increase in labour requirements. In particular, the input necessary for the preparation of seedbeds is higher. The different operations needed for the preparation of seedbeds are:

Table No. 34

Labour hours required for the preparation of seedbeds

OPERATION	TIME IN HOURS PER ha.
Ploughing	12.0[145]
Harrowing	3.5[146]
Making of ditches and furrows	9.0[147]
Total	24.5

Thus for the preparation of seedbeds 24.5 hours per hectare are required, provided the farmer owns a donkey, horse or mule.

Since there is no rice cultivation in the Faisal Settlement project, Haradh, the labour input for rice is based on another source.[148]

To sow cereals manually 3.0 hours per hectare[149] are needed and to harvest cereals by hand one needs 96 hours per hectare.[150]

The labour input required for plant cultivation is detailed as follows:

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
October				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Vegetables	0.104	planting	67.50	7.020
	0.207	spraying	9.10	1.884
	0.207	handhoeing	41.25	8.539
Barley	0.447	preparing seedbed	24.50	10.952
Wheat	0.206	preparing seedbed	24.50	5.047
Potatoes	0.231	spraying	9.10	2.102
	0.193	handhoeing	41.25	7.961
				45.157
		Man-hours required for irrigation:		17.270
		Total man-hours required for cultivation:		62.427
November				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Vegetables	0.207	handhoeing	41.25	8.539
	0.207	spraying	9.10	1.884
	0.207	top dressing	13.02	2.695
Lettuce	0.207	preparing seedbed	24.50	5.072
Barley	0.447	sowing	3.00	1.341
Wheat	0.206	sowing	3.00	0.618
Maize	0.043	harvesting	30.00	1.290
Sunflowers	0.034	harvesting	30.00	1.020
Onions	0.104	harvesting	300.00	31.200

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
Rice	0.099	preparing seedbed*	20.00	1.980
Potatoes	0.038	harvesting	120.00	4.560
	0.063	handhoeing	41.25	2.599
	0.193	spraying	9.10	1.756
				66.206
		Man-hours required for irrigation:		24.440
		Total man-hours required for cultivation:		90.646
December				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Vegetables	0.207	handhoeing	41.25	8.539
	0.207	spraying	9.10	1.884
Lettuce	0.207	planting	432.00	89.424
Rice	0.099	preparing seedbed	20.00	1.980
	0.099	preparing fields**	60.00	5.940
	0.099	transplanting	20.00	1.980
Onions	0.104	harvesting	300.00	31.200
Potatoes	0.130	harvesting	120.00	15.600
	0.063	spraying	9.10	0.573
				158.772
		Man-hours required for irrigation:		23.950
		Total man-hours required for cultivation:		182.722

* Preparation of seedbeds includes ploughing, harrowing, preparing dykes, levelling, treating seeds, sowing, fencing and caring for the seeds.

** Preparation of fields includes ploughing, cleaning and repairing dykes, spreading compost or manure, and harrowing.

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
January				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Vegetables	0.104	harvesting	367.80	38.251
Lettuce	0.207	handhoeing	66.25	13.714
	0.207	spraying	7.28	1.507
Rice	0.099	preparing fields	60.00	5.940
	0.099	transplanting	20.00	1.980
Potatoes	0.063	harvesting	120.00	7.560
Wheat	0.206	top dressing	1.86	0.383
	0.206	spraying	2.04	0.420
Barley	0.447	top dressing	1.86	0.831
	0.447	spraying	2.04	0.912
Onions	0.104	preparing seedbed	24.50	2.548
				75.698
		Man-hours required for irrigation:		22.410
		Total man-hours required for cultivation:		98.108
February				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Vegetables	0.104	harvesting	367.80	38.251
Onions	0.104	preparing seedbed	24.50	2.548
	0.104	planting	432.00	44.928

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
Rice	0.197	caring for crop*	6.50	1.281
				88.660
		Man-hours required for irrigation:		15.830
		Total man-hours required for cultivation:		104.490
March				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Wheat	0.206	harvesting	96.00	19.776
Barley	0.447	harvesting	96.00	42.912
Sorghum	0.031	preparing seedbed	24.50	0.760
Onions	0.104	planting	432.00	44.928
Rice	0.197	caring for crop	6.50	1.281
				111.309
		Man-hours required for irrigation:		14.250
		Total man-hours required for cultivation:		125.559
April				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Sorghum**	0.031	sowing	17.00	0.527
Rice	0.197	caring for crop	6.5	1.281
				3.460
		Man-hours required for irrigation:		14.860
		Total man-hours required for cultivation:		18.320

* Caring for the crops includes replanting, fertilizing, weeding, controlling pests and diseases.

** [illegible] is treated like maize.

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
May				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Sorghum	0.031	handhoeing	7.50	0.233
Rice	0.197	caring for the crop	6.50	1.281
				3.166
		Man-hours required for irrigation:		15.320
		Total man-hours required for cultivation:		18.486
June				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Potatoes	0.038	preparing seedbed	24.50	0.931
Rice	0.099	harvesting	92.00	9.108
				11.691
		Man-hours required for irrigation:		18.250
		Total man-hours required for cultivation:		29.941
July				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Rice	0.099	harvesting	92.00	9.108
Sorghum	0.031	harvesting	30.00	0.930
Maize	0.043	preparing seedbed	24.50	1.054
Sunflowers	0.034	preparing seedbed	24.50	0.833

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
Potatoes	0.130	preparing seedbed	24.50	3.185
	0.038	planting	54.00	2.052
				18.814
		Man-hours required for irrigation:		12.380
		Total man-hours required for cultivation:		31.194
August				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443
Maize	0.043	sowing	17.00	0.731
Sunflowers*	0.034	sowing	17.00	0.578
Potatoes	0.130	planting	54.00	7.020
	0.063	preparing seedbed	24.50	1.544
	0.038	spraying	9.10	0.346
	0.038	handhoeing	41.25	1.568
Vegetables	0.104	preparing seedbed	24.50	2.548
				15.987
		Man-hours required for irrigation:		16.110
		Total man-hours required for cultivation:		32.097
September				
Alfalfa	0.186	making hay	6.50	1.209
	0.186	spraying	2.38	0.443

* Sunflowers are treated like maize.

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
Vegetables	0.104	planting	67.50	7.020
	0.104	preparing seedbed	24.50	2.548
Maize	0.043	top dressing	1.86	0.080
	0.043	spraying	2.04	0.088
	0.043	handhoeing	9.00	0.387
Sunflowers	0.034	top dressing	1.86	0.063
	0.034	spraying	2.04	0.069
	0.034	handhoeing	9.00	0.306
Potatoes	0.168	spraying	9.10	1.529
	0.168	handhoeing	41.25	6.930
	0.063	planting	54.00	3.402
				24.074
		Man-hours required for irrigation:		17.830
		Total man-hours required for cultivation:		41.904

Labour input for irrigation

1.8 ltr./sec. per hectare of water is available for irrigation. That is, based on an irrigation every sixth day, 10.8 ltr./sec. per hectare are available for 24 hours to each farmer. It should be possible for two neighbours to come to an agreement on irrigation times, so that using a shift system at least 21.6 ltr./sec., or 77,760 ltr. per hour, are at the disposal of each farmer at one time, thus halving the irrigation time. The following calculations are therefore based on a water supply of 21.6 ltr./sec.

Travel time need not be calculated since the farms in the Old Oasis are near the villages and some farmers even live on their farms.

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
October			
Alfalfa	0.186	1,917	356.562
Potatoes	0.231	1,629	375.299
Maize	0.043	1,821	78.303
Sunflowers	0.034	1,821	61.914
Onions	0.207	758	156.906
Vegetables	0.207	1,517	314.019
			1,343.003 cu.m.

Man-hours required for irrigation: 17.27

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
November			
Alfalfa	0.186	1,701	316.386
Wheat	0.206	1,446	297.876
Barley	0.447	1,446	646.362
Potatoes	0.231	1,446	334.026
Maize	0.022	708	15.576
Sunflowers	0.017	708	12.036
Vegetables	0.207	1,346	278.622
			1,900.884 cu.m.

Man-hours required for irrigation: 24.44

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
December			
Alfalfa	0.186	1,431	266.166
Rice	0.099	1,004	99.396
Wheat	0.206	1,216	250.496
Barley	0.447	1,216	543.552
Potatoes	0.193	1,216	234.688
Lettuce	0.207	1,132	234.324

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
Vegetables	0.207	1,132	234.324
			1,862.946 cu.m.

Man-hours required for irrigation: 23.95

January			
Alfalfa	0.186	1,296	241.056
Rice	0.197	1,814	357.358
Wheat	0.206	1,102	227.012
Barley	0.447	1,102	492.594
Lettuce	0.207	1,026	212.382
Vegetables	0.207	1,026	212.382
			1,742.784 cu.m.

Man-hours required for irrigation: 22.41

February			
Alfalfa	0.186	1,289	239.754
Rice	0.197	1,777	350.069
Wheat	0.206	504	103.824
Barley	0.447	504	225.288
Lettuce	0.207	1,004	207.828
Onions	0.104	502	52.208
Vegetables	0.104	502	52.208
			1,231.179 cu.m.

Man-hours required for irrigation: 15.83

March			
Alfalfa	0.186	1,404	261.144
Rice	0.197	1,966	387.302

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
Lettuce	0.207	1,111	229.977
Onions	0.207	1,111	229.977
			1,108.400 cu.m.

Man-hours required for irrigation: 14.25

April			
Alfalfa	0.186	1,674	311.364
Rice	0.197	2,344	461.768
Sorghum	0.031	1,256	38.936
Lettuce	0.104	663	68.932
Onions	0.207	1,325	274.275
			1,155.275 cu.m.

Man-hours required for irrigation: 14.86

May			
Alfalfa	0.186	1,836	341.496
Rice	0.197	2,570	506.290
Sorghum	0.031	1,377	42.687
Onions	0.207	1,453	300.771
			1,191.244 cu.m.

Man-hours required for irrigation: 15.32

June			
Alfalfa	0.186	2,187	406.782
Rice	0.197	3,062	603.214
Sorghum	0.031	1,640	50.840

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
Onions	0.207	1,731	358.317
			1,419.153 cu.m.

Man-hours required for irrigation: 18.25

July			
Alfalfa	0.186	2,241	416.826
Rice	0.099	1,568	155.232
Sorghum	0.016	1,671	26.736
Onions	0.207	1,774	367.218
			966.012 cu.m.

Man-hours required for irrigation: 12.38

August			
Alfalfa	0.186	2,214	411.804
Potatoes	0.168	1,882	316.176
Maize	0.043	2,103	90.429
Sunflowers	0.034	2,103	71.502
Onions	0.207	1,752	362.664
			1,252.575 cu.m.

Man-hours required for irrigation: 16.11

September			
Alfalfa	0.186	2,106	391.716
Potatoes	0.231	1,790	412.490
Maize	0.043	2,001	86.043
Sunflowers	0.034	2,001	68.034
Onions	0.207	1,652	341.964

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
Vegetables	0.104	826	85.904
			1,386.151 cu.m.

Man-hours required for irrigation: 17.83

Labour input for livestock

The labour input required for cattle keeping on this farm has been disregarded.

On five hectare farms the daily working time for 26 sheep is assumed to be 15 minutes (see page No. 184) and the daily labour input required for nine sheep on this farm type is assumed to be 10 minutes. This seems to be too much considering the number of sheep, but the basic labour requirement always takes a certain amount of time regardless of the number of animals.

Total labour input

Consequently, the total labour input required for each 1.808 ha. farm is as shown in Table No. 35 and Diagram No. 6.

Economy of five hectare farms

The above calculations show that the present maximum farm size of 1.808 ha. is too small to assure an adequate income for the two full-time family workers on each farm. Therefore it appears to be desirable to establish farms with an area of five hectares, each farm having only one full-time worker. At present, this will only be possible on the newly developed 12,000 ha., but on the other 8,000 ha. the farm size should also be enlarged.

Some labour is then also freed for employment elsewhere.

The following calculations illustrate in detail that this recommendation is economically feasible.

The area under cultivation and the cropping pattern of these five

Diagram No. 6

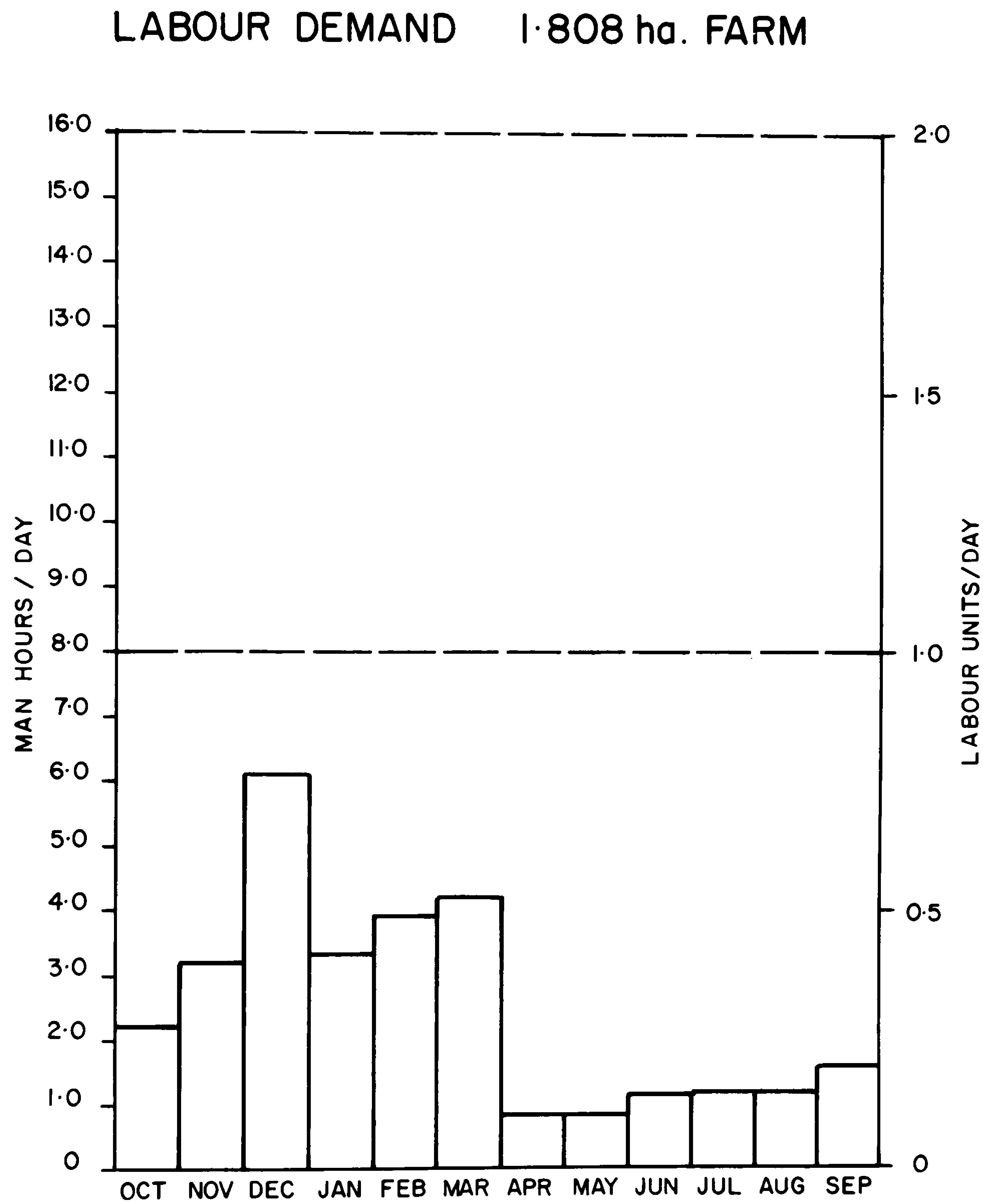

LABOUR DEMAND 1·808 ha. FARM
MAN HOURS / DAY
LABOUR UNITS/DAY
16·0
15·0
14·0
13·0
12·0
11·0
10·0
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
0
2·0
1·5
1·0
0·5
0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

Table No. 35 Total labour input required for 1.808 ha. farms

MONTH	MAN-HOURS FOR FIELD CROP	MAN-HOURS FOR LIVESTOCK	MONTHLY TOTAL MAN-HOURS	DAILY TOTAL MAN-HOURS	DEMANDED LABOUR UNITS*
October	62.427	5.2	67.63	2.18	0.27
November	90.646	5.0	95.65	3.19	0.40
December	182.722	5.2	187.92	6.06	0.76
January	98.108	5.2	103.31	3.33	0.42
February	104.490	4.7	109.19	3.90	0.49
March	125.559	5.2	130.76	4.22	0.53
April	18.320	5.0	23.32	0.78	0.10
May	18.486	5.2	23.69	0.76	0.10
June	29.941	5.0	34.94	1.16	0.15
July	31.194	5.2	36.39	1.17	0.15
August	32.097	5.2	37.30	1.20	0.15
September	41.904	5.0	46.90	1.56	0.20
Total	835.894	61.1			

* One labour unit = one full-time labourer working 200 hours monthly.

hectare farms are shown below.

Table No. 36 (See Diagram No. 7)

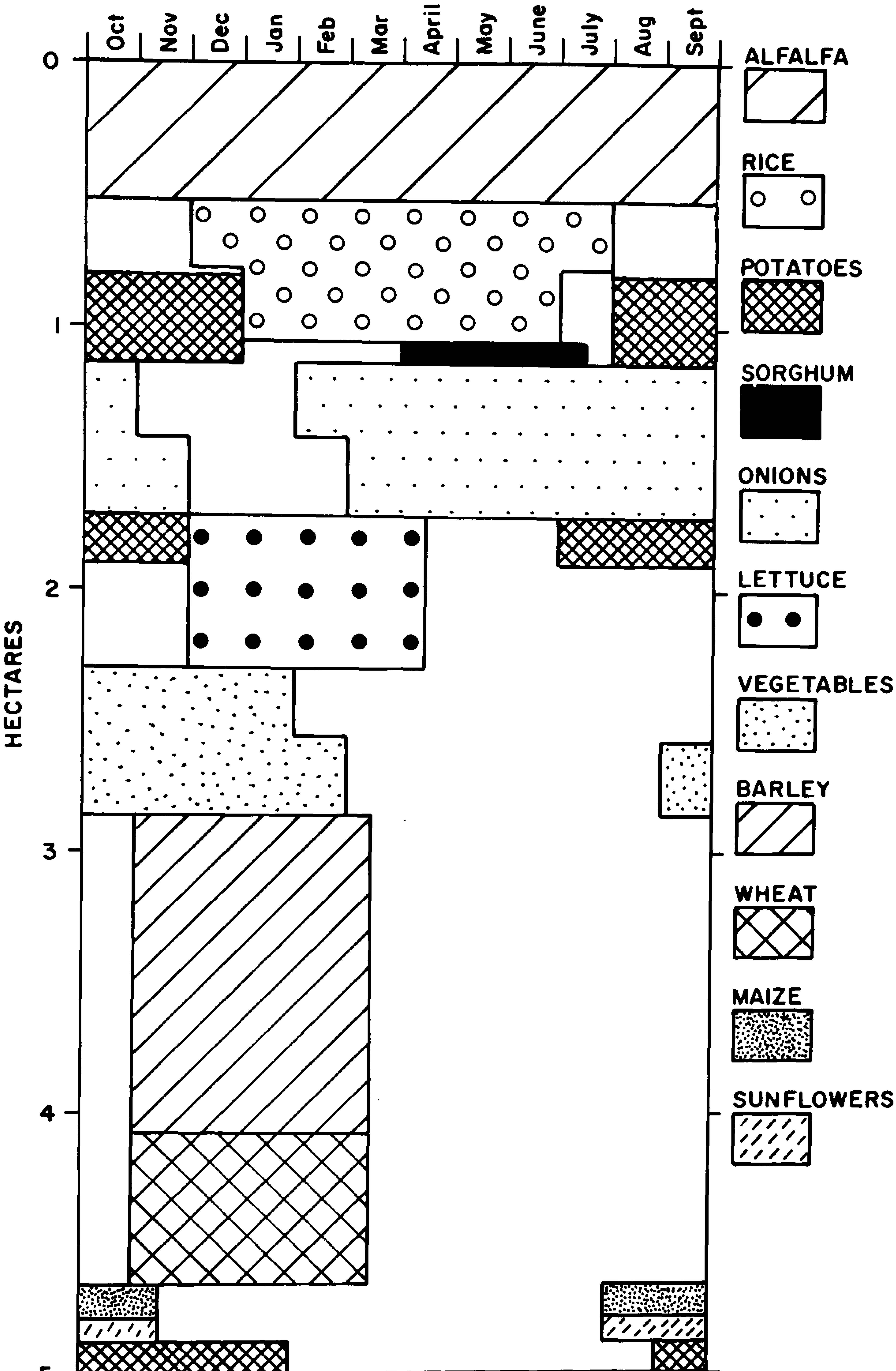
Cultivated crops and area under cultivation

CROP	AREA IN HECTARES
Vegetables	1.715 (including onions and lettuce)
Wheat	0.570
Barley	1.225
Potatoes	0.640
Rice	0.545
Alfalfa	0.515
Sorghum	0.085
Maize	0.120
Sunflowers	0.095
Total	5.510 ha.

Furthermore, 26 sheep (25.655) and one cow (1.494) will be kept on each farm. Whereas the 26 sheep require considerable labour input, that required for the cow is so small that it can be ignored.

The 26 sheep should consist of nine ewes and 17 lambs. The labour input required for keeping these animals is detailed in the following tables.

CROPPING PATTERN 5·00 ha FARM



	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
Cultivated Area	2·63	3·99	4·31	4·12	4·00	3·10	2·00	1·72	1·72	1·55	1·94	2·35
% Under Cultivation	52·6	79·8	86·2	82·4	80·0	62·0	40·0	34·4	34·4	31·0	38·8	47·0

Diagram No. 7

Table No. 37 Yearly labour hours for nine ewes

WORK	TIME IN HOURS
Feeding	41.45
Litter	8.76
Paring	0.56
Dipping	2.34
Clearing of fold	2.43
Lambing	5.58
Total	61.10

This is the equivalent of a daily working time of 0.167 hours (10.02 minutes) for the ewes.

The following working time is required for the 17 lambs.

Table No. 38 Yearly labour hours for 17 lambs

WORK	TIME IN HOURS
Feeding	17.16
Litter	3.63
Dipping	2.21
Clearing of fold	2.30
Total	25.30

This is the equivalent of a daily working time of 0.07 hours (4.20 minutes) for the lambs.

Thus for the 26 sheep a daily average working time of about 15 minutes is required.

Labour input for irrigation

Based on a water supply of 21.6 ltr./sec. per farm, the working time required for irrigation is as shown below.

Travel time has not been considered. This is entirely justfied within the Old Oasis. However, in some parts of the newly developed land travel time may be required in future, but as no definite decision has been taken as to how large the farms will be, who will get the farms, and where these people will live, it is valid to ignore travel time in this area, too.

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
October			
Alfalfa	0.515	1,917	987.255
Potatoes	0.760	1,629	1,238.040
Maize	0.120	1,821	218.520
Sunflowers	0.095	1,821	172.995
Onions	0.572	758	433.576
Vegetables	0.572	1,517	867.724
			3,918.110 cu.m.

Man-hours required for irrigation: 50.38

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
November			
Alfalfa	0.515	1,701	876.015
Wheat	0.570	1,446	824.220
Barley	1.225	1,446	1,771.350
Potatoes	0.760	1,446	1,098.960
Maize	0.120	708	84.960
Sunflowers	0.095	708	67.260
Vegetables	0.572	1,346	769.912
			5,492.912 cu.m.

Man-hours required for irrigation: 70.64

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
December			
Alfalfa	0.515	1,431	736.965
Rice	0.273	1,004	274.092
Wheat	0.570	1,216	693.120
Barley	1.225	1,216	1,489.600
Potatoes	0.580	1,216	705.280
Lettuce	0.572	1,132	647.504
Vegetables	0.572	1,132	647.504
			5,194.065 cu.m.

Man-hours required for irrigation: 66.80

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
January			
Alfalfa	0.515	1,296	667.440
Rice	0.545	1,814	988.630
Wheat	0.570	1,102	628.140
Barley	1.225	1,102	1,349.950
Lettuce	0.572	1,026	586.872
Vegetables	0.572	1,026	586.872
			4,807.904 cu.m.

Man-hours required for irrigation: 61.83

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
February			
Alfalfa	0.515	1,289	663.835
Rice	0.545	1,777	968.465
Wheat	0.570	504	287.280
Barley	1.225	504	617.400
Lettuce	0.572	1,004	574.288
Onions	0.286	502	143.572

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
Vegetables	0.286	502	143.572
			3,398.412 cu.m.

Man-hours required for irrigation: 43.70

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
March			
Alfalfa	0.515	1,404	723.060
Rice	0.545	1,966	1,071.470
Lettuce	0.572	1,111	635.492
Onions	0.572	1,111	635.492
			3,065.514 cu.m.

Man-hours required for irrigation: 39.42

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
April			
Alfalfa	0.515	1,674	862.110
Rice	0.545	2,344	1,277.480
Sorghum	0.085	1,256	106.760
Lettuce	0.286	663	189.618
Onions	0.572	1,325	757.900
			3,193.868 cu.m.

Man-hours required for irrigation: 41.07

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
May			
Alfalfa	0.515	1,836	945.540
Rice	0.545	2,570	1,400.650
Sorghum	0.085	1,377	117.045
Onions	0.572	1,453	831.116
			3,294.351 cu.m.

Man-hours required for irrigation: 42.37

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
June			
Alfalfa	0.515	2,187	1,126.305
Rice	0.545	3,062	1,668.790
Sorghum	0.085	1,640	139.400
Onions	0.572	1,731	990.132
			3,924.627 cu.m.

Man-hours required for irrigation: 50.47

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
July			
Alfalfa	0.515	2,241	1,154.115
Rice	0.273	1,568	428.064
Sorghum	0.043	1,671	71.853
Onions	0.572	1,774	1,014.728
			2,668.760 cu.m.

Man-hours required for irrigation: 34.32

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
August			
Alfalfa	0.515	2,214	1,140.210
Potatoes	0.640	1,882	1,204.480
Maize	0.120	2,103	252.360
Sunflower	0.095	2,103	199.785
Onions	0.572	1,752	1,002.144
			3,798.979 cu.m.

Man-hours required for irrigation: 48.86

Month-crop	Hectares	Cu.m. water/ha.	Cu.m. water/area
September			
Alfalfa	0.515	2,106	1,084.590
Potatoes	0.760	1,790	1,360.400
Maize	0.120	2,001	240.120
Sunflower	0.095	2,001	190.095
Onions	0.572	1,652	944.944
Vegetables	0.286	826	236.236
			4,056.385 cu.m.

Man-hours required for irrigation: 52.17

Labour input for cultivation

Because there would be no palm-trees on the newly developed land, mechanisation is possible. Thus, farms on this area require less manual labour than do the farms in the Old Oasis although machine costs have to be considered. Below the monthly requirements for cultivation are shown.

Month-crop	Hectares	Work	Man-hours per ha.	Man-hours area
October				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Vegetables	0.286	planting	67.50	19.305
	0.572	spraying	9.10	5.205
	0.572	handhoeing	41.25	23.595
Barley	1.225	preparing seedbed	10.20	12.495
Wheat	0.570	preparing seedbed	10.20	5.814

Month-crop	Hectares	Work	Man-hours per ha.	Man-hours area
Potatoes	0.460	spraying	9.10	4.186
	0.460	handhoeing	41.25	18.975
				94.149
		Man-hours required for irrigation:		50.380
		Total man-hours required for cultivation:		144.529
November				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Vegetables	0.572	handhoeing	41.25	23.595
	0.572	spraying	9.10	5.203
	0.572	top dressing	13.02	7.447
Lettuce	0.572	preparing seedbed	13.80	7.894
Maize	0.120	harvesting	30.00	3.600
Sunflowers	0.095	harvesting	30.00	2.850
Rice	0.273	preparing seedbed	20.00	5.460
Potatoes	0.180	harvesting	120.00	21.600
	0.460	spraying	9.10	4.186
	0.120	handhoeing	41.25	4.950
Onions	0.286	harvesting	300.00	85.800
				177.159
		Man-hours required for irrigation:		70.640
		Total man-hours required for cultivation:		247.799

Month-crop	Hectares	Work	Man-hours per ha.	Man-hours area
December				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Vegetables	0.572	handhoeing	41.25	23.595
	0.572	spraying	9.10	5.205
Lettuce	0.572	planting	432.00	247.104
Onions dry	0.286	harvesting	300.00	85.800
Potatoes	0.460	harvesting	120.00	55.200
	0.120	spraying	9.10	1.092
Rice	0.273	preparing seedbed	20.00	5.460
	0.273	preparing field	60.00	16.380
	0.273	transplanting	20.00	5.460
				449.870
		Man-hours required for irrigation:		66.800
		Total man-hours required for cultivation:		516.670
January				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Vegetables	0.286	harvesting	367.80	105.191
Lettuce	0.572	handhoeing	66.25	37.895
	0.572	spraying	7.28	4.164
Potatoes	0.120	harvesting	120.00	14.400
Wheat	0.570	top dressing	1.86	1.060
	0.570	spraying	2.04	1.163
Barley	1.225	top dressing	1.86	2.279
	1.225	spraying	2.04	2.499

Month-crop	Hectares	Work	Man-hours per ha.	Man-hours area
Onions dry	0.286	preparing seedbed	13.80	3.947
Rice	0.273	preparing field	60.00	16.380
	0.273	transplanting	20.00	5.460
				199.012
		Man-hours required for irrigation:		61.830
		Total man-hours required for cultivation:		260.842
February				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Vegetables	0.286	harvesting	367.80	105.191
Onions dry	0.286	preparing seedbed	13.80	3.947
	0.286	planting	432.00	123.552
Rice	0.545	caring for crop	6.50	3.543
				240.807
		Man-hours required for irrigation:		43.700
		Total man-hours required for cultivation:		284.507
March				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Sorghum	0.085	preparing seedbed	10.20	0.867
Onions dry	0.286	planting	432.00	123.552
Rice	0.545	caring for crop	6.50	3.543
				132.536
		Man-hours required for irrigation:		39.420
		Total man-hours required for cultivation:		171.956

Month-crop	Hectares	Work	Man-hours per ha.	Man-hours area
April				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Sorghum	0.085	sowing	17.00	1.445
Rice	0.545	caring for crop	6.50	3.543
				9.562
		Man-hours required for irrigation:		41.070
		Total man-hours required for cultivation:		50.632
May				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Sorghum	0.085	handhoeing	7.50	0.638
Rice	0.545	caring for crop	6.50	3.543
				8.755
		Man-hours required for irrigation:		42.370
		Total man-hours required for cultivation:		51.125
June				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Potatoes	0.180	preparing seedbed	13.80	2.484
Rice	0.273	harvesting	92.00	25.116
				32.174
		Man-hours required for irrigation:		50.470
		Total man-hours required for cultivation:		82.644

Month-crop	Hectares	Work	Man-hours per ha.	Man-hours area
July				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Rice	0.273	harvesting	92.00	25.116
Sorghum	0.085	harvesting	30.00	2.550
Maize	0.120	preparing seedbed	10.20	1.224
Sunflower	0.095	preparing seedbed	10.20	0.969
Potatoes	0.460	preparing seedbed	13.80	6.348
	0.180	planting	54.00	9.720
				50.501
		Man-hours required for irrigation:		34.320
		Total man-hours required for cultivation:		84.821
August				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Maize	0.120	sowing	17.00	2.040
Sunflower	0.095	sowing	17.00	1.615
Potatoes	0.460	planting	54.00	24.840
	0.120	preparing seedbed	13.80	1.656
	0.180	spraying	9.10	1.638
	0.180	handhoeing	41.25	7.425
Vegetables	0.286	preparing seedbed	13.80	3.947
				47.735
		Man-hours required for irrigation:		48.860
		Total man-hours required for cultivation:		96.595

Month-crop	Hectares	Work	Man-hours per ha.	Man-hours area
September				
Alfalfa	0.515	making hay	6.50	3.348
	0.515	spraying	2.38	1.226
Vegetables	0.286	planting	67.50	19.305
	0.286	preparing seedbed	13.80	3.947
Maize	0.120	top dressing	1.86	0.223
	0.120	spraying	2.04	0.245
	0.120	handhoeing	9.00	1.080
Sunflower	0.095	top dressing	1.86	0.177
	0.095	spraying	2.04	0.194
	0.095	handhoeing	9.00	0.855
Potatoes	0.640	spraying	9.10	5.824
	0.640	handhoeing	41.25	26.400
	0.120	planting	54.00	6.480
				69.304
	Man-hours required for irrigation:			52.170
	Total man-hours required for cultivation:			121.474

The total labour input required for the five hectare farms is as shown in Table No. 39.

Diagram No. 8 and Table No. 39 show that the labour input required can almost always be supplied by one full-time family worker with an eight hour day, only in December will this not suffice. However, the additional labour demand during December would only be about five hours daily and this could either be covered by family members and or by some hired labour. In this study it is assumed that this additional demand will be covered by family members.

Diagram No. 8

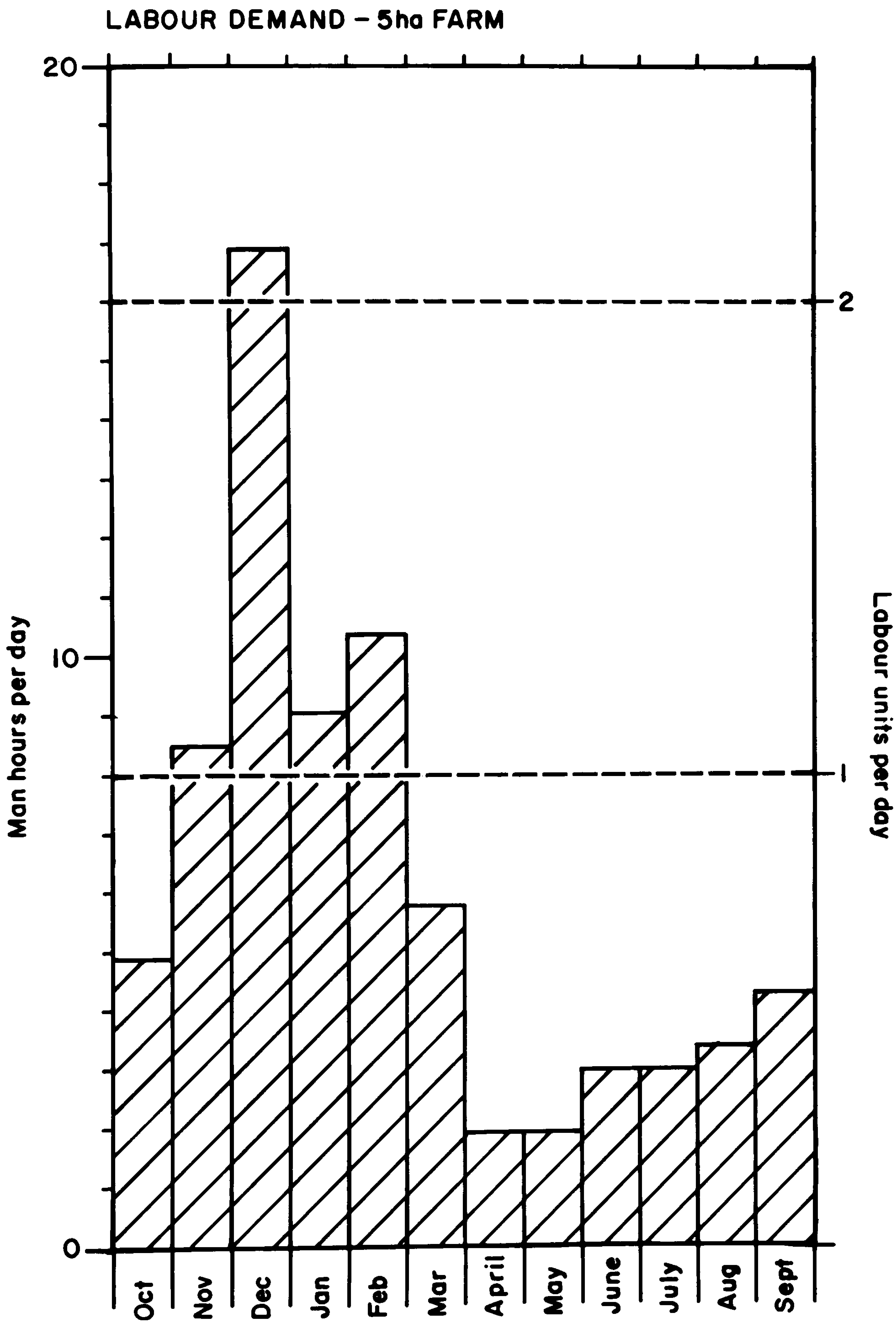

LABOUR DEMAND – 5ha FARM
20
10
0
2
1
Man hours per day
Labour units per day
Oct
Nov
Dec
Jan
Feb
Mar
April
May
June
July
Aug
Sept

Table No. 39 Labour demand of five hectare farms

MONTH	MAN-HOURS FOR CULTIVATION	MAN-HOURS FOR SHEEP	MONTHLY TOTAL MAN-HOURS	DAILY TOTAL MAN-HOURS	DEMANDED LABOUR UNITS
October	144.529	7.75	152.279	4.9	0.6
November	247.799	7.50	255.299	8.5	1.1
December	516.670	7.75	523.750	16.9	2.1
January	260.842	7.75	268.592	8.7	1.1
February	284.507	7.00	291.507	10.4	1.3
March	171.956	7.75	179.706	5.8	0.7
April	50.632	7.50	58.132	1.9	0.2
May	51.125	7.75	58.875	1.9	0.2
June	82.644	7.50	90.144	3.00	0.4
July	84.821	7.75	92.571	3.0	0.4
August	96.595	7.75	104.345	3.4	0.4
September	121.474	7.50	128.974	4.3	0.5
Total	2,113.594	91.25			

Pattern of expenditure for animal husbandry

To feed the 26 sheep and one cow the following area of fodder crops is necessary

Table No. 40 Area necessary for livestock

CROP	AREA IN HECTARES SHEEP	CATTLE
Alfalfa	0.345	0.170
Maize	0.009	0.015
Sunflower	-	0.095
Sorghum	0.085	-
Barley	-	0.595
Total	0.439	0.875

The costs of the production means for these crops are detailed below.

Table No. 41 Expenditure for sheep

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.345	Alfalfa			
	Seeds	50 kg.	13.00	224.25
	Fertilizer	400 kg.	0.52	71.76
	Plant protection	120 SR	-	41.40
	Machine costs*	87 SR	-	30.02
	Water	7,343.67 cu.m.**	0.10	734.37
				1,101.80

* The machine costs are the same as those for the project in Haradh.

** The amount of water is not per hectare but per cropped area.

Table No. 41 (continued)

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.045	Maize			
	Seeds	15 kg.	0.60	0.41
	Fertilizer	500 kg.	0.52	11.70
	Plant protection	20 SR	-	0.90
	Machine costs	87 SR	-	3.92
	Water	298.49 cu.m.	0.10	29.85
				46.78
0.085	Sorghum			
	Seeds	15 kg.	0.80	1.02
	Fertilizer	500 kg.	0.52	22.10
	Plant protection	20 SR	-	1.70
	Machine costs	87 SR	-	7.40
	Water	505.24 cu.m.	0.10	50.52
				82.74

This results in a total expenditure of 1,231.32 SR.

Table No. 42 Expenditure for one cow

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.595	Barley			
	Seeds	120 kg.	0.70	49.98
	Fertilizer	500 kg.	0.52	154.70
	Plant protection	20 SR	-	14.28
	Machine costs	87 SR	-	51.77
	Water	2,539.46 cu.m.	0.10	253.95
				524.68
0.170	Alfalfa			
	Seeds	50 kg.	13.00	110.50
	Fertilizer	400 kg.	0.52	35.36
	Plant protection	120 SR	-	20.40
	Machine costs	87 SR	-	14.79
	Water	3,618.62 cu.m.	0.10	361.86
				542.91
0.095	Sunflower			
	Seeds	15 kg.	0.90	1.28
	Fertilizer	500 kg.	0.52	24.70
	Plant protection	20 SR	-	1.90
	Machine costs	87 SR	-	8.27
	Water	630.14 cu.m.	0.10	63.01
				99.16

Table No. 42 (continued)

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.075	Maize			
	Seeds	15 kg.	0.60	0.68
	Fertilizer	500 kg.	0.52	19.50
	Plant protection	20 SR	-	1.50
	Machine costs	87 SR	-	6.53
	Water	497.48 cu.m.	0.10	49.75
				77.96

One thousand, six hundred and sixty-six kilogrammes of grains would be harvested on the 0.595 ha. of barley. 166.60 SR could be earned if advantage is taken of the difference in price between locally produced and imported barley. This results in a decrease of the total expenditure for cattle from 1,244.71 SR to 1,078.11 SR. However, as the products from the cow will be consumed by the family these expenses will appear as losses.

Table No. 43 Expenditure for crop cultivation

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.571	Vegetables			
	Seeds	100 SR	-	57.10
	Fertilizer	600 kg.	52.00	178.15
	Plant protection	60 SR	-	34.26
	Machine costs	87 SR	-	49.68
	Water	3,625.28 cu.m.	0.10	362.53
				681.72

Table No. 43 (continued)

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.571	Onions			
	Seeds	5 kg.	140.00	399.70
	Fertilizer	600 kg.	52.00	178.15
	Plant protection	40 SR	-	22.84
	Machine costs	87 SR	-	49.68
	Water	6,885.12 cu.m.	0.10	688.51
				1,338.88
0.571	Lettuce			
	Seeds	5 kg.	140.00	399.70
	Fertilizer	600 kg.	52.00	178.15
	Plant protection	40 SR	-	22.84
	Machine costs	87 SR	-	49.68
	Water	2,932.66 cu.m.	0.10	293.27
				943.64
0.570	Wheat			
	Seeds	120 kg.	1.00	68.40
	Fertilizer	500 kg.	52.00	148.20
	Plant protection	24 SR	-	13.68
	Machine costs	87 SR	-	49.59
	Water	2,432.76 cu.m.	0.10	243.28
				523.15

Table No. 43 (continued)

HECTARES	CROP	AMOUNT/ha.	SR/UNIT	SR/AREA
0.630	Barley			
	Seeds	120 kg.	0.70	52.92
	Fertilizer	500 kg.	52.00	163.80
	Plant protection	24 SR	-	15.12
	Machine costs	87 SR	-	54.81
	Water	2,688.84 cu.m.	0.10	268.88
				555.53
0.640	Potatoes			
	Seeds	1,200 kg.	1.40	1,075.20
	Fertilizer	600 kg.	52.00	199.68
	Plant protection	60 SR	-	38.40
	Machine costs	87 SR	-	55.68
	Water	5,096.32 cu.m.	0.10	509.63
				1,878.59
0.545	Rice			
	Seeds	135 kg.	1.00	73.58
	Fertilizer	1,000 kg.	52.00	238.40
	Plant protection	60 SR	-	32.70
	Machine costs	87 SR	-	47.42
	Water	8,777.23 cu.m.	0.10	877.72
				1,269.82

The value of the crops from each five hectare farm is as follows:

Table No. 44 Value of cash crops

HECTARES	CROP	YIELDS IN kg. per ha.	YIELDS IN kg./area	PRICE SR PER kg.	VALUE OF GROWN CROPS
0.571	Vegetables	10,000	5,710.0	0.65	3,711.50
0.571	Onions	14,000	7,994.0	0.72	5,755.68
0.571	Lettuce	14,000	7,994.0	0.72	5,755.68
0.570	Wheat	3,000	1,710.0	0.86	1,470.60
0.630	Barley	2,800	1,764.0	0.45	793.80
0.640	Potatoes	12,500	8,000.0	0.88	7,040.00
0.545	Rice	2,360	1,286.2	1.00	2,286.20
Total					26,813.46

The expenditure must be deducted from the value of the agricultural products, leaving a net value of 19,692.70 SR.

Table No. 45

Net value of agricultural products (in SR)

PRODUCT	VALUE	EXPENDITURE	NET VALUE	LOSS
Vegetables	3,711.50	681.72	3,029.78	-
Onions	5,755.68	1,338.88	4,416.80	-
Lettuce	5,755.68	943.64	4,812.04	-
Wheat	1,470.60	523.15	947.45	-
Barley	793.80	555.53	238.27	-
Potatoes	7,040.00	1,878.59	5,161.41	-
Rice	2,286.20	1,269.82	1,016.38	-
Lambs	2,380.00	1,231.32	1,148.68	-
Cattle	-	1,244.71	-	1,078.11
Total			20,770.81	1,078.11

Marketing

The total annual vegetable production of five hectare farms is 21.698 tons*. Of this, 4.006 tons can be sold within the oasis and 17.692 tons must be marketed in the Western Province. Thus, based on an average price of 0.77 SR per kilogramme for truck transport from Hofuf to the western markets, the transport costs are 13,622.84 SR. Furthermore, assuming an average annual consumption of vegetables of 67.50 kg. per person, the average seven member family has a consumption of 0.473 tons of vegetables, which results in a deduction of 329.50 SR. Seven lambs

* The output of vegetables of 5.00 ha. farms is 21.698 tons per annum. However, based on the output calculated for the entire project on page No. 152 the output should be 21.704 tons. This difference is caused by rounding of decimals in the calculation.

will be consumed in order to cover the family's demand for meat, which means a deduction of 980.00 SR. Thus, the remaining family cash income will be 4,760.36 SR. This implies:

Monthly income of:	396.70 SR
Income per head per annum:	680.05 SR
Monthly income per labour unit:	396.70 SR
Hourly wage of:	1.90 SR

The income shown above makes farming in Al Hassa desirable, especially since a great proportion of the family's consumption is already covered. The farm successfully fulfills an important social role because as there is always a male member of the family working on the fields, it is also possible for the female members of the family to spend their leisure time there.

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CHAPTER THREE

THE AVU KETA PROJECT, GHANA

Location of the project (see Map No 1)

The Avu Keta project is located 6° North and 0° 45' East, in the southern part of the Volta Region of Ghana. The project area extends 38 km. North-South and 45 km. East-West, encompassing an area of about 130,000 ha., with 135,000 inhabitants.

The borders of the project area were chosen in such a way as to ensure that the scheme would function as a structurally and economically self-sufficient unit. The northern boundary follows the Sogakofe Highway from Tefle bridge in the West as far as Atiti in the East, from where it runs directly to Blekuse on the coast. To the West, the area is bounded by the Volta River, while to the South and East the sea, i.e. the Gulf of Guinea, forms a natural boundary.[1]

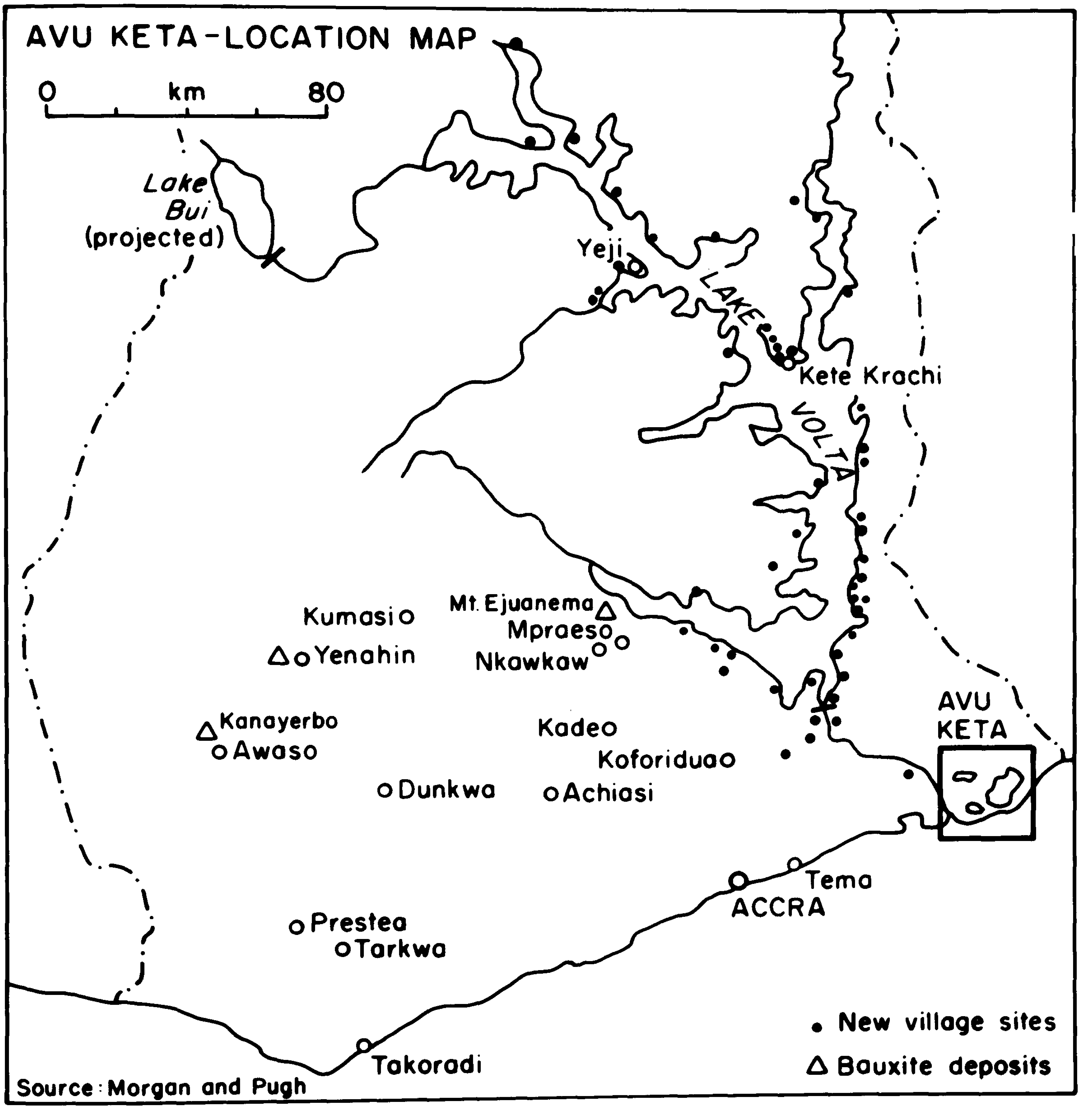
Population

The project area is inhabited mostly by EWE speaking people who number 563,005 in Ghana.[2] Most of the 135,000 inhabitants of the region belong to three tribes: the Anlo, the majority group, the Tongu and the Agave. (See Map No 2)

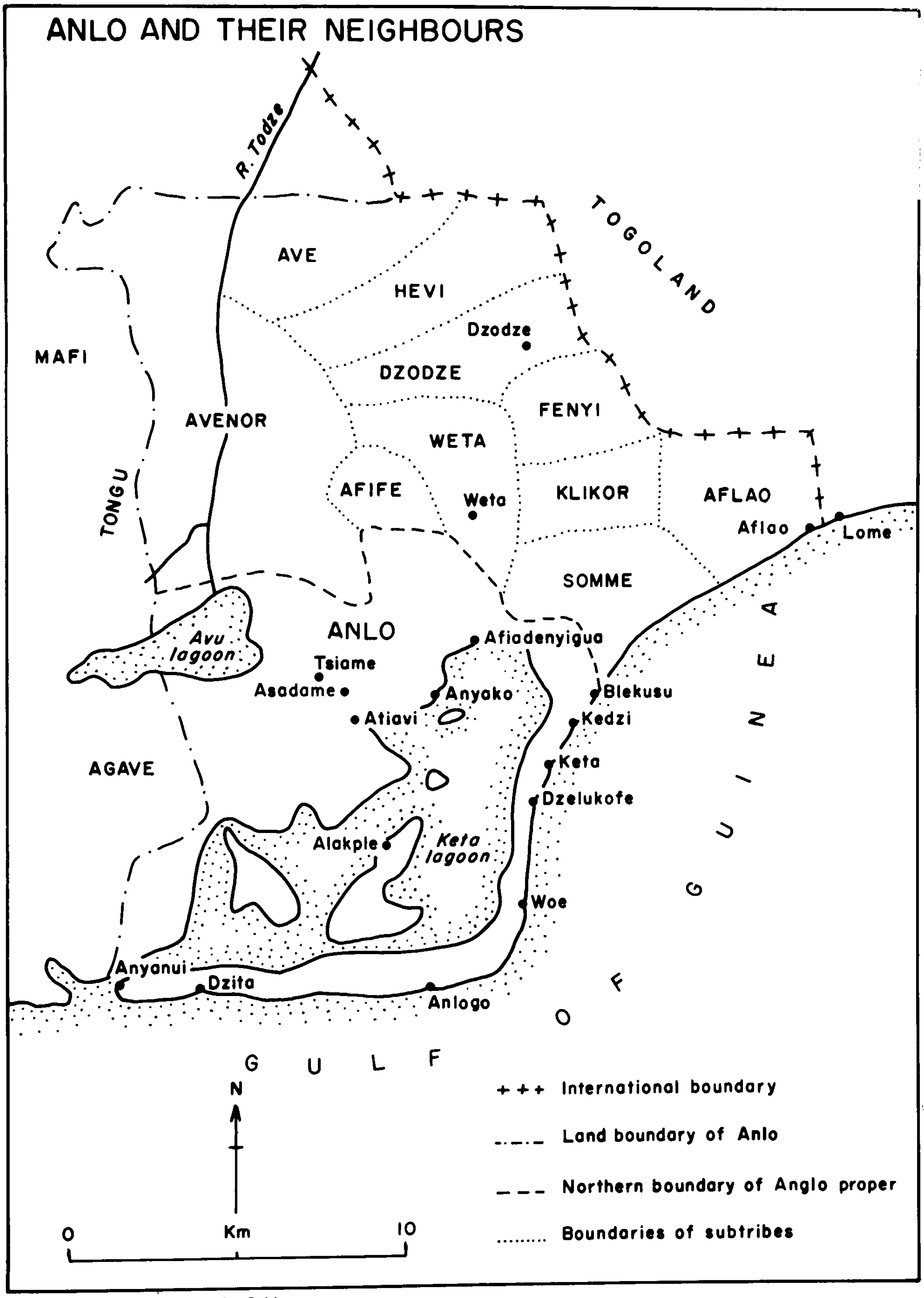
The distribution of population in the project area is as follows: 70,000 in the Anlo South district, 30,000 in the Keta district and 16,000 in part of Anlo North and 19,000 in Tongu.[3]

Keta town, the commercial and administrative centre of the area, has 16,000 inhabitants. Schools, offices and large European stores are found there, it has a small harbour, and every fourth day a market, supplied by traders from Ghana, Toga, Dahomey and Nigeria. However, its importance is decreasing. The traditional capital Anlo (11,000 inhabitants) has a more promising future because of the discovery of oil in its district.

Map No. 1


AVU KETA-LOCATION MAP
0 km 80
Lake
Bui
(projected)
Yeji
LAKE
Kete Krachi
VOLTA
Kumasi
Yenahin
Mt. Ejuanema
Mpraeso
Nkawkaw
Kanayerbo
Awaso
Kadeo
Koforidua
Dunkwa
Achiasi
AVU
KETA
Tema
ACCRA
Prestea
Tarkwa
Takoradi
New village sites
Bauxite deposits
Source: Morgan and Pugh

Map No. 2



SOURCE: NUKUNYA G.K.

It also has schools, a market with a similar turnover to that of Keta, a police station and a teacher training college.[4]

Table No 1 shows other settlements in the area.

Table No 1

NAME OF SETTLEMENT	NUMBER OF INHABITANTS[5]
Woe	3,450
Aflao	7,490
Denu	1,823
Kedzi	5,015
Dzelukofe	5,511
Tegbi	5,924
Dzita	1,814
Anyako	5,097
Afiadenyigba	4,920
Tsiame	3,833
Atiavi	2,811

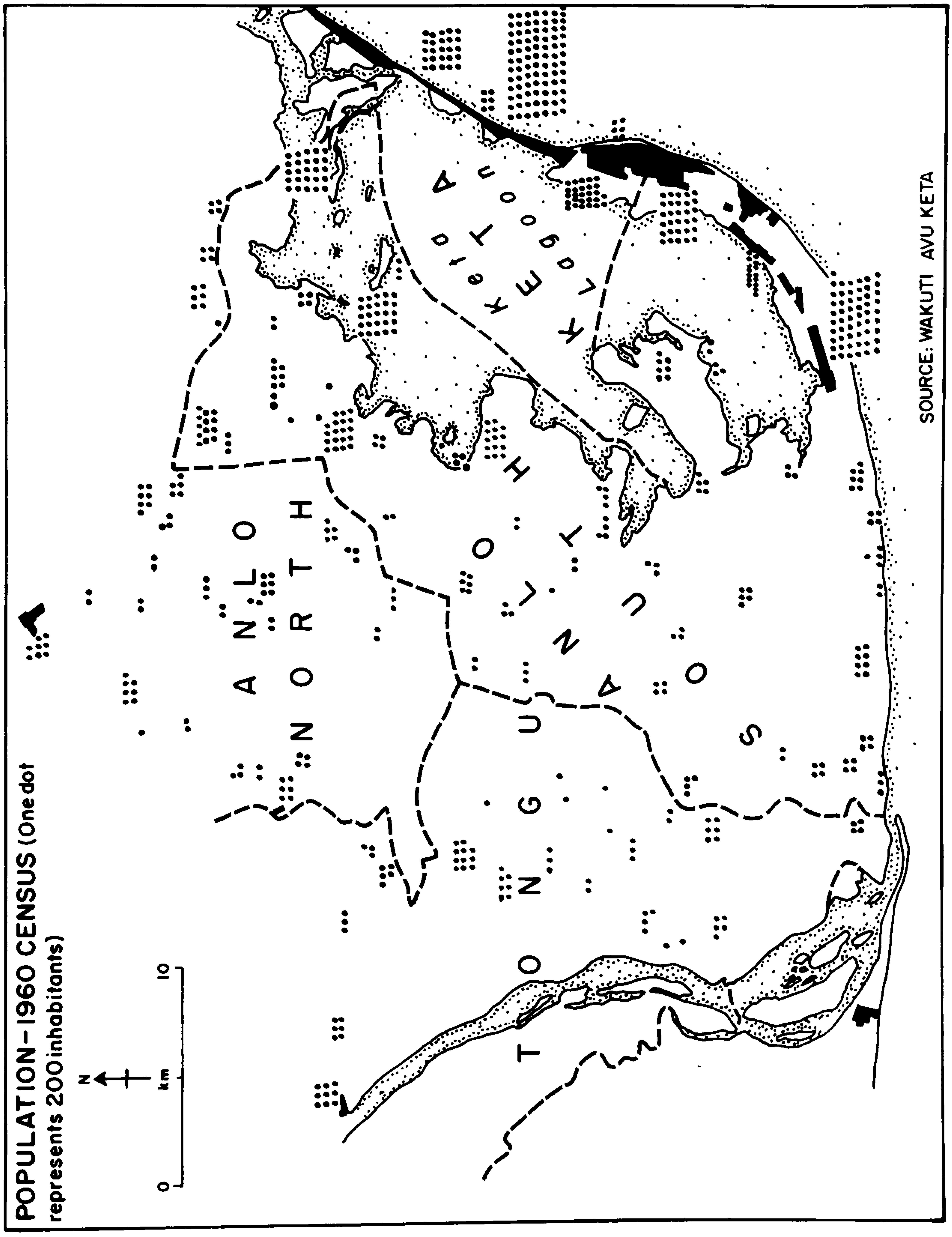
The distribution of the population is illustrated on Map No 3.

The proportion of EWE speaking people and their religion is shown in the following table.

Table No 2 Tribal membership and religion[6]

EWE	TRIBAL MEMBERSHIP Anlo South	Keta	RELIGION IN PERCENTAGE	
Number of EWES	69,000	28,000	Christian	48
As a percentage of the total population	99%	93%	Traditional	45
Percentage born in the area	88%		Others	7
Percentage immigrated	11%		Total	100

Map No. 3


POPULATION-1960 CENSUS (One dot represents 200 inhabitants)
N
0
10
km
ANLO NORTH
ANLO SOUTH
TONGU
Keta Lagoon
SOURCE: WAKUTI AVU KETA

The inhabitants of the region are patrilineal and patrilocal, but individual property is transmitted matrilineally.[7] They are organized in so-called clans, sub-clans and extended families, but these "clans" are not clans in the strict sense of the word, because marriage within the clan is normal.

Originally the EWE came from southern Nigeria and occupied the left bank of the Volta River where they live in small nucleated villages. Their houses are built of mud with thatched grass roofs, although today galvanized iron sheets are also used for roofing. Each house has a fenced compound planted with trees, and individually-owned trees grow between the houses and around the villages. Small fenced, privately-owned gardens are also found in this region. All fields near the villages seem to be permanently under cultivation.[8]

The most densely populated part of the project area is Keta with 160 inhabitants per sq. km., followed by Anlo South with 120 inhabitants per sq. km., then Anlo North and Tongu, each with 70 inhabitants per sq. km. The average density of population in the project area as a whole is 128 inhabitants per sq. km., whilst the average population density of Ghana is only 29 per sq. km. (see Table No 3). Thus, the density of population in the project area is 3.5 times greater than the national average. It can be concluded that this area is overpopulated, especially since large areas are unsuitable for settlement because of lagoons and flooding. Increasing population thus results in migration from the project area.[9]

This situation is described by Nukunya:[10]

"One factor which accelerates the estrangement of the Anlo from his indigenous culture, and which at the same time reduces his influence on the traditional society, is the inevitable tendency to find his future not in his natal community but in a commercial or industrial centre. In the absence of great commercial and industrial centres in the Anlo district he realizes his ambition in most cases in the large towns outside Anlo country, such as Accra, Kumasi and Takoradi."

To overcome this situation the Ghanaian Government introduced several measures. With the introduction of "Workers' Brigades", State farms and a "Back to the Land" campaign, the migration slowed down marginally. Further, due to decentralisation of the Government offices and the local need for school teachers, desirable jobs became available in the area.[11]

Table No 3 Population density[12]

POPULATION	GHANA	VOLTA	ANLO SOUTH	KETA	PROJECT AREA, ANLO SOUTH AND KETA
	in millions		in thousands		
Male inhabitants*	3.4	0.38	34	14	48
Female inhabitants*	3.3	0.40	36	16	52
Total	6.7	0.78	70	30	100
Size in sq. km.	-	-	687.9	186.5	775.4
Inh./sq. km.	29	38	119	159	128

In Anlo South migration from the villages is especially great. Whilst the total population of Ghana increased by about 60 per cent from 1948 until 1960, it only rose by 20 per cent in the densely populated Anlo South region. The increase during this period is shown in detail in the table below.

* Almost the same proportion has been found in another source, i.e. 151,617 males to 152,614 females.13

Table No 4 Increase in population[14]*

REGION	UNIT	1948	1960	INCREASE IN PERCENTAGE
Ghana	millions	4.12	6.73	63
Volta	millions	0.50	0.78	57
Anlo South	thousands	58	70	21
Keta	thousands	18	30	60**

According to another source[15] based on the 1948 census the number of inhabitants must have fallen considerably. This census states that the total number of inhabitants was 304,231 (of which 245,380, i.e. 81 per cent, were EWES), that is a density of population of about 60 persons per sq. km. The Census Report states further that "there is evidence of extensive western migration of EWE". This could account for the smaller number of inhabitants now.

Because of the limitations imposed by flooding, the number of towns and villages is small - in Anlo South 111 and in Keta region only five.

Table No 5 Number of villages and towns[16]

REGION	No. OF VILLAGES AND TOWNS 1948	No. OF VILLAGES AND TOWNS 1960	No. OF HOUSES 1960
Ghana	15,000	30,000	636,000
Of them Volta	1,800	3,800	84,000
Anlo South	93	111	8,600
Keta	6	5	2,600

* The figures can only be compared to a limited extent due to the use of different statistical methods in 1948 and 1960.

** In Keta there was the possibility of taking up other non-agricultural professions.

In Keta region more than 90 per cent of the population live in villages with more than 5,000 inhabitants, whereas this figure is only 30 per cent for Anlo South.

Table No 6 Population in several villages[17]

INHABITANTS PER VILLAGE	No. OF VILLAGES Anlo South	Keta	No. OF INHABITANTS Anlo South	Keta
under 100	45	-	1,700	-
100 to 200	20	-	2,900	-
200 to 500	15	-	5,200	-
500 to 1,000	17	-	12,300	-
1,000 to 2,000	6	2	8,100	2,500
2,000 to 5,000	5	-	17,600	-
over 5,000	3	3	22,100	27,200
Total	111	5	69,900	29,700

In comparison with the national average, school attendance is high, especially in the Keta region.

Table No 7

Attendance at school of persons over six in the Volta Region[18]*

ATTENDANCE AT SCHOOL	TOTAL	MALE	FEMALE
Never attended school	401	159	242
Has attended	94	64	30
Attending at present	108	70	38

* As the local district totals were not available the above figures are for the whole Volta Region.

Economic and social aspects

The employment situation in Ghana and the project area is shown in Table No. 8.

In Ghana as a whole, 45 per cent of the men are professionally registered, whilst in the project area less than 40 per cent are. This situation is reversed for female employees. Thirty-three per cent of the female population of Ghana is professionally registered, whereas in the project area this number is 45 per cent. In Ghana as a whole nine per cent of all men are traders, but in the Avu Keta region this figure is more than doubled. The situation for women is comparable. About 28 per cent of the female employees of Ghana live by trade, compared with 80 per cent in the project area.[22]

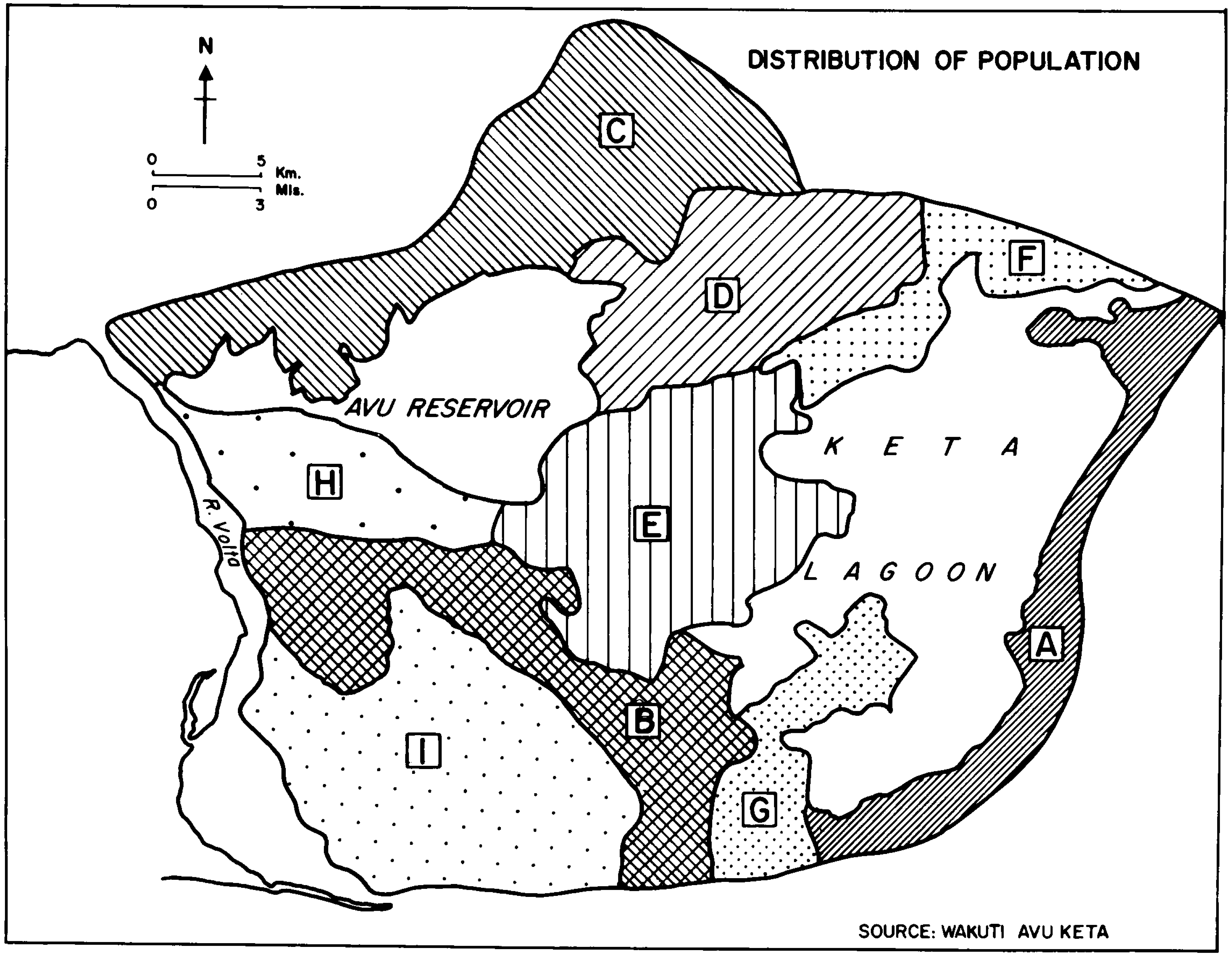
In Ghana about 56 per cent of the male population is employed in agriculture, whereas the figure is only 30 per cent in the overpopulated Anlo South region and 12 per cent in the Keta region. Other employment is provided by fishing, trade, weaving and pottery. As there are no other employment possibilities many are under or unemployed.[23]

All figures previously mentioned show a distinct instability in the social structure which results from the lack of land and overpopulation of the project area, overpopulation being evidenced by the relatively high rate of forced emigration. It is therefore necessary to relieve this instability by providing new agricultural opportunities.

After the measures planned have been put into effect, the population should rapidly increase. In the first year the rate of increase is expected to be at least four per cent and in the following years two to three per cent. Thus the population will more than double in the next decade. The increase within the next 25 years is illustrated in Map No. 4.

Taking a cultivated area of about 30,000 ha. as a basis for calculation, of which 2.5 ha. will belong to each family of about seven to eight persons,

Map No. 4



A	70000 INH.	880 INH / Km 2280 INH/ sq.MI.	D	38000 INH.	400 INH/Km 1035 INH/sq. MI.	G	10000 INH.	190 INH/Km 490 INH/sq.MI.
B	41000 INH.	400 INH/ Km 1035 INH/ sq.MI.	E	36000 INH.	400 INH/Km 1035 INH/sq. MI.	H	10000 INH	180 INH/Km 465 INH/sq.MI.
C	39000 INH.	230 INH/ Km. 595 INH/ sq.MI.	F	10000 INH.	220 INH/Km 570 IN	I	10000 INH	70 INH/Km 181 INH sq.MI.

Table No. 8 — Number of employees - over 15 years[19]

OCCUPATION	GHANA MALE	GHANA FEMALE	ANLO SOUTH MALE	ANLO SOUTH FEMALE	KETA MALE	KETA FEMALE
	in 1,000		persons		persons	
Agriculture	500	411	4,307*	1,466	58*	29
Oil palms, coffee, tea	15	11	3	-	2	-
Cocoa	374	148	27	6	3	-
Tobacco, rubber	2	-	5	5	1	-
Total agriculture	891	570	4,342	1,477	64	29
Stock farming	6	1	53	63	9	19
Agricultural service	30	1	21	2	16	-
Forestry and hunting	23	1	37	27	2	1
Fishery	53	3	4,049**	42**	1,944**	26**
1. Agriculture, forestry, fishery	1,003	576	8,502	1,611	2,035	75
2. Mining	46	2	5	8	2	-
3. Handicraft	136	99	2,455	1,768	921	546
4. Construction	87	3	510	10	521	41
5. Supply of energy and water	13	-	39	-	171	-
6. Trade	96	276	487	12,639	587	6,127
7. Transport	68	1	335	-	370	-
8. Services (mostly civil)	124	31	557	559	717	405
Total 1-8	1,573	988	12,890	16,595	5,324	7,242

* Fifty per cent of the adult male population grow onions, so they earn an income of about 100 Ghanaian pounds per year. 20

** Nukunya mentioned[21] that 50,000 people earn a living from fishing, but due to overfishing this number is decreasing. This refers only to sea fishing because lagoon fishing is done only on a small scale.

about 80,000 people could live on agriculture given favourable conditions. At present 20,000 people just manage to support themselves from agriculture.[24] Whether this improvement will be possible depends to a large extent on the ability of the inhabitants to profit from the new sophisticated scheme.

The people in the coastal belt are accustomed to cash crops since they grew coconut trees until the late 1940s when their trees were almost completely destroyed by diseases and erosion.[25] Furthermore, the onion farmers cultivate a completely market orientated crop.

But most of the inhabitants are shifting cultivators, and it is the attitudes and abilities of these farmers which will influence and determine the success or failure of the new scheme.

<u>The main features of shifting cultivation</u>[26]

1. Shifting cultivation involves "an almost negligible minimum of labour output". It is simple and uncomplicated.
2. Shifting cultivation is characterized by "the lack of weeding and the use of a single inventory of tools".
3. Crop rotation is not practised and is replaced by soil rotation. After the harvest the plot will not be used for a specified period of time.

<u>Nutrition</u>

Eighty per cent of the necessary calories are derived from manioc, maize, yams, plantain, taro, millets, sorghums and rice.[27] These foods are usually supplemented by peanut or oil palm sauce and occasionally by fish or clams. Meat seems to be a luxury. Vegetables are scarce in the whole area, but chillies are common. From this it is evident that vegetable protein in the diet is low and this shortage is supplemented by animal protein from fish and clams, at present the only available source. Deficiencies of vitamin A are evident where no palm oil is used, except during the mango season, but vitamin B may still be lacking. Adequate vitamin C may be obtained from raw cassava, chillies and sugar-cane and, when available, from mango.[28]

Present land use

On the whole, the people of the region are farmers, but only a very small area is cultivated. Most of the fields are located in the higher north-eastern part of the project area. In the southern part, the so-called Avu Keta Lagoon, suitable land is scarce.

It is very difficult to state the exact figures of the yields as harvesting is very irregular.[29] Nevertheless, the following yields have been estimated.

Table No. 9 Estimated yields[30]

CROP	YIELDS IN kg./ha.
Cassava - fresh	7,000
Groundnuts	670
Maize	600 to 700

The crops which can be grown in the Avu Keta region are those found in irrigated tropical regions, with a few exceptions. One important restricting factor is the high level of humidity throughout the year. Cotton and sorghum, for example, are sensitive to excessive humidity and to a lesser degree humidity may also be harmful to sugar-cane, especially during the ripening period.[31]

There are three farming systems in the area: shifting cultivation, compound farming, and irrigated farming. The extent to which each is practised varies. Shifting cultivation is found all over the project area while compound farming is widely practised on the Keta bay-mouth bar and, to a lesser extent, near the larger villages. Irrigated gardens are mostly used for cultivation of onions between Anyanui and Dzita, on either side of the main road, and between Wuti, Anloga and Woe.[32]

Shifting cultivation

Cassava, corn, millets, rice, cocoa palms and oil palms are the main crops grown under shifting cultivation, lesser crops being yam, chilli, tobacco, mangoes and peanuts. Shifting cultivation is practised as dry farming and rotation varies from place to place.[33]

Compound farming

This is practised on small plots of land beside the villages, which are cultivated permanently by members of the family. These small areas are wholly or partially manured with cattle dung in order to grow valuable crops like tobacco, chillies and vegetables. Dry farming is practised during the dry season when there is not enough water for irrigation.

The local term "Compound Farming" is apt to mislead because these plots are neither an area surrounding a hut nor enclosed by a wall or fence.[34]

Irrigated gardens

These are small areas used by individual farmers to cultivate vegetables, especially onions, under irrigation. Wells as deep as 1.5 m. are situated near the gardens. Because the ground water level is high, water is taken out in buckets and sprinkled over the vegetable and onion fields.[35]

Another type of agriculture is practised in the depressions, from which the water gradually retreats after the floods. These areas are cultivated during the dry season preceeding the main rainy season. The typical crops are: cassava, maize, groundnuts, cowpeas, oil palms, mango and tobacco. In depressions with deeper soil cassava is the main crop whilst in the more fertile sandy areas peanuts, cowpeas, tomatoes, okra and other vegetables are grown. On the higher parts where natural conditions are suitable, oil palms, mangoes and kapok are grown. The overall impression is that cassava is the most important crop. There are no cereals apart from maize.[36]

Explanation of the map of the present land use

The total project area is about 130,000 ha., of which 30,000 ha. will constitute the agricultural scheme itself. From Map No. 5, which shows the land use during February-April 1968 dry season, the following major areas can be distinguished:[37]

a. Lagoons and water courses (which are easily recognisable even during the dry season): Keta lagoon, Avu, Aglaw, Abatsivi and Tetua lagoons, Todzie river and the outlet from the Keta lagoon to the Volta mouth. These lagoons and water courses cover about 40,000 ha. or about 31 per cent of the total area.

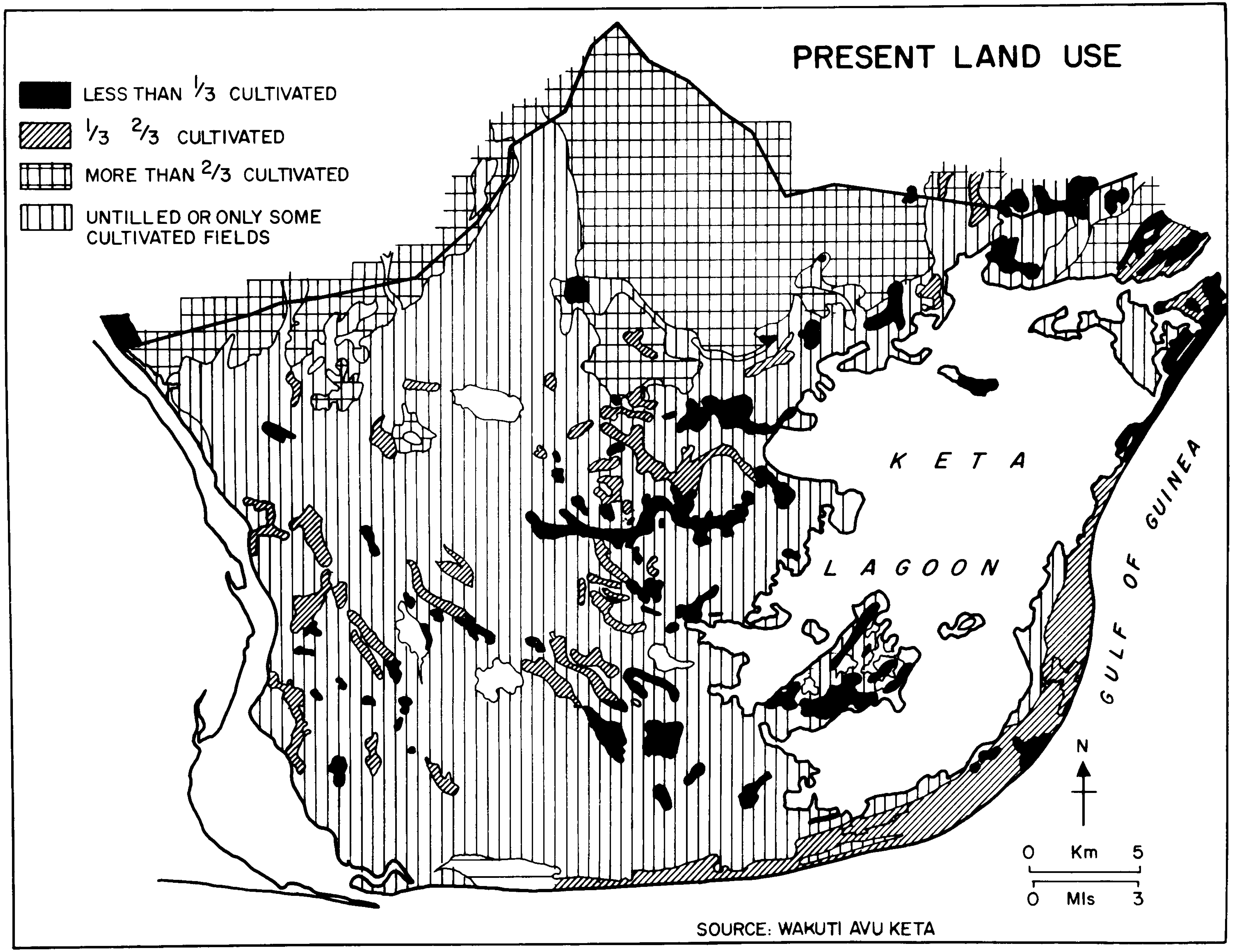
b. Swampy grassland, bush savannah and fallow areas (where there is only a little cultivation): with very few exceptions, the entire Avu Keta lagoon area, with savannah and fallow on the higher areas. This type of land use covers about 55,000 ha. - about 42 per cent of the total project area.

c. Areas of which less than one third is cultivated: mixed with surfaces like (b) generally as small plots. These fields are surrounded by bush savannah or grassland and cover about 8,000 ha. - about six per cent of the area.

d. Areas of which one to two thirds are under cultivation: the Keta bay-mouth bar, between the Tetve and Abatsivi lagoons, north of the Tetve lagoon, and some areas near the eastern shore of the Volta River. This land use type covers about 9,000 ha. - seven per cent of the total project area.[38]

e. Areas of which more than two thirds are under cultivation: the majority of the north-eastern part of the project area, land south of the main

Map No. 5


PRESENT LAND USE
LESS THAN 1/3 CULTIVATED
1/3 2/3 CULTIVATED
MORE THAN 2/3 CULTIVATED
UNTILLED OR ONLY SOME CULTIVATED FIELDS
KETA
LAGOON
GULF OF GUINEA
N
0 Km 5
0 Mls 3
SOURCE: WAKUTI AVU KETA

road Sogakofe - Dabala junction - Akatsi, the land between Anyanui and Dzita, and the land between Wuti - Anloga - Woe where vegetables and onions are the main crops. This land use type covers 18,000 ha. - about 14 per cent of the total project area.[39]

Table No. 10 summarizes the land use situation.

Table No. 10 Present land use[40]

DESIGNATION	SIZE IN ha.	PORTION IN PERCENTAGE
a. Water	40,000	31
b. Fallow land, swamps, grassland, bush savannah	55,000	42
c. Areas of which less than one third is cultivated	8,000	6
d. Areas of which one to two thirds are cultivated	9,000	7
e. Areas of which more than two thirds are cultivated	18,000	14
Total	130,000	100

The following cropping pattern can be assumed for most of the larger areas used for agriculture, except for the farming land between Anyanui and Dzita and between Anloga and Woe where mainly vegetables and onions are grown:[41]

Fifty per cent cassava

Thirty per cent maize

Twenty per cent miscellaneous crops such as tobacco, yam, vegetables and palm trees

State farms

In the early 1950s a programme was started to establish large-scale farms.[42] The objective was:[43]

" ..., the State Farms Corporation should concern itself with the introduction of new crops and proven techniques and establish itself in uncultivated, rather than already farmed, areas. This would be an effective means of popularizing new methods and ensuring that idle land resources are put to productive use."

In 1965, 105 farms of this type had been established, including 42 demonstration and experimental stations and eight Agricultural Development Corporation projects.[44]

One of these, the Afife State Farm covers about 3,000 ha. and is situated directly north of the Tefle - Denu road. In 1962 a one kilometre wide dam was built by the Soviet Union at the upper end of a flooded valley. The reservoir has been filled and will irrigate the land below the dam but before the irrigation and drainage canals could be constructed the Russians left the country with the overthrow of Nkrumah at the beginning of 1966. The project is thus only half completed and is not being used at present, but it would be possible to complete the essential works relatively cheaply. This would create an excellent experimental unit, especially for the irrigated rice which will be grown on the project's farms as all necessary farming equipment was left when the Russians left the country.[45]

The cropping pattern of this farm is shown below.

Table No. 11

Cropping pattern of the Afife State Farm in 1968 - in acres[46]

CROP	MAJOR SEASON - MARCH TO AUGUST objective 1968	obtained
Rice (non irrigated)	4,500	2,500
Maize	600	300
Cowpeas	50	18
Total	5,150	2,818
Total in ha.	2,060	1,127

Land ownership

The project area land is communally owned, all family members of the tribe having the right to farm and live on as much land as they can care for. In addition they may also hunt, fish or collect wild fruit from anywhere within their area. Thus there is no exclusive individual possession but it is customary to ask for permission from the head of the family before engaging in these activities.[47] The occupants are allowed to sell the products of the land and to build on it.[48]

The "ownership" of all the land lies in the person of the chief or the priest, who resembles a representative more than an actual owner, as he is entrusted with the welfare and defence of the community.

No single person has full control of the land, but once a family is well settled it acts as if it were the owner.[49]

But possibilities to get "individually owned" land do exist, where the owner can use the land as he wishes, and these are:[50]

1. if land, previously unused, is cleared and cultivated by an individual;
2. if land is used for the cultivation of cash crops;
3. "by purchase or mortgage";
4. "by gift or by testamentory disposition".

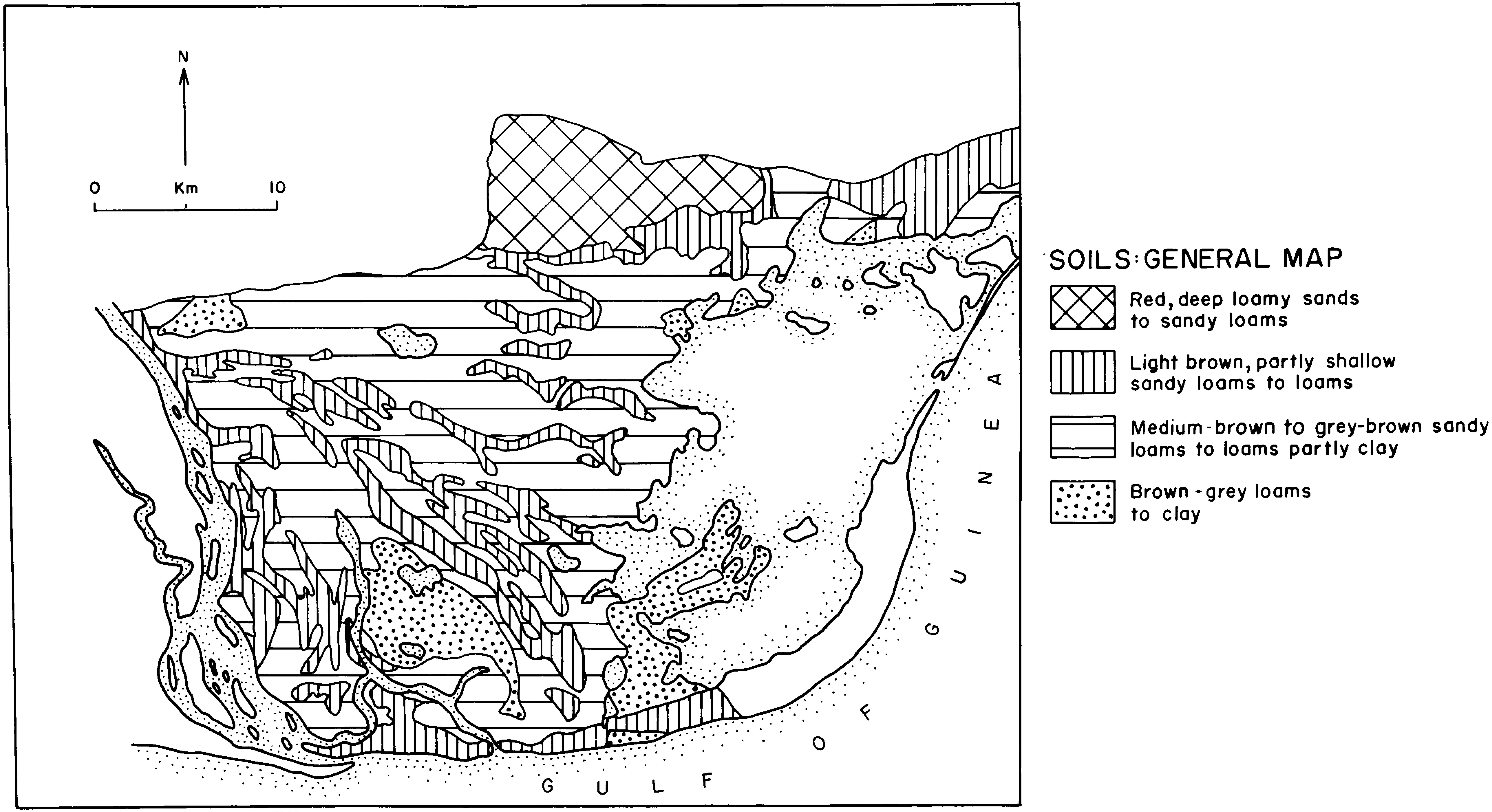
In areas with a shortage of land, such as the coastal areas, "individually owned" land is more common. Furthermore, the greater the commercial value of the crops grown the greater the urge to own the land individually.[51]

Soil[52] (see Map No. 6)

The area's soil is almost entirely alluvial and is subject to fluviatile, and to a lesser degree, eolian displacements. The only non-alluvial part of the project area is the north-eastern terrace of tertiary sediments.

Even during the dry season the ground water level is rarely more than three metres below the surface throughout most of the project area,

Map No. 6



SOURCE: WAKUTI AVU KETA

the only exception being the tertiary terrace which is on higher ground. Here the ground water level is deeper and cannot affect the plant growth.

The following four types of soil can be found:

a. Red earth of the tertiary cooluvium: good arable soils, most of which are already cultivated.

b. Waterlogged soils with a hardpan of alluvial river delta deposits: arable soils, now mainly supporting bush savannah.

c. Gleys from the alluvial river deposits: conditionally arable soils, now supporting grass savannah or mangrove: suitable for the cultivation of rice, although irrigation and drainage are necessary.

e. Semi-terrestrial to sub-hydrical soils, which are flooded during the rainy season and are non arable soils.

Further explanation:

a. The soils are deep loamy sands and sandy loams of tertiary cooluvium. They are bright red and easily penetrated by plant roots. However, they contain neither phosphoric acid nor nitrogen. K, Na, Mg and Ca are present in amounts varying from low to medium. The acidity of the soils ranges from medium to low and they are usually free from carbonates and stones. In the upper soil the humus content is also very low, i.e. 0.24 per cent. In the hardpan the C-content decreases to 0.1 per cent.

Most of the soil in this category is already under cultivation and so can be discounted from the plan for rice cultivation. To increase the yields, this soil needs organic and mineral fertilizer.

b. These light brown soils vary from sandy loams to loams of alluvial river deposits, with a consolidated hardpan which starts at a depth of 40 cm. and extends to a depth of 125 cm. Plant roots cannot penetrate this hardpan.

The humus content of the upper soil is low, i.e. 0.5 per cent and decreases to 0.1 per cent beyond a depth of 15 cm. The upper soil and the hardpan have a low content of K, Na, Mg and Ca. Beyond a depth of 80 cm. in the hardpan the nutritive content is slightly higher. The content of iron increases from the surface downwards from 0.44 per cent to 1.68 per cent. Nitrogen, phosphoric acid and potassium are missing from the nutritive substances. The acidity of the soil ranges from slight to medium. There are no easily soluble salts concentrated in a way that might endanger the plants and no carbonates. The soils are mostly free of stones and small amounts of gravel occur. The upper soil may sometimes consist of sand or loamy sand, some of which has been carried by the wind. The hardpan horizon has a great influence over suitability for cultivation and varies in depth from a few centimetres to over 50 cm. below the surface, and is more than 100 cm. thick.

Since the water movement and plant rooting are heavily obstructed, a deeper loosening must be carried out before cultivation, and organic and mineral fertilizer will be necessary. These soils are hardly ever suitable for rice cultivation, and must be used for cassava, sugar cane, beans, millet, maize or local fruit trees.

c. Mapping unit (c) is a group of soils whose texture, water condition and also salinity require appropriate treatment which makes them suitable for rice cultivation.

Grey-brown to black-grey loam to clay sediments are found mainly in old tributaries of the Volta River and in larger low lying areas.

Numerous streams occur in the southern plains and in certain areas a thin cover of peat has formed. The soil is heavier in the Atiavi-Glime region and halophytes grow on the shores of the Keta lagoon, but moor soil formation does not occur here. In the northern part near Avalavi, as in the case of all other undisturbed sedimentation zones, sediments of clay accumulate.

All category (c) soils belong to the acid gleys of alluvial clayey loam to clay. Below a humid and heavily rooted A-horizon lies a mottled G_o-horizon which is continuously being eroded and reduced in parts, as it is located in the capillary zone of the ground-water range. The G_r-horizon is a grey-brown horizon which is constantly influenced by the ground-water. Even in the A-horizon the infiltration rate is very low, in the range of 0.1 to 0.4 cm./h. and the hard-pan is almost impermeable. When draining, the soil can become as hard as brick. The soils are medium to very acid in parts. They are rich in Na, K and Ca and are free from stones. The degree of salinity is especially high on the shore of the lagoons and near the streams, but the upper soil is rarely saline, or at least only in pockets, and it is usually in a concentration of 10 mm.hos./cm. 25°C which may reduce the yields. Most of the soils in mapping area (c) were leached in the rootable upper soil and hard-pan due to the high precipitation, so that the yields should not be affected when salt-tolerant crops are cultivated, provided that the drainage system will continue to have a leaching effect.

The content of nutritive matters varies. Generally the potassium content is high, but phosphoric acid is absent. Due to the physical and chemical properties of the soils, and their occurrence in large flat areas, these soils will be suitable, after they have been treated, for the cultivation of irrigated rice.

e. Mapping unit (e) comprises soils which, under the present circumstances, are subject to regular floods which occur in the immediate vicinity of the coast because of the tide. Soils of this category also occur in the interior as a result of the rainfall and on the land surrounding the shore of the lagoons because of the irregular discharge conditions and water level fluctuations there.

This soil mainly consists of brown-grey loam to clay and is often barren or has halophytes growing on it. Because of the irregular water conditions the areas with this soil are not arable.

Climate

The climate in this part of Ghana is mainly determined by the movement of oceanic air masses arriving from the southern Atlantic. Continental air masses hardly ever reach this coastal belt and thus high relative humidity predominates throughout the year.[53]

There is no accurate information on winds in the project area, but it can be stated that the wind velocity is fairly low along the coastal belt. The average velocity in Accra and further inland is below 10 km./h., e.g. at Akuse 5 km./h. During storms, which are rare, much higher wind velocities have been recorded, e.g. in Accra 110 km./h., but these heavy storms have only been of short duration.

Monsoon winds predominate, blowing from the southern Atlantic in an East-North-East direction.[54]

Compared with other tropical areas of West Africa the average rainfall of 920 mm. in the project area is low. Rain falls mainly during the two wet seasons which are separated by dry periods, sometimes lasting from three to five months.[55]

The main rainy season during which about 60 per cent of the total annual precipitation occurs, begins about the middle of March and ends at the beginning of July. Highest rainfall is usually in June, but sometimes in May. On average, 30 per cent of the annual precipitation falls in June alone. A shorter and milder rainy season extends from mid-September to mid-November, usually reaching a peak in October. In the second minor rainy season the precipitation only reaches about 20 per cent of the annual value.

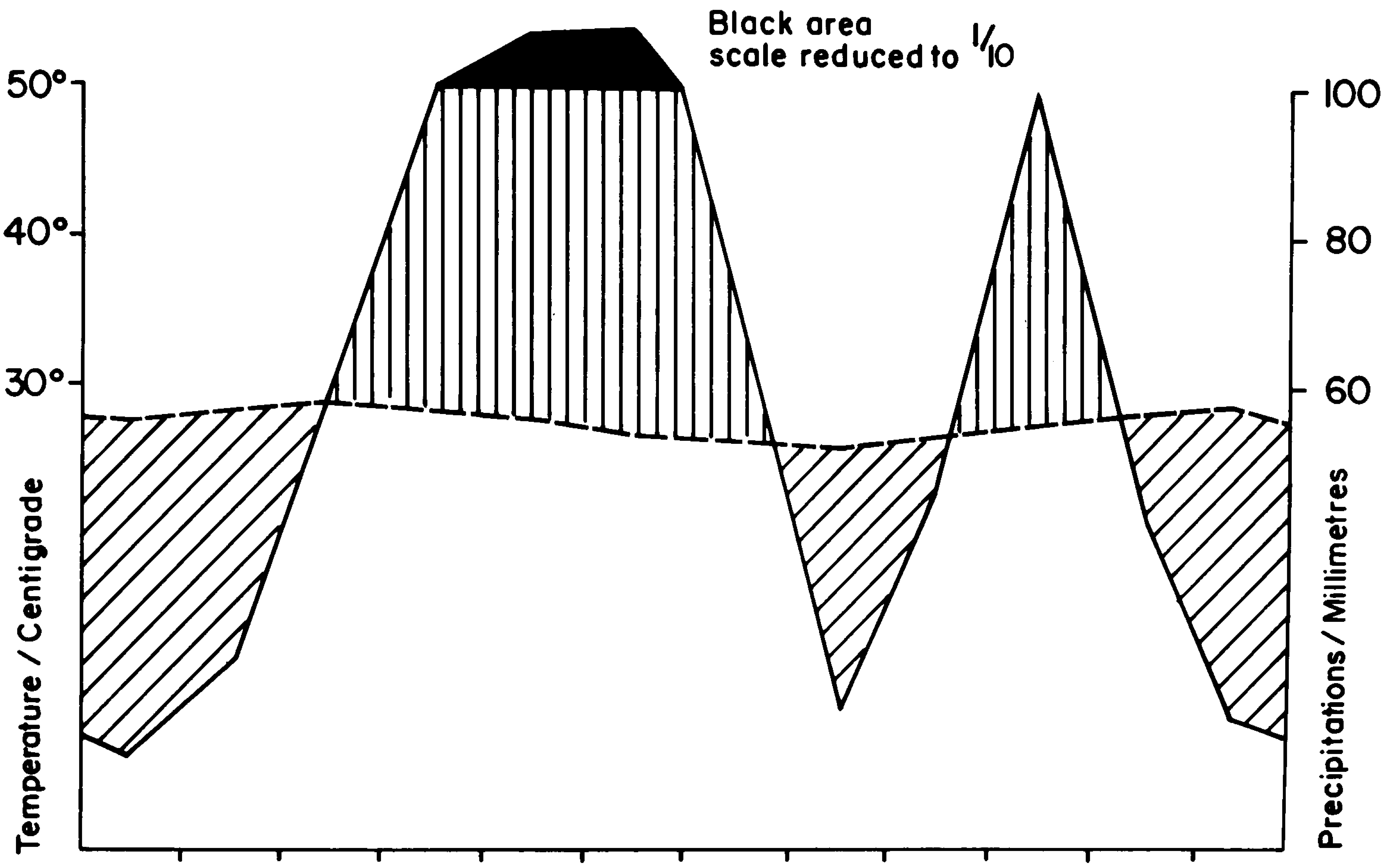
Table No. 12

Frequency of occurrence of daily rain over a period of 10 years[56]

No. OF RAINDAYS AT STATION	RAINFALL IN mm.						
	40-60	60-80	80-100	100-120	120-140	140-160	+160
Afifa Den Yigba	21	8	5	2	3	1	-
Anyako	21	6	3	2	-	-	-
Abor	34	6	1	1	-	-	-
Dabala	25	12	3	1	-	-	-
Sogakofe	20	8	3	2	2	-	-
Keta	21	12	3	3	1	1	1
Anloga	25	13	4	1	2	1	-

Diagram No. 1

CLIMATIC DIAGRAM OF KETA/GHANA (1·5m. above N.N)
After H. Walter and H. Lieth
Klima diagramm - Weltatlas, Fischer, Jena 1960



——— curve of mean monthly precipatations
- - - - curve of mean monthly temperature

Humid period

Dry season

Mean annual temperature 27·7° C
Mean annual precipitations 827 mm
Absolute maximum 37·2°c
Mean daily maximum of the hotest month 33·2°c
Mean daily temperature variation 6·6°c
Mean daily minimum of coldest month 23·3°c
Absolute minimum 20·0°c

In extremely dry years a second rainy season may not occur, while in very wet years the first rainy season may merge with the second.[57]

Temperature is fairly high showing only small annual and monthly fluctuations. The mean annual temperature is about +28°C. [58]

The relative humidity is 86 per cent on average and since local fluctuations in humidity are not noticeable, humidity recorded at Ada may be taken as typical for the entire project.

When planning an agricultural scheme in tropical regions, one of the most important tasks is to establish the degree of potential evaporation. The annual evaporation from a free water surface in the Volta lake region according to various sources and methods is shown below:[61]

Penman	1,600 mm.
Mayer	1,750 mm.
Kosta	1,570 mm.
Aluminium Ltd.	1,520 mm.
Halcrow	1,370 mm.
Average	1,560 mm.

Approximately 12 hours daylight can be assumed in the equatorial belt, monthly fluctuations not exceeding a few minutes. (See Table No. 15)

Daily sunshine-hours amount to about 50 per cent of the total daylight hours. (See Table No. 16)

In summary, the coastal region, in which the project area is located, may be regarded as a semi-arid climatic zone having constantly high temperatures, a high humidity and an evaporation rate higher than the rainfall, i.e. 1.7:1.0. [64] Therefore irrigation is necessary for intensive agricultural production.

For further details see Volume II, Part III, Diagrams 1, 2 and 3 and Map No. 1.

Table No. 13

Long-term monthly average of the daily maximum and minimum temperature at Keta in °F [59]

	J	F	M	A	M	J	J	A	S	O	N	D	MEAN °F	MEAN °C
Maximum														
Highest	92	92	93	92	92	91	86	85	87	89	90	91		
Average	89	90	91	91	89	86	84	84	85	87	89	89	88	31
Lowest	87	88	89	89	88	84	81	81	83	85	87	88		
Minimum														
Lowest	73	76	76	75	75	73	72	71	73	73	73	75		
Average	76	77	78	77	77	75	74	73	74	75	77	77	76	24
Highest	78	79	80	80	80	76	76	75	77	77	78	79		
Mean	83	84	85	84	83	81	79	78	80	81	83	83	82	28

Table No. 14

Humidity at Ada in percentage - five years average[60]

TIME	J	F	M	A	M	J	J	A	S	O	N	D	MEAN
0000	89	90	90	88	89	91	94	96	94	91	89	91	81 (sic)
0600	90	92	89	91	93	93	95	97	95	93	92	92	93
1200	71	74	74	76	77	82	81	80	78	75	74	71	76
1800	83	86	85	84	85	88	90	91	90	88	86	87	87
Mean monthly	85	85	84	83	84	87	89	90	89	95	83	83	86

Table No. 15 **Average length of daylight in the project area, in hours**[62]

J	F	M	A	M	J	J	A	S	O	N	D	MEAN
11.8	11.9	12.1	12.3	12.4	12.5	12.4	12.3	12.2	12.0	11.9	11.8	12.1

Table No. 16 **Average daily duration of sunshine at Ata - in hours**[63]

	J	F	M	A	M	J	J	A	S	O	N	D	MEAN
Hours of sunshine	7.1	7.2	7.2	7.0	6.6	4.8	5.4	6.3	6.7	7.8	8.4	7.8	6.9
Percentage of possible	60	61	60	57	53	38	44	51	55	65	70	60	57.0

Topography[65]

The Avu Keta region is very flat with a slope often less than 0.1 per thousand, and this fact of predominantly very low gradient, particularly in relationship to sea-level and river hydrology is the most significant topographical phenomenon.

Topographically, there are two landscape types: the south and south-western region and the uplands in the north-east.

The flat southern part which includes more than three quarters of the total project area is slightly sloping and large sections of the region, especially around the Keta lagoon, lie at sea-level. The land rises up to a terrace 5 to 20 km. long and only two metres wide, which runs in a southerly and a south-easterly direction. The higher land in this region is protected from the sea by a ridge of about 4.60 m.

The north-western part containing the Avu lagoon and the Todzie river is also fairly flat, although the slope of terrain is greater. Whilst the bottom of the Avu lagoon lies at 1.2 m., and the natural embankment beside the southern shore of the lagoon rises up to three metres, the bed of the Todzie river slopes quite steeply in a northerly direction. The land rises up to 20 m. at the Sogakofe-Akatsi road.

There is a greater difference in height in the north-eastern uplands, varying in height from 6.10 m. in the south to 55.00 m. in the north near Akatsi.

The southern and north-western regions unlike the uplands of the north-east are characterized by widespread river deposits and along the coast sea currents have influenced the formation of bay-mouth bars and lagoons.

The Todzie river, whose bed is about 15 m. wide, flows in a north-south direction into the project area. The river flows into the Avu lagoon from whence the water runs into many small streams over the deeply furrowed low lying regions, forming small lagoons and rivulets between the Avu and Keta lagoons.

During the rainy season lagoon water levels rise rapidly and the Avu and Keta lagoons join together to form one large water body. During the dry season on the other hand they shrink considerably.

The Hurontololi, Aglaw, Agbatsivi and Angaw lagoons lie in the south-west of the region and almost dry up during the dry season. In the rainy season the Todzie river brings much water. From the Avu lagoon water flows through the Hurontololi lagoon and then into the Aglaw, Agbatsivi and Angaw lagoons finally reaching the Keta lagoon by numerous small brooks. In wet years the whole region is flooded.

The Keta lagoon is the largest in the area. In the dry season it covers about 30,000 ha. whereas during the rainy season it expands to cover large parts of the southernmost region. It has no regular discharge into the sea, being separated from the Gulf of Guinea by a one to 1.5 km. bay-mouth bar. There is one link between the lagoon and the Volta mouth in the south-western part but this is blocked by weed hindering flow. It was found that even when the water level was very high discharge into the sea was insignificant.

The Aku and Belikpa rivers are much smaller than the Todzie river, but the volume of water that they carry is important for the development of the area. Both rivers flow in a north-south direction through the north-eastern part of the project area. After crossing the Afife-Atiti road, they flow into the Keta lagoon. During the rainy seasons both rivers rise rapidly and flood their valleys to a depth of up to 90 cm.

Water control

The basic prerequisite for any development of the Avu Keta region is complete water control, which will include all water quantities flowing into the area as well as the precipitation falling onto the surface.

Under present circumstances there are floods every year which cause severe losses (see Maps Nos. 7 and 8). The only way to drain the area after a flood is to dig a canal in the Keta bay-mouth bar between Keta and Kedzi. Floods occur when rising water levels in the Todzie, Aka and Belikpa rivers, caused by rainfall in their catchment areas, coincide with precipitation within the project area. Another cause is the penetration of water from the Volta mouth into the area.

A canal, the Keta Creek, joins the Keta lagoon with the Volta mouth, and would be suitable for draining the area if it were developed. At present, however, its drainage ability is insufficient.

A link between the Avu lagoon and the Volta River exists only during the rainy season, but it does not relieve the lower lying region around the Keta lagoon.[66]

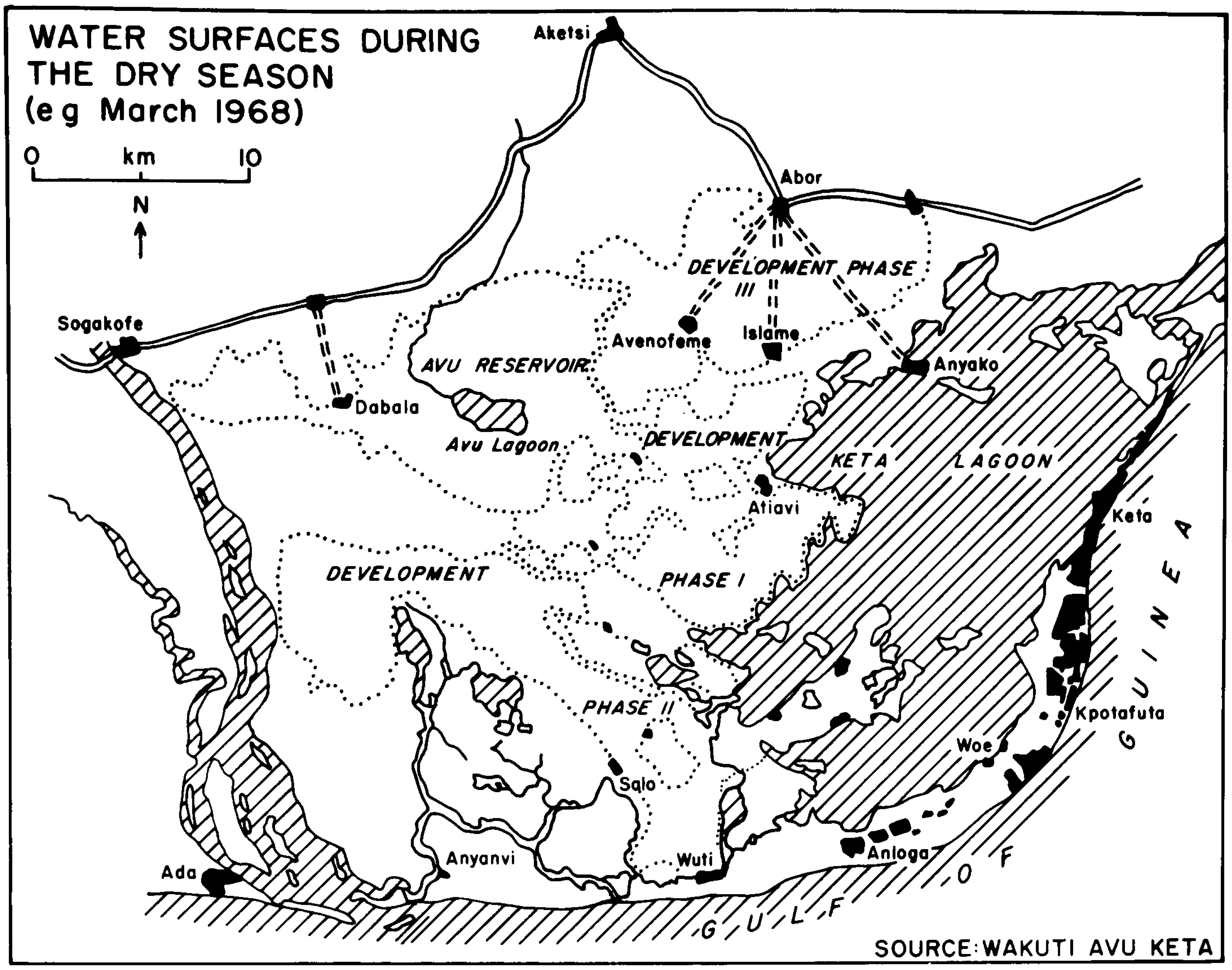
Thus the following measures are necessary:[67]

1. Sufficient drainage of the Todzie river waters and its tributary, the Kelo river;
2. Protection of the region against penetration by water from the Volta estuary and penetration by flood waters from the Gulf;
3. Sufficient drainage of the water from the Aka and Belikpa rivers and the Denu lagoon.

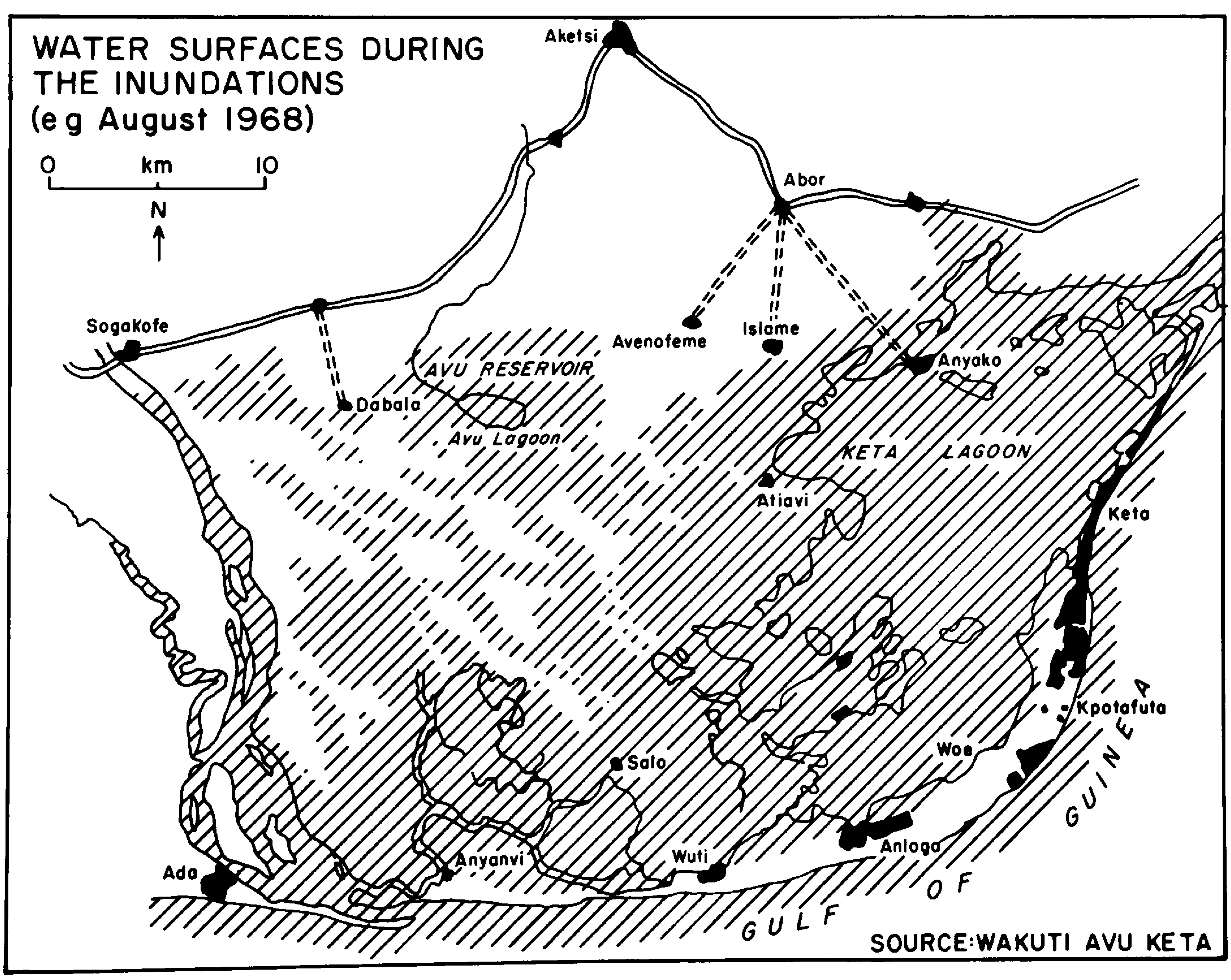
Todzie river flood control

The Todzie river is the major river which flows into the area. Its peak flow occurs in June with 220 cu.m./sec. and has a maximum duration of five days.[68]

The construction of the Avu reservoir, including Avu and Aka lagoon, appears to be the best solution. This reservoir will be used for the Todzie waters and for irrigation purposes.[69] During the peak flow this water will be directed through a 200 m. long canal into the Volta River.[70]



Maps Nos. 7 and 8



Volta flood and sea-water intrusion canal

To prevent penetration of water from the Volta mouth and the Gulf a dike is planned from Anyanui to the end of the Volta River, a distance of about eight kilometres. Since water levels in the Volta mouth (measured at Anyanui) do not rise higher than 5.5 feet NLD, the height of the dike, including freeboard, should be eight feet NLD.[71] This dike will carry the Sogakofe-Anyanui district road.[72]

Aka and Belikpa flood relief[73]

The peak flow of the Aka river is 20 cu. m./sec. and the peak flow of the Belikpa river 12 cu.m./sec. An effective measure to control this flow would be a 15 km. long flood relief canal starting at Afife, following the north-eastern border of the project area and discharging at Blekuse into the sea. Water from the Aka river would flow into the canal at its northern end, followed by water from the Belikpa river entering the canal between Avalavi and Atiti. Near Blekuse, the canal would also have to absorb the surface drainage water from the Denu lagoon which amounts to 10 cu.m./sec.

Water resources development

Large areas of fertile land will be available after drainage of the flood water.[74]

The Keta and the Avu lagoon, if developed, would be able to store excess water. It is clear from Table No. 17 that the Avu lagoon is the most suitable for water storage.

Normal dry year[75]

The 185 million cubic metres of water supplied by the Todzie river will suffice in normal dry years for evaporation losses as well as irrigation requirements.

Thus in January 110 million cubic metres of water must be available in the reservoir so that there will be enough water to last through the

Table No. 17 — Comparison of two possible reservoirs for irrigation water[77]

	KETA LAGOON	AVU LAGOON
Suitability as natural reservoir	Favourable, existing lagoon without important development	Unfavourable, only after construction of a dam
Situation of the Todzie inflow	Unfavourable, connection canal necessary	Good, directly at the junction
RESERVOIR DATA		
Maximum water-level	0.0 NLD (hardly any discharge possibilities)	4.5 m. + (14.5 ft. NLD) (good discharge possibilities)
Maximum water depth	1.5 m. (5 ft.)	3.2 m. (10.5 ft.)
Maximum reservoir capacity	210 million cu.m. (170,000 acre ft.)	260 million cu.m. (210,000 acre ft.)
Maximum reservoir surface	265 million sq.m. (66,000 acres)	120 million sq.m. (30,000 acres)
Bottom height (referred to NLD)	1.5 m. - NLD (NLD - 5 ft.)	NLD 1.2 m. (NLD 4 ft.)
Flood retention	Not possible, only by artificial enlargement of the reservoir, 2.5 ft. = 50% more	Sufficient, depending on the selection of the dam height 100-120 million cu.m.
Flow of floods through the reservoir	Not possible, additional flood canal necessary discharge into the sea requires a higher lagoon water-level	Possible, outlet structure in the dam to Volta River
Type of irrigation water supply	Pumps (for both areas)	Area 1 gravitational, area 3 by pumps
Quality of water	Not good, measures against penetration of salt-water are necessary	Good, suitable as potable water after corresponding treatment
Drainage of the development areas into the Keta Lagoon	Bad, at lagoon water-level of 0 m. NLD at elevation of water-level over NLD no natural drainage possibilities in the Keta Lagoon	Good, at corresponding lowering of the water-level in the lagoon

dry months. The water-level should be about three metres NLD in January and this will have fallen to 2.30 m. by the beginning of June. At this level the storage capacity is about 50 million cubic metres. This is the so-called "dead storage", since for topographical reasons the water which lies below this level cannot be used for gravitational discharge.

By the end of October the water-level in the reservoir will reach its highest of about 3.40 m. in a dry year, with a corresponding storage capacity of about 150 million cubic metres. By the end of May and during the first half of June it would be advisable to lower the water level as protection against extremely high floods in June.

Wet year[76]

Of the initial filling of 150 million cubic metres about 80 million cubic metres will be released during May into the Volta River, so that the water-level in the reservoir will have fallen to about 2.4 m. by June. By the beginning of June the reservoir water will have risen to its highest level of about 3.4 m. In order to ensure flood control about 110 million cubic metres surplus water only should be retained until the beginning of September, after which it should be drained into the Volta River. This corresponds to a steady outflow of about 40 cu.m./sec. The total amount of water released in a wet year into the Volta River comes to about 370 million cubic metres. Calculation of the flood retention capacity is based on the fact that no discharge from the reservoir into the Volta River will be possible because of the high Volta water-levels, mostly from September to November. The storage of all inflow during a wet year from September to November requires a minimum retention capacity of about 100 million cubic metres of flood water. For security reasons the flood retention capacity is designed at 110 million cubic metres although only 100 million cubic metres are in fact necessary. The resulting storage capacity of 260 million cubic metres thus implies a water-level of about 4.4 m. NLD, so that at a crest height of 5.5 m. NLD a free-board of about 1.1 m. remains.

Average wet year[78]

It should be noted that total excess water which must be released during an average year amounts to about 190 million cubic metres, the volume that the entire Todzie river drains off in a dry year.

Irrigation water requirement for Phase I, II and III

Phase I[79]

Complete irrigation is only provided for rice, other crops receiving only supplementary irrigation, depending on the water reserves of the planned water reservoir. Therefore, the water to be removed from the Avu reservoir is calculated only for the cultivation of rice.

In addition to the calculation for a dry year, the irrigation water for average years and for wet years must be calculated, since knowledge of these will be important for operation of the planned reservoir. (See Table No. 18)

Phase II[80]

During the first vegetation period from March until August rice, tobacco and maize will be irrigated. During the second vegetation period only rice will be irrigated. The water requirement is calculated for the most unfavourable conditions, i.e. for a dry year. (See Table No. 19)

Phase III[81]

Tobacco and maize will be irrigated during the first vegetation period, and groundnuts and vegetables will be irrigated during the second vegetation period. Nevertheless, the pumps and the irrigation system are designed with a capacity to irrigate all crops if necessary. (See Table No. 20)

Irrigation[82] (see Map No. 9)

Development Phase I will be irrigated as there is a natural slope from

Map No. 9

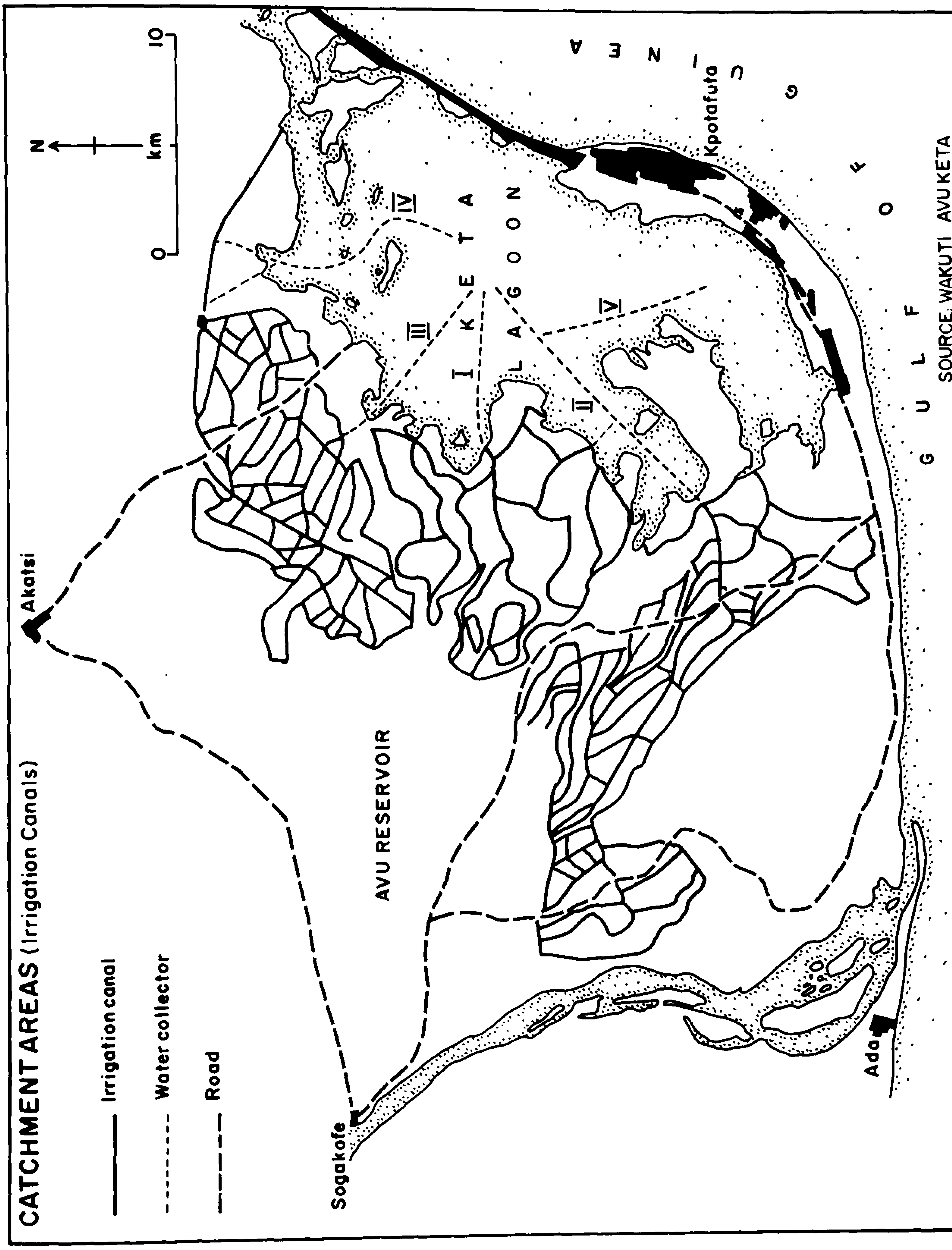

CATCHMENT AREAS (Irrigation Canals)
Irrigation canal
Water collector
Road
N
0
km
10
Sogakofe
Akatsi
AVU RESERVOIR
KETA LAGOON
I
II
III
IV
V
Kpotafuta
Ada
GULF OF GUINEA
SOURCE: WAKUTI AVUKETA

Table No. 18 — Water requirement in million cubic metres

YEAR	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Dry	1.8	-	12.6	9.6	11.7	0.6	6.0	-	13.2	12.0	18.0	12.2	97.7
Average	1.8	-	11.7	7.2	9.3	-	5.4	-	12.6	11.4	17.4	12.2	89.0
Wet	1.8	-	10.8	5.4	6.0	-	3.9	-	11.7	9.6	16.2	12.2	77.6

Table No. 19 — Water requirement in million cubic metres

CROP	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Rice	1.5	-	10.1	7.7	9.4	0.5	4.8	-	10.5	9.6	14.4	9.9	78.4
Tobacco	-	-	-	-	2.0	-	2.0	-	-	-	-	-	4.0
Maize	-	-	-	-	0.5	-	-	-	-	-	-	-	0.5
Total	1.5	-	10.1	7.7	11.9	0.5	6.8	-	10.5	9.6	14.4	9.9	82.9

Table No. 20 Water requirement in million cubic metres

CROP	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Maize	-	-	-	-	1.5	-	-	-	-	-	-	-	1.5
Groundnuts	-	-	-	-	-	-	-	-	-	2.5	3.8	-	6.3
Vegetables	-	-	-	-	1.5	-	-	-	-	1.0	1.5	-	4.0
Tobacco	-	-	-	-	3.8	-	3.8	-	-	-	-	-	7.6
Total	-	-	-	-	6.8	-	3.8	-	-	3.5	5.3	-	19.4

the Avu reservoir.

Development Phase II will be irrigated by the waters of the Volta River, which must be pumped to the area. The water will be pumped to a reservoir at the highest point of the area from whence it will be distributed by gravitational flow.

Development Phase III will be irrigated with Volta waters, which must first be pumped to the Avu reservoir and then to a reservoir at the highest point of the area from whence it will be distributed by gravitational flow.

Area I and 75 per cent of area II - rice cultivation

Small fields 50 m. wide and up to 100 m. long are planned and will be surrounded by small dams. During the seed and growth period the cultivated land lies about 10 cm. under water. Small amounts of water will flow continuously through the fields, so that the water will not stagnate. Each field will have a drainage pipe to empty it if required.

Area III and 25 per cent of area II - tobacco and vegetable cultivation

The irrigation will be either of the "border strip" or "furrow" method. The strips will be 6 m. x 150 m. and will have a slope of one to three per thousand and the water will be directed into these by means of syphons.

Depending on the soil type and the crop the land will be irrigated every four to six days.

Irrigation time

For rice: day and night

For other crops: only during daylight

Crops and water requirement

The following water requirements for the various crops have been calculated:

Rice - first vegetation period - 142 days

Consumptive use 670 mm.

Amount of rainfall effective for irrigation: 270 mm.
Subsidiary irrigation crop requirement: 400 mm. = 670 mm.

<u>Rice</u> - second vegetation period - 120 days

Consumptive use 600 mm.

Amount of rainfall effective for irrigation: 40 mm.
Subsidiary irrigation crop requirement: 560 mm. = 600 mm.

<u>Other crops</u> - first vegetation period - 163 days

Consumptive use 470 mm.

Amount of rainfall effective for irrigation: 270 mm.
Subsidiary irrigation crop requirement: 200 mm. = 470 mm.

<u>Other crops</u> - second vegetation period - 122 days

Consumptive use 240 mm.

Amount of rainfall effective for irrigation: 40 mm.
Subsidiary irrigation crop requirement: 200 mm. = 240 mm.

All structures will be designed to irrigate for 12 hours continuously. Thus 21 ltr./sec. x ha. is needed for area I and 75 per cent of area II and 1.4 ltr./sec. x ha. for area III and 25 per cent of area II. The storage capacity of the Avu reservoir - 240,000,000 cu.m. - is therefore sufficient.

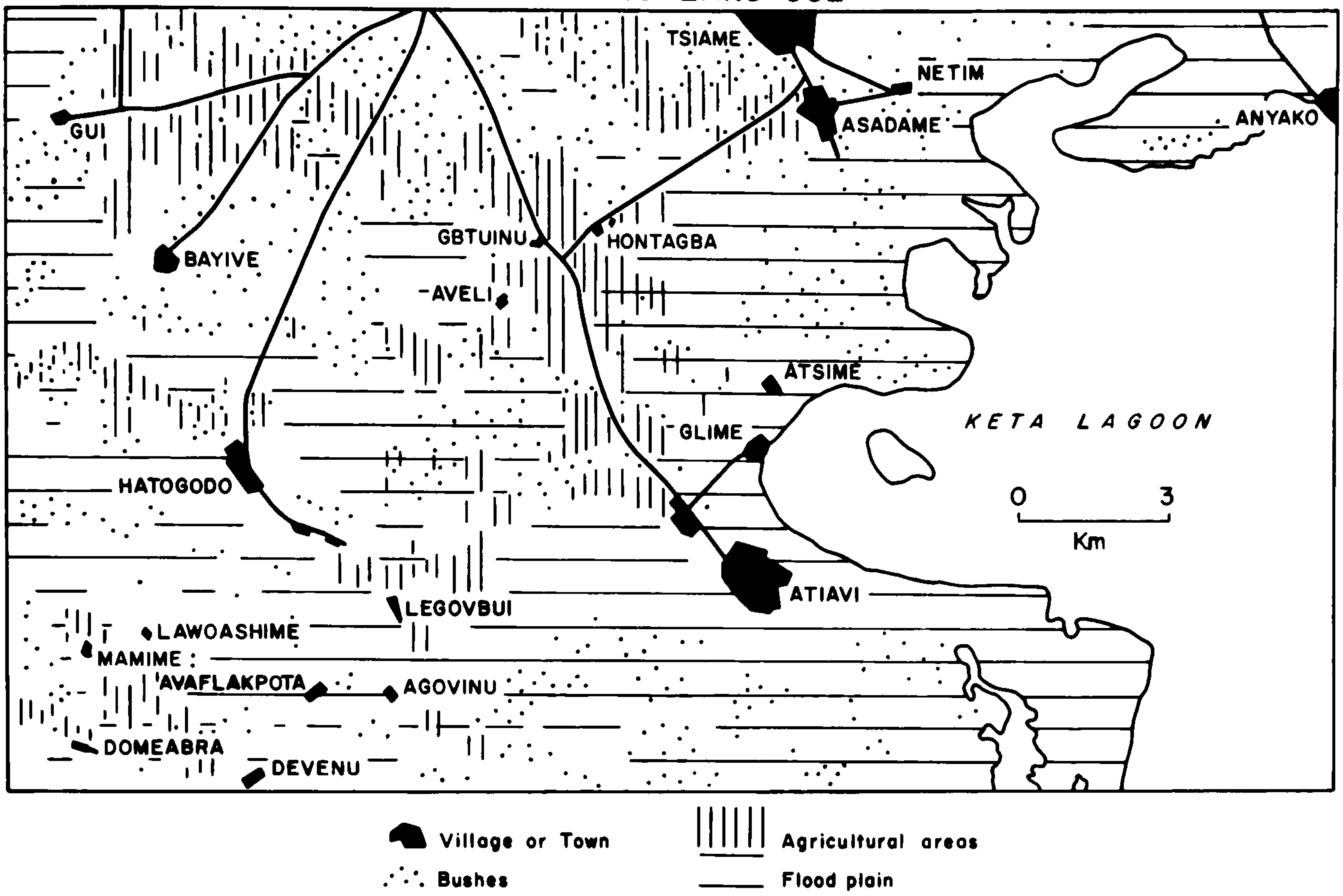
The main irrigation canals will be lined with concrete only in places where there is danger of considerable water losses. All canals will be equipped with the necessary bridges and culverts.

Maps Nos. 10 and 11 show the same area before development and after the canals will have been established.

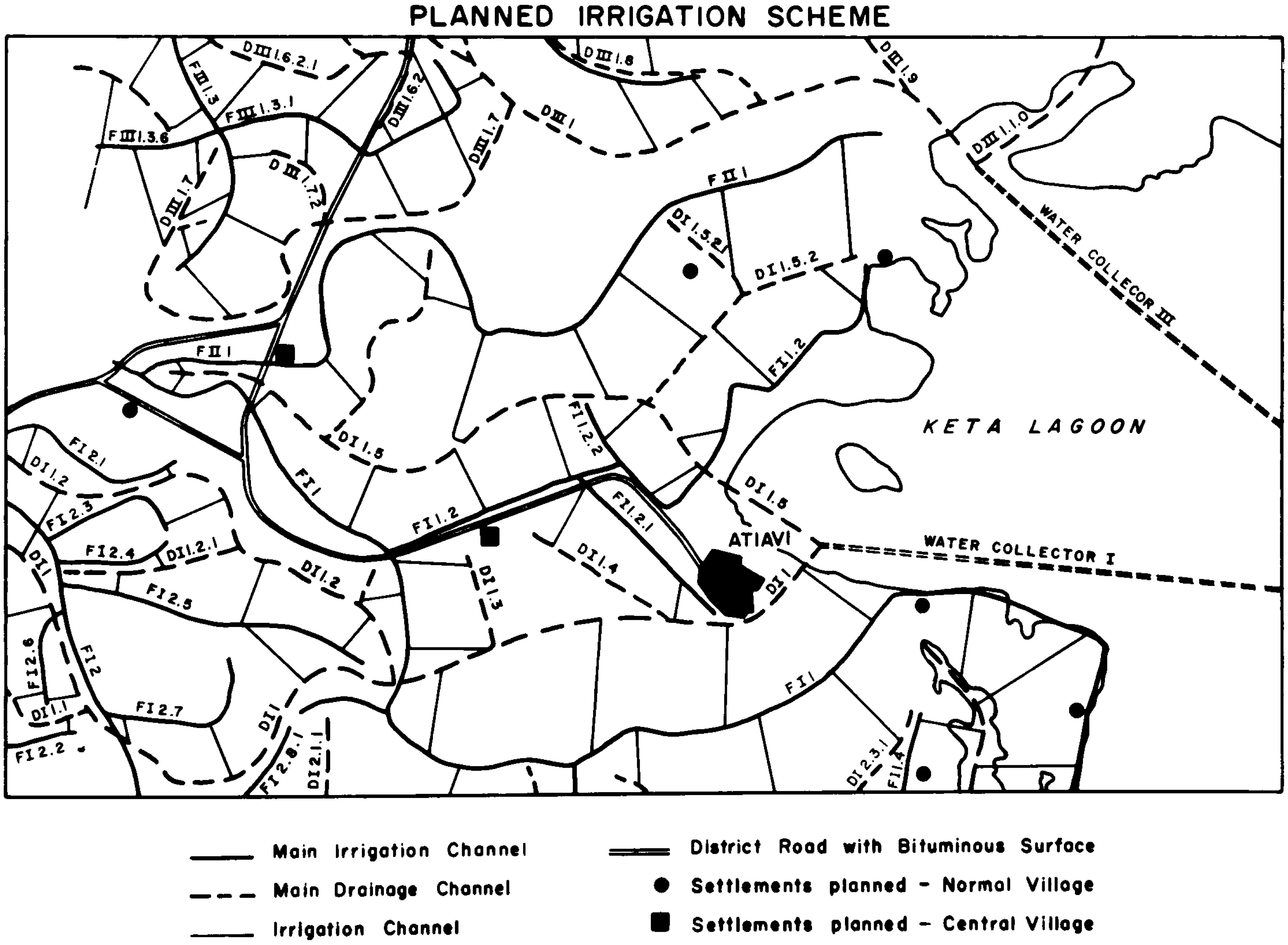
<u>Drainage</u>[83] (see Map No. 12)

The Keta Lagoon with its low water-level will be the most suitable destination for the drainage water. Only in extremely dry years will the Keta basin dry up completely, however, in the deepest parts the

EXISTING LAND USE



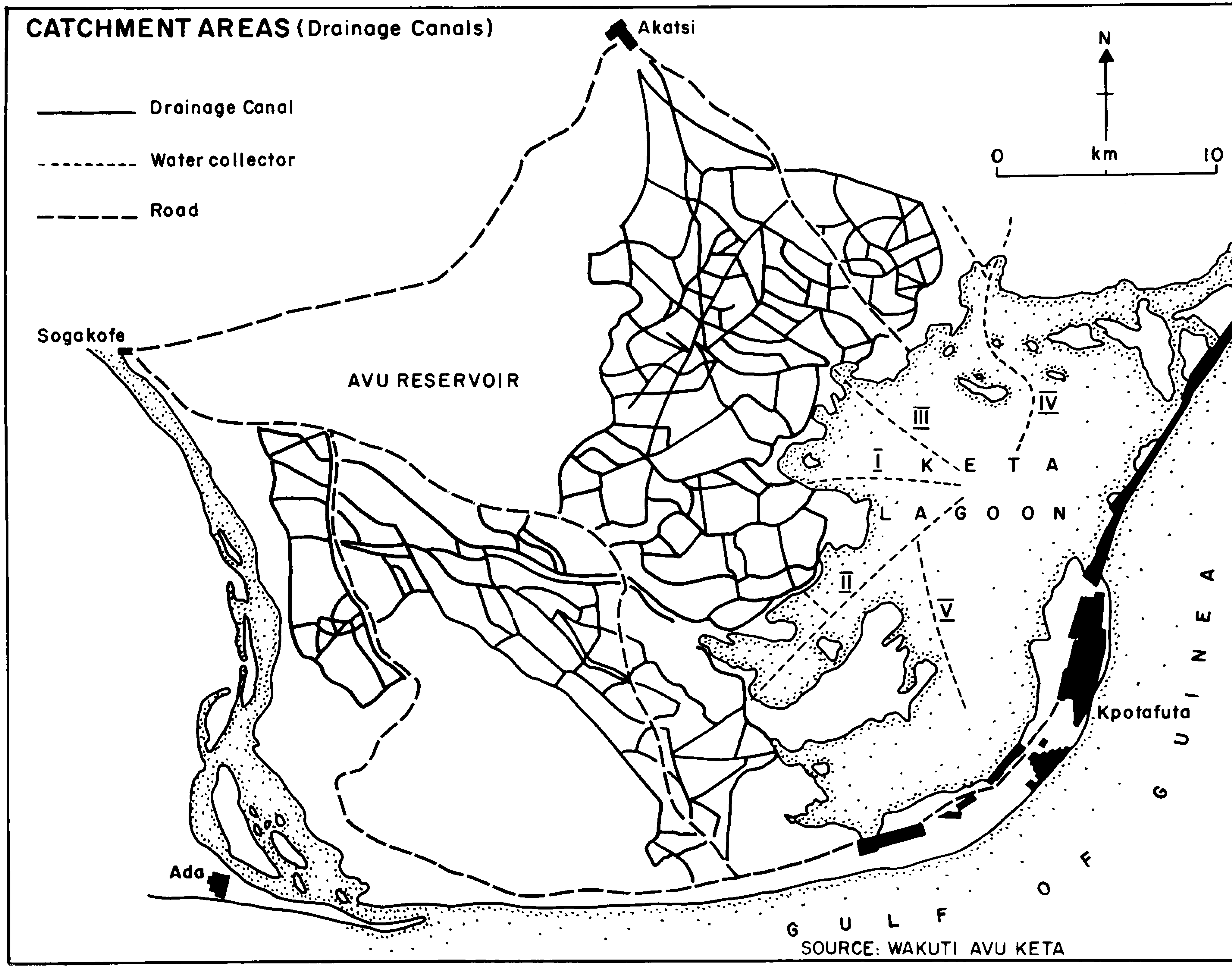
PLANNED IRRIGATION SCHEME



SOURCE WAKUTI AVU KETA

Maps Nos. 10 and 11

Map No. 12


CATCHMENT AREAS (Drainage Canals)
Drainage Canal
Water collector
Road
Akatsi
Sogakofe
AVU RESERVOIR
N
0
km
10
III
IV
I
KETA
LAGOON
II
V
Kpotafuta
Ada
GULF OF GUINEA
SOURCE: WAKUTI AVU KETA

water-level will nearly be always -0.60 m. NLD. If the water-level of the lagoon is lowered by about 0.30 m. this will be enough to drain the project area thoroughly, especially since the lower lying parts will be cultivated with rice.

It is intended to lower the ground water-level from 0.60 m. to 0.8 m., above all in area III and the parts of area II which will not be cultivated with rice.

The drainage areas I, II and III are more or less the same as development phase I, II and III. In addition there is a diversion canal north of area II which provides for drainage of an area of 4,000 ha. outside the project area. Similarly there is a canal north of area III which drains an area of 2,150 ha. beyond the project area.

Drainage area DI

This drainage area covers 17,500 ha. including the area drained by the diversion canal north of area II. This canal is about 11 km. long and ranges in depth from 1.0 m. to 2.5 m. and its bottom width varies from 1.5 m. to 10.5 m.

The courses of all the canals have been planned so that the water from the whole area will flow by gravitation.

All main canals will have a trapezoidal cross-section and an inclination slope of 1:2. Their widths vary between 0.50 m. at their upper ends and 12.0 m. at their openings into the Keta basin. The canals usually have a bottom gradient of 0.1 per thousand. Apart from the first section, the velocity of flow ranges from 0.30 to 0.45 m./sec. in spite of the small slope. The water depth varies from 0.50 m. to 1.20 m.

This area contains four drainage systems, that is, DI-1, DI-2, DI-3 and DI-4.

The length of all main drainage canals of these systems is 100 km. Their discharge ability is 2.5 ltr./sec. per hectare.

DI-1 must drain 16.25 cu.m./sec. of water from a drainage area of 6,500 ha.

DI-2 has a drainage area of 4,000 ha. and must therefore conduct 10.00 cu.m./sec.

DI-3 has to drain 4.00 cu.m./sec. of water from an area of 1,600 ha.

DI-4 must drain 13.50 cu.m./sec. from an area of 5,400 ha., including the area outside the project north of area II.

After all the canals have released their water the collector will have received a total of 43.75 cu.m./sec.

During the floods the water-level of all canals will reach -0.30 m. Thus even when the water-level is high, there will be no backflow from the Keta basin.

The lateral drainage canals, 220 m. apart from each other, will absorb the water from the field ditches and direct it into the main canals.

These canals will have a bottom width of 0.50 m., with a slope of 1:1.5, the bottom gradient will come to 0.1 per thousand, and the depth will vary between 0.60 m. and 0.80 m. The planned length of each canal is 2,000 m. and their discharge rate will be 0.110 cu.m./sec.

The total length of the lateral canals will be 450 km.

At crossings with roads, rivers, streams and other canals, pipe culverts will be installed ranging from 300 to 500 mm. in diameter.

From the rice fields the water will flow into ditches which will lead it into the lateral canals. The bottom width of these ditches will be 0.50 m., they will have an inclination slope of 1:1.5 and mean depth of 0.60 m. The gradient will be 0.1 per thousand up to 0.5 per thousand. Their total length will be 1,500 km. and they will be 55 m. apart from each other.

<u>Drainage area DII</u>

This area covers about 10,300 ha.

DII-1 and DII-2 are the main canals in this area.

They will have a trapezoidal cross-section and their bottom width will range from 0.50 m. to 15.0 m. All canals will have an inclination slope of 1:2 and the bottom gradient will usually be 0.1 per thousand. With a few exceptions, the minimum velocity will not fall below 0.30 m./sec. and the maximum velocity will rarely rise above 0.50 m./sec. The depth of the water will vary between 0.65 m. and 1.20 m. Their total length will be 115 km. and their rate of discharge will reach 2.5 ltr./sec. per hectare.

DII-1 serves an area of 5,900 ha. and must drain at a rate of 14.75 ltr./sec.

DII-2 has a drainage area of 4,400 ha. and must therefore conduct 11.0 ltr./sec.

Beyond the junction of both canals, the flood collector will receive 25.75 ltr./sec.

The water-level of all the canals will reach -0.30 m. at the point of discharge and thus no backflow will occur at the highest water-level.

Crossing structures such as pipe culverts or bridges will be provided where roads and canals cross.

The lateral drainage canals will take the water from the ditches in the rice fields and will drain fields with other crops directly. The distance between the canals in the rice fields will be 220 m. and in fields with "border strip" or "furrow" irrigation, 170 m. They will have a bottom width of 0.50 m. and an inclination slope of 1:1.5. Their bottom gradients will usually be 0.1 per thousand and their depths between 0.60 and 0.80 m. The maximum length of each canal in the rice fields will be 1,500 m. and each must carry a maximum of 82 ltr./sec. The maximum length of the canals in fields cultivated with crops other than rice will also be 1,500 m., but because of their shorter distance from each other, only 170 m., they must carry 64 ltr./sec.

The total length of all lateral canals will be about 500 km. Ditches are planned only in the rice fields and will be arranged in the same way as in DI.

Drainage area III

The size of this area is 10,800 ha.

The main canal is DIII-1 and, like the others, will have a trapezoidal cross-section. The bottom width will vary between 0.50 m. and 8.0 m. and the inclination slope will be 1:2. In general the gradient will be between 0.1 per thousand and 0.5 per thousand. The water depth will range from 0.20 m. to 1.50 m. and the velocity of flow will fluctuate between 0.30 m./sec. and 0.90 m./sec.

The total length of the main drainage canal will be about 140 km. DIII-1 has to drain 27.00 cu.m./sec. from an area of 10,800 ha.

The water-level will reach -0.30 m. at the outlets into the flood collectors in the Keta basin and thus no backflow will occur at the highest water-level.

Land lying north of area III which covers an area of 2,150 ha. will be drained by a diversion canal 12 km. long. This canal will not have connection with DIII-1 and will lead the water directly into the Avu reservoir.

Where crossings with roads and other canals occur, crossing structures are planned, the dimension of which depends on the amount of water to be drained.

The fields will be drained by lateral canals, 170 m. apart from each other. With a maximum length of 800 m. and a volume of discharge of 2.5 ltr./sec. per hectare, each canal must drain 34 ltr./sec. The lateral canals will have a bottom width of 5.00 m., an inclination slope of 1:1.5, and a bottom gradient varying between 0.1 per thousand and

0.3 per thousand. The depth of the canals will have to be 0.80 m.

The total length of the lateral canals will be about 600 km. Pipe culverts will be arranged at crossings with roads and other canals and they will vary between 300 and 500 mm. in diameter.

Keta Lagoon

As the Keta Lagoon lies so low, all the inland drainage water will flow into it by gravitation. The water-level in the lagoon will fall considerably if all water flowing in from outside is excluded. According to the season, the water-level will vary between -0.30 m. and -0.90 m. NLD, and so it will lie between 0.65 m. and 1.21 m. below the mean level of the ocean. Thus a natural flow from all three drainage areas into the lagoon is assured.

The Keta Lagoon has a surface area of about 300 sq.km. The water in the lagoon is at present very saline as when the water-level in the lagoon is low salt-water trickles through the Keta creek into the lagoon. After the construction of the flood control dam east of the Volta mouth, the inflow of salt-water through the creek will be prevented. However, it cannot be expected that the lagoon water will lose its salinity, because the Keta Lagoon will function as an evaporation basin in future. Although the salt concentration will be diluted by fresh water during the rainy season salinity will increase with dry season evaporation. The Keta Lagoon will become dry only during rainless years. In order to prevent the formation of pools and swamps, and to ensure a constant flow, four drainage flood collectors will be dug leading to the deepest point at -1.52 m. NLD. The width of the flood collectors will range between 15 and 50 m., according to the volume of discharge.

It should be reaffirmed that the narrow stretch of the Keta bay-mouth bar between Keta and Kedzi, which is less than 200 m. wide, endangers the whole project. If the ocean breaks through this bay-mouth bar, salt-water will enter the Keta Lagoon and submerge parts of the surrounding lower lying cultivated land. Through the construction of fish ponds 50 per cent of the existing costs entailed in widening the bay-mouth bar by at least 1,000 m. could be borne by the fish pond scheme. Further, these ponds will prevent the penetration of salt-water into the Keta Lagoon.

Drinking water supply[84]

The situation with regard to the potable water supply of the project area is extremely bad and if it is not remedied in the near future, the health of the population will be considerably affected.

The Avu Keta region has no central water supply, only Keta and some neighbouring towns having a sufficient supply of water. But the quality is bad as the existing wells contain very saline water. The water for the other villages is obtained from lagoons and water courses.

These conditions will improve with the development of the area and the construction of a central water supply.

There are two sources for the drinking water supply, the Volta River and the Avu reservoir. Both have water of similar quality, but the central position of the Avu reservoir has many economic advantages. Therefore it is suggested that the water-works should be built there.

Water consumption is estimated to be approximately 60 ltr. daily per head. Taking the addition of 10 per cent into account, owing to losses of water and the consumption of the water-works itself, the following water demand results:

Table No. 21

YEAR	INHABITANTS	WATER REQUIREMENTS 60 ltr./inh./day	10% loss	TOTAL (approx.) cu.m./day
1970	135,000	8,100	810	8,900
1975	164,000	9,850	985	10,900
1980	198,000	11,900	1,190	13,100
1985	218,000	13,100	1,310	14,400
1990	240,000	14,400	1,440	15,800
1995	264,000	15,900	1,590	17,500

Extension of the water supply will be made in three stages. (See Map No. 13)

Phase I: Capacity 6,000 cu.m./day - starting in the fourth year of the project;

Phase II: Capacity 12,000 cu.m./day - will assure supply up to 1980 approximately;

Phase III: Capacity 18,000 cu.m./day - will assure supply up to 1995 approximately.

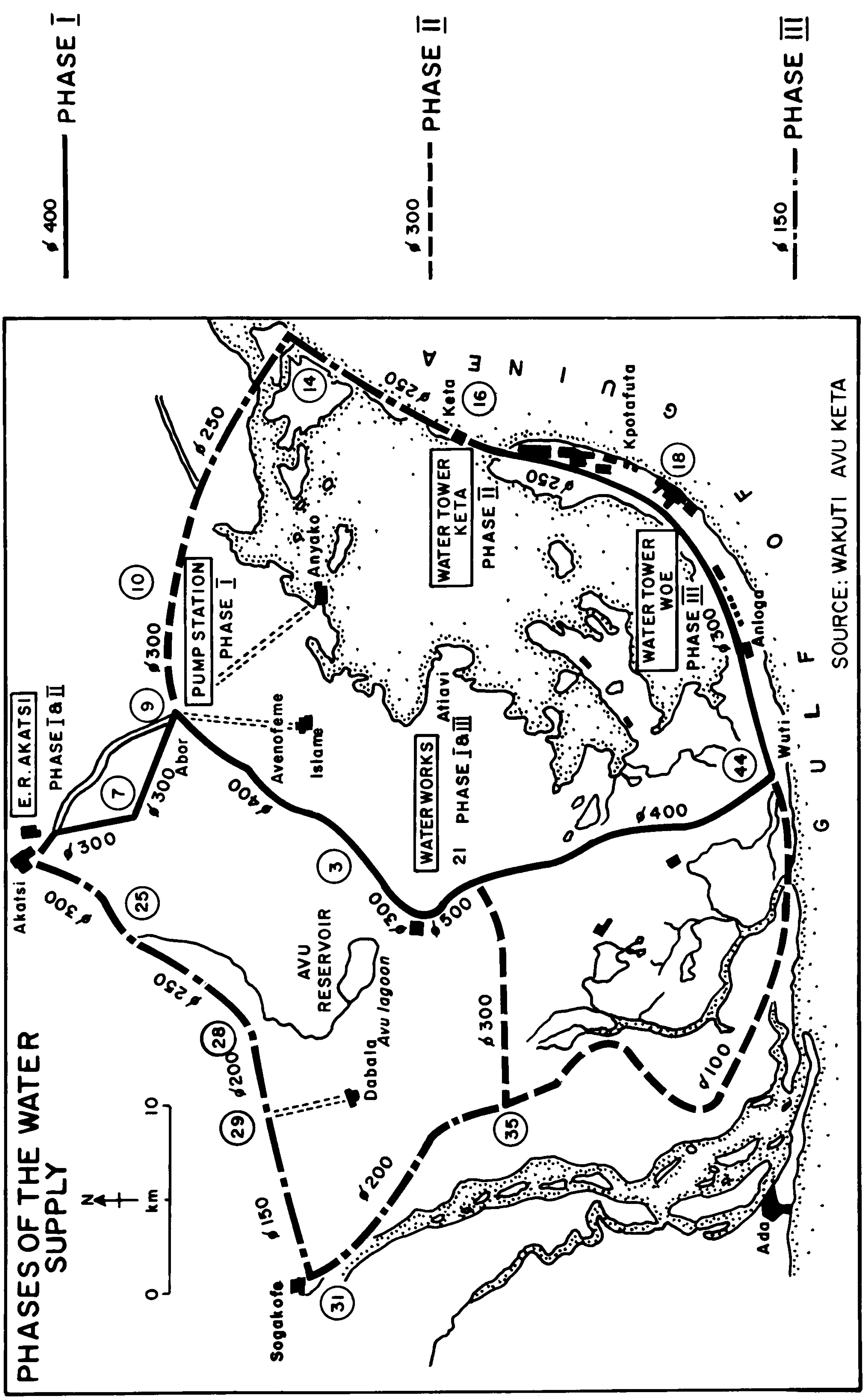
Consequently, the development stages for the water supply must be:

Table No. 22

Phase	cu.m./day	WATER QUANTITIES 20 hours cu.m./h.	20 hours ltr./s.	12 hours cu.m./h.	12 hours ltr./s.
I	6,000	300	84	500	140
II	12,000	600	166	1,000	278
III	18,000	900	250	1,500	416

Water from the Avu reservoir demands special processing.

Map No. 13


PHASES OF THE WATER SUPPLY
N
0 km 10
ø 400 PHASE I
ø 300 PHASE II
ø 150 PHASE III
E.R. AKATSI
PHASE I & II
Akatsi
PUMP STATION
PHASE I
WATERWORKS
21 PHASE I & III
WATER TOWER KETA
PHASE II
WATER TOWER WOE
PHASE III
AVU RESERVOIR
Avu lagoon
Dabala
Sogakofe
Ada
Wuti
Anloga
Kpotafuta
Keta
Anyako
Abor
Avenofeme
Islame
Atiavi
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GULF OF GUINEA
SOURCE: WAKUTI AVU KETA

Chemical analysis of the untreated water

In November 1968 the following water samples were taken: Volta River (ferry place Agordome), Avu Lagoon (south of Dabala). Sampling by WAKUTI field camp, Afife on November 17 1968.

1. Chemical analysis*

Chemical analysis*	Volta	Avu
Nitrate ion NO_3^{-1}	1.8 mg./l.	0.9 mg./l.
Nitrite ion NO_2^{-1}	0.01 mg./l.	0.0 mg./l.
Ammonium ion NH_4^{+1}	0.1 mg./l.	0.4 mg./l.
Phosphate ion HPO_4^{-4}	0.1 mg./l.	0.0 mg./l.
Chloride ion CL^{-4}	10.6 mg./l.	10.6 mg./l.
Sulphate ion SO_4^{-2}	7.3 mg./l.	less than 10 mg./l.
Iron ion Fe^{+2}	0.9 mg./l.	0.9 mg./l.
Manganese ion Mn^{+2}	0.0 mg./l.	0.0 mg./l.
Total hardness	3.6^{o}d	2.5^{o}d
Carbonate hardness	3.6^{o}d	2.5^{o}d
pH	7.5	6.9
Potassium permanganate consumption	19.9 mg./l	28.8 mg./l.
Evaporation residue	132.0 mg./l.	68.5 mg./l.

2. Bacteriological test

Bacteriological test	Volta	Avu
Bacterium Coli	1 ml.	1 ml.
Coliform Bacterium	1 ml.	1 ml.

Chemical test**

Designation	Volta River	Avu Lagoon
Appearance: after four days standing	with fine grey-brown suspensoids	by fine yellow-brown suspensoids clear with a fringe of yellow
Odour:	inobtrusive	musty

* This test was made by Institut National d'Hygiene, Lome.

** This test was made by Chemical Test Laboratories, Siegen.

Settable suspensoids after two hours:	0.1 ml./l.	0.25 ml./l.
Air temperature:	-	-
pH-value (electrometric)	7.2	6.6
Evaporation residue (mg./l.)	59	69
Ignition residue (mg./l.)	42	38
Ignition loss (mg./l.)	17	31
In-alcalinity (m.val./l.)	0.62	0.64
Comb. carbon dioxide (mg./l.)	14	14
Ammonium (mg. NH_4/l.)	0.48	0.35
Nitrite (mg. NO_2/l.)	0.04	0.0
Nitrate (mg. NO_3/l.)	1.5	1.14
Phosphate (mg. PO_4/l.)	0.05	0.02
Chloride (mg. Cl./l.)	2.0	6.0
Sulphate (mg. SO_4/l.)	2.0	1.0
Potassium permanganate consumption (mg./l.)	9.0	30.0
Iron (mg. Fe/l.) total	0.07	0.9
Manganese (mg. Mn/l.)	0.1	0.0
Total hardness	1.6^o	1.6^o
Carbonate hardness, apparent	1.7^o	1.8^o
Non-carbonate hardness, actual	1.6^o	1.6^o

Resettlement[85]

It is intended that about 30,000 ha. will be reclaimed on which 11,000 new farm settlements will be built. There will also be a resettlement of the necessary craftsmen, merchants and administrators. Such facilities as shops, schools, workshops, administrative buildings and dispensaries will accompany the new farms, villages and towns. If possible, the population of the project area will be resettled on the new farms as will many people from the nearby northern region who are of the same tribe as those of the project area.

Another problem arises from the dense population of the Keta bay-mouth bar where the mean density of population is 1,800 inhabitants per square kilometre. Additional settlement areas must be created to reduce this overcrowding.

The following works are planned:

1. Reclamation of 9,800 ha. for irrigated agriculture between Avu and Keta Lagoons. This land will be suitable mainly for rice cultivation in Development Phase I.
2. Reclamation of 10,800 ha. for irrigated agriculture in the south and south-west of irrigation area I. Of this area, 75 per cent is suitable for the cultivation of rice and 25 per cent for growing tobacco and food crops. This cultivation is planned for Development Phase II.
3. Reclamation of 10,000 ha. for irrigated agriculture, west of the Avu Lagoon in the Uplands. The land in this region is suitable for tobacco and food crops and will be cultivated in Development Phase III.
4. Widening of the Keta bay-mouth bar in the Kedzi-Vodza-Keta region. In parts, this bar is only 200 m. wide and in these sections it should be widened to 1,000 m., thus increasing its area to 600 ha. and relieving overcrowding.

Population Development

At present the Avu Keta area covers 130,000 ha. and has about 135,000 inhabitants. The mean population density is thus 105 persons per square kilometre.

About 50,000 people, or 37 per cent of the total population, live on the Keta bay-mouth bar which is only 27 km. long and between 200 and 2,000 m. wide.

Because of poor living conditions in the project area, the population growth there has been lower than the average for Ghana. With improved living conditions a more rapid growth can be expected. Assuming a population growth rate of four per cent per annum in the first 10 years and a further two per cent per annum in the following years, the population of the project area will have risen after 10 years to 198,000 and after 20 years to 240,000. After 25 years the population will have increased to 264,000 inhabitants.

In areas I, II and III and their nearby districts the population is:

Table No. 23

AREA	APPROXIMATE NUMBER OF INHABITANTS
I	11,000
II	12,000
III	21,000
Total	44,000

After subtracting the land area required for roads, canals and housing, the area reclaimed in the project area will be:

Table No. 24

AREA	SIZE IN ha.
I	9,000
II	9,800
III	9,000
Total	27,800

Allowing 2.5 ha. for each farm in area I and 75 per cent of area II and 2.8 ha. for 25 per cent of area II and area III, the following number of farms can be established:

Table No. 25

AREA	NUMBER OF FARMS
Area I	3,600
75 per cent of area II	3,000
25 per cent of area II	900
Area III	3,200
Total	10,700

Assuming an average of 7.5 persons per family, the farms will be able to support the following number of people:

Table No. 26

AREA	NUMBER OF PEOPLE
I	27,000
II	29,000
III	24,000
Total	80,000

Additional new settlers, such as craftsmen, merchants and administrators will constitute 40 per cent of the total, so that the total population will be:

Table No. 27

AREA	NUMBER OF INHABITANTS
I	38,000
II	41,000
III	34,000
Total	113,000

Thus, the following number of people will have to be resettled:

Table No. 28

AREA	NUMBER OF PEOPLE
I	27,000
II	29,000
III	13,000
Total	69,000

If one house per 7.5 persons is taken as the norm, the number of houses and apartments which must be built is:

Table No. 29

AREA	NUMBER OF HOUSES
I	3,600
II	3,900
III	1,800
Total	9,300

The Keta bay-mouth bar is greatly overpopulated and cannot support an increase in population. Some will therefore migrate to the reclaimed areas.

The new villages (see Map No. 14)

The resettled population will live in newly built villages which will either be built within or on the border of the project area so that for individual farms the greatest distance between farmhouse and fields will not exceed 1.5 km.

The number of villages planned is as follows:

Area I - Four central villages with 4,000 inhabitants each - 16,000 inh.

Map No. 14


AVU KETA CENTRAL VILLAGE
HOSPITAL
SCHOOL
Court
Post Office and
Telecom Centre
Town
Administration
Covered Market
Motor Park
Manager's
Residence
Kitchen
Manager's
Office
Resthouses
Bungalows
Shops
AG Main and
Storage
Source : Wakuti

	Ten villages with 1,100 inhabitants each	- 11,000 inh.
	Total	27,000 inh.
Area II	- Five central villages with 3,600 inhabitants each	- 18,000 inh.
	Ten villages with 1,100 inhabitants each	- 11,000 inh.
	Total	29,000 inh.
Area III	- Three central villages with 3,000 inhabitants each	- 9,000 inh.
	Four villages with 1,000 inhabitants each	- 4,000 inh.
	Total	13,000 inh.

In the Kedzi-Vodza-Keta settlement area there are already towns, so that plans of central villages are unnecessary.

Three villages with 2,000 inhabitants each	- 6,000 inh.
Two villages with 1,500 inhabitants each	- 3,000 inh.
Total	9,000 inh.

The above is only one of many possible allocations. Further investigation is necessary before the villages are actually built.

Village facilities

The villages will contain the administration, schools, marketing and commercial centre in addition to farmhouses.

Each village should be connected by an all weather road. Moreover, the villages will have potable water and a power supply. The sewage water should be collected and, provided there is no detrimental industrial sewage, should be led into the irrigation canals.

Farmhouses

Two sizes are proposed:

Farmhouse, grade I, comprising:

Living area	58.52 sq.m.
Facilities	16.66 sq.m.
For animals	44.32 sq.m.

Farmhouse, grade II, comprising:

Living area	34.16 sq.m.
Facilities	9.63 sq.m.
For animals	16.22 sq.m.

Table No. 30

Summary of buildings to be built in the project area[86]

DESIGNATION	AREA I	AREA II	AREA III	REGION KEDZI VODZA-KETA	TOTAL
Farmhouses	2,100	2,300	440	-	4,840
Other houses	1,500	1,600	1,160	1,210	5,470
Town administration	4	5	3	-	12
Village administration	10	10	4	5	29
Police station	4	5	3	-	12
Hospital	4	5	3	-	12
Dispensary	10	10	4	5	29
Central school	4	5	3	-	12
School	10	10	4	5	29
Rest house	10	10	4	5	29
Hotel and restaurant	4	5	3	-	12
Post office	14	15	7	5	41
Covered market stalls	130	150	80	50	410
Shopping centre	18	20	10	5	53
Machinery pool and large store	4	5	3	-	12
Machinery pool and small store	10	10	4	-	24

Power

The Avu Keta region has no general power supply although some diesel generators supply individual houses or parts of villages, such as police stations and hospitals. In addition, the State Farm in Afife has its own generator.

With the establishment of the scheme this situation will be improved.[87]

Transport

The following are the most important existing types of road:

1. District roads with a bituminous surface on a stabilized base of laterite gravel.
2. Unpaved laterite roads with a stabilized base of laterite.
3. Field paths with a natural surface.

The waterways also carry traffic and this is especially true for those villages situated near the Volta, near lagoons, or in swampy districts.[88]

Existing roads with bituminized surfaces[89]

The Accra-Lome highway skirts the northern border of the project area and is connected to the Denu-Keta-Anyanui main road on the Keta bay-mouth bar. The Accra-Lome highway is part of the West African coastal highway which will connect all West African states. The highway varies in width between six and eight metres.

The second bituminized road, which is four to six metres wide, goes from Denu via Keta-Anloga to Anyanui along the Keta bay-mouth bar and is linked with the interior.

Existing roads with laterite surface[90]

Apart from the bituminized roads, the transport network in the project area is hardly developed.

The main laterite-surfaced roads are as follows:

1. From Dabala junction to Abor.
2. From Abor via Avenofeme to Atiavi.
3. From Abor to Tsiome.
4. From Abor to Anyako.

The width of these roads varies between four and six metres.

Tracks and paths[91]

These range from two to three metres in width and require permanent maintenance.

Planning[92] (see Map No. 15)

As noted above, the area will have a population within the next 25 years of 264,000. Therefore traffic is likely to increase considerably within and around the area.

A new system is planned to cope with this traffic which will have the following features:

1. A system of asphalted district roads.
2. A system of feeder roads linking those villages not connected by district roads.

This system will be established in three phases.

Phase I

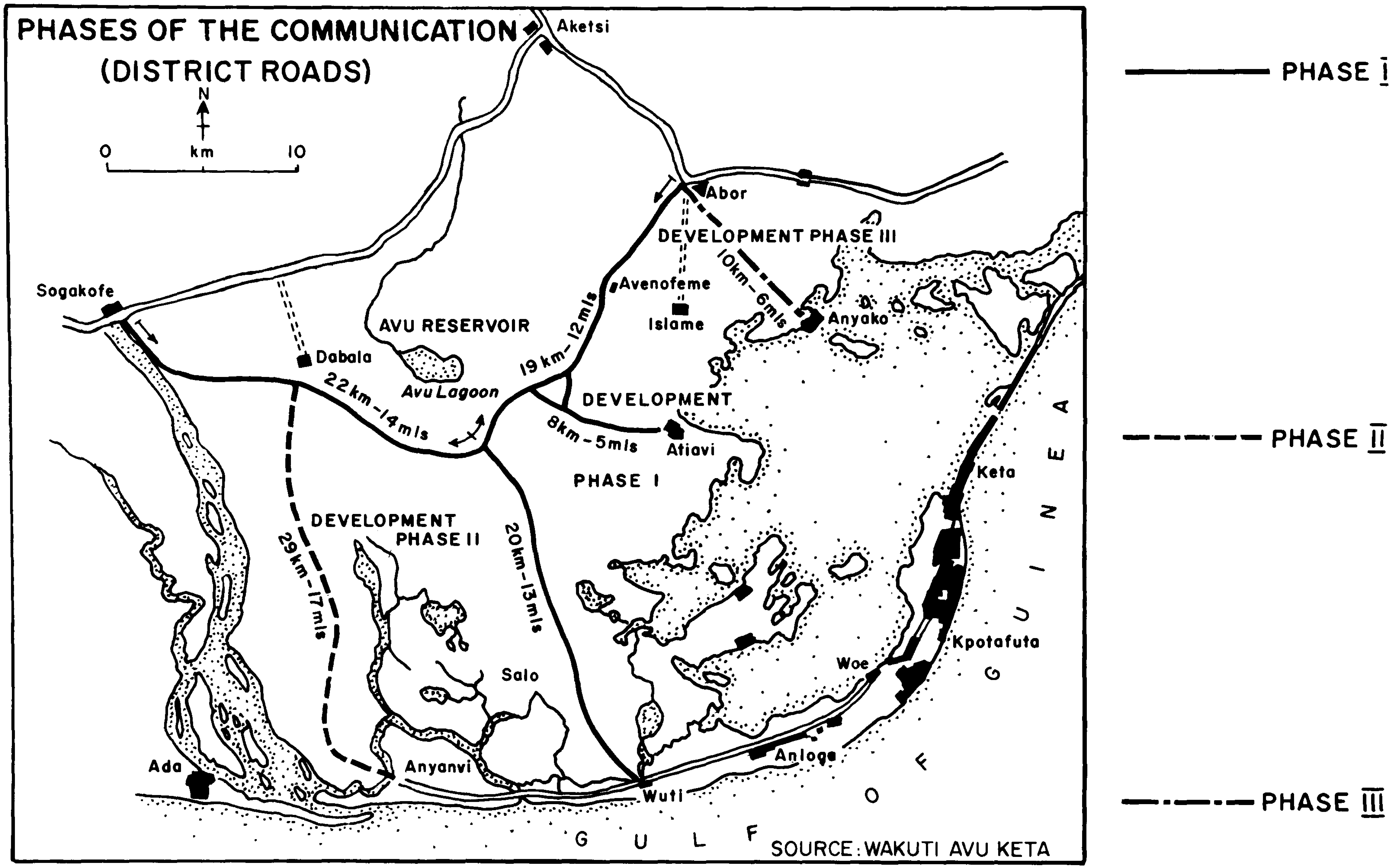
1. District roads:	Sogakofe-Bleamezado	- about	22 km.
	Bleamezado-Wuti	- about	20 km.
	Bleamezado-Abor	- about	19 km.
	Hatogodo-Atiavi	- about	9 km.
	Total		70 km.

2. Laterite roads: Roads within development area I, with a total length of about 62 km.

Phase II

1. District roads: Lolito-Galotse-Anyanui - about 27 km.
2. Laterite roads: Roads within development area II with a total length of about 81 km.
   Connecting road in Alakple area of about 8 km.
   Roads in the area between development area II and the Volta River of about 42 km.
   Total: 131 km.

Map No. 15


PHASES OF THE COMMUNICATION
(DISTRICT ROADS)
N
0
km
10
Aketsi
Abor
DEVELOPMENT PHASE III
10km - 6mls
Anyako
Avenofeme
Islame
Sogakofe
AVU RESERVOIR
Dabala
Avu Lagoon
19km - 12mls
22km - 14mls
DEVELOPMENT
8km - 5mls
Atiavi
PHASE I
DEVELOPMENT
PHASE II
29km - 17mls
20km - 13mls
Salo
Keta
Kpotafuta
Woe
Anloga
Ada
Anyanvi
Wuti
GULF OF GUINEA
SOURCE: WAKUTI AVU KETA
PHASE I
PHASE II
PHASE III

Phase III

1. District roads: Abor-Anyako - about 10 km.

2. Laterite roads: Roads within development area III with a total length of about 59 km.

Waterways

Because of the many lagoons, creeks and watercourses, the waterways are important in the southern region.[93] However, many of these waterways will disappear due to the development of the area.[94]

Industry and trade[95]

Industry in the area is of little importance and most of the products are sold in the home markets.

The following branches are the most important:

Exploitation of salt

A small salt producing industry has grown in the southern part of the area. It is centred on the northern shore of the Keta Lagoon, the creek at Tunu and the Agbatsivi Lagoon.

Boat building

A boat building industry has grown up at the Keta Lagoon and at the Keta bay-mouth bar. Canoes and larger fishing boats are built, mostly in small workshops, and the major part of the production is sold in the Avu Keta area.

Forges

In some villages, e.g. in Tove, hooks, points of lances for fishing and other wrought iron tools are manufactured. Some of these tools are sold in Accra. In addition the manufacture of cloth, fishing nets, sleeping mats, pottery, building materials and wines and spirits is undertaken on a small scale at several places.

On the Keta bay-mouth bar, in Keta and in Anlo, small workshops for the repair of motor-cars, pumps and agricultural implements are found.

Trade is flourishing and is very well organized with numerous traders and commercial enterprices operating in the area.

The most important markets held in the area are those on the Keta bay-mouth bar, especially in Keta and Anlo. Of minor importance are the markets in Adutor, Dabala, Sogakofe, Akatsi, Abor, Avenofeme, Atiavi, Tsiame, Anyako and Afife.

Agricultural, fishing and local industrial products are sold as well as household supplies.

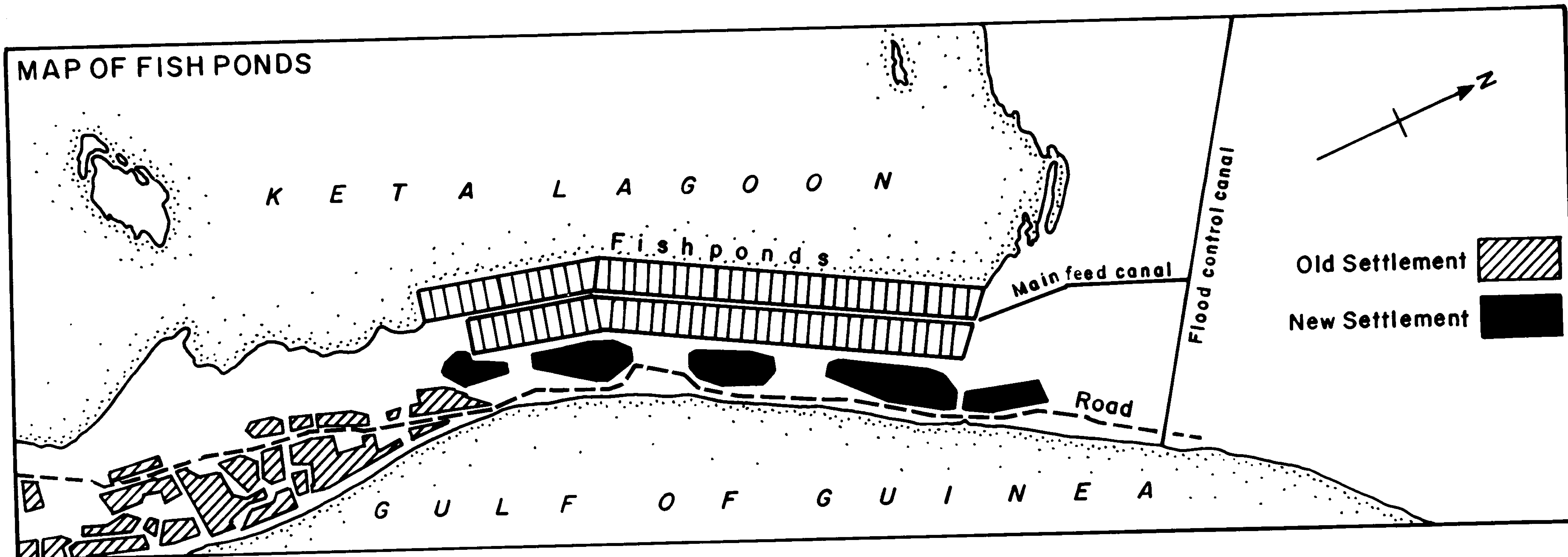
<u>Fishing</u> (see Map No. 16)

With the establishment of the project, the population can be supplied with protein from meat and vegetables, but fish, a major protein source, should be kept in drainage canals, lagoons, creeks and reservoirs, on the irrigated rice land and in fish-ponds to be established at the eastern border of the Keta Lagoon. It is hoped that the latter will compensate for the loss of fish resulting from the development of the Avu Keta Lagoon area. However, to fully develop these possibilities training services should be established for the education of the population, since intensive fish keeping requires much skill. It may also be advisable before developing full-scale fishing to create a small experimental station.[96]

There will be a total of 80 fish-ponds, not exceeding 10 ha. each, and each having an independent water supply and drainage system.

The pond water supply is assured during the major rainy season (March to July), and the minor one (September to November), but there will only be limited amounts available during the remaining months. Nevertheless, the Aka and Belikpa rivers still have water in the dry seasons. Thus, assuming normal conditions, the ponds are assured an adequate water supply.[97] Thus there are possibilities for a fish processing industry.

Map No. 16



SOURCE: WAKUTI AVU KETA

Planned agricultural development

In the Avu Keta project two farm types of different size and cropping pattern are planned. In area I and in 75 per cent of area II the soil is suitable for rice cultivation; here the size of each farm will be 2.5 ha., two thirds of which will be used to grow rice and one third for food crops. The farms in area III and 25 per cent of area II will have a size of 2.8 ha., 50 per cent cultivated with tobacco and 50 per cent food crops.

It is planned that each farmer will have two bullocks for working purposes, one cow and two young stock. The cows will be fertilized by bulls kept by the community.[98] Thus each farmer will own a total of five livestock. For this stock the area required for fodder crops must be:

Table No. 30 Area for fodder crops

ANIMAL	NUMBER	AREA REQUIRED
Bullocks	2	1.252 ha.
Cow	1	0.625 ha.
Young stock	2	1.138 ha.
Total		3.015 ha.

Furthermore, a total area of 86 ha. is required to supply fodder for the community's bulls.

But since the annual cropped area of each farm (first and second vegetative period) is only 4.047 ha. in area I and 75 per cent of area II, and 5.098 ha. in area III and 25 per cent of area II, in this situation the area under fodder required for keeping working cattle is excessive.

Moreover, the plans for agricultural production in the project area are based on the assumption that ploughing, disking, and harrowing will be performed by tractor. Thus, if cattle were to be kept for working purposes the investment on these animals would largely be wasted, because the bullocks would not be used to capacity. For these two reasons the plans for the keeping of working cattle must be rejected as unsound.

2.5 ha. farms

The planned 2.5 ha. farms will have the following cropping pattern: (See Diagram No. 2).

First vegetative period	Second vegetative period
1.60 ha. rice	1.60 ha. rice
0.27 ha. maize	
0.27 ha. cassava	
0.27 ha. legumes	

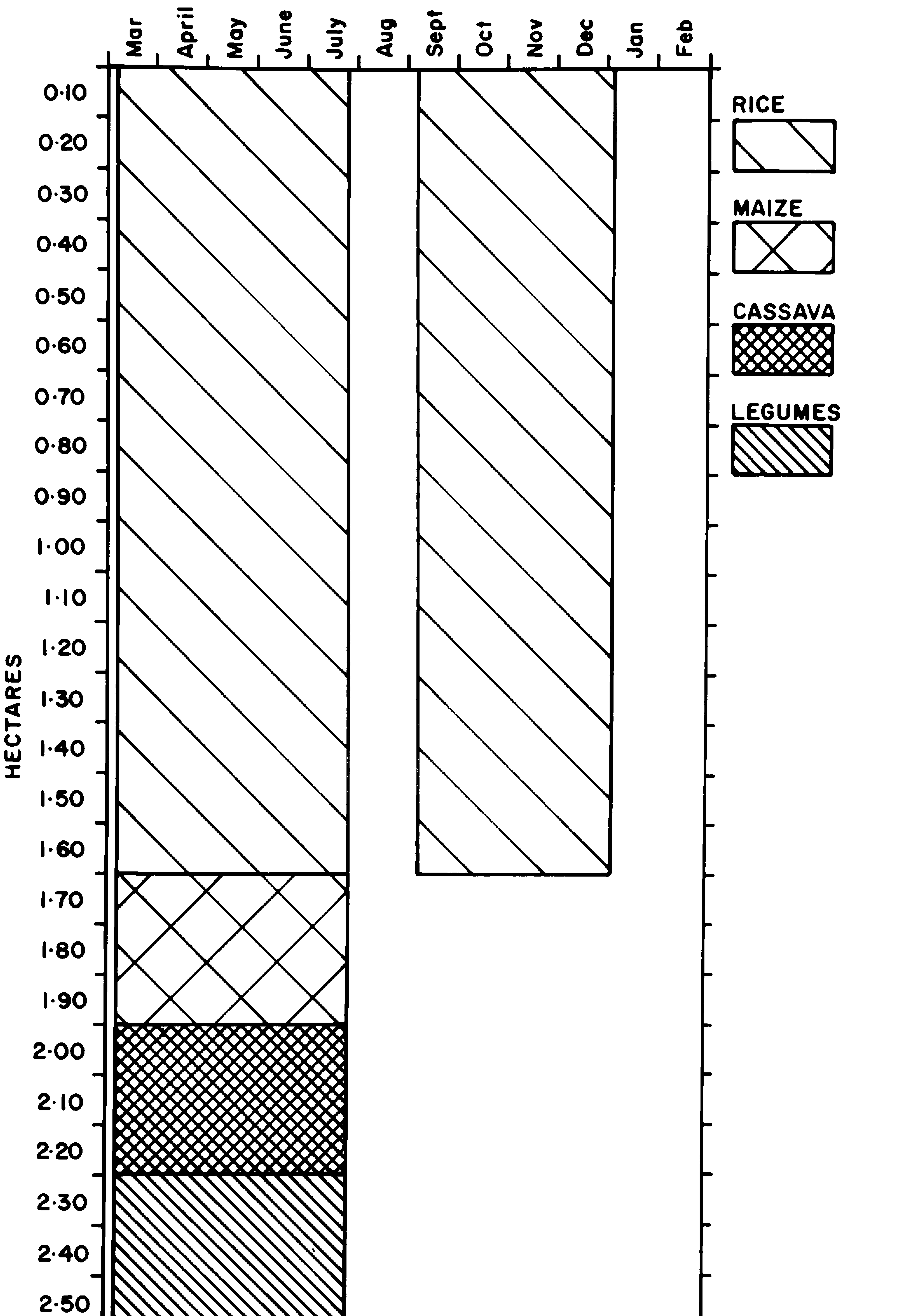
Animal husbandry is practised only to a limited extent, and thus the small crop-area required for fodder production is ignored here.

Of the above crops, only cassava is consumed by the family at present and the adoption of improved cultivation methods will result in a considerable increase in the yields of all these crops. Thus the present cassava yield of 9,400 kg./ha. will be available for marketing as the expected increase in production will more than cover the family consumption.

Labour input

As the table below shows, the labour input for irrigation is minimal.

CROPPING PATTERN— 2·5 HECTARE FARM



Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	
2·0	2·5	2·5	2·5	2·0	0·0	1·3	1·6	1·6	1·6	0·25	0·0	Hectares
80	100	100	100	80	0·0	53·3	66	66	66	10	0·0	% of cultivated area

Diagram No. 2

Table No. 31 Labour input for irrigation

MONTH	AMOUNT OF WATER IN cu.m. AREA I	75% OF AREA II	IRRIGATION TIME IN HOURS AREA I	75% OF AREA II
January	320	244	-	-
February	-	-	-	-
March	2,240	1,649	8	8
April	1,706	1,257	-	-
May	2,080	1,548*	-	0.19
June	106	82	-	-
July	10,667	784	-	-
August	-	-	-	-
September	2,347	1,714	8	8
October	2,133	1,567	-	-
November	3,200	2,351	-	-
December	2,169	1,616	-	-

For the irrigation of maize on 75 per cent of area II in May the amount of water available is assumed to be 20.00 ltr./sec.

The labour input for the other work is shown below.

* Of this 13.7 cu.m. are necessary for irrigation of maize.

Labour input for crops

Month-crop	Hectares	Type of work	Man-hours[99] per ha.	Man-hours required
March				
Rice	1.60	sowing/planting	19.77	31.63
Maize	0.27	sowing	118.62	32.03
Cassava	0.27	preparing seedbed	118.62	32.03
Legumes	0.27	planting	237.22	64.05
		Total man-hours for cultivation:		159.74
April				
Maize	0.27	top dressing	19.77	5.34
Cassava	0.27	planting	59.30	16.01
Legumes	0.27	spraying	118.62	32.03
	0.27	handhoeing	118.62	32.03
	0.27	top dressing	39.54	10.68
		Total man-hours for cultivation:		96.09
May				
Rice	1.60	top dressing	39.54	63.26
Maize	0.27	spraying	158.14	42.70
Legumes	0.27	spraying	118.62	32.03
	0.27	handhoeing	118.62	32.03
		Total man-hours for cultivation:		170.02
June				
Rice	1.60	handhoeing	39.54	63.26
Maize	0.27	top dressing	19.77	5.34
Cassava	0.27	putting soil around them	39.54	10.68

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
Legumes	0.27	top dressing	39.54	10.68
		Total man-hours for cultivation:		89.96
July				
Rice	1.60	harvesting	395.36	632.58
Maize	0.27	harvesting	355.82	96.07
	0.27	carriage, storage, drying	79.08	21.35
Cassava	0.27	harvesting for home consumption	54.36	14.68
Legumes	0.27	harvesting	395.36	107.02
		Total man-hours for cultivation:		871.70
August				
Rice	1.60	preparing seedbed	237.22	379.55
Cassava	0.27	harvesting for home consumption	54.36	14.68
	0.27	preparing seedbed	118.62	32.03
		Total man-hours for cultivation:		426.26
September				
Rice	1.60	sowing/planting	19.77	31.63
Cassava	0.27	planting	59.30	16.01
	0.27	harvesting for home consumption	54.36	14.68
		Total man-hours for cultivation:		62.32
October				
Cassava	0.27	top dressing	54.36	14.68
		Total man-hours for cultivation:		14.68

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
November				
Rice	1.60	top dressing	39.54	63.26
		Total man-hours for cultivation:		63.26
December				
Rice	1.60	handhoeing	39.54	63.26
Cassava	0.27	harvesting	54.36	14.68
		Total man-hours for cultivation:		77.94
January				
Rice	1.60	harvesting	395.36	632.58
Cassava	0.27	harvesting	54.36	14.68
		Total man-hours for cultivation:		647.26
February				
Rice	1.60	preparing seedbed	237.22	379.55
Maize	0.27	preparing seedbed	59.30	16.01
Legumes	0.27	preparing seedbed	79.08	21.35
		Total man-hours for cultivation:		416.91

The overall labour input for a 2.5 ha. farm is thus as shown in Table No. 32.

Two labour units will be available on each of these farms. The annual average working time per labour unit estimated at 2,400 hours, that is 200 hours monthly or 25 working days of eight hours each per month.

The labour input required in area I differs by only 0.19 hours in May from the requirement of farms in 75 per cent of area II. This

Table No. 32 Overall labour input for 2.5 ha. farms

MONTH	MAN-HOURS FOR FIELD WORK	MAN-HOURS FOR IRRIGATION AREA I	MAN-HOURS FOR IRRIGATION 75% OF AREA II	TOTAL MAN-HOURS AREA I	TOTAL MAN-HOURS 75% OF AREA II
March	159.74	8	8	167.74	167.74
April	96.09	-	-	96.09	96.09
May	170.02	-	0.19	170.02	170.21
June	89.96	-	-	89.96	89.96
July	871.70	-	-	871.70	871.70
August	426.26	-	-	426.26	426.26
September	62.32	8	8	70.32	70.32
October	14.68	-	-	14.68	14.68
November	63.26	-	-	63.26	63.26
December	77.94	-	-	77.94	77.94
January	647.26	-	-	647.26	647.26
February	416.91	-	-	416.91	416.91

minimal difference may be ignored. Thus the labour input for both farm types is regarded as being equal.

Table No. 33

Working time for farms in area I and 75 per cent of area II

MONTH	DAILY WORKING TIME IN HOURS	MONTHLY WORKING TIME IN HOURS	PERCENTAGE OF 2 LABOUR UNITS
March	6.71	167.74	41.94
April	3.84	96.09	24.00
May	6.80	170.02	42.50
June	3.59	89.96	22.43
July	34.87	871.70	217.93
August	17.05	426.26	106.56
September	2.81	70.32	17.56
October	0.59	14.68	3.69
November	2.53	63.26	15.81
December	3.11	77.94	19.43
January	25.89	647.26	161.81
February	16.68	416.91	105.38

This situation is also illustrated in Diagram No. 3 and, together with other evaluations of labour input - both total and seasonal, is again critically considered in Chapter 5.

Value of the cash crops

The pattern of expenditure required for each of the field crops is shown below.

The patterns of expenditure differ between area I, first vegetative period, area I, second vegetative period, area II, first vegetative period and area II, second vegetative period, because of the different amounts of water required.


LABOUR INPUT FOR 2·5 ha FARM
Man hours per day
Labour units per day
40
30
20
10
0
5
4
3
2
1
0
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb

Diagram No. 3

Table No. 34 Expenditure for cash crops

HECTARES	CROP	AMOUNT/ha.[100]	NC/UNIT[101]	NC/AREA
1.60	Rice: area I, 1st. vegetative period			
	Seeds	67.26 kg.	0.15	16.140
	Fertilizer	67.26 kg. = 19.18 NC		30.688
	Plant protection	4.9 pints	1.40	10.976
	Water*	-	-	4.184
		10,377.41 cu.m.**		7.907
	Management	14.826 NC		23.721
	General	9.884 NC		15.814
				109.430
1.60	Rice: area I, 2nd. vegetative period			
	Water	6,281.78 cu.m.		2.533
				107.799
1.60	Rice: area II, 1st. vegetative period			
	Water	2,793.47 cu.m.		4.291
				109.537
1.60	Rice: area II, 2nd. vegetative period			
	Water	4,628.68 cu.m.		7.110
				112.356

* For the maintenance of ditches, canals and other structures a price of 4.9 NC per hectare has been assumed.

** According to WAKUTI[102] pumping costs will be 0.00015 NC to lift one cubic metre of water by one metre. Thus the price of one cubic metre of water will be:

in area I (to be lifted 1.68 m.) 0.000252 NC,
in area II (to be lifted 6.40 m.) 0.000960 NC,
in area III (to be lifted 1.68 m.) 0.000252 NC.

The height to be lifted in area III is based on the most unfavourable conditions, i.e. lowest water-level in the Volta and highest in the equalizing reservoir.

Table No. 34 (continued)

HECTARES	CROP	AMOUNT/ha.	NC/UNIT	NC/AREA
0.27	Maize: area I			
	Seeds	33.63 kg.	0.17	1.544
	Fertilizer	67.26 kg. = 21.50 NC		5.805
	Plant protection	22.42 kg.	0.37	2.239
	Water	-	-	1.340
	Management	14.826 NC		4.003
	General	9.884 NC		2.668
				17.599
0.27	Maize: area II			
	Water	50.48 cu.m.		0.013
				17.612
0.27	Cassava: area I and area II			
	Seeds	-		-
	Fertilizer	15 kg. = 5.44 NC		1.467
	Plant protection	-		-
	Water	-		1.340
	Management	14.826 NC		4.003
	General	9.884 NC		2.668
				9.478

Table No. 34 (continued)

HECTARES	CROP	AMOUNT/ha.	NC/UNIT	NC/AREA
0.27	Legumes: area I and area II			
	Seeds	33.63 kg.	0.15	1.362
	Fertilizer	50 kg. = 20.02		5.405
	Plant protection	22.42 kg.	0.37	2.239
	Water	-	-	1.340
	Management	14.826 NC		4.003
	General	9.884 NC		2.668
				17.017

The gross value of the cash crops produced on each 2.5 ha. farm would thus be as shown in Table No. 35.

But, after deduction of the expenditure a net return value of 389.987 NC would still remain for each farm in area I.

Table No. 36 Net value of the cash crops

CROP	VALUE IN NC	EXPENDITURE IN NC	NET VALUE IN NC	LOSS IN NC
Rice	589.56	217.209	372.351	-
Maize	18.13	17.599	0.531	-
Cassava	30.46	9.478	20.982	-
Legumes	13.14	17.017	-	3.877

The net value for each farm in 75 per cent of area II will be 380.962 NC.

Table No. 35 — Value of the cash crops

HECTARES	CROP	YIELD IN 100 kg. PER ha.	YIELD IN 100 kg. PER AREA	PRICE NC/kg.	TOTAL VALUE IN NC
1.60	Rice	18.80[103]	30.08	0.098[107]	294.78
1.60	Rice	18.80	30.08	0.098	294.78
0.27	Maize	9.60[104]	2.59	0.070[108]	18.13
0.27	Cassava	94.00[105]	25.38	0.012[109]	30.46
0.27	Legumes	2.70[106]	0.73	0.180[110]	13.14
Total value of the crops					651.29

Table No. 37 Net value of the cash crops

CROP	VALUE IN NC	EXPENDITURE IN NC	NET VALUE IN NC	LOSS IN NC
Rice	589.56	221.893	367.667	-
Maize	18.13	17.612	0.518	-
Cassava	30.46	9.478	20.982	-
Legumes	13.14	17.017	-	3.877

It will be noted that if net returns are calculated some crops are grown at an accounting loss.

2.8 ha. farms

The projected 2.8 ha. farm will have the following cropping pattern: (see Diagram No. 4).

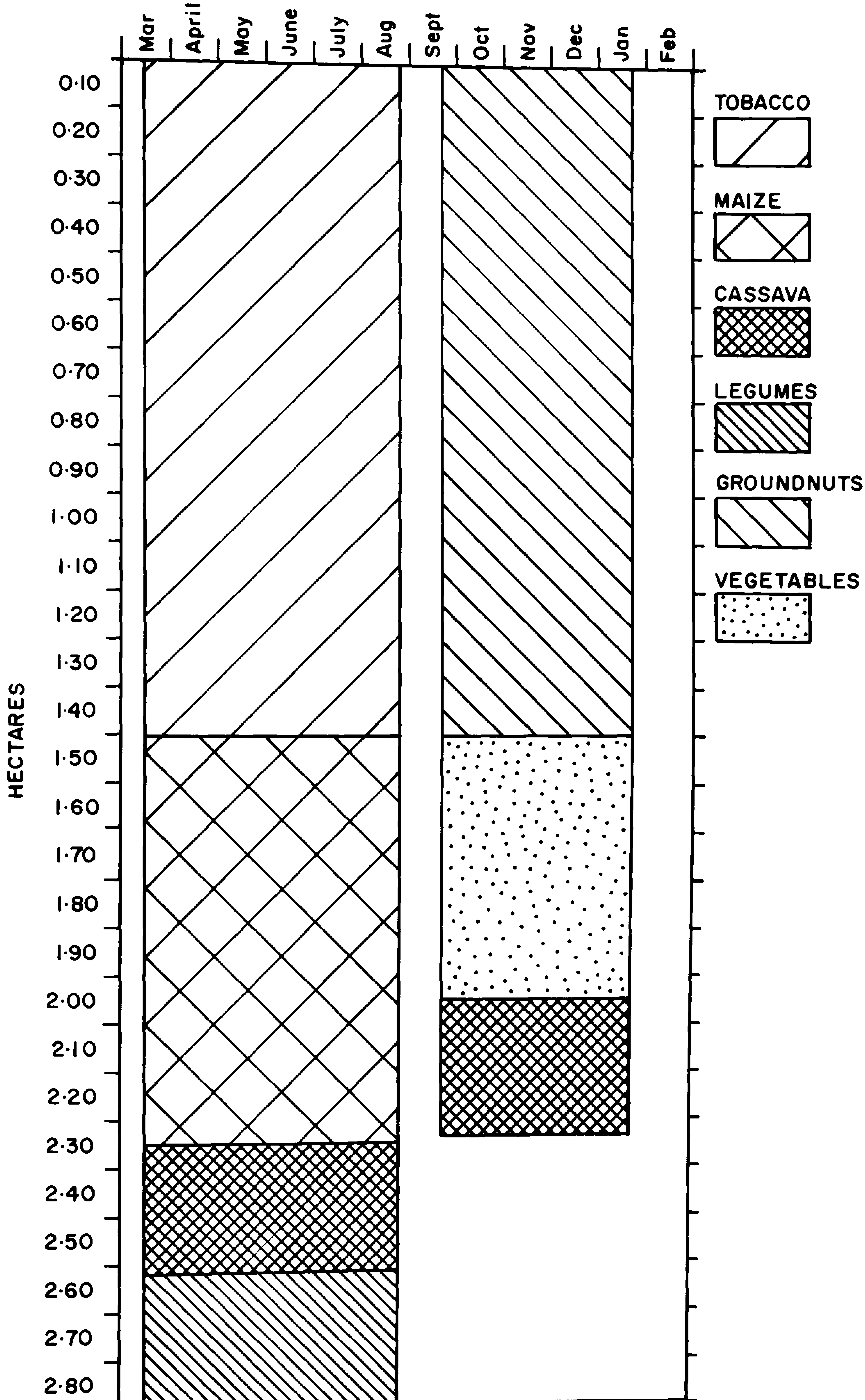
First vegetative period	Second vegetative period
1.40 ha. tobacco	1.40 ha. groundnuts
0.85 ha. maize	0.56 ha. vegetables
0.28 ha. legumes	0.28 ha. cassava
0.28 ha. cassava	

Here again, all crops are cash crops and the area required for fodder will be ignored.

Labour input

With all farmers irrigating for 12 hours per day each sixth day, the volume of water available to each farmer is 10.26 ltr./sec. for 25 per cent of area II, 10.50 ltr./sec. for area III, first vegetative period and 12.00 ltr./sec. for area III, second vegetative period. But by working two shifts of six hours each, and doubling the rate of water application, which is technically possible, the irrigation time could be halved.

CROPPING PATTERN - 2·8 HECTARE FARM



Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	
1·4	2·8	2·8	2·8	2·8	2·3	0·9	2·24	2·24	2·24	2·4	0·0	Hectares
50	100	100	100	100	83·6	32·1	80	80	80	53·6	0·0	% of cultivated area

Diagram No. 4

Table No. 38 Labour input for irrigation

MONTH	QUANTITY OF WATER IN cu.m. 25% OF AREA II	AREA III	IRRIGATION TIME IN HOURS 25% OF AREA II	AREA III
January	-	-	-	-
February	-	-	-	-
March	-	-	-	-
April	-	-	-	-
May	328.6	731.1	8.90	19.34
June	-	-	-	-
July	285.7	591.1	7.74	15.64
August	-	-	-	-
September	-	-	-	-
October	-	451.1	-	10.44
November	-	684.4	-	15.84
December	-	-	-	-

The labour input for field work is shown below:

Labour input for field work

Month-crop	Hectares	Type of work	Man-hours per ha.[111]	Man-hours required
March				
Tobacco	1.40	planting	118.62	166.07
Maize	0.85	sowing	118.62	100.83
Cassava	0.28	preparing seedbed	118.62	33.21
Legumes	0.28	planting	237.22	66.42
		Total man-hours for cultivation:		366.53

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
April				
Tobacco	1.40	handhoeing	79.08	110.71
Maize	0.85	top dressing	19.77	16.80
Cassava	0.28	planting	59.30	16.60
Legumes	0.28	spraying	118.62	33.21
	0.28	handhoeing	118.62	33.21
	0.28	top dressing	39.54	11.07
		Total man-hours for cultivation:		221.60
May				
Tobacco	1.40	top dressing	39.54	55.36
Maize	0.85	spraying	158.14	134.42
Legumes	0.28	spraying	118.62	33.21
	0.28	handhoeing	118.62	33.21
		Total man-hours for fieldwork:		256.20
June				
Tobacco	1.40	handhoeing	79.08	110.71
Maize	0.85	top dressing	19.77	16.80
Cassava	0.28	putting soil around them	39.54	11.07
Legumes	0.28	top dressing	39.54	11.07
		Total man-hours for fieldwork		149.65

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
July				
Tobacco	1.40	handhoeing	79.08	110.71
Cassava	0.28	harvesting for home consumption	54.36	15.22
Legumes	0.28	harvesting	395.36	110.70
Vegetables	0.56	preparing seedbed	158.14	88.56
		Total man-hours for fieldwork:		325.19
August				
Tobacco	1.40	harvesting	355.82	498.15
	1.40	carrying, drying, storage	197.70	276.78
Maize	0.85	harvesting	395.36	336.06
	0.85	carrying, drying, storage	79.08	67.22
Cassava	0.28	harvesting for home consumption	54.36	15.22
	0.28	preparing seedbed	118.62	33.21
		Total man-hours for fieldwork:		1,226.64
September				
Groundnuts	1.40	sowing	237.22	332.11
Vegetables	0.56	planting	237.22	132.84
Cassava	0.28	planting	59.30	16.60
	0.28	harvesting for home consumption	54.36	15.22
		Total man-hours for fieldwork:		496.77

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
October				
Groundnuts	1.40	handhoeing	39.54	55.36
Vegetables	0.56	spraying	118.62	66.43
	0.56	handhoeing	118.62	66.43
	0.56	top dressing	39.54	22.14
Cassava	0.28	harvesting	54.36	15.22
		Total man-hours for fieldwork:		225.58
November				
Groundnuts	1.40	top dressing	39.54	55.36
Vegetables	0.56	spraying	118.62	66.44
	0.56	handhoeing	118.62	66.44
	0.56	top dressing	39.54	22.14
		Total man-hours for fieldwork:		210.38
December				
Groundnuts	1.40	handhoeing	39.54	55.36
Cassava	0.28	harvesting	54.36	15.22
		Total man-hours for fieldwork		70.58
January				
Groundnuts	1.40	harvesting	449.72	629.61
	1.40	carrying, drying, storage	138.38	193.61
Vegetables	0.56	harvesting	449.72	251.84
	0.56	carrying, drying, storage	177.91	99.30

Month-crop	Hectares	Type of work	Man-hours per ha.	Man-hours required
Cassava	0.28	harvesting	54.36	15.22
		Total man-hours for fieldwork:		1,260.28
February				
Maize	0.85	preparing seedbed	59.30	50.41
Tobacco	1.40	preparing seedbed	118.62	166.07
Legumes	0.28	preparing seedbed	79.07	22.14
		Total man-hours for fieldwork:		238.62

Thus the total labour input required for a 2.8 ha. farm is as shown in Table No. 39.

Two labour units would be available on each of these farms. The annual working time per labour unit is estimated at 2,400 hours, that is, 200 hours monthly or 25 working days of eight hours each per month. Thus the labour units required are as shown in Table No. 40.

Table No. 39 Overall labour input for 2.8 ha. farms

MONTH	MAN-HOURS FOR FIELDWORK	MAN-HOURS FOR IRRIGATION		TOTAL MAN-HOURS	
		AREA I	75% OF AREA II	AREA I	75% OF AREA II
March	366.53	-	-	366.53	366.53
April	221.60	-	-	221.60	221.53
May	256.20	8.90	19.34	265.10	275.54
June	149.65	-	-	149.65	149.65
July	325.19	7.74	15.64	332.93	340.83
August	1,226.64	-	-	1,226.64	1,226.64
September	496.77	-	-	496.77	496.77
October	225.58	-	10.44	225.58	236.02
November	210.38	-	15.84	210.38	226.22
December	70.58	-	-	70.58	70.58
January	1,260.28	-	-	1,260.28	1,260.28
February	238.62	-	-	238.62	238.62

Table No. 40 Labour units required

MONTH	DAILY WORKING HOURS 25% OF AREA II	AREA III	MONTHLY WORKING HOURS 25% OF AREA II	AREA III	PERCENTAGE OF 2 LABOUR UNITS 25% OF AREA II	AREA III
March	14.66	14.66	366.53	366.53	91.63	91.63
April	8.86	8.86	221.60	221.60	55.38	55.38
May	10.60	11.02	265.10	275.54	66.25	68.88
June	5.99	5.99	149.65	149.65	37.43	37.43
July	13.32	13.63	332.93	340.83	83.25	85.19
August	49.66	49.66	1,226.64	1,226.64	310.38	310.38
September	19.87	19.87	496.77	496.77	124.19	124.19
October	9.02	9.44	225.58	236.02	56.38	59.00
November	8.42	9.05	210.38	226.22	52.63	56.56
December	2.82	2.82	70.58	70.58	17.63	17.63
January	50.41	50.41	1,260.28	1,260.28	315.06	315.06
February	9.54	9.54	238.62	238.62	59.63	59.63

(See Diagram No. 5 and Chapter 5, pp. 421-423)

LABOUR INPUT 2·8ha FARM

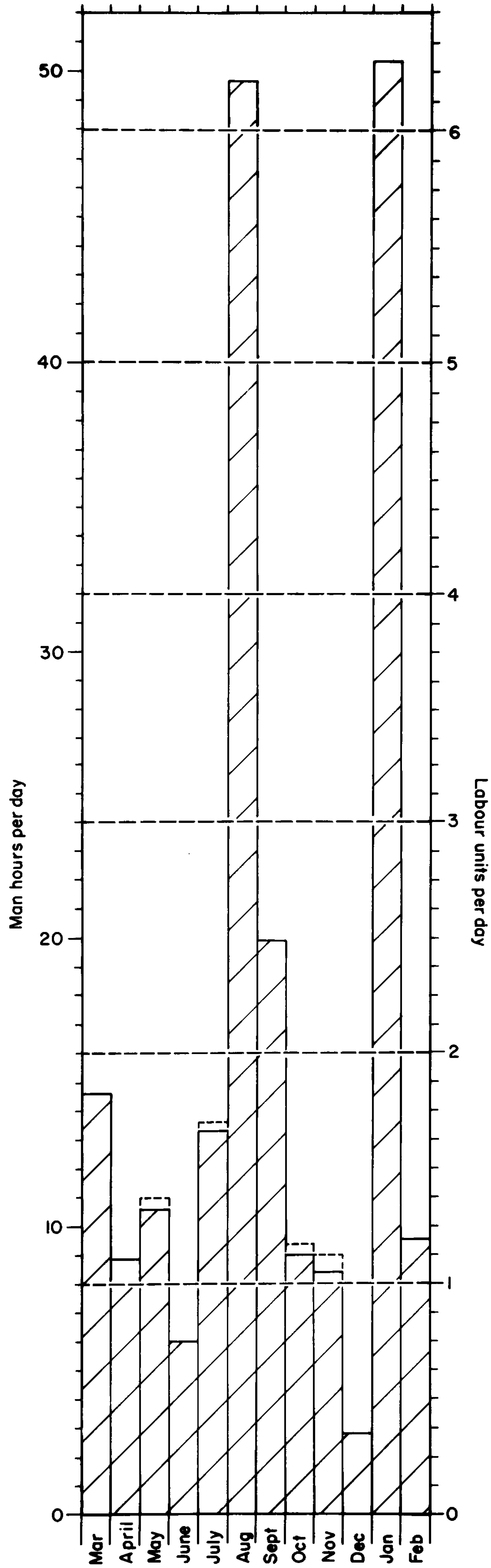


Diagram No. 5

Value of the cash crops

The pattern of expenditure required for each of the cash crops is as follows:

Table No. 41 Expenditure for cash crops

HECTARES	CROP	AMOUNT/ha.[112]	NC/UNIT[113]	NC/AREA
1.40	Tobacco: 25% of area II			
	Seeds	14,826 seedlings*		-
	Fertilizer	116.14 kg. = 14.83 NC		20.762
	Plant protection	3.7 pints	1.40	7.252
	Water**	403.42 cu.m.		0.542
				6.919
	Management	14.826 NC		20.756
	General	9.884 NC		13.838
				70.069
1.40	Tobacco: area III			
	Water	834.88 cu.m.		0.295
				69.822
0.85	Maize: 25% of area II			
	Seeds	33.63 kg.	0.17	4.860
	Fertilizer	148.26 kg. = 21.50 NC		18.275
	Plant protection	22.42 kg.	0.42	8.004
	Water	50.48 cu.m.		0.041
				4.200

* Seedlings are supplied free by the State Products Corporation.

** See footnotes on page 292.

Table No. 41 (continued)

HECTARES	CROP	AMOUNT/ha.	NC/UNIT	NC/AREA
	Management	14.826 NC		12.600
	General	9.884 NC		8.400
				56.380
0.85	Maize: area III			
	Water	164.74 cu.m.		0.035
				56.374
0.28	Cassava: 1st. and 2nd. vegetative period of 25% of area II and area III			
	Seeds	-	-	-
	Fertilizer	37.06 kg. = 5.44 NC		1.523
	Plant protection	-	-	-
	Water			1.400
	Management	14.826 NC		4.151
	General	9.884 NC		2.768
				9.842
0.28	Legumes: 25% of area II and area III			
	Seeds	22.42 kg.	0.15	0.942
	Fertilizer	123.55 kg. = 20.00 NC		5.600
	Plant protection	22.42 kg.	0.37	2.323
	Water			1.259
	Management	14.826 NC		4.151
	General	9.884 NC		2.768
				17.043

Table No. 41 (continued)

HECTARES	CROP	AMOUNT/ha.	NC/UNIT	NC/AREA
1.40	Groundnuts: 25% of area II			
	Seeds	44.84 kg.	0.31	19.461
	Fertilizer	123.55 kg. = 20.00 NC		28.000
	Plant protection	22.42 kg.	0.37	11.614
	Water			6.919
	Management	14.826 NC		20.756
	General	9.884 NC		13.838
				100.588
1.40	Groundnuts: area III			
	Water	691.88 cu.m.		0.244
				100.832
0.56	Vegetables: 25% of area II			
	Seeds	11.21 kg.	0.62	3.892
	Fertilizer	296.52 kg. = 42.50 NC		23.800
	Plant protection	7.4 pints	1.40	5.800
	Water			2.768
	Management	14.826 NC		8.303
	General	9.884 NC		5.535
				50.098
0.56	Vegetables: area III			
	Water	274.45 cu.m.		0.039
				50.137

Table No. 42 Value of the cash crops

HECTARES	CROP	YIELD IN 100 kg. PER ha.	YIELD IN 100 kg. PER AREA	PRICE[114] NC/kg.	TOTAL VALUE IN NC
1.40	Tobacco	3.40[115]	4.76	0.600	285.60
0.85	Maize	9.60[116]	8.16	0.070	57.12
0.28	Cassava	94.00[117]	26.32	0.012	31.58
0.28	Cassava	94.00	26.32	0.012	31.58
0.28	Legumes	2.70[118]	0.76	0.180	13.68
1.40	Groundnuts	7.10[119]	9.94	0.200	198.80
0.56	Vegetables	96.00[120]	53.76	0.100	537.60
Total value of the crops					1,155.96

The total cash value of crops produced on each farm would thus be as shown in Table No. 42.

After deducting the expenditure for farms in 25 per cent of area II a net value of 842.30 NC still remains.

Table No. 43 Net value of cash crops

CROP	VALUE IN NC	EXPENDITURE IN NC	NET VALUE IN NC	LOSS IN NC
Tobacco	285.60	70.069	215.53	-
Maize	57.12	56.380	0.74	-
Cassava	63.16	19.684	43.48	-
Legumes	13.68	17.043	-	3.36
Groundnuts	198.80	100.588	98.21	-
Vegetables	537.80	50.098	487.70	-

For the cash crops in area III the remaining net value is 842.28 NC.

Table No. 44 Net value of cash crops

CROP	VALUE IN NC	EXPENDITURE IN NC	NET VALUE IN NC	LOSS IN NC
Tobacco	285.60	69.822	215.78	-
Maize	57.12	56.374	0.75	-
Cassava	63.16	19.684	43.48	-
Legumes	13.68	17.043	-	3.36
Groundnuts	198.80	100.832	97.97	-
Vegetables	537.80	50.137	487.66	-

Marketing situation

Almost all of the 135,000 inhabitants of the area are either engaged in subsistence agriculture or cash crop production. Also, many, besides having non-agricultural jobs, cultivate small gardens the produce of which is used for domestic consumption.

In the future, 113,000 of the inhabitants will live on the new project, 60 per cent earning their living from agriculture and 40 per cent earning a living from non-agricultural occupations. The latter 22,000 people will most probably continue cultivating their gardens and compound farms outside the scheme. Vegetables, lima beans, maize, groundnuts, yams and cotton are brought from these farms and gardens to the markets within the area and in Accra, in addition to supplying of the domestic consumption of these non-agriculturalists.

The yields on which the calculation of the agricultural production of the new scheme is based are average yields for Ghana, but after an initial period the yields from the new farms should be considerably higher and this increase is assumed to cover the food requirements of the inhabitants of the scheme. Thus the surplus produce will have to be marketed elsewhere.

Very good marketing possibilities exist as over two fifths of Ghana's total population of about seven million live in the southern part of the country,[121] but Accra is the major consumption centre and the rural centres will act as collecting stations for the transport of the scheme's produce to Accra.[122]

The marketing prospects for tobacco and rice, the main crops of the scheme, are particularly good. The tobacco factory in Takoradi can absorb all tobacco grown.[123] Ghana intends to be self-sufficient in rice by 1975, which implies a doubling of domestic rice production by then. Imported rice is currently between 11 per cent in Accra and 37 per cent at Tamale more expensive than locally produced rice.[124] Thus, the latter would provide a secure source of income for the producers.

Compared with other agricultural areas the location of the Avu Keta project is advantageous as the average distance to the markets does not result in very high transport costs.

A revival of the traditional trade between the project area and Accra can be expected as soon as the new road network is finished.[125]

Apart from the question of transport itself, there is the problem of collecting all the products in order to be able to send them on a co-operative basis to the markets. But this should not be difficult as the rural population of Ghana has a long tradition of co-operative marketing. The first marketing board was established in 1928 for cocoa, and others were in operation during World War II for the marketing of yams. In 1944 the Department of Co-operation was created which took over these functions and in 1948 the establishment of consumer co-operatives was unsuccessfully attempted.[126] In 1953-54 the Co-operative Department had three organisations: (1) for banking, (2) for produce and marketing and (3) for supply.[127] Its centre in Sogakofe[128] could organize the supply of the markets in Accra.

Before the goods come to Sogakofe they will have to be collected in the project area, which is an average distance of 28 km. from Sogakofe. Thus, with a distance of 160 km. from Sogakofe to Accra[129] the goods will have to be transported about 188 km. in order to reach the market.

In 1963 the transport costs for truck transport was four to six pence per ton/mile,[130] i.e. 1.51 new pence per ton/kilometre. These figures should still be valid, as it is possible to obtain a cost reduction of 25 per cent when a dry weather road is improved by asphalting and a reduction of 15 per cent when a dry weather road is changed into a laterite road,[131] and the roads from Accra via Sogakofe to the towns and main villages in the project area will be asphalted while the smaller places will be connected by laterite roads.

From this, the following transport costs per farm are derived:

Table No. 45

Transport costs per farm in area I and 75 per cent of area II

PRODUCT	AMOUNT IN kg.	TRANSPORT COSTS IN £G	IN NC*
Rice	6,086	17.27	34.54
Maize	260	0.74	1.48
Cassava	2,549	6.98	13.96
Legumes	73	0.21	0.42

Table No. 46

Transport costs per farm in area III and 25 per cent of area II

PRODUCT	AMOUNT IN kg.	TRANSPORT COSTS IN £G	IN NC
Tobacco	482	1.38	2.76
Maize	816	2.32	4.64
Cassava	5,326	15.12	30.24
Legumes	77	0.22	0.44
Groundnuts	1,006	2.86	5.72
Vegetables	5,439	15.44	30.88

After deducting the transport costs from the net value the latter is again reduced and the losses are increased. The value of the crops after deduction of transport costs is shown in the following tables.

Table No. 47

Value of crops after deducting transport costs

CROP	PROFIT	LOSS
Rice	333.514	-
Maize	-	0.830
Cassava	7.116	-
Legumes	-	4.432
Total	340.630	5.262

Table No. 48

Value of crops after deducting transport costs in 75 per cent of area

CROP	PROFIT	LOSS
Rice	328.746	-
Maize	-	0.870
Cassava	7.116	-
Legumes	-	4.432
Total	335.862	5.302

Table No. 49

Value of crops after deducting transport costs in 25 per cent of area II

CROP	PROFIT	LOSS
Tobacco	215.541	-
Maize	-	2.599
Cassava	15.860	-
Legumes	-	4.010
Groundnuts	93.638	-
Vegetables	462.340	-
Total	787.379	6.609

Table No. 50

Value of crops after deducting transport costs in area III

CROP	PROFIT	LOSS
Tobacco	215.792	-
Maize	-	2.575
Cassava	15.860	-
Legumes	-	4.010
Groundnuts	93.559	-
Vegetables	462.234	-
Total	787.445	6.585

Consequently, the family income for each farm is as shown in the following table.

Table No. 51

Projected family income in Avu Keta (in £G)

	AREA I	75% OF AREA II	25% OF AREA II	AREA III
Family income per year	167.684	165.280	390.385	390.430
Monthly family income	14.328	14.130	32.534	32.542
Annual income per head	22.925	22.608	52.055	52.067
Monthly income per labour unit	7.164	7.065	16.268	16.271
Hourly wage	0.036	0.036	0.082	0.082

Whereas the originally planned income from farms in area III and 25 per cent of area II will make life in the project attractive, the low income from farms in area I and 75 per cent of area II will probably not stop migration to the industrial centres.

The difference between the incomes of the two farm types is caused by different cropping patterns, and in order to achieve an adequate income from the farms in area I and 75 per cent of area II it is necessary to base the production on an improved cropping pattern. This more suitable cropping pattern should be as follows:

First vegetative period	Second vegetative period
1.60 ha. rice	1.60 ha. rice
0.40 ha. cassava	0.80 ha. vegetables
0.40 ha. tobacco	

The main crop in this recommended cropping pattern in both vegetative periods is rice. Cassava and tobacco will occupy equal areas in the first vegetative period because although tobacco would bring a higher profit, cassava is the main item of the diet and its demand is assured. During the second vegetative period only vegetables will be grown as a second crop. The other possible crop, i.e. groundnuts, would bring smaller returns and has a smaller labour demand than vegetables only in October and November. However, during these months a higher labour input for vegetables coincides with an almost negligible labour demand from other crops.

The family income which can be achieved from this farm type is about 545 £G, and this could be increased by cultivating a greater proportion of vegetables. If the whole of the farm was cultivated with vegetables, and hired labour did the work, family income would be about 3,000 £G yearly. However, it would be advisable to increase the proportion of vegetables grown only after the farmers have improved their knowledge and skill.

The extremely high labour demand of both farm types during peak periods will cause a decrease in the family income since labourers will have to be hired during these periods. (This question of labour demand and supply is considered again in Chapter 5).

Based on 12.4 hours of daylight in July, 12.3 hours in August and 11.8 hours in January, each of the farmers could theoretically be expected to work 12 hours every day during these peak periods. Thus the two full-time farmers on each farm would together work 744 hours per month. This is the maximum that could be expected from the on-farm labour force and is almost certainly greater than the amount of time the farmers would be prepared to expend.

Thus, in July alone, at least 135 labourer-hours would have to be hired and paid for when using the original cropping pattern in area I and 75 per cent of area II; based on an average earning of 32 pence per labourer per day, this would result in a family income reduction of 3.84 £G. The family income would thus become about 164 £G in area I and about 161 £G in 75 per cent of area II.

There remains for area III and 25 per cent of area II an additional requirement for hired labour of 492 hours in August and 460 hours in January, which results in a reduction in family income of £G 4.92 in August and £G 4.68 in January. Thus the final family income will decrease to about £G 380 in 25 per cent of area II and area III.

The modified cropping pattern for area I and 75 per cent of area II alters the labour demand so that about £G 3.00 per farm would have to be paid in August and about £G 17.00 per farm in January for hired labour. Using the modified system, the final family income would be about £G 525 for both farm types which is comparatively high and should encourage the people to stay in the area.

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104. Ibid., p. 62

105. Ibid., p. 118

106. Ibid., p. 182

107. WAKUTI, Feasibility Study, Vol. V, p. 212

108. Ibid., Vol. VI, p. 47

109. Ibid.

110. Ibid.

111. Ibid., p. 54

112. Ibid., pp. 54-56

113. Ibid.

114. Ibid., p. 47

115. FAO, Production Yearbook 1971, p. 278

116. Ibid., p. 62

117. Ibid., p. 118

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119. Ibid., p. 234

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121. R.J. Harrison Church, West Africa, A Study of the Environment and Men's Use of it, (London, 1963), pp. 364-374

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128. Ibid., p. 49

129. H. von der Decken, Agrarökonomische Berechnungen (Feasibility Study) zum Avu Keta Projekt der Firma WAKUTI, unpublished, 3.9.1968

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CHAPTER FOUR

TAUORGA OASIS, LIBYA

Location of the project (see Maps Nos. 1 and 2)

The Tauorga Irrigation Project lies approximately 32° 05" latitude North and 15° 03" longitude East along the Misurata-Sirte road near the village of Tauorga. It is approximately 35 km. south of Misurata, 26 km. from the sea and about 10 to 20 m. above sea-level. The project area covers about 3,000 ha. and is roughly square in shape.

The project area lies mainly between the old Sirte-Misurata road and the new main Sirte-Misurata road. The project covers the area from road km. 32, south of Misurata, to the former Italian irrigation project, approximatley 39 km. away.

The borders of the area are as follows:

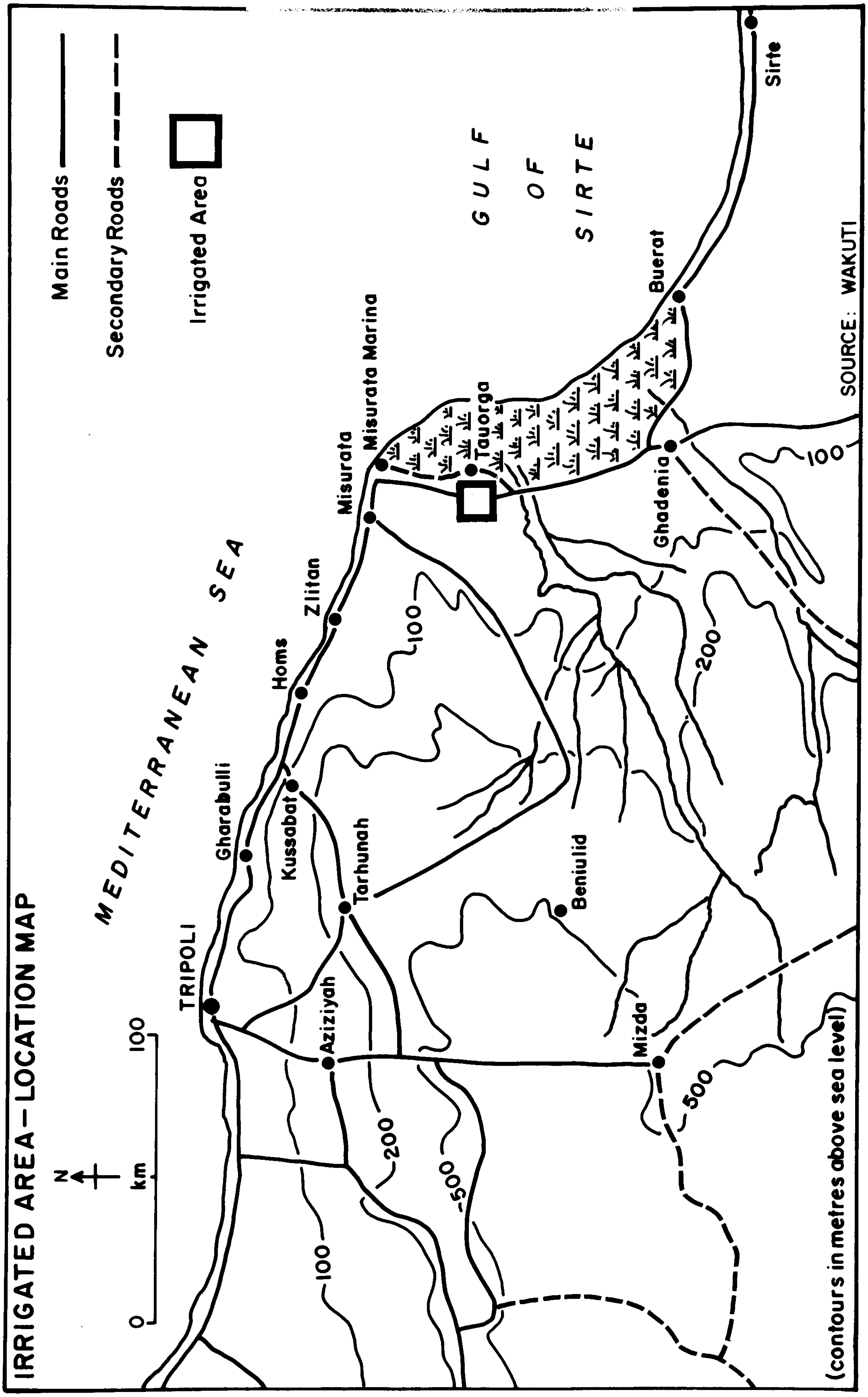
The project extends about 1.2 km. east of the old Misurata-Sirte road. The northern border is a hummock zone with partly cultivable land. The western border is the main Sirte-Misurata road and the project extends one kilometre to the west of the road.[1]

In 1937 the Italians started to develop the project area, but development stopped probably because of the war or the discovery of ground-water of better quality in the north.[2] In 1938 the Italians designed a project of 2,000 ha. for irrigation west of the present Misurata-Sirte road.[3]

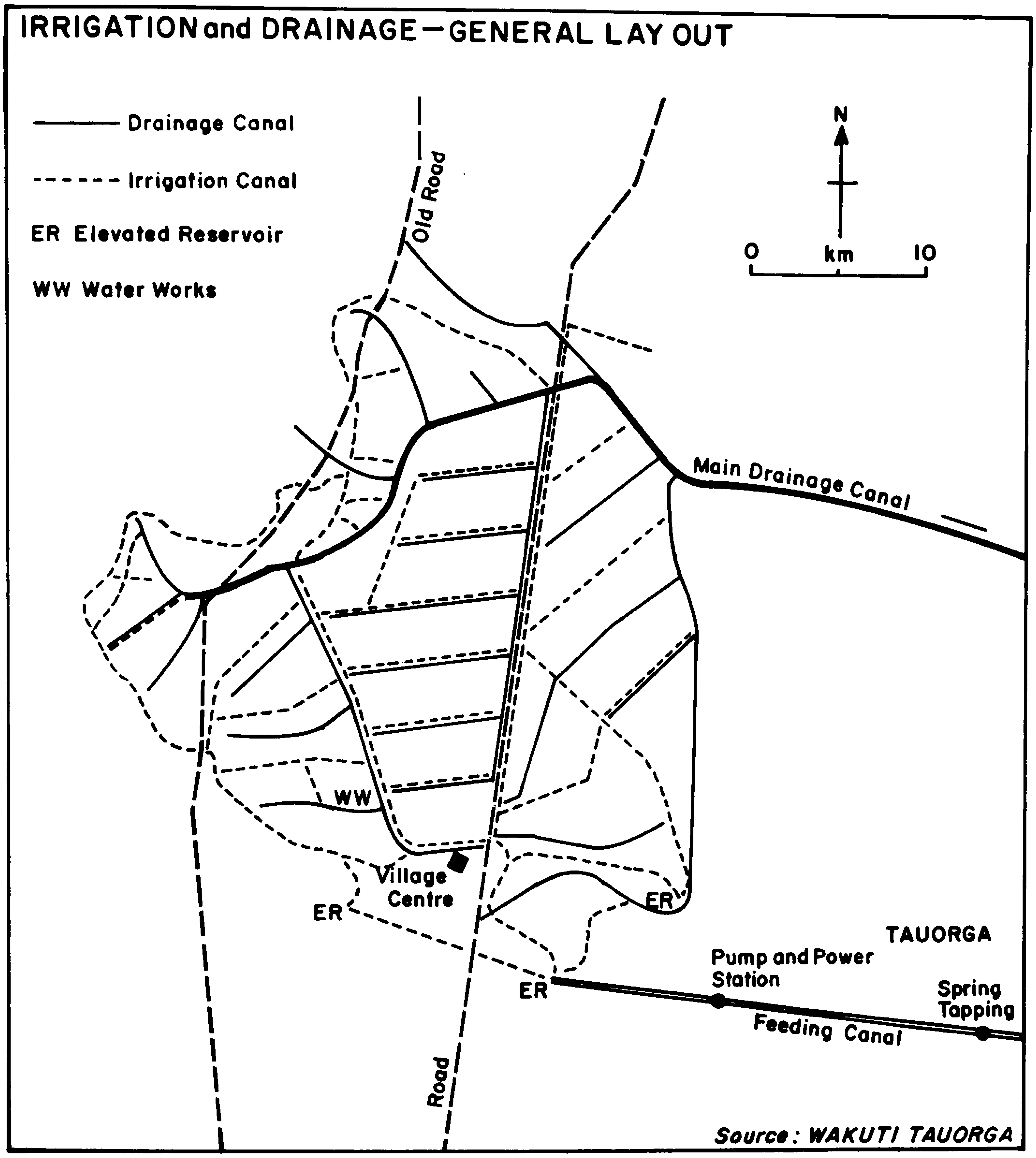
Population

The total population of Misurata Province, 61,625 persons, consists of settlers, semi-nomads and full-nomads. The population density in the province was, according to the 1954 and 1964 census,[4] respectively 73 and 88 persons per square kilometre, which indicates an increase of 20.57 per cent during the 10 year period.

Map No. 1


IRRIGATED AREA—LOCATION MAP
N
0
100
km
Main Roads
Secondary Roads
Irrigated Area
MEDITERRANEAN SEA
GULF OF SIRTE
TRIPOLI
Gharabulli
Kussabat
Tarhunah
Homs
Zlitan
Misurata
Misurata Marina
Tauorga
Buerat
Sirte
Ghadenia
Beniulid
Aziziyah
Mizda
100
200
500
(contours in metres above sea level)
SOURCE: WAKUTI

Map No. 2


IRRIGATION and DRAINAGE—GENERAL LAY OUT
Drainage Canal
Irrigation Canal
ER Elevated Reservoir
WW Water Works
N
0 km 10
Old Road
Main Drainage Canal
WW
Village Centre
ER
ER
ER
TAUORGA
Pump and Power Station
Spring Tapping
Feeding Canal
Road
Source: WAKUTI TAUORGA

In 1962 6,975 persons were semi-nomads and nomads, and 54,650 persons were settled in towns, villages, oases or in camps with tents. The latter includes the inhabitants of the Tauorga oasis, and these are the people for whom the project has been established so as to improve their living conditions.

In Tauorga, in 1962, 6,855 people were living of which 1,400, or 20 per cent, were Arabs and Mulattos, the other 5,500, or 80 per cent, negroes called Shushan.[5] The number of inhabitants in the actual project area differs according to different sources, i.e. between 5,000[6] and 11,000[7] people live in the project area.

The situation of the population in the oasis has been described by Di Agostini in 1917, based on the 1913 census,[8] and until the activities caused by the establishment of the project hardly any changes appeared.

The average family size in Tauorga oasis is assumed to be eight persons.[9] Polygamy is practised in 7.6 per cent of the families and the male:female ratio is 100 to 104.5. The birth rate and the death rate were respectively 45.4 and 10.3 in the Misurata area in 1970.[10]

The former negro slaves, having mixed mainly with Berbers, are emancipated and are completely free and independent. They are the real masters of the oasis because of their large number.

The diet of the inhabitants of Tauorga is based on barley, wheat and dates with somewhat limited amounts of meat and milk.

The economic situation in the oasis forced at least one member of each family to look for employment outside the oasis in non-agricultural jobs. In April 1974 the jobs which the rural population would most likely occupy if they gave up farming yielded the following incomes:

Table No. 1 Comparative incomes in Misurata[11]

OCCUPATIONS	INCOME/MONTH/DINAR
Labourer	50
Mason	150
Administrator	52.5 to 300
Policeman	72 to 300
Soldier	72 to 300
Driver	120 to 180

The minimum wage for any Governmental job and for companies working on behalf of the Government is 52.5 Dinar per month.

Present land use

The most important industry in Libya is the oil industry, which is the basis of the economy, and the source of funds for all future economic development. But only small numbers can be employed by oil companies, and the oil industry will be able to absorb a maximum of only about 15,000 local labourers in future. Therefore it is necessary to strengthen the other sources on income.

Agriculture employs more than 80 per cent of the population and as there are, with the exception of the oil industry, few other employment opportunities, this situation will not alter very much in the near future, but exact data are not available.

At present, Libya has the following land use: (in hectares)

LAND USE	TRIPOLITANIA	CYRENAICA	FEZZAN
Cultivated land	400,000	200,000	?
Pasture	8 million	4 million	?
Garden plots	?	?	2,700
Tree culture	?	?	120,000

The main tree cultures for the whole of Libya are:

Almond trees	1.8 million	Date trees	3 millions with a yield of 30,000 tons
Citrus trees	450,000	Olive trees	3.4 millions with a yield of 5,000 tons of oil
Fig trees	58,000		

Peanuts, introduced after the war, are successfully grown.

The total agricultural area is 140,000 sq.km., or eight per cent of the total area of Libya.

The main source of income in the project area and its vicinity is cattle rearing; this applies especially to the Bedouins.

In the project area small scale extensive shifting cultivation is practised in the wadis. Also, the area supplies the inhabitants with fire wood.

The farms in the Tauorga oasis are very small, varying between 0.24 ha. and 4.00 ha.

Between about 95,000 and 100,000 [12] palm trees are grown in the oasis. In addition to the palms, the following crops are grown: barley, tomatoes, beans, melons, water melons and chillis.[13]

The former Italian development area of about 75 ha. in the southern part of the project area is not used at all; its eight metre deep dug well is now dry and a drilled well, 665 m. deep, is closed. Approximately one kilometre south of the planned irrigation area there is a small oasis irrigated by a 16 m. deep dug well.

Two wells, the Bir Al Quidarigah, 11 m. deep, in the Wadi Sasu and the Bir Jimi, eight metres deep, at the northern border of the region supply only animals.[14]

The different items of the family income are shown:[15]

Table No. 2 Source of income

SOURCE	PROPORTION IN PERCENTAGE
Palm cultivation	45
Reed work	30
Crops (cereals)	20
Rearing of animals	5
Total	100

Only a small amount of the water from the Tauorga springs is used at the moment, and most of the discharge of the Tauorga spring evaporates unused in the Sabkah Tauorga. This sabkah stretches for 120 km. along the coast and has no discharge into the sea.

Even during Roman times the Tauorga springs were used for irrigation and the relics of Italian efforts to establish an irrigation project are found in the region.[16]

Research station

At present there is no research or demonstration unit working for the project. However, the establishment of such a unit at a later stage is being considered.[17]

Land tenure

The land and the date trees in the oasis are owned by the Arabs and Mulattos. In general the negroid population does not own any land, but cultivates the fields on behalf of the owners in return for 50 per cent of the harvest.[18]

Project policy indicates that 300 families will be settled, regardless of whether they were landowners or labourers in the old oasis. Preference will be given to those families whose members have been working in the project during the construction period and those whose size assures an adequate labour force.

The farms will be owned by the farmers, but they will be allowed to sell their farms only to the Government. Furthermore, disintegration of the 10 ha. units will not be allowed.

Whether the farmers will have to pay for their farms or not has not yet been decided fianlly. Nevertheless, there are already opinions as to how they would have to pay if in fact they did so. One opinion is that they will pay 50 per cent of the value of the farms for the subsequent 15 years. But the method of valuing the farms is not yet clear.[19]

Soil

Of the total project area of 8,000 ha. about 3,000 ha. with suitable soils have been selected for the agricultural land itself.

The wadis Gilgel and El Hauat end in an extensive basin where the soils developed under desert conditions. These soils fall into five categories as detailed below and as indicated as mapping units in Map No. 3.

Table No. 3

CATEGORY	GENERAL CHARACTER	DEGREE OF SALINITY	
a	thick loess layers	low	arable
b	50 cm.	medium to very high	
c	thin loess layer	low	
d	25 to 50 cm.	high - extremely high	
e	shallow or rock		non arable

In order to prepare the land for agricultural production, levelling is necessary. In mapping unit (a) and (b) levelling does not create any serious problem because the loess layer is more than 50 cm. thick. Areas (c) and (d) require levelling, but because of the thinner loess layer overlying extremely compacted lower marl horizons, a deep ploughing is also required in order to mix the loess and marl. However, where the layer is extremely thin, i.e. under 25 cm., levelling should be avoided.[20]

The water infiltration rates usually lie between three and five centimetres per hour, but in some places infiltration rates are as low as 0.25 cm. per hour and the highest rate is 7.3 cm. per hour.[21]

The following is a description of the map units shown in Map No. 3.

Mapping unit (a)

These soils are good arable, as their loess layer is more than 50 cm. thick. The main rooting zone extends to a depth of 50 to 75 cm.,[22] but is up to 140 cm.[23] deep in some places.

The ph value is 8.0, sometimes reaching 8.5. These soils are of a saline-alkaline type. The content of P_2O_5 available to plants is small, and the K_2O content is in general very high.[24] According to another source the P_2O_5 content is adequate.[25]

Mapping unit (b)

These soils differ from the soils of mapping unit (a) mainly in their degree of salinity, but this salinity can easily be decreased by leaching. Thus these soils are good arable.[26]

Mapping unit (c)

The main difference between soils of this mapping unit and soils of mapping unit (a) is the former's thinner loess layer of 25 to 50 cm. Here the soils are a little sandier which causes a higher infiltration rate. They are arable soils.[27]

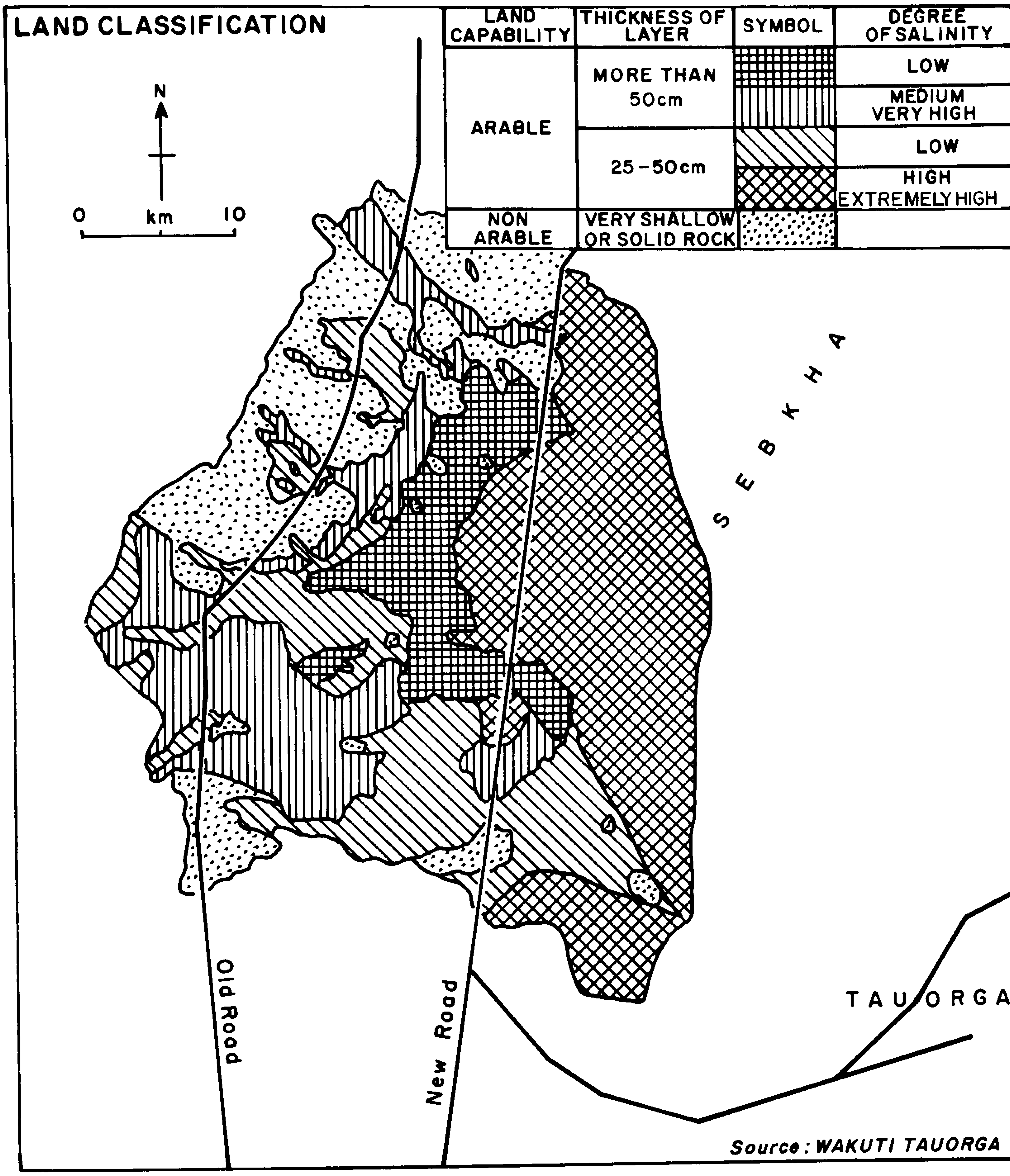
Mapping unit (d)

These soils differ from those in mapping unit (c) only in their salt content. With leaching, however, they can easily become arable.[28]

Mapping unit (e)

This unit includes solid rocks with a thin covering of sand or a

Map No. 3


LAND CLASSIFICATION
N
0 km 10
LAND CAPABILITY
THICKNESS OF LAYER
SYMBOL
DEGREE OF SALINITY
ARABLE
MORE THAN 50cm
LOW
MEDIUM VERY HIGH
25-50cm
LOW
HIGH EXTREMELY HIGH
NON ARABLE
VERY SHALLOW OR SOLID ROCK
SEBKHA
Old Road
New Road
TAUORGA
Source: WAKUTI TAUORGA

loess layer less than 25 cm. thick in some places. These layers are too thin for agricultural cultivation and these soils are thus not arable.[29]

Map No. 1, Volume II, Part 4, is an additional geological map.

Climate (See Diagram No. 1)

In general, the climate is arid. Climatic data for the project area are not available, and therefore data from Misurata and Sirte have been used. This data was supplemented by data collected in Tauorga during the field investigations.

The rainfall in particular differs greatly between Misurata and the project area. The average rainfall of Misurata is 250 mm./year, while the rainfall of the project area is approximately only 125 mm.

The degree of humidity in the project area also varies considerably from that in Misurata.

The difference between the temperature of the two areas is very small.

The average annual evaporation from a free water surface is 2,000 mm. and when the Ghibli is blowing it may reach more than 18 mm. daily.[30]

Table No. 4 gives a summary of meteorological data collected by the stations in Misurata and Sirte.

Salination

Heavy salination occurs in mapping units (b) and (d). The high permeability of the soil and the high solubility of the salt make leaching easy, but a considerable amount of water will be required for this.[32]

Leaching tests showed a salts content of surface layers between three and five per cent.[33]

In D1 and D2, with an irrigation rate of about 850 mm. applied over a period of 10 days the decrease in salinity was as follows:[34]

Diagram No. 1

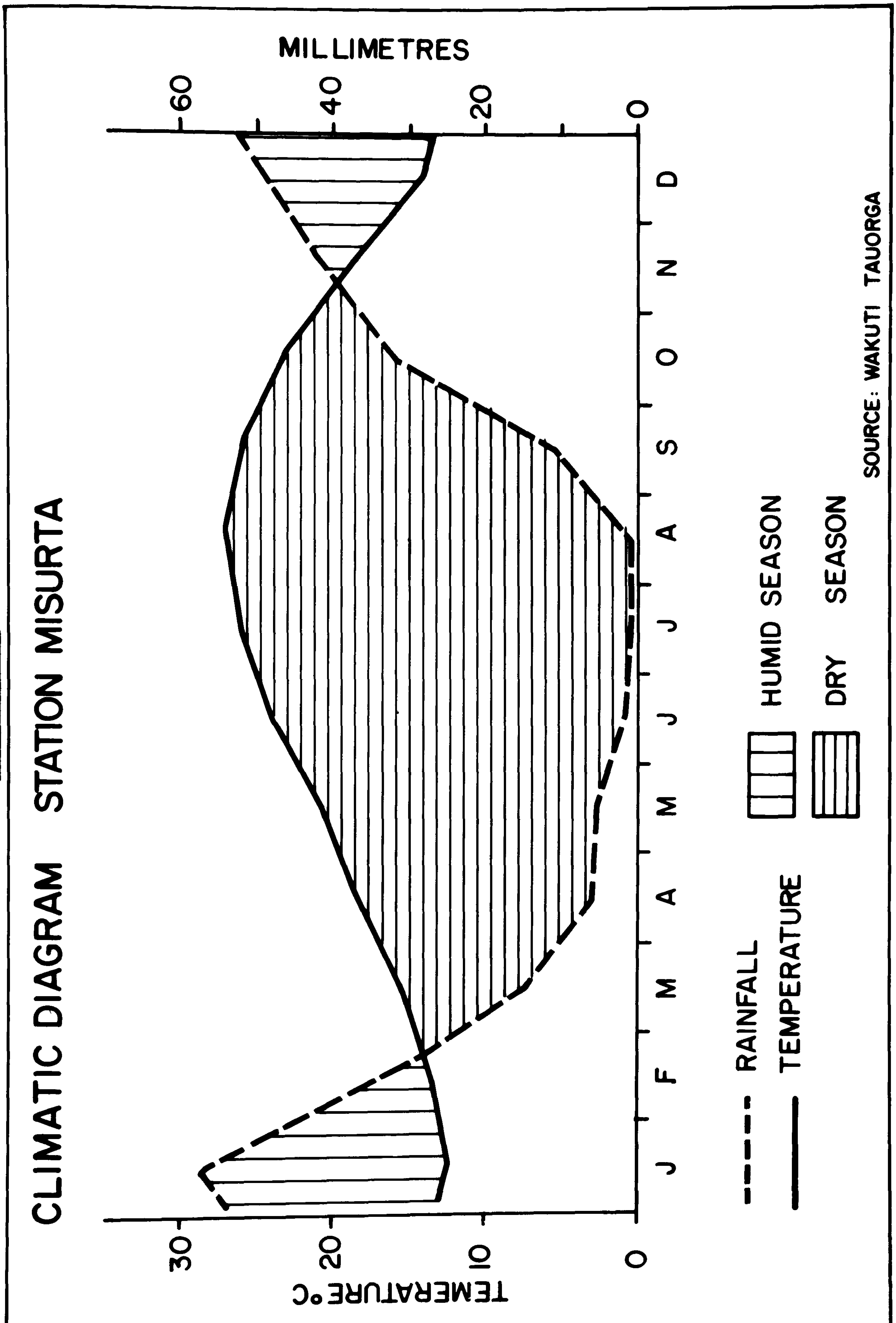

CLIMATIC DIAGRAM STATION MISURTA
MILLIMETRES
60
40
20
0
TEMERATURE °C
30
20
10
0
J
F
M
A
M
J
J
A
S
O
N
D
RAINFALL
TEMPERATURE
HUMID SEASON
DRY SEASON
SOURCE: WAKUTI TAUORGA

Table No. 4 Meteorological data (Misurata-Sirte)[31]

STATION AND DATA MISURATA	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR	PERIOD
T. Mean Max.	17.5	19.0	21.5	24.1	26.2	29.8	31.7	32.2	31.2	28.7	24.1	19.1	25.4	18 yrs.
T. Mean Min.	7.4	8.0	9.8	12.4	15.2	18.5	20.6	21.8	20.7	17.6	13.7	9.1	14.6	18 yrs.
T. Mean	12.5	13.5	15.6	18.3	20.7	24.1	26.2	27.0	25.9	23.2	18.9	14.1	20.0	18 yrs.
T. Ex. Max.	30.1	32.6	38.8	45.2	44.9	51.2	46.8	46.1	47.6	46.1	35.7	28.9	51.2	18 yrs.
T. Ex. Min.	0.2	0.3	1.2	1.2	8.2	11.2	15.2	17.2	12.5	9.1	5.0	2.0	0.2	18 yrs.
Mean Rel. Hum.	63	64	61	57	58	58	60	61	63	62	65	66	62	18 yrs.
Mean Rainfall	57.3	33.2	14.5	5.7	5.0	1.4	0.0	0.6	10.6	32.1	41.3	48.7	250.4	32 yrs.
SIRTE														
T. Mean Max.	17.8	18.9	21.2	25.2	27.4	29.5	30.3	31.0	30.7	29.2	24.7	19.7	25.5	14 yrs.
T. Mean Min.	8.0	8.8	11.0	13.4	16.2	18.8	21.2	22.4	21.1	18.4	13.5	9.3	15.2	14 yrs.
T. Mean	12.9	13.9	16.1	19.3	21.8	24.2	25.7	26.7	25.9	23.8	19.1	14.5	20.4	14 yrs.
T. Ex. Max.	28.4	34.5	38.2	45.0	45.8	51.0	46.4	46.6	43.5	41.0	38.0	29.5	51.0	14 yrs.
T. Ex. Min.	1.9	0.4	1.8	4.5	6.0	9.5	10.2	18.0	14.8	11.0	6.7	2.0	0.4	14 yrs.
Mean Rel. Hum.	66	66	62	58	62	62	65	67	68	64	65	64	64	14 yrs.
Mean Rainfall	38.4	24.8	12.9	2.4	1.7	0.5	0.0	0.0	9.9	13.7	22.3	35.9	162.5	26 yrs.

Table No. 5

	D1 DECREASE IN PERCENTAGE	D2 DECREASE IN PERCENTAGE
Potassium	91	89
Sodium	97	96
Magnesium	84	86
Calcium	27	29
Chloride	97	96
Sulphate	64	63

Topography

The area slopes from east to west. At the western border of the Sabkah of Tauorga the height is approximately 10 m. above sea-level; there follows a slope to an area 15 m. above sea-level, with hummocks of alluvial blown sand. These hummocks are rarely found in the areas south of Kararim-Gioda.

To the west of the Sirte-Misurata highway, south and west of the former Italian irrigation area, the terrain slopes from 20 up to 40 m. above sea-level.

The main part of the project area is a plain 20 m. above sea-level, which is crossed by several wadis on the western border. These wadis are from north to south:[35]

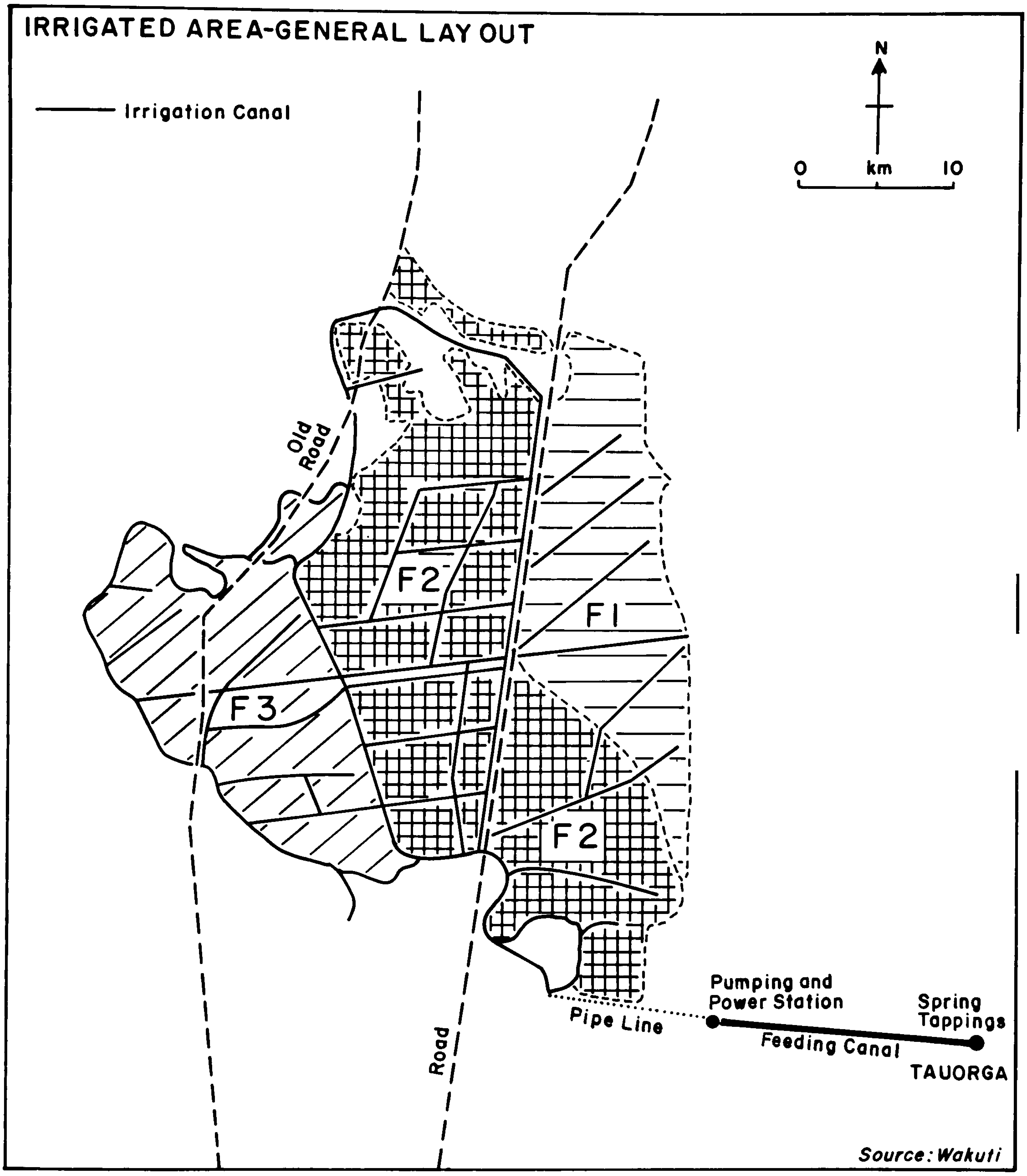
Wadi Gilgel - Wadi Sasu - Wadi El Hauat

Irrigation (See Map No. 4)

Three water sources are available for irrigation:[36]

1. Dug wells from a ground-water level 5.0 to 20.0 m. deep.
2. Drilled wells 500 to 600 m. deep.
3. Tauorga springs.

Map No. 4


IRRIGATED AREA-GENERAL LAY OUT
Irrigation Canal
N
0 km 10
Old Road
F2
F1
F3
F2
Road
Pipe Line
Pumping and Power Station
Feeding Canal
Spring Tappings
TAUORGA
Source: Wakuti

Existing water reserves

Dug wells

The chemical quality of the water of these wells is shown in Table No. 9 . The chemical analysis of all samples taken can be seen in Table No. 1, Volume II, Part four.

According to the chemical analyses the shallow wells have a high salt content with chlorides and sulphur exceeding 1,000 ppm. Only the Bir Jimi well had a lower salt content - 439.7 ppm.

The upper aquifer is fed mainly by the rare rainfall and can only supply a limited amount of water through the shallow wells.

South of Tauorga there are wells up to 24 m. deep supplying the water needs of the farms in that locality. The output of these wells is estimated to be 0.5 cu.m./sec.[37]

Drilled deep wells

A number of drilled wells between 528 and 665 m. deep are found in the area. These wells are artesian or semi-artesian, and most of them will have to be equipped with pumps. However, some of them deliver artesian water by natural outflow (see Table No. 10).

Most of the water originates from the Upper Cretaceous limestone stratum, about 500 to 600 m. deep. The deepest well, 665 m. deep, is in the project area 1.250 km. west of the main Sirte-Misurata road. But this well is blocked at present, however, in 1956 an output of 130 cu.m./h. was measured. Other wells in the area supply up to a maximum of 250 cu.m./h. The following table shows the output of a number of wells.

Table No. 6

WELL	DELIVERY IN cu.m./h.	YEAR
Pozzo 15	200	1939
Pozzo 14	250	1939
Pozzo 13	150 in 1940	1956 only 30 cu.m./h.
Pozzo 12	250	1938
Pozzo 20	70	1939
Misurata 1	200	1938
Tauorga Deep Well	130	1956

The average output of these wells is 178 cu.m./h. Assuming the output of each well drilled in future to be 120 cu.m./h., a projected water demand of 2.5 cu.m./sec. for the irrigation scheme would require 75 wells.[38] Therefore, it is more economical to use the Tauorga springs than to drill new wells, particularly since the quality of water from these wells is not expected to be better than that from the springs.[29]

The Tauorga deep well can be enlarged for potable water, but when more water is needed later, due to the increasing population and industrialisation, it will be necessary to drill more wells.[40]

Tauorga springs

The artesian water of the deep wells and Tauorga springs originates in the limestone layer of the Upper Cretaceous. It is probable that this relatively large quantity of artesian water originates in the eastern part of Djebel Nefussa with its higher annual rainfall.

Before World War II the output of the springs was calculated to be 3.5 cu.m./sec., in November 1961 5.00 cu.m./sec.[41] and in April 1965 3.02 cu.m./sec.[42]

The chemical analyses made in March 1965 showed the following:

Temperature	31°C
Specific conductance	4.2 micromhos at 25°C
ph	7.4
Total hardness as $CaCO_3$	1,333.8 ppm
Total dissolved solids	2,940.0 ppm
SiO_4	24.0 ppm
Ca	292.0 ppm
Mg	147.1 ppm
Na	494.2 ppm
K	32.8 ppm
HCO_3	296.5 ppm
CO_3	-
Cl	914.9 ppm
SO_4	864.1 ppm
NO_2	0.004 ppm
NO_3	20.7 ppm
Fe	traces

The SAR value of the spring water is 6; thus there is no sodium danger to plants. The water falls into class C4-S2 according to the American classification. Thus the water is suitable for irrigation.

All machine and steel parts which touch the spring water must be protected against corrosion, and high quality concrete must be used.

Chemical quality of different aquifers in the area

Water in the area of Tauorga can be placed in the following two categories:[42] (See Volume II, Part four, Table No. 2)

Table No. 7

1. Ground-water from the Upper Aquifer (Dug Wells)

CLASS	WELL No.	PROPORTION IN PERCENTAGE
Fair	5	11
Poor	2, 3, 4, 9, 11, 13, 15	78
Brackish	14	11

"Good" or "salty" water does not occur.

Table No. 8

2. Artesian water (drilled wells and Tauorga springs)

CLASS	WELL OR SPRING No.	PROPORTION IN PERCENTAGE
Fair	Sample No. 6 (Kararim) Tauorga Deep Well	33
Poor	No. 7 (Pozzo 12) No. 8 (Pozzo 13 or 14) Tauorga springs (No. A+16 = B) (No. A+16 = B)	50
Brackish	No. 17 (Pozzo 15)	17

"Good" and "salty" water does not occur.

Water demand of the cultivated plants

The agricultural area will be irrigated by open canals. The methods applied will be "border strip" and "furrow" on the one hand, and "basin irrigation" for tree cultures on the other. The water demand from these methods is as follows:

Table No. 9

Dug wells[44]

No. OF WELL	NAME OF WELL	DEPTH OF WELL IN m.	DEPTH TO WATER LEVEL IN m.	SALINITY ppm	CL ppm	CLASSIFICATION (JONES 1964)	TEMPERATURE + °C
19		8.00	dry	-	-	-	-
2	Farm near Mantiquat Al Qurayy'r	16.50	15.50	3,284	1,007	poor	20.5
3	Bi'r Al Aniyah	13.70-14.50	13.00	2,680	837	poor	18.0
4	Bi'r Al Qidariyah	11.10	10.00	3,228	858	poor	-
5	Bi'r Jimi	7.50	6.65	1,720	440	fair	20.0
9	Bi'r Al Judayyidah	18.50	18.00	2,250	979	poor	-
10	Bi'r Qasr Bin Karmah	24.00	dry	-	-	-	-
11	Farm I south-west of Tauorga	13.50	dry (15.00)	-	-	poor	-
12	Farm II south-west of Tauorga	23.80	11.50	-	-	poor	-
13	Shallow well of Farm II south-west of Tauorga	12.00	11.00	-	1,113.4	poor	-
14	Shallow well of Farm III south-west of Tauorga	9.80	9.30	-	1,446.8	brackish	-
15	Bi'r Al Kararim	3.25	3.00	-	1,099.3	poor	-
171	Shotpoint borehole M3/171 (1956)	27.20	18.10	-	-	-	-

Table No. 10

Drilled deep wells[45]

No. OF WELL	NAME OF WELL	DEPTH OF WELL IN m.	DEPTH TO WATER LEVEL IN m.	SALINITY ppm	CL ppm	CLASSIFICATION (JONES 1964)	TEMPERATURE + °C
6	Artesian well - Kararim		+ 1.9	-	361.7	Fair	30
7	Drilled artesian well (Pozzo No. 12)	528.00	+ 1.75	1,700	355–432.6	Poor	34
8	Artesian drilled well	657.00	+ 0.5	3,746	1,482.2	Poor	-
17	Drilled deep well (Pozzo No. 15)	607.00	-	4,020–4,670	1,730–1,880	Brackish	39.5
	Drilled deep well Tauorga	665.00	(Blocked)	-	250.00	Fair	39.0

Table No. 11 Water demand

CROP	VEGETATION PERIOD	WATER DEMAND mm.	cu.m./ha.
Beets	October-April	955	9,550
Beets	March-August	1,519	15,190
Alfalfa	All the year round	3,453	34,530
Vegetable	All the year round	2,760	27,600
Corn	October-April	872	8,720

These demands include:

1. Evapotranspiration rate.
2. Feeder canal losses and water distribution losses (10 per cent).
3. Infiltration losses (20 per cent).
4. Surface discharge and evaporation during irrigation (10 per cent).
5. In addition, 36.5 per cent of the amount of water stated under (1) to (4) is necessary for leaching.[46]

It can be seen from Tables Nos. 12 and 13 that the actual consumption of the plants is far less than the total demand.

The available quantity of water is 78.0 million cu.m./year. This is sufficient as the yearly total demand is 63.772 million cu.m., which equals approximately 2,500 ltr./sec.[50] (See Table No. 13)

Water requirement for the scheme

The projected experimental farm and the old oasis will be supplied with 0.1 cu.m./sec. of water each.

The new scheme requires 2,430 ltr./sec. which represents a monthly supply of 6.498 million cu.m.

The maximum demand in July with a cultivated area of 1,800 ha. is 1.35 ltr./sec. x ha. The maximum demand in March with a cultivated area of 3,100 ha. is 0.64 ltr./sec. x ha.

Table No. 12 Water consumption of plants (in mm.)[47]

CROP	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	IN TOTAL
Pot. Etp.	80	90	112	150	191	215	220	213	189	160	119	81	1820
Beets	58	66	77	57	-	-	-	-	-	50	87	59	454
Beets	-	-	50	110	139	157	161	104	-	-	-	-	721
Alfalfa	72	81	101	135	172	194	198	192	170	144	107	73	1639
Dates	65	73	91	122	155	174	178	173	153	130	96	66	1476
Vegetables	58	65	81	108	138	155	158	153	136	115	86	58	1311
Corn	52	59	73	50	-	-	-	-	-	50	77	53	414

Table No. 13 Water consumption of plants for the whole scheme in 1,000 cu.m.[48]

CROP	AREA IN ha.	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
Alfalfa	600	918	1,026	1,278	1,704	2,172	2,454	2,502	2,424	2,148	1,818	1,350	924	20,718
Vegetable	600	732	822	1,026	1,362	1,746	1,956	1,998	1,932	1,716	1,452	1,086	732	16,560
Beets	600	732	834	972	720	-	-	-	-	-	630	1,098	744	5,730
Vegetable	600	-	-	-	-	1,746	1,856	1,998	1,932	1,716	-	-	-	9,348
Corn	1,300	1,440	1,623	2,015	1,374	-	-	-	-	-	1,374	822	1,468	11,416
TOTAL	3,100	3,892	4,305	5,291	5,160	5,664	6,366	6,498	6,288	5,580	5,274	5,656	3,868	63,772

Table No. 14 Water demand for plants per ha. (in mm.)[49]

CROP	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
Beets	122	139	162	120	-	-	-	-	-	105	183	124	955
Beets	-	-	105	232	293	331	339	219	-	-	-	-	1519
Alfalfa	153	171	213	284	362	409	417	404	358	303	225	154	3453
Dates	137	154	192	257	326	366	375	364	322	274	202	139	3108
Vegetable	122	137	171	227	291	326	333	322	286	242	181	122	2760
Corn	110	124	154	105	-	-	-	-	-	105	162	112	872

The supply for the three irrigation areas of the project will be as follows:

Table No. 15

AREA	SIZE IN ha.	DEMAND IN ltr./sec.
F1	719.3	559
F2	1,631.3	1,269
F3	773.0	602
Total	3,123.6	2,430

Thus the total demand will be 2.430 cu.m./sec. based on a 24 hour day irrigation system. The output from Tauorga springs of 3.020 cu.m./sec. is thus sufficient to meet the total demand, but since the pump station will work for 20 hours daily the demand will increase to 3.120 cu.m./sec. This slightly exceeds the output of the springs and will result in a lowering of the water-level in the springs to 6.35. To ensure the water supply to the scheme the calculations in this study are based on a spring water-level of +6.23 above sea-level.[51]

Tapping of the Tauorga springs

The Tauorga springs have been lined by an earth dam with a crest of one metre above the hydrostatic spring level. The two springs have been connected by a canal. Three different outlets have been provided:

1. To feed the canal, with a discharge rate of 3.20 cu.m./sec.;
2. To the pumping station at the projected experimental farm, at a rate of 0.10 cu.m./sec., and
3. To the Old Oasis Canal, at a discharge rate of 0.10 cu.m./sec.

The dimensions of the outlets have been calculated on the basis of the lowest expected spring water-level. The discharge of the outlet of the Old Oasis Canal will vary from 70 to 160 ltr./sec. according to the varying water-level of the springs.[52]

Feeder canal

The required 3.20 cu.m./sec. of water, sufficient for 20 hours irrigation, is supplied by Tauorga springs, from which it flows through the feeder canal to the pump station. This canal is 3,000 m. long and has a gradient of 0.1 per cent; i.e. it descends from 4.92 m. above sea-level at the spring to 4.62 m. above sea-level at the pump station. It is 4.00 m. wide and 1.20 m. deep.[53]

Pumping station and elevated reservoirs[54]

From the pumping station the water is pumped into the elevated reservoirs, and branch pipes are installed to lead the water directly into the stilling basins in case one of the elevated reservoirs has to be repaired.

The water to be stored in the elevated reservoirs will be sufficient to irrigate for three to four hours. Thus the water demand of the plants can be satisfied even if there is a short breakdown in one of the pumps, as shown in the table below.

Table No. 16 Elevated reservoirs - input and output of irrigation water

No. OF ELEVATED RESERVOIR	INPUT FROM THE PUMP STATION cu.m./sec.	OUTPUT TO THE MAIN CANAL cu.m./sec.	CAPACITY IN cu.m.	IRRIGATION TIME IN HOURS
ER 1	0.736	0.559	8,000	3.98
ER 2	1.672	1.269	15,150	3.31
ER 3	0.792	0.602	8,000	3.70

Main canals

These canals bring the water from the reservoirs to the sub-canals in the different irrigation areas.

The length of the three main canals is as follows:

Table No. 17

No. OF CANAL	LENGTH IN km.[55]
F1	5.755
F2	9.180
F3	6.310
Total	21.245

The bottom width of these canals varies between one and four metres, their depths are between 0.80 m. and 1.10 m. and they have gradients from 0.1 per thousand to 0.3 per thousand. This results in a velocity of flow varying from 0.30 m./sec. to 0.70 m./sec.[56]

All canals are built of reinforced concrete. A four metre long overflow has been provided at the end of the main canals, their crest being 0.20 m. from the top.[57]

To meet the water demand of the agricultural area the canals supply the following quantities of water:[58]

Table No. 18

No. OF CANAL	SUPPLY IN ltr./sec.	DEMAND IN ltr./sec.
F1	700	559
F2	1,575	1,269
F3	700	602

Sub-canals

The sub-canals supply the lateral canals with irrigation water. Their total length is 46.858 km.

Generally the distance between the sub-canals is 700 m. These canals follow the slope of terrain and therefore several bottom falls are necessary.[59]

The bottom width of these canals varies from 0.60 m. to 1.00 m. The canals are 0.75 m. deep and the water 0.60 m. deep. At the end of each sub-canal an overflow, 2.00 m. long, is provided. The incline varies between 0.1 per thousand and 0.8 per thousand. This results in a velocity of flow ranging from 0.30 m./sec. to 1.00 m./sec., thus preventing damages. At the junction of the sub-canals and the lateral canals, the sub-canals are 0.50 m. higher.[60]

These canals are built of reinforced concrete.[61]

Based on an irrigation time of six hours every four days, 16 lateral canals can be supplied with their maximum water demand of 175 ltr./sec., which is 60 per cent of the summer maximum water. But there are a number of sub-canals which supply more than 16 lateral canals and are designed to carry more water:

For up to 16 lateral canals	175 ltr./sec.
For 17 to 32 lateral canals	350 ltr./sec.
For more than 32 lateral canals	525 ltr./sec.

Lateral canals

The lateral canals will lead the water supplied by the sub-canals to the fields.

The lengths of the different canals range from 600 to 700 m. and the distance between them from 140 m. to 160 m. The total length of the lateral canals is detailed below:

Table No. 19

IRRIGATION AREA	LENGTH IN km.
F1	48.280
F2	101.320
F3	47.220
Total	196.820

These canals are also built with reinforced concrete.[62] The bottom width is 0.60 m. and the gradient 0.35 per thousand. For the normal canal 175 ltr./sec. will be the maximum capacity with a velocity of flow of 0.53 m./sec.[63] The maximum water demand of 1.82 ltr./sec. and the fact that some farmers will cultivate up to 60 per cent alfalfa is taken as the basis for calculation of the size of these canals. Thus the actual water quantity to be distributed is 175 ltr./sec. This quantity is sufficient for a cultivation area of 60 per cent of the total agricultural area during summer. It is also higher than the demand in March when 100 per cent of the area is cultivated, when the demand is 103 ltr./sec. for a 10 ha. farm.[64]

Structures in the irrigation canals[65]

In order to keep the velocity of flow within safe limits, bottom falls are installed in some places in the main and sub-canals. These bottom falls are 0.50 m., 0.80 m., 1.00 m. or 1.30 m. high, depending upon the gradient of the terrain.

Where the main and sub-canals cross roads, sag pipes have been installed.

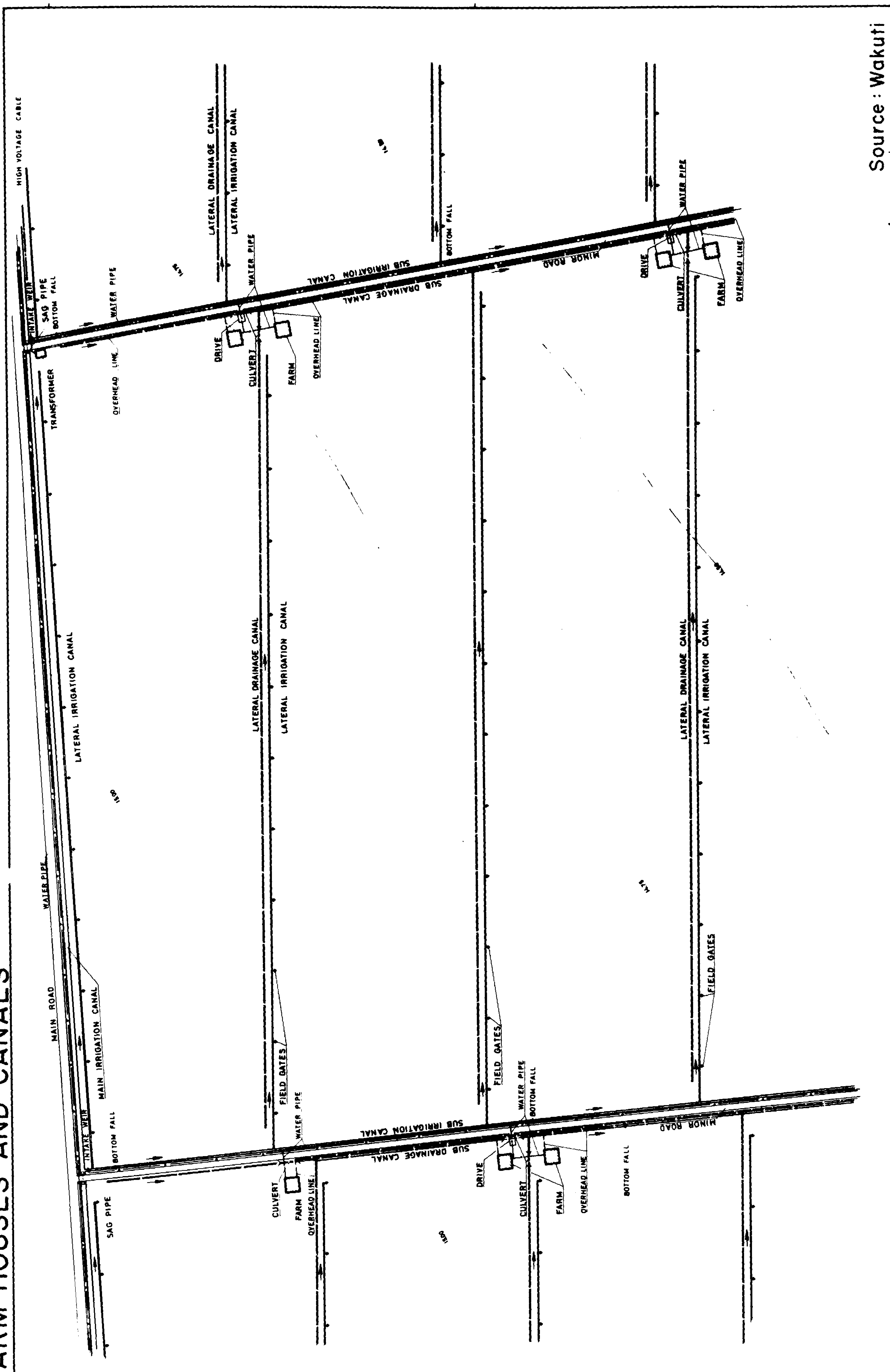
Map No. 4 shows the total irrigation network, and Map No. 5 illustrates the arrangement of the farms in this network.

Structures for drainage canals

The bottom falls, necessary in some places, are of different heights

Map No. 5

FARM HOUSES AND CANALS



according to the gradient of the terrain. These heights are: 0.50 m., 0.80 m. and 1.00 m., and they are linked to stilling basins of 3.50 m., 4.00 m. and 4.50 m. in length respectively. The bottom falls, the stilling basins and the three metre long stabilized slopes from the stilling basins downstream are made of concrete.

Where main and sub-canals cross roads, culverts are installed, varying in length from 16.00 m. to 60.00 m., designed for 1.5 x the flood discharge.[68]

Lateral canals

The lateral drainage canals run parallel to the lateral irrigation canals at an average distance of 150 m. apart from each other, and are between 600 m. and 700 m. long.

The specifications of the canals are detailed below:[69]

Canal length	600 to 700 m.
Terrain incline in direction of flow	appr. 0.5‰
Bottom incline of the canals	1.0‰
Discharge	10.00 ltr./sec.
Water depth	0.12 m.
Canal depth when branching to the sub-canal	appr. 1.2 m.
Canal depth at the beginning	appr. 0.9 m.
Bottom width	0.40 m.
Slope	1:1

Their total length is as follows:[70]

Table No. 20

AREA	LENGTH IN km.
D1	64.690
D1.1	51.700
D1.2	47.490
D1.3	12.150
Total	176.030

Sub-canals

These canals will lead the water from the lateral canals to the main canals and they will be able to discharge between 0.41 ltr./sec. x sq.km. and 0.96 ltr./sec. x sq.km. To avoid any damage the velocity of flow has to be between 0.30 m./sec. and 0.60 m./sec. Therefore their dimension is as follows:

Table No.

Bottom width	0.50 m. (except D1a with 2.00 m.)
Incline	0.2‰
Slope	1:1.5

Bottom falls are installed in some places and, where necessary, the slope food is supported by stone fascines. Several sub-canals will be supplied with water from areas outside the scheme, such as D1b, with a discharge quantity of 3.00 cu.m./sec., including the drainage water from wadi Sasu, and D1g with 1.10 cu.m./sec., including the drainage water of wadi El Hauat.[71]

The total length of the sub-canals is 39.580 km.[72]

Main canals (See Map No. 6)

The main canals will lead the drainage water from the sub-canals to the main canal D1.

Their dimensions are detailed below:

Table No. 20a Dimension of main canals

Bottom width	0.5 m. to 4.00 m.
Slope	1:1.5
Incline	0.35‰ to 1.5‰
Depth	minimum 2.00 m.

Bottom falls are installed in some places and where the canals are situated in sandy areas, the slope foot has been stabilized by stone fascines.

The velocity of flow in these canals will be from 0.30 m./sec. to 0.60 m./sec.

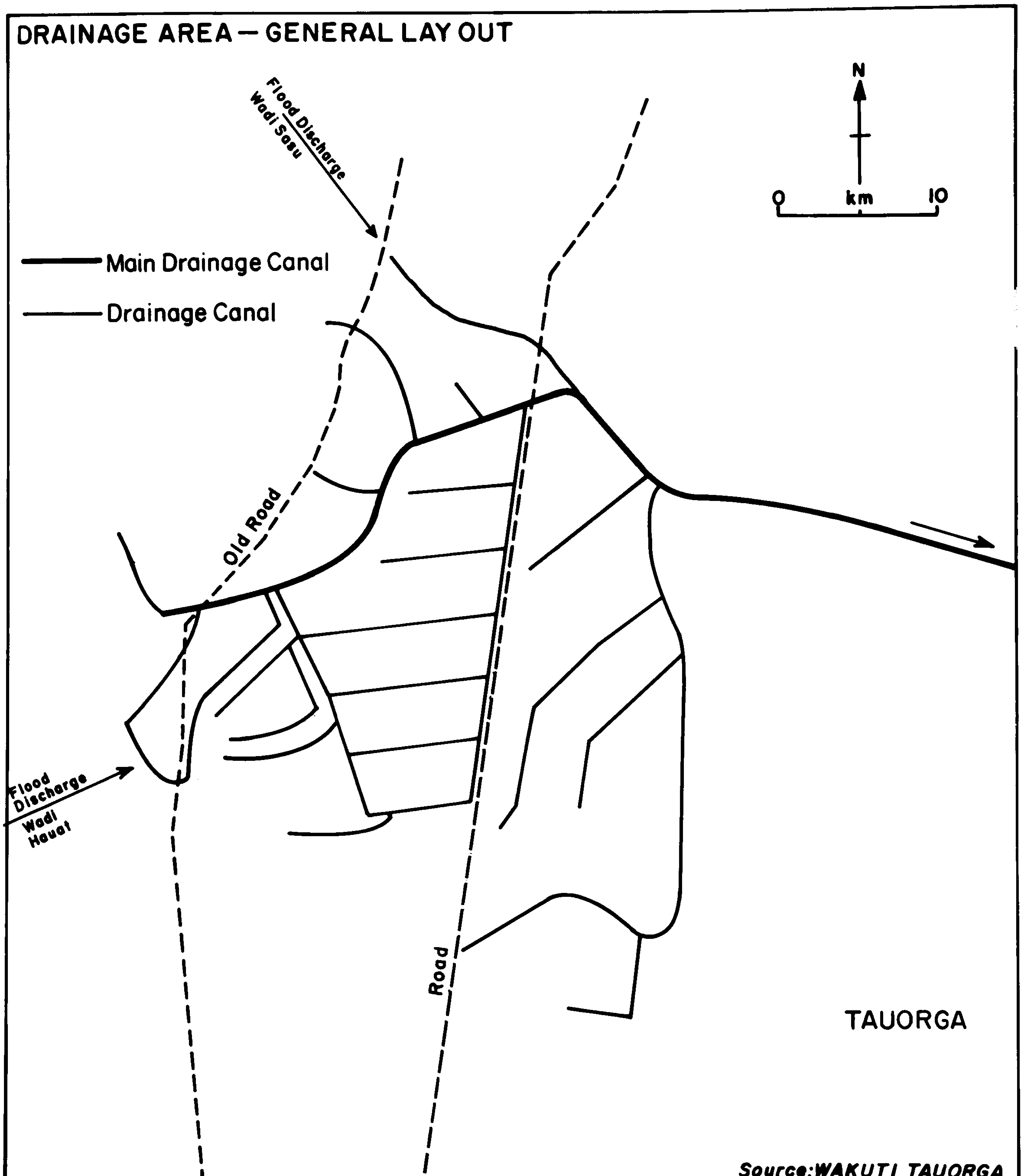
The canal D1, planned for a discharge of 4.1 cu.m./sec, will lead the drainage water into the Sabkah Tauorga, 7.5 km. away from the scheme and 5.00 m. lower than the eastern border of the project area.[73]

The lengths of the main drainage canals are as follows:[74]

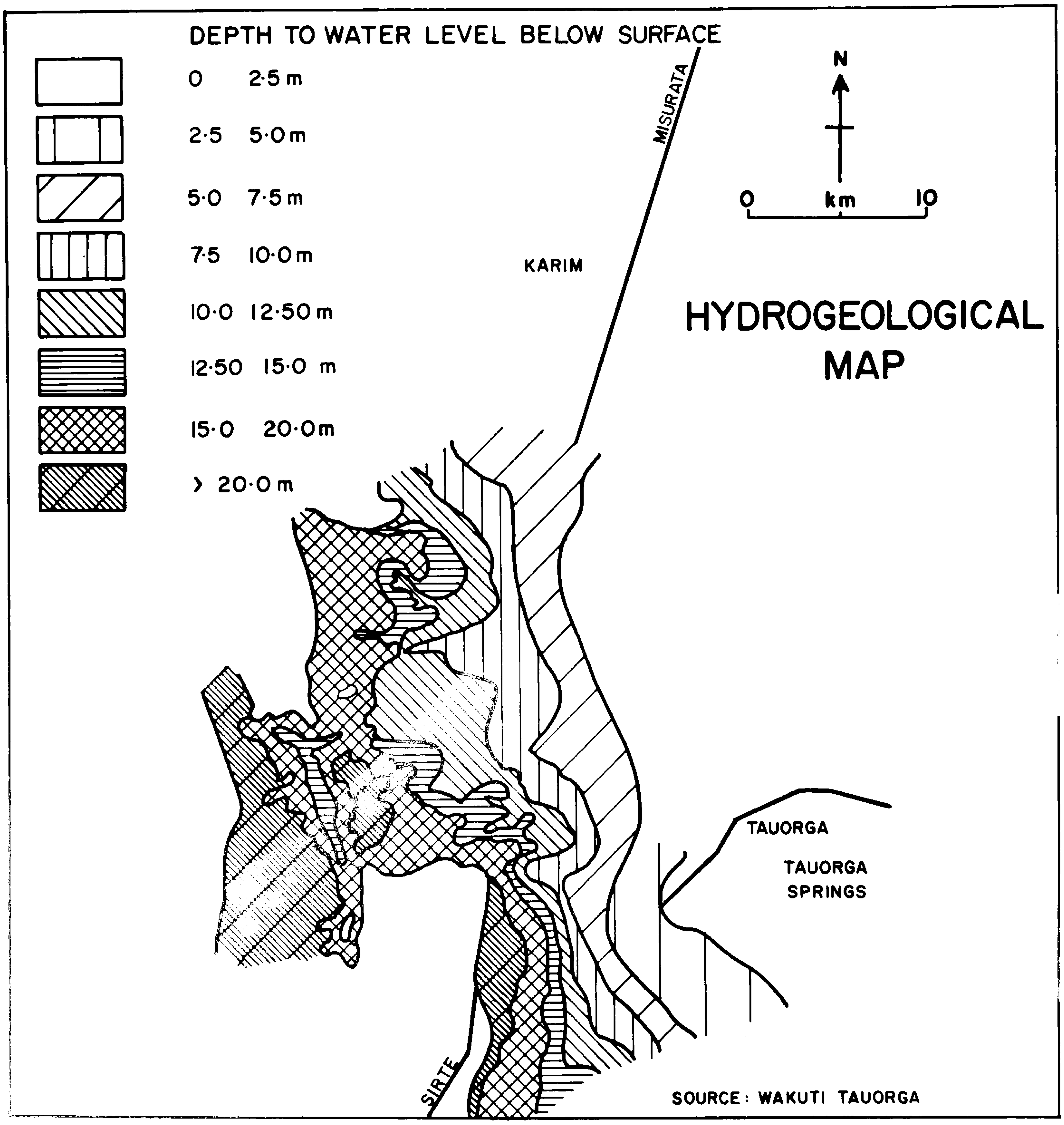
Table No. 21

CANAL	LENGTH IN km.
D1	14.540
D1.1	5.555
D1.2	3.820
D1.3	1.770
Total	26.085

Map No. 6


DRAINAGE AREA — GENERAL LAY OUT
Flood Discharge
Wadi Sasu
N
0 km 10
Main Drainage Canal
Drainage Canal
Old Road
Flood Discharge
Wadi Hauat
Road
TAUORGA
Source: WAKUTI TAUORGA

Map No. 7


DEPTH TO WATER LEVEL BELOW SURFACE
0 2·5 m
2·5 5·0 m
5·0 7·5 m
7·5 10·0 m
10·0 12·50 m
12·50 15·0 m
15·0 20·0 m
› 20·0 m
MISURATA
N
0 km 10
KARIM
HYDROGEOLOGICAL MAP
TAUORGA
TAUORGA SPRINGS
SIRTE
SOURCE: WAKUTI TAUORGA

Drinking water

The Tauorga Deep Well will supply the scheme with drinking water and its output of 130 cu.m./sec. is substantially higher than the estimated water demand of 330 cu.m./day. Unfortunately, the well is blocked at present so that no samples could be taken and from earlier analyses only the chloride content of 250 ppm is known. But since the well water originates from the same aquifer as that in the other wells it should have the same quality and thus be suitable as drinking water without any special treatment.

A pipeline system will supply the farms, the village centre and all other buildings with potable water. Since the water of the Deep Well is very corrosive only PVC pipes will be used for this system.[75]

The total demand for drinking water will be as follows:[76]

Table No. 22

Water consumption per farm/day

8 persons with a demand of 80 ltr./day each	640 ltr.
2 cows with a demand of 50 ltr./day each	100 ltr.
2 donkeys with a demand of 40 ltr./day each	80 ltr.
5 sheep with a demand of 20 ltr./day each	100 ltr.
15 hens, etc.	10 ltr.
	930 ltr.

Table No. 23 Total demand

Supply for farms (300 x 930 = 280,000 ltr./day)	280 cu.m./day
Public demand appr.	20 cu.m./day
Water losses appr. 10%	30 cu.m./day
	330 cu.m./day

The maximum consumption per hour will be 9.2 ltr./sec.

Power supply

The pumping station, the village centre, the water-works and the farms will be supplied with energy from a Diesel power station.[77]

Resettlement

The Tauorga scheme is essentially a simple project of improving agriculture, housing and other facilities for the present oasis dwellers. This will make it possible for the people to remain in the area as it enables them to earn an adequate income, thus preventing depopulation.

Each family will be given a farm and for the whole community a village centre with all necessary facilities will be established.

Village centre[78] (see Map No. 7)

All social, administrative and other buildings required for the servicing of the project area will be located in the village centre. All buildings are being built around a 70 x 100 m. market place. The following buildings are being built in the village centre: municipal school, mosque, covered market and storage, 18 shops, one hotel, and a block of flats for the necessary project staff. Inhabitants of the old oasis will also use these facilities.

Farm units[79] (see Map No. 8)

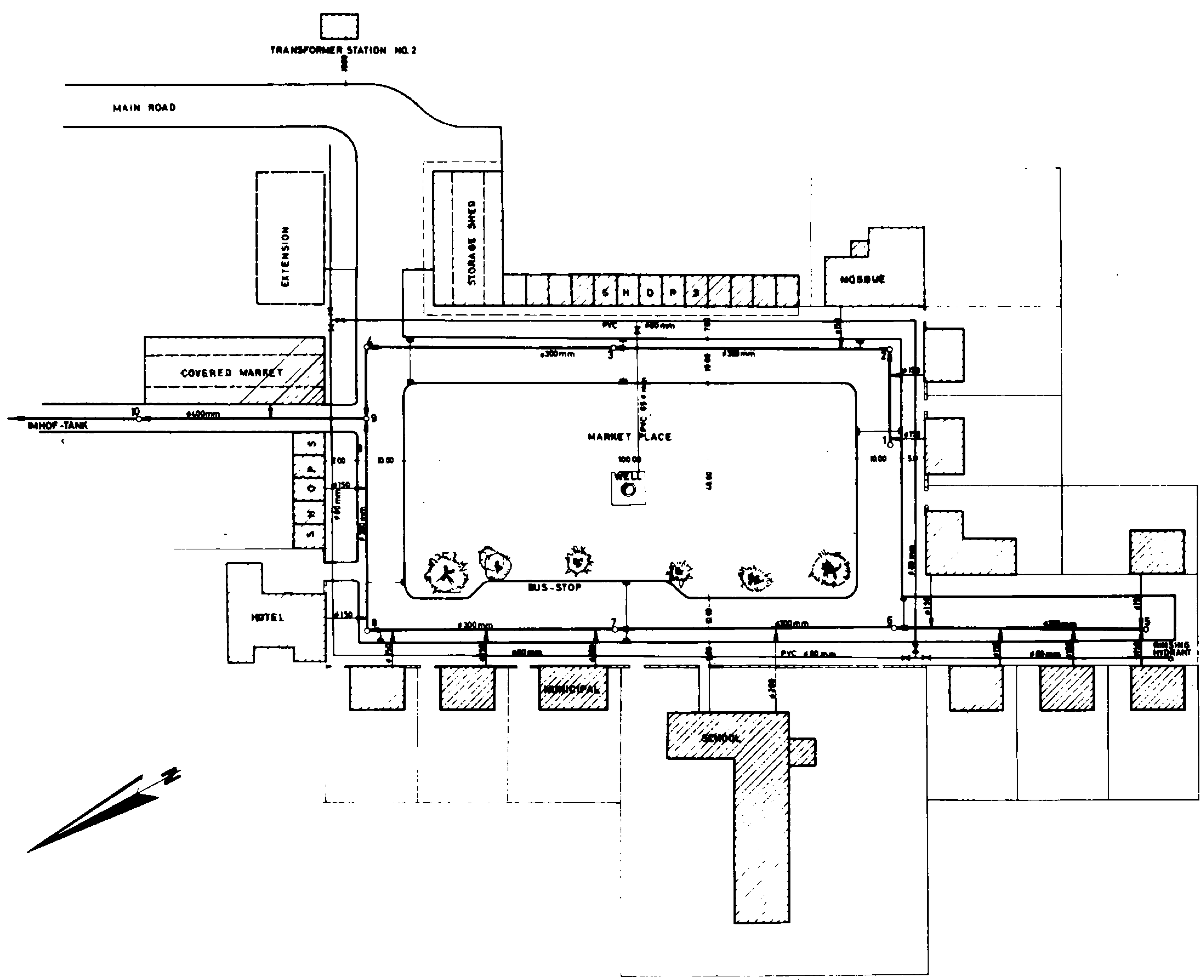
Two hundred and eighty-eight farms will be established on the 3,123 ha. scheme and their sizes will vary between 10 ha. and 12 ha., depending on their distance from the irrigation canals. In most cases the farms will lie on a lateral irrigation canal.

The farmhouses will be situated at road crossings and there will thus always be groups of several farms.

All farmhouses will be the same size, i.e. a dwelling of 103 cu.m. with the following facilities: four rooms, court-yard, WC, shower and storage room for farm products. In addition, each farm will have its own stable.

Map No. 8

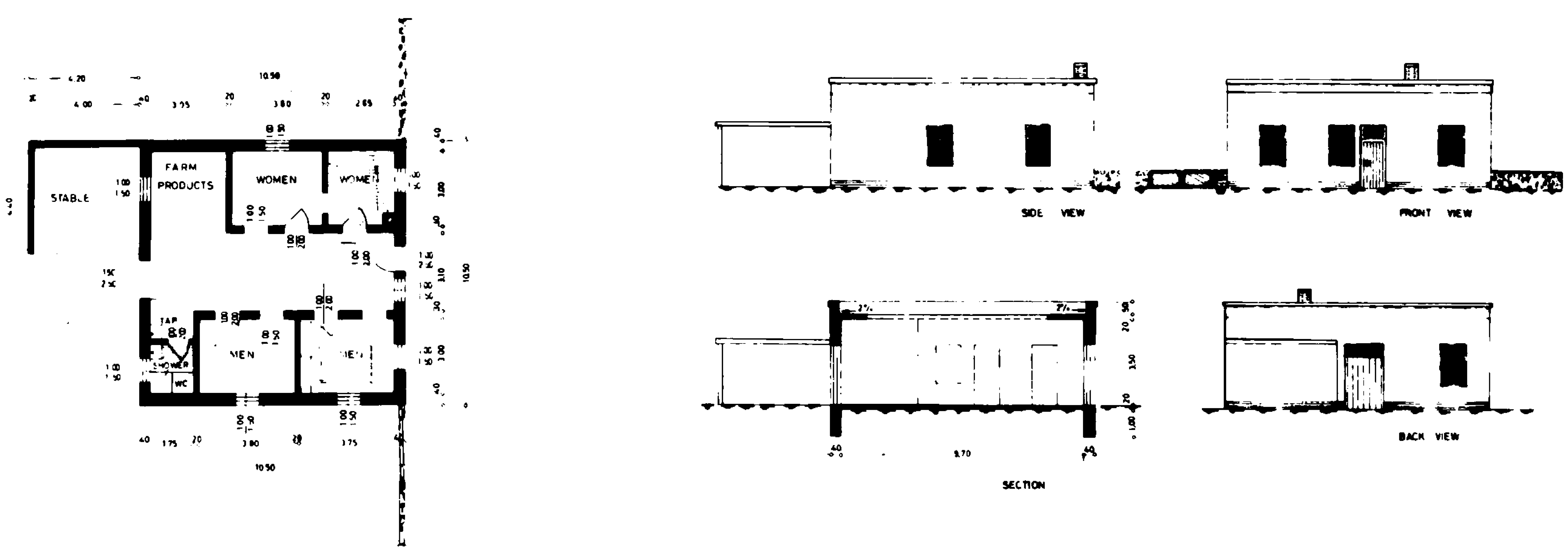
TAUORGA — VILLAGE LAYOUT



Source: Wakuti

Map No. 9

FARM HOUSES



Source : Wakuti

Transport

The coast road, 1,822 km. long, passes through the project.

In the old oasis the road conditions are very bad. An extremely complicated system of canals influences the network of roads and between them is a large number of paths.[80]

The irrigation area of 3,100 ha., the village centre and the other buildings are connected by roads which run parallel to the drainage canals. Main roads run along the main drainage canals and subsidiary roads along the subsidiary canals.

Main and subsidiary roads differ in width only.

Main roads have a metalled surface and a width of six metres.

Subsidiary roads have a metalled surface and a width of four metres.

A total of 77 km., that is 32 km. main roads and 45 km. subsidiary roads have been built.

Bridges

Where irrigation and drainage canals cross roads, sagpipes and culverts have been installed, except in five cases where bridges have been built.[81]

Industry and trade

Trade and industry in the Misurata area are not highly developed. There are a few processing plants for agricultural products, a small fishing industry, and small quantities of gypsum, marble, limestone, sulphur and natron are exploited. In addition, there is some small-scale handicraft industry.[82] Palm cultivation and mat-making (from rushes) are the two basic activities in Tauorga oasis. However, the mat production is declining rapidly. Now families are eager to have at least one of their members living and working outside the oasis who can provide them with a regular income.[83]

Planned agricultural development

The salty Tauorga water hinders the cultivation of fruit-trees such as olives, almonds, citrus or apricots. The water quality limits potential cultivation mainly to sorghum, alfalfa, beets and graminaes, but if the soil were leached, even wheat could be grown.

The following table shows the cultivation time and the yields of the plants to be grown.

Table No. 23[84] Cultivation time and yields

CROP	SOWING TIME	HARVESTING TIME	YIELDS/ YEARLY
Alfalfa	Sept.-April	all the year	100 tons/ha.
Sugar beets	Oct.-March	April-August	50 tons/ha. 12% sugar
Clover	March		
Barley	November	April	2.5 tons/ha.
Wheat			
Dates	all the year	all the year	2.5 kg./tree

Originally, the following cropping pattern was planned:

40% cereals (mainly barley) 20% beets

20% alfalfa 20% leguminous plants as vegetables

However, when calculating the demand of the animals which will be kept on the farms, a slight modification proved necessary, giving a cropping pattern as follows:

38% cereals (mainly barley) 22% beets

20% alfalfa 20% leguminous plants as vegetables

The rotation for the first five years should be as follows:

1st. YEAR	2nd. YEAR	3rd. YEAR	4th. YEAR	5th. YEAR[85]
Cereals	Cereals	Beets	Cereals	Cereals
Beets	Beets	Cereals	Beets	Beets
Alfalfa	Cereals	Alfalfa	Alfalfa	Cereals
H/vegetables	Alfalfa	H/vegetables	H/vegetables	H/vegetables
	H/vegetables			Alfalfa

———————— F A R M H O U S E S ————————

H = leguminous crops

The agricultural area will be allocated in three sections. On section I, near the farmhouses, one half will be planted with legumes and the other half with vegetables. After four to six years these crops will be moved to section II and the crops from the latter to section I. In section III cereals (two thirds) and beets (one third) will be grown. Under this arrangement, all the intensive crops will be grown near the farmhouses.[86]

In order to save money, one tractor will be provided for every four farms. This tractor (15 to 20 hp.) will be equipped as follows: one disc plough, one disc harrow, one harrow, one drilling machine, one trailer. In addition, a small threshing set will be necessary for every 10 farms.[87]

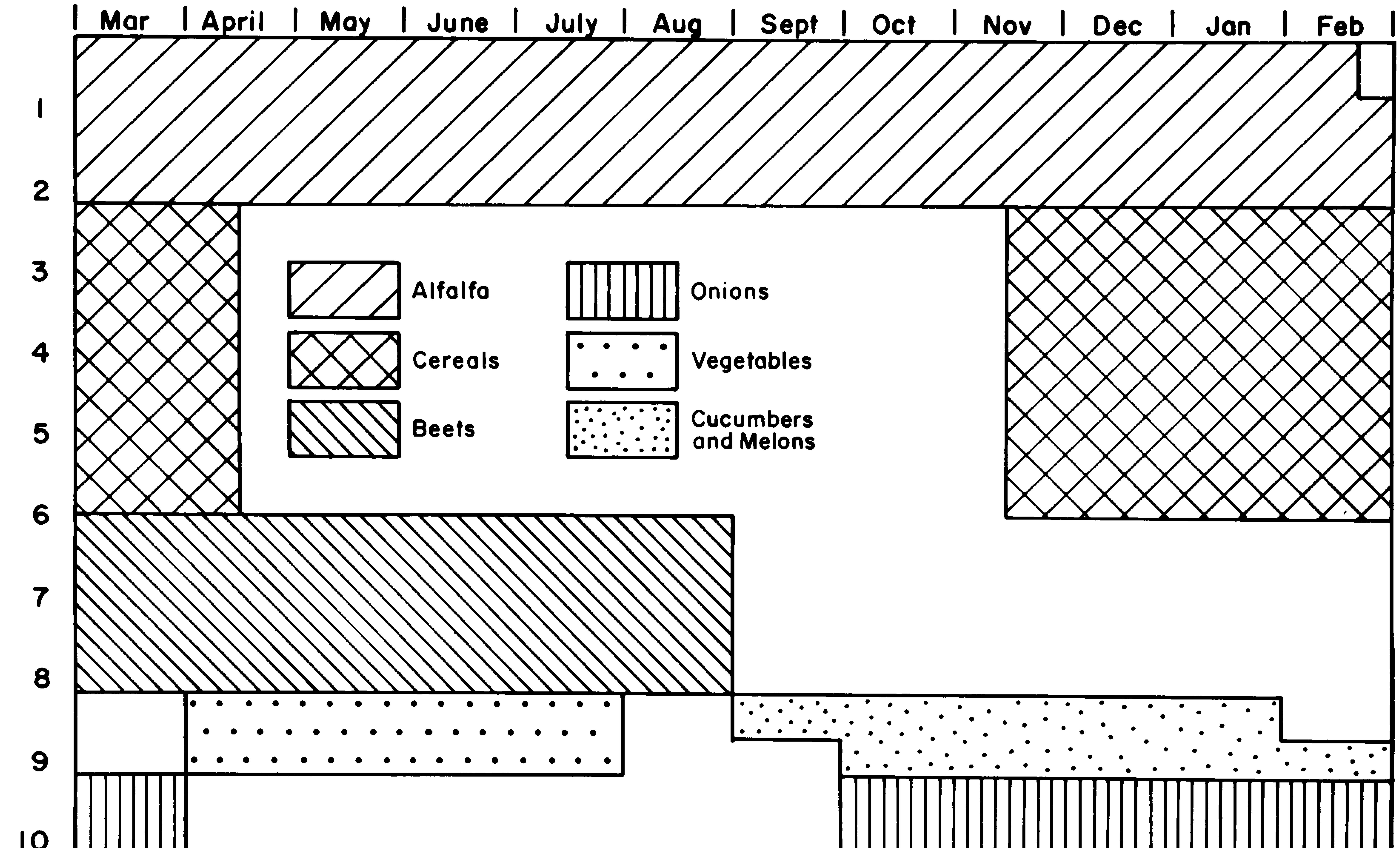
At present, normal practice is for the Government to buy the machines and then to lend them to the farmers.[88]

The livestock which will be kept on each farm is as follows: two cows, two donkeys or mules, five sheep and 10 to 15 fowls.[89] Furthermore, each farm will fatten one ox yearly.[90]

The proposed size of the farms to be established in the scheme will be about 10 ha. These farms will have the following cropping pattern: (See Diagram No. 2)

Diagram No. 2

CROPPING PATTERN - 10 Hectare Farm



	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
ha	9·00	7·00	5·00	5·00	5·00	4·00	2·50	4·00	6·00	8·00	8·00	7·50
% c.a.	90·00	70·00	50·00	50·00	50·00	50·00	25·00	40·00	60·00	80·00	80·00	75·00

3.8 ha. cereals

2.0 ha. alfalfa

2.2 ha. beets

2.0 ha. leguminous

For the livestock, that is, two cows, one ox, two donkeys, five sheep and 10 to 15 fowls, the following fodder rations will have to be provided:

Table No. 24 Fodder requirement for livestock

FODDER	DEMAND TONS/YEAR	YIELD TONS/ha.	DEMANDED AREA IN ha.
Alfalfa green	11.0	100.0	0.110
hay	1.6	20.0	0.080
Barley grain	2.6	2.5	1.040
straw	2.9	2.5	1.160
Beets	11.0	5.0	2.200
Total			3.430*

The necessary daily demand for a 550 kg. cow with a daily output of 10 ltr. of milk with four per cent fat is as follows:[91]

Dry matter	11-15 kg.
Digestible protein	900 gr.
Starch units	5,750
Ballast	about 4 kg.
Protein: starch proportion	1:6.4

Furthermore, 100 gr. daily of a good mineral feed are necessary.

It follows from the tables above that the daily ration for a cow

* The straw requirements have been ignored in the following calculations.

in the project will be as follows:

Table No. 25

Daily ration and its nutritive substance

FODDER	AMOUNT kg.	DRY MATTER kg.	DIGESTIBLE PROTEIN/gr.	STARCH UNITS	BALLAST kg.
Alfalfa green	15.0	3.750	450	1,500	0.975
hay	2.2	1.936	297	713	0.713
Barley grain	2.5	3.010	263	2,412	0.525
straw	4.0	3.396	24	704	1.676
Beets	15.0	1.875	240	1,110	220
Total	39.7	13.967	1,274	6,439	4.109

The protein: starch proportion is 1:5.05. This is not ideal, but under the circumstances, unavoidable.

It is assumed that the oxen will be fattened for 18 months, i.e. until they have reached a weight of 400 to 500 kg. Each will have the following fodder demand during these 18 months.

Table No. 26
Fodder requirement for one ox during 18 months

FODDER	AMOUNT IN kg.
Alfalfa green	2,640
hay	840
Barley grain	1,050
straw	1,560
Concentrate	90
Skimmed milk	600
Whole milk	225

The composition of this demand is detailed below:

Table No. 27

Ration for the first to fourth month[92]

WEEK	WHOLE MILK kg.	SKIMMED MILK kg.	CONCENTRATE gr.	HAY gr.
2	7	-	100	-
3	5	3	200	50
4	4	4	300	100
5	3	5	300	150
6	3	5	400	150
7	2	6	500	200
8	2	6	600	250
9	2	6	800	300
10	2	6	1,000	350
11	1	7	1,200	400
12	1	7	1,400	500
13	-	8	1,500	600
14	-	8	1,500	700
15	-	8	1,500	800
16	-	8	1,500	900
Total	225 kg.	600 kg.	90 kg.	40 kg.

Fifth to eighth month

Table No. 28

Daily ration and its nutritive substance

FODDER	AMOUNT kg.	DRY MATTER kg.	DIGESTIBLE PROTEIN/gr.	STARCH UNITS
Alfalfa green	5.0	1.250	150	500
hay	2.0	1.760	270	648
Barley grain	1.0	860	75	689
Total		3.870	495	1,837

The protein: starch proportion in this ration is 1:4.12. At the end of this period the weight will be 125 to 200 kg.

Ninth to twelfth month

Table No. 29

Daily ration and its nutritive substance

FODDER	AMOUNT kg.	DRY MATTER kg.	DIGESTIBLE PROTEIN/gr.	STARCH UNITS
Alfalfa green	5.0	1.250	150	500
hay	2.0	1.760	270	648
Barley grain	1.0	0.860	75	689
straw	4.0	3.496	24	704
Total		7.366	519	2,541

The protein: starch ratio is 1:4.9. At the end of this period the weight will be 200 to 300 kg.

Thirteenth to fifteenth month

Table No. 30

Daily ration and its nutritive substance

FODDER	AMOUNT kg.	DRY MATTER kg.	DIGESTIBLE PROTEIN/gr.	STARCH UNITS
Alfalfa green	8.0	2.000	240	800
hay	2.0	1.760	270	648
Barley grain	4.0	3.440	300	2,756
straw	5.0	4.370	30	880
Total		11.570	840	5,084

The protein:starch ratio in this ration is 1:6.1. At the end of this period the weight will be 300 to 400 kg.

Sixteenth to eighteenth month

Table No. 31

Daily ration and its nutritive substance

FODDER	AMOUNT kg.	DRY MATTER kg.	DIGESTIBLE PROTEIN/gr.	STARCH UNITS
Alfalfa green	8.0	2.000	240	800
hay	2.0	1.760	270	648
Barley grain	5.0	4.300	375	3,445
straw	7.0	5.718	42	1,232

The protein: starch ratio in this ration is 1:6.61. At the end of this period the weight will be 400 to 500 kg.

In order to meet the fodder demands the following cultivated area is necessary:

Table No. 32 Required area

FODDER	AREA IN ha.
Alfalfa	0.050
Barley grain	0.445
Total	0.495

Since on each farm 3.8 ha. of barley will be harvested, enough straw will be available. Therefore the area necessary for the supply of straw has not been taken into consideration.

Five sheep

As a basis for the calculation it is assumed that the average sheep will be fed with the ration necessary for sheep pregnant for three to five months.

The required daily demand for five sheep is:

Table No. 33

Demand in nutritive substance[93]

DRY MATTER kg.	DIGESTIBLE PROTEIN/gr.	STARCH UNITS
6-8	425	3,250

In order to meet this demand the following ration is required:

Table No. 34

Daily ration and its nutritive substance

FODDER	AMOUNT kg.	DRY MATTER kg.	DIGESTIBLE PROTEIN/gr.	STARCH UNITS
Alfalfa green	4.5	1.125	135	450
hay	1.0	0.880	135	324
Barley grain	2.0	1.720	150	1,378
straw	5.0	4.370	30	880
Total		8.095	450	3,032

Following from this, the yearly demand is as follows:

Table No. 35

Fodder requirement and cultivation area

FODDER	AMOUNT IN TONS	AREA IN ha.
Alfalfa	3.5	0.035
Barley	0.73	0.295
Total		0.330

Here again the demand for straw is ignored.

Two donkeys

The two donkeys will have a daily demand of:

Table No. 36

Demand of nutritive substance for two donkeys

Dry matter	12 to 15 kg.
Digestible protein	400 gr.
Starch units	3.8 kg.
Ballast	4.5 to 5.5 kg.

This equals the requirement of a 600 kg. horse,[94] and requires the following daily ration:

Table No. 37

Daily ration for two donkeys

FODDER	AMOUNT kg.	DRY MATTER kg.	DIGESTIBLE PROTEIN	STARCH UNITS	BALLAST kg.
Barley straw	12.0	10.474	72	2,112	5.028
Alfalfa hay	3.0	2.64	405	972	972
Total		13.114	477	3,084	6.000

The above ration results in an annual demand of:

Table No. 38 Annual demand

FODDER	QUANTITY IN kg.
Barley straw	4,380
Alfalfa hay	1,095

Here again the area for straw has been ignored. The area necessary for alfalfa hay is 0.055 ha.

The fowls kept on these farms will be fed with commercial food-stuffs, i.e. no agricultural area is necessary to meet their food requirements.

Pattern of expenditure for plant production

The pattern of expenditure for all crops, that is, the cash crops and the crops necessary for the livestock, is shown below.

No costs for plant protection arise in the project as these will be met by the Government.[95] The other production means also will be subsidized.[96] Furthermore, the water will be supplied free of charge at first, but whether this situation will be permanent has still to be decided.[97] For ploughing with a three disc plough the farmer will have to pay 2.250 Dinar per hectare and for ploughing with a nine disc plough 1.250 Dinar;[98] for harvesting one hectare of cereals 5.000 Dinar, for sowing one hectare of cereals 1,250 Dinar[99] and for any other work 1.250 Dinar. However, these prices only apply to members of co-operatives, and the prices for non-members will be higher.[100]

Machine costs per hectare for different crops

Table No. 39 Machine costs for alfalfa

WORK	PRICE PER ha.
Ploughing	1.750 Dinar (average price)
Harrowing	1.250 Dinar
Total	3.000 Dinar

Table No. 40 Machine costs for cereals

WORK	PRICE PER ha.
Ploughing	1.750 Dinar
Harrowing	1.250 Dinar
Sowing	1.250 Dinar
Harvesting	5.000 Dinar
Total	9.250 Dinar

Table No. 41 Machine costs for beets

WORK	PRICE PER ha.
Ploughing	1.750 Dinar
Harrowing	1.250 Dinar
Total	3.000 Dinar

Table No. 42 Machine costs for vegetables

WORK	PRICE PER ha.
Ploughing	1.750 Dinar
Harrowing	1.250 Dinar
To make furrows	1.250 Dinar
Total	4.250 Dinar

Taking into account the above-mentioned, expenditure will be as follows:

Table No. 43

Pattern of expenditure for the area necessary for milk production

HECTARES	CROP	AMOUNT/ha.	DINAR/UNIT	DINAR/AREA
0.190	Alfalfa			
	Seeds*	50 kg.	1.25/kg.[101]	3.958
	Fertilizer (PK)	400 kg.	1.20/100 kg.[102]	0.912
	Machine costs*	3 Dinar	-	0.190
				5.060
1.040	Barley			
	Seeds	120 kg.	0.036/kg.[103]	4.492
	Fertilizer (NPK)	500 kg.	2.8/100 kg.[104]	14.560
	Machine costs	9.250 Dinar	-	9.620
				28.672
2.200	Beets			
	Seeds	-**	-	-
	Fertilizer (NPK)	600 kg.	2.8/100 kg.	36.960
	Machine costs	3 Dinar	-	6.600
				43.560

Total expenditure for the area necessary for milk production is 127.292 Dinar.

* Every third year.

** Beets are unfamiliar to the farmers and must be introduced.

Table No. 44

Pattern of expenditure for the area required for one ox

HECTARES	CROP	AMOUNT/ha.	DINAR/UNIT	DINAR/AREA
0.050	Alfalfa			
	Seeds*	50 kg.	1.25/kg.	1.041
	Fertilizer (PK)	400 kg.	1.2/100 kg.	0.240
	Machine costs*	3 Dinar	-	0.050
				1.331
0.445	Barley			
	Seeds	120 kg.	0.036/kg.	1.922
	Fertilizer (NPK)	500 kg.	2.8/100 kg.	6.230
	Machine costs	9.250 Dinar	-	4.116
				12.268

Total expenditure for the area required for one ox is 13.599 Dinar.

The required 600 ltr. skimmed milk would have to be made from milk powder as there is no skimmed milk available in Libya. Assuming that a quantity of 100 gr. of powdered milk is necessary to make one litre of skimmed milk, the required amount per ox is 60 kg. As there is no powdered skimmed milk available in Libya either, this will have to be imported at first. Thus, the price of 15 Dinar per 100 kg. (subsidized) is an assumed one. Based on the above, the expenditure on skimmed milk will be nine Dinar per ox.

* Every third year.

Table No. 45

Pattern of expenditure for the area required for five sheep

HECTARES	CROP	AMOUNT/ha.	DINAR/UNIT	DINAR/AREA
0.035	Alfalfa			
	Seeds*	50 kg.	1.25/kg.	0.729
	Fertilizer (PK)	400 kg.	1.2/100 kg.	0.168
	Machine costs*	3 Dinar	-	0.035
				0.932
0.295	Barley			
	Seeds	120 kg.	0.036/kg.	1.274
	Fertilizer (NPK)	500 kg.	2.8/100 kg.	4.130
	Machine costs	9.250 Dinar	-	2.729
				8.133

Total expenditure for the area required for five sheep is 9.065 Dinar.

For the 10 hens 438 kg. of food-stuff is required, costing 5.00 Dinar for 100 kg.[105] Thus 21.90 Dinar will have to be spent on poultry. (The price of 5.00 Dinar for 100 kg. chicken-feed is subsidized by the Government.)

* Every third year.

Table No. 46

Pattern of expenditure for the area necessary to keep two donkeys

HECTARES	CROP	AMOUNT/ha.	DINAR/UNIT	DINAR/AREA
0.055	Alfalfa			
	Seeds*	50 kg.	1.25/kg.	1.147
	Fertilizer (PK)	400 kg.	1.2/100 kg.	0.264
	Machine costs*	3 Dinar	-	0.055
				1.466

Total expenditure for the area necessary to keep two donkeys is 1.466 Dinar.

* Every third year.

Table No. 47

Pattern of expenditure for the cash crops

HECTARES	CROP	AMOUNT/ha.	DINAR/UNIT	DINAR/AREA
1.670	Alfalfa			
	Seeds*	50 kg.	1.250/kg.	34.792
	Fertilizer (PK)	400 kg.	1.2/100 kg.	8.016
	Machine costs*	3 Dinar	-	1.670
				44.478
2.00	Barley			
	Seeds	120 kg.	0.036/kg.	8.640
	Fertilizer (NPK)	500 kg.	2.8/100 kg.	28.000
	Machine costs	9.250 Dinar	-	18.500
				55.140
0.400	Onions			
	Seeds	5 kg.	4.04/kg.[106]	8.080
	Fertilizer (NPK)	600 kg.	2.8/100 kg.	6.720
	Machine costs	4.250 Dinar	-	1.700
				16.500
0.400	Tomatoes			
	Seeds	2.00 kg.[107]	4.00/kg.[108]	3.200
	Fertilizer (NPK)	600 kg.	2.8/100 kg.	6.720
	Machine costs	4.250 Dinar	-	1.700
				11.620
0.400	Water-melons			
	Seeds	2.50 kg.[109]	3.00/kg.[110]	3.000
	Fertilizer (NPK)	500 kg.	2.8/100 kg.	5.600
	Machine costs	4.250 Dinar	-	1.700
				10.300
0.400	Dry peas			
	Seeds	80 kg.[111]	0.40/kg.[112]	12.800
	Fertilizer (NPK)	600 kg.	2.8/100 kg.	6.720
	Machine costs	4.250 Dinar	-	1.700
				21.220
0.400	Broad-beans			
	Seeds	60 kg.[113]	0.175/kg.[114]	4.200
	Fertilizer (NPK)	600 kg.	2.8/100 kg.	6.720
	Machine costs	4.250 Dinar	-	1.700
				12.620

Returns from agricultural production

Assuming a daily consumption of five litres of milk by the family and an additional consumption of 225 ltr. by the ox, there would still remain 4,275 ltr. for marketing. Based on a price of 0.150 Dinar per litre, which is the price of imported milk,[115] assuming production costs of 0.075* and processing costs of 0.035 Dinar, a hypothetical income 0.040 Dinar per litre of milk could be earned, i.e. for 4,275 ltr. the income could be 171.00 Dinar.

The fattened ox when sold with a final weight of 400 kg. will bring an income of 88.000 Dinar. This is based on a meat price of 0.550 Dinar per kilogramme[116] and a carcase dressing percentage of 40 per cent.

The five sheep will be consumed by the eight family members, and thus the sheep have no recognized cash value for the farmer.

Ten hens with a yearly production of 150 eggs each (this is a conservative estimate) will produce 1,000 eggs for market after home consumption has been deducted. As the price for one egg** is 0.0275 Dinar in Misurata[117] the income will thus be 27.500 Dinar.

Consequently, the total value of the produce from livestock is as follows:

* In Haradh, Saudi Arabia, production costs of 0.71 SR per litre, which is the equivalent of 0.075 Dinar, were calculated.

** Statements on egg prices are inconsistent. In 1970 the price of eggs was 0.070 Dinar for four eggs[118] and a chicken farmer sold eggs near Misurata in April 1974 for 0.030 Dinar each. However, the price chosen for the above calculation was provided by Mohamed Al Alem, a chicken farmer in Misurata, in April 1974, and was chosen because Mr. Al Alem has a very good knowledge of the egg market in the area.

Table No. 48 Returns from livestock

PRODUCT	RETURN IN DINAR
Milk	171.000
Ox	88.000
Eggs	27.500
Total	286.500

Return from cash crops

After the area necessary for the supply of the livestock has been deducted, the following area remains for cash crop:

Table No. 49 Cash crop area and yields

CROP	AREA IN ha.	YIELDS/TONS/ha.	YIELDS/TONS/ha.
Alfalfa	1.670	100.00	167.00
Cereals	2.000	2.50	5.00
Onions	0.400	6.10[119]	2.44
Tomatoes	0.400	18.40[120]	7.36
Water-melons	0.400	13.60[121]	5.44
Peas	0.400	1.50[122]	0.60
Broad-beans	0.400	0.25[123]	0.10
Total	5.670		

With the exception of alfalfa and barley, the yields tabulated for these crops are the average for Libya. Yields in the project will most probably be higher after the initial period, thus in the above table no family consumption has been deducted from the yields. It is probable that, even after family consumption is deducted, the yields will be higher than those shown in the above table.

For the cash crops the following prices can be gained:

Table No. 50 Cash crop prices

CROP	PRICE PER UNIT	VALUE/AREA IN DINAR
Alfalfa (hay)	7 Dinar per 100 kg.[124]	2,359.00
Barley	0.06 Dinar per kg.*[125]	300.00
Onions	0.087 Dinar per kg.[126]	215.28
Tomatoes	0.048 Dinar per kg.[127]	353.28
Water-melons	0.040 Dinar per kg.[128]	217.60
Peas	0.140 Dinar per kg.[129]	84.00
Beans	0.069 Dinar per kg.[130]	6.80
Total		3,535.96

The cash crops have a total value of 3,822 Dinar and production expenditure will have to be deducted from this.

* Whereas all the other prices in this table are wholesale, this is a retail price. In all Libyan statistics the wholesale price for barley is always given by the weight unit "MARTA", which is unknown to the author. The price of 0.06 Dinar is the average price for Tripoli (0.062) and Misurata (0.058).

Table No. 51

Value of agricultural produce after deduction of expenses

PRODUCT	VALUE IN DINAR	EXPENDITURE IN DINAR	REMAINING VALUE IN DINAR	LOSS IN DINAR
Alfalfa (hay)	2,359.00	44.48	2,314.52	-
Barley	300.00	55.14	244.86	-
Onions	215.28	16.50	198.78	-
Tomatoes	353.28	11.62	341.66	-
Water-melons	217.60	10.30	207.30	-
Peas	84.00	21.22	62.78	-
Beans	6.80	12.62	-	5.82
Milk	171.00	127.29	43.71	-
Ox	88.00	22.60	65.40	-
Sheep	-	9.07	-	9.07
Eggs	27.50	21.90	5.60	-

The loss of 9.07 Dinar for sheep is not a genuine loss, as the animals are consumed by the family, but this figure represents foregone profit.

Marketing situation

Misurata is the most important market for Eastern Tripolitania.[131] Nevertheless, the number of inhabitants, 20,000 for Misurata and 83,000 for Misurata plus hinterland,[132] is too small to absorb the goods which will be produced in the project. Furthermore, this market is already supplied by the farms around Misurata and Tauorga. The farms in this area are in excellent condition and are partly irrigated and could, if the demand increased, produce more than they do at present.

However, eggs and milk from the project could be sold in Misurata. All the area's milk supply currently comes from abroad and thus there is an opportunity to sell the milk from the project locally. The area is supplied partly by local and partly by imported eggs and an increased supply could thus be absorbed by the market.[133]

Since there are no larger towns or villages in the area, the market for the other products will be Tripoli. The distance between Tauorga and Tripoli is 260 km. and the road is in excellent condition.

The quantities which each farmer will produce are shown in the following table:

Table No. 52 Products and market

PRODUCT	QUANTITY	MARKET
Alfalfa hay	33.4 tons	Tripoli
Cereals	5.0 tons	Tripoli
Leguminous	15.94 tons	Tripoli
Ox	400 kg.	Tripoli
Milk	4,275 ltr.	Misurata
Eggs	1,000 pieces	Misurata

The transport costs for road transport are 10 Dinar per ton from Misurata to Tripoli, i.e. 45.50 Millimes per ton/km.[134] Thus each farmer must expect the following transport costs:

Table No. 53 Transport costs

PRODUCT	TRANSPORT COSTS IN DINAR	
Alfalfa hay	395.12	
Cereal	59.15	
Leguminous	188.57	
Ox	4.73	
Milk	7.80	The transport costs for milk is not known. The price of 10 Dinar per ton/km. is used.
Eggs	-	No costs will be considered as the demand is so great that the dealers will come to the farms to get eggs.[135]
Total	655.37	

These transport costs will have to be deducted from the 3,473.19 Dinar.

Table No. 54
Income from a 10 ha. farm (in Dinar)

PRODUCT	VALUE	TRANSPORT COSTS	PROFIT	LOSS
Alfalfa hay	2,314.52	395.12	1,919.40	-
Cereals	244.86	59.15	185.71	-
Leguminous	804.70	188.57	616.13	-
Ox	65.40	4.73	60.67	-
Milk	43.71	7.80	35.91	-
Sheep	- 9.07	-	-	9.07
Eggs	5.60	-	5.60	-

Two labourers from outside the family will have to be hired and paid as each family will most probably not have more than two full-time labourers. One thousand, two hundred Dinar per year will have to be deducted as wages for these men from the 2,814.35 Dinar. This 1,614.35 Dinar will remain as the family income. This implies:

a monthly family income of	134.53 Dinar
income per head of	201.79 Dinar
a monthly income per labour unit of	67.27 Dinar

After deducting the 4,800 working hours for the hired labourers, 4,324.53 working hours remain for the family members, who can thus earn a wage of 0.373 Dinar per hour.

Labour demand

The present physical condition of the oasis and the present employment of the inhabitants in non-agricultural jobs make it clear that the future settlers have a limited knowledge of agriculture; nevertheless, officially, it is believed that they are good farmers.[136] This is most unlikely since being a farmer means not only the ability to perform a specific set of jobs, but rather a complete involvement in agriculture, and a way of life dictated by the cultivation calendar. As this has not yet been achieved, in spite of their having received a good training, the settlers cannot be considered farmers, and thus the speed and quality of their work will not be equal to that of true farmers. Consequently, the following calculations are based on the assumption that the settlers will have a lower performance than that of experienced farmers. Their performance will probably be very similar to that obtained at the Demonstration and Training Farm in Haradh, Saudi Arabia, and the results achieved there are the basis of the labour input calculations for the Tauorga Project. This labour input is as detailed below:

Labour input for irrigation

Each of the farms will be supplied with 10.14 ltr./sec., i.e. 36,504 ltr./h.

Travel time is unimportant as the farmhouses are situated in the agricultural area.

The labour input required for irrigation is shown below:

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
March			
Alfalfa	2.0	2,130	4,260
Cereals	3.8	1,540	5,852
Beets	2.2	1,050	2,310
Onions	1.0	1,710	1,710
			14,132 cu.m.

Man hours for irrigation: 387.14

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
April			
Alfalfa	2.0	2,840	5,680
Cereals	1.9	1,050	1,995
Beets	2.2	2,320	5,104
Vegetables	1.0	2,270	2,270
			15,049 cu.m.

Man hours for irrigation: 412.26

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
May			
Alfalfa	2.0	3,620	7,240
Beets	2.2	2,930	6,446
Vegetables	1.0	2,910	2,910
			16,596 cu.m.

Man hours for irrigation: 454.64

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
June			
Alfalfa	2.0	4,090	8,180
Beets	2.2	3,310	7,282
Vegetables	1.0	3,260	3,260
			18,722 cu.m.

Man hours for irrigation: 512.88

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
July			
Alfalfa	2.0	4,170	8,340
Beets	2.2	3,390	7,458
Vegetables	1.0	3,330	3,330
			19,128 cu.m.

Man hours for irrigation: 524.00

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
August			
Alfalfa	2.0	4,040	8,080
Beets	2.2	2,190	2,818
			10,898 cu.m.

Man hours for irrigation: 353.33

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
September			
Alfalfa	2.0	3,580	7,160
Cucumber and melons	0.5	2,860	1,430
			8,590 cu.m.

Man hours for irrigation: 235.32

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
October			
Alfalfa	2.0	3,030	6,060
Cucumber and melons	1.0	2,420	2,420
Onions	1.0	2,420	2,420
			10,900 cu.m.

Man hours for irrigation: 298.59

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
November			
Alfalfa	2.0	2,250	4,500
Cereals	1.9	1,620	3,078
Cucumber and melons	1.0	1,810	1,810
Onions	1.0	1,810	1,810
			11.198 cu.m.

Man hours for irrigation: 306.76

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
December			
Alfalfa	2.0	1,540	3,080
Cereals	3.8	1,120	4,256
Cucumber and melons	1.0	1,220	1,220
Onions	1.0	1,220	1,220
			9,776 cu.m.

Man hours for irrigation: 267.81

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
January			
Alfalfa	2.0	1,530	3,060
Cereals	3.8	1,100	4,180
Cucumber and melons	1.0	1,220	1,220
Onions	1.0	1,220	1,220
			9,680 cu.m.

Man hours for irrigation: 265.18

Month/crop	Area in ha.	cu.m. water/ha.	cu.m. water/area
February			
Alfalfa	2.0	1,710	3,420
Cereals	3.8	1,240	4,712
Cucumber and melons	0.5	1,370	0,685
Onions	1.0	1,370	1,370
			10,187 cu.m.

Man hours for irrigation: 278.07

Labour input for field crops

The following calculation shows the labour input required for the crops. As plant protection will be undertaken for all crops free of charge by the Government, the labour demand for plant protection is not considered in the calculation.

Month/crop	Area/ha.	Work	Man hours ha.	Man hours area
March				
Alfalfa	2.00	making hay	10.00	20.00
Beets	2.20	sowing	50.00	110.00
	2.20	top dressing	3.10	6.82

Month/crop	Area/ha.	Work	Man hours ha.	Man hours area
Onions	1.00	harvesting	500.00	500.00
				636.82
		Man hours for irrigation:		387.14
		Total man hours for cultivation:		1,023.76
April				
Alfalfa	2.00	making hay	10.00	20.00
	2.00	top dressing	3.10	6.20
Beets	2.20	handhoeing and singling	132.50	291.50
Vegetables	1.00	planting	75.00	75.00
Cereals	3.80	harvesting*	-	-
				392.70
		Man hours for irrigation:		412.26
		Total man hours for cultivation:		804.96
May				
Alfalfa	2.00	making hay	10.00	20.00
Beets	2.20	handhoeing	87.50	192.50
Vegetables	1.00	handhoeing	87.50	82.50
				295.00
		Man hours for irrigation:		454.64
		Total man hours for cultivation:		749.64

* Cereals will be harvested by equipment from the machinery pool for which the farmer will be charged 5.00 Dinar per hectare.[137]

Month/crop	Area/ha.	Work	Man hours ha.	Man hours area
June				
Alfalfa	2.00	making hay	10.00	20.00
Vegetables	1.00	handhoeing	82.50	82.50
	1.00	top dressing	21.70	21.70
				124.20
		Man hours for irrigation:		512.88
		Total man hours for cultivation:		637.08
July				
Alfalfa	2.00	making hay	10.00	20.00
Vegetables	1.00	harvesting	613.00	613.00
				633.00
		Man hours for irrigation:		524.00
		Total man hours for cultivation:		1,157.00
August				
Alfalfa	2.00	making hay	10.00	20.00
Beets	2.20	harvesting	200.00	440.00
Onions	1.00	preparing seedbed	23.00	23.00
Vegetables	1.00	handhoeing	82.50	82.50
Cucumber and melons	1.00	preparing seedbed	23.00	23.00
				588.50
		Man hours for irrigation:		353.33
		Total man hours for cultivation:		941.83

Month/crop	Area/ha.	Work	Man hours ha.	Man hours area
October				
Alfalfa	2.00	making hay	10.00	20.00
Onions	1.00	planting	480.00	480.00
Cucumber and melons	0.50	sowing	30.00	15.00
	1.00	handhoeing	87.50	87.50
				602.50
		Man hours for irrigation:		298.59
		Total man hours for cultivation:		901.09
November				
Alfalfa	2.00	making hay	10.00	20.00
Cereals	3.80	sowing*	-	-
Onions	1.00	handhoeing	132.50	132.50
Cucumber and melons	1.00	handhoeing	87.50	87.50
				240.00
		Man hours for irrigation:		306.76
		Total man hours for cultivation:		546.76
December				
Alfalfa	2.00	making hay	10.00	20.00
				20.00
		Man hours for irrigation:		267.81
		Total man hours for cultivation:		287.81

* Sowing of cereals will be done by equipment from the machinery pool for which the farmers will be charged 1.250 Dinar per hectare.

Month/crop	Area/ha.	Work	Man hours ha.	Man hours area
January				
Alfalfa	2.00	making hay	10.00	20.00
Cereals	3.80	top dressing	3.10	11.78
Onions	1.00	top dressing	35.00	35.00
	1.00	handhoeing	132.50	132.50
Cucumber and melons	0.50	harvesting	350.00	175.00
				374.28
		Man hours for irrigation:		265.18
		Total man hours for cultivation:		639.46
February				
Alfalfa	2.00	making hay	10.00	20.00
Vegetables	1.00	preparing seedbed	23.00	23.00
Cucumber and melons	0.50	harvesting	350.00	175.00
				218.00
		Man hours for irrigation:		278.07
		Total man hours for cultivation:		496.07

Labour input for animal husbandry

The man hours necessary to care for the animals are shown below. This is also based on figures calculated for the Faisal Settlement Project, Haradh.

Table No. 55 Labour input for livestock

ANIMAL	NUMBER	MAN HOURS PER YEAR
Cow	2	436.00
Ox	1	57.63
Sheep	5	33.95
Fowls	15	.
Donkey	2	.
Total		527.58

That is, every day 1.5 hours (1.44) must be spent in feeding and caring for the livestock.

Consequently, the overall labour input for a 10 ha. farm is as follows:

Table No. 56 Labour input - 10 ha. farm

MONTH	MAN HOURS FIELD CROPS	MAN HOURS LIVESTOCK	TOTAL MAN HOURS
March	1,023.76	46.5	1,070.26
April	804.96	45.0	849.96
May	749.64	46.5	796.14
June	637.08	45.0	682.08
July	1,157.00	46.5	1,203.50
August	941.83	46.5	988.33
September	391.87	45.0	436.87
October	901.09	46.5	947.59
November	546.76	45.0	591.76
December	287.81	46.5	334.31
January	639.46	46.5	685.96
February	496.07	42.0	538.07

For the settlers the hypothetical daily working time will be eight hours. As they will work 25 days per month this results in 200 hours per month, i.e. 2,400 hours per year for each full-time worker. However, the settlers can be expected to work 12 hours daily during peak times.

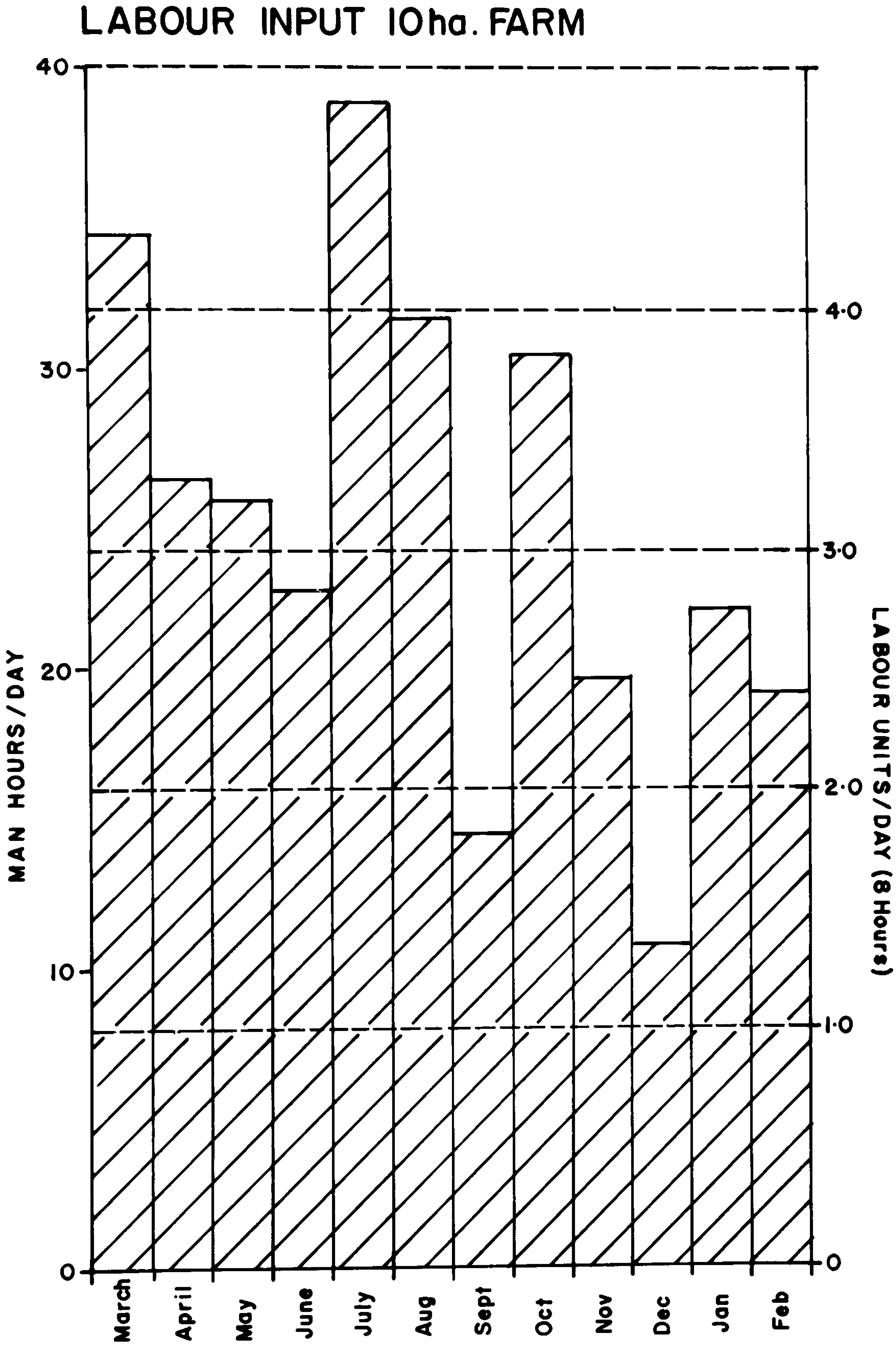
The following table shows the labour units required for each month.

Table No. 57 Required labour units

MONTH	MONTHLY WORKING HOURS	DAILY WORKING HOURS	CALCULATED LABOUR UNITS FOR A DAILY WORKING TIME OF (hours)		ACTUAL WORK-MEN FOR 8 AND 12 HOURS DAILY	
			8	12	8	12
March	1,070.26	34.52	4.32	2.66	5	3
April	849.96	26.33	3.29	2.19	4	3
May	796.14	25.68	3.21	2.14	4	3
June	682.08	22.74	2.84	1.86	3	2
July	1,203.50	38.82	4.85	3.23	5	4
August	988.33	31.88	3.99	2.62	4	3
September	436.87	14.56	1.82	1.21	2	2
October	947.59	30.57	3.83	2.55	4	3
November	591.76	19.72	2.46	1.61	3	2
December	334.31	10.78	1.35	0.86	2	1
January	685.96	22.13	2.77	1.84	3	2
February	538.07	19.24	2.41	1.60	3	2
Total	9,124.53					

Table No. 57 and Diagram No. 3 show that for a daily working time of eight hours at least four permanent full-time labourers are required. For a daily working time of 12 hours (which is not realistic over a long period) three full-time labourers are required. As it cannot be expected

Diagram No. 3


LABOUR INPUT 10ha. FARM
MAN HOURS/DAY
LABOUR UNITS/DAY (8 Hours)
40
30
20
10
0
4·0
3·0
2·0
1·0
0
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb

that all families to be settled have four able full-time labourers, it is assumed that two labourers from outside the family will have to be employed on each farm. Thus it is assured that all necessary work will be done.

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CHAPTER FIVE

EVALUATION

Agriculture, even in its simplest traditional form, is a highly sophisticated balanced economic undertaking which, as long as an attained balance is not disturbed, does not require any further development. However, in each of the four projects under consideration the balance has, in fact, been disturbed. Poverty alone, which originated from disturbance of the balance, has not been sufficient in itself to create an indigenous desire or capacity for development. Thus intervention from outside is necessary in order to raise the standard of living of the people involved and to prevent wastage of agricultural resources.

A modern agricultural development project is not necessarily the only way to development. Cultural change, or a growth in demand for agricultural products, for example, can be equally effective. But response to factors such as these usually takes a long time and the need for development is immediate. A planned development project is a way of overcoming this problem.

Agricultural schemes are themselves influenced by a range of factors, some of which are more conducive to project success than others, as was shown in chapters one to four.

Table No. 1 indicates in summary form how the suitability of these factors differs especially from case to case. Factors conducive to project success are shown by "+", those inhibitive as "-", and those of uncertain influence by "?".

Table No. 1

Suitability of factors influencing development directly

FACTOR	HARADH	HOFUF	AVU KETA	TAUORGA
Population				
Number	-	+	+	+/?
Tradition	-	+	+	+
Education	-	+	+	+
Nutrition	+	+	+	+/?
Soil	+	+/-	+/?	+
Climate	+	+	+	+
Water				
Quantity	+	+	+	+
Quality	+	+	+	+
Access	+/?	+/-	+	+
Irrigation scheme	+	+	+	+
Drainage scheme	+	+	+	+
Topography	+	+	+	+
Resettlement scheme	-	?	+	+
Transport	-/+	+	+	+
Family income	+/-	-/+	+	+
Labour demand	+/?	-/+	-	+
Marketing	-	+	+	+
Supervisors	-	+	+	+/?

Among these factors the "Supervisors" occupy a special position. In any development project which assumes or relies on outside intervention it is clear that such intervention cannot merely involve the supply of imported capital equipment or the supply of technological know-how in design and construction; it must include guidance in the use by indigenous groups of alien techniques and concepts. "Supervision" in this sense must be supplied adequately if a project is to succeed and here the quality as well as quantity of supervisors input is important. However, their importance diminishes as development progresses if their work has been effective. That is, their influence is only temporary but of great importance to the project in order to guide it successfully through the initial phases. Therefore, they are considered to be just as valuable a factor as the others in ensuring development but all too often ignored in planning. The following represents a valuable guideline to this particular need.[1]

"1. The staff should be sufficiently large so that any one agent is not required to cover too many villages. In the beginning of such a programme it is far better to serve a few districts well than to attempt to cover the whole country and achieve nothing.

2. The field staff must be required to live and work in daily contact with the people they are expected to serve.

3. The men who are employed in such work must have a knowledge of village life and a sympathetic understanding of the peasants in order that they may deal intelligently and effectively with practical rural problems and inspire confidence in the farmers.

4. These extension agents must in the Middle East (<u>and elsewhere</u>,*) have a training that is practical, even if it is not very extensive or scientific. Proper supervision by able leaders can go far to make up for the lack of adequate training on the part of the field staff.

5. Work of this kind is difficult, and the life strenuous. Therefore, the employees must have adequate remuneration."

* "and elsewhere" added by author.

One of the main functions of the supervisors will be, for example, to ensure that the farmers grow the chosen crop in the right field at the right time, otherwise a machinery pool would not work properly. In order to obtain the best possible utilisation from the pool, it is absolutely essential to cultivate large land units, but since the farms are small, this has to be achieved by a planned uniform cropping pattern. Diagram No. 1 exemplifies such an arrangement.

Here all the farms have the same crop in neighbouring fields and thus enable the machinery to be used on large units in spite of the fact that each particular farmer will cultivate only a small area with a given crop.

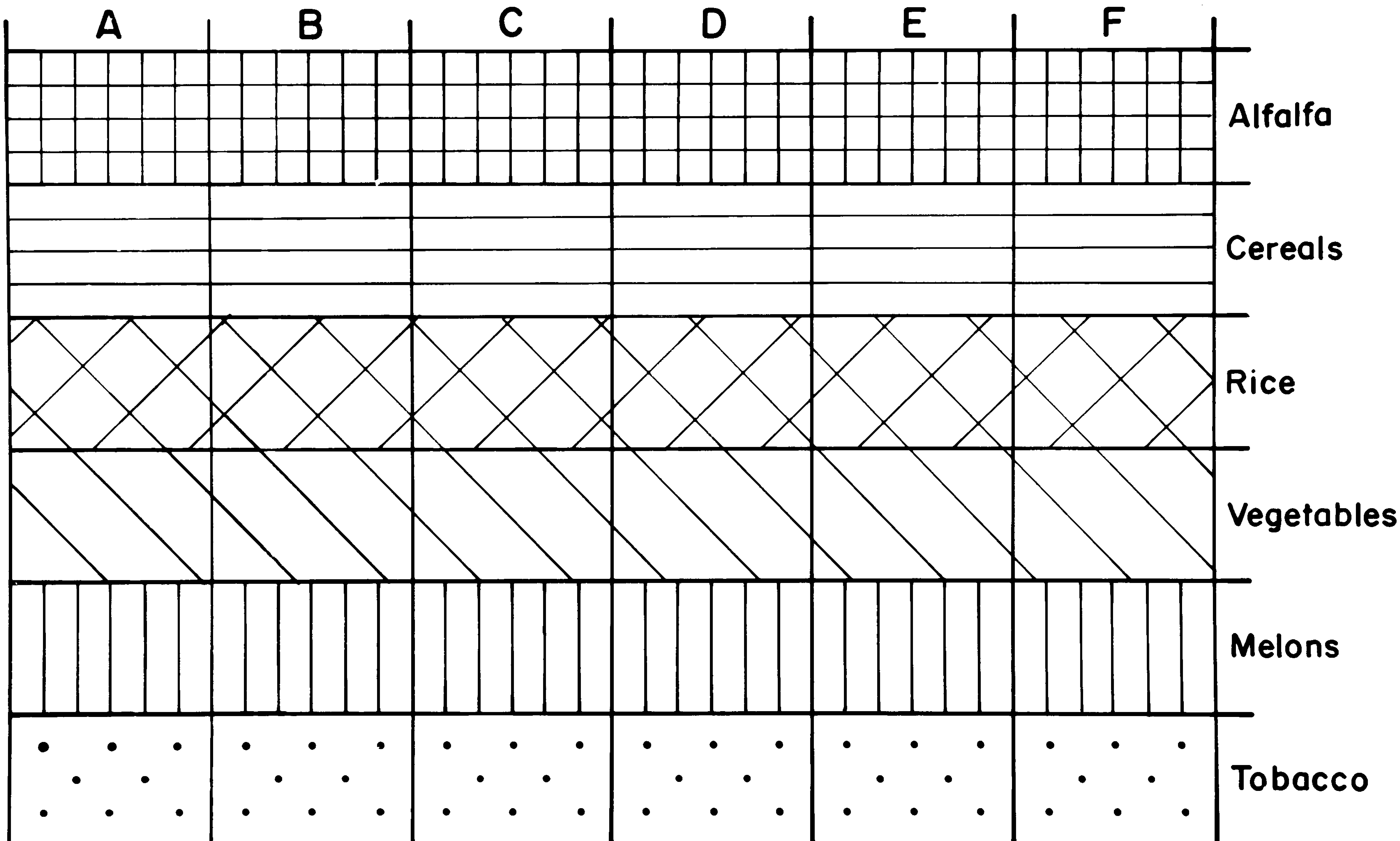
The supervisors, then, are the connecting link between production factors, the technical and the human parts of the project, and real development can only be achieved when these parts can work together without friction. Only where the supervisors are accepted by the settlers can new ideas be introduced.

The main factors of production are (1) natural resources, (2) labour and (3) capital. In projects such as the four under consideration all three factors are static in type. It is obvious that the natural resources (soil - water - climate) are static in absolute terms. In addition, a labour force consisting of people who live already in the area is also static until demographic changes occur. Capital, however, is not necessarily static in character, but here, as soon as capital investment is made, it becomes part of the fixed resource inventory and thus static until new flows and accumulation processes develop.

The only fundamentally non-static factors are the production means such as seeds, fertilizer, machinery etc. and the supervisors, and except for the supervisors even these, as physical manifestation of the capital investment noted above, have some static characteristics.

Diagram No. 1

FARMS



(Model of compulsory cultivation)

This situation has many advantages which should be exploited. Whereas a static factor even when not entirely suitable must be accepted, a non-static factor can be changed or replaced, allowing the possibility of continuous improvement. For the advisors this means that: (1) unsuitable persons can be replaced, (2) in crises more supervisors can be employed and (3) at the end of the supervision period the number of supervisors can be reduced gradually. These points could ensure that there is always the right number of able supervisors available.

Only when the supervision functions properly can co-operation without friction between settlers and decision making authorities for the benefit of the implementation of the newly established project be achieved, and only then can long-term success in the form of self-sustained development be achieved.

Given this general point let us now evaluate each project in terms of the factors shown in Table No. 1.

<u>Haradh</u>

The original plan for settlement in the area was to give 1,000 eight-member families a farm of four hectares each. But since only 7,559 persons in 1,191 families (chapter 1, p. 18), lived in the area, and of these only 6,521 persons (chapter 1, p. 21) wished to become farmers, the <u>number of inhabitants</u> is too small. In addition, during the settlement process a number of these people would leave, especially since about 50 per cent of the people questioned were 15 years of age and younger (chapter 1, p. 20).

Irrigation projects with their great capital investments require a highly intensive production in order to achieve high returns. That is, these projects are based on valuable cash crops, intensive vegetable cultivation, processing, or any combination of these, and thus demand a permanent high labour input.

Experience gained in the project shows that tradition does not allow the farm workers to do certain jobs (chapter 1, p. 24). Furthermore, it appeared doubtful whether the people regarded as the future farmers were able and willing to assure the high labour input which the production in the scheme would require (chapter 1, p. 82).

The degree of education, i.e. literacy, was very low (chapter 1, p. 21), so the farmers were unable to do even the simplest form of book-keeping and could not use written information. Everything would have to be shown to them personally by the extension workers and their farms would have to be supervised very closely. Consequently, a great number of supervisors would be involved.

Nutrition (chapter 1, p. 25) of the future farmers was adequate for their traditional life but needs improvement when the men would be working permanently on the fields. Experience gained from the labourers on the Demonstration and Training Farm shows that they were not prejudiced against improvement of their diet, and the family consumption planned for the settlers (chapter 1, p. 57) would assure an adequate diet for farm work. Thus their nutritional level will have no negative influence on the project.

Soil: the bare wadi walls, and some of the side wadis, (chapter 1, p. 32), may suffer erosion, the detritus from which could endanger the project. But as anti-erosion measures are very simple, and do not require heavy investment, this potential threat to agricultural production will most probably be averted.

Climate is the strongest restricting factor of agricultural production in the project area. However, as the crops, cropping pattern, cultivation time, area under cultivation (chapter 1, p. 50) and the animals to be kept (chapter 1, p. 49) are already selected with this climate in mind, no negative repercussions are expected.

Water quantity (chapter 1, p. 37), quality (chapter 1, p. 37) and access (chapter 1, p. 34) were the basis of the design of the irrigation system (chapter 1, pp. 32-36) and the drainage system (chapter 1, pp. 39-43). The scheme is planned so that an irrigation time of 24 hours is necessary. As night-work conflicts with the customs of the future settlers drawbacks could be expected, at least during the initial period.

The topography of the wadi floor (chapter 1, p. 32) is favourable for farming, and only a little levelling is necessary. The only constraint to potential cultivable area is the width of the wadi - one kilometre.

The original plans for resettlement envisaged a community composed of members drawn from several tribes (chapter 1, p. 19). But this planned group is too small, while the majority of the members of the leading tribe in the area, the Al Murrah, has been neglected.

Experience of other projects shows that all subtribes should be considered, that is, an equally strong group of each subtribe should be settled. On the other hand, the leaders of the Al Jaber subtribe said (chapter 1, p. 44) they would consider settlement only if they could stay together. However, if their condition were met, it would mean that one subtribe only would occupy most of the project. But all members of the Al Murrah need support, since 20 per cent have already given up camel nomadism because the sources of income are declining (chapter 1, p. 44) and some have given up their tribal membership completely.

For the project, i.e. for the technical part, it would be preferable, at least in the initial phase, to favour, for purposes of land allocation, the labour force of the Demonstration and Training Farm, but this is a very small group and consists only of members of the Al Ghurfran and the Al Jaber subtribes (chapter 1, p. 45).

However, the composition of the labour force is more or less speculative since apart from the original plan, which intended 8,000 people in the area to be settled, no official statement has ever been made. This illustrates that the situation concerning settlement is very unclear and this hindered or at least complicated progress.

The roads in the project area are sufficient for any traffic which the project could generate (chapter 1, p. 48), but the link to the road network of Saudi Arabia is not good: the connection to the main Riyadh - Hofuf road is interrupted by a 140 km. unpaved track, which makes the transport of perishable agricultural products impossible.

Hypothetical family income from agricultural production before marketing of 15,570.90 SR from a four hectare farm (chapter 1, p. 59), 9,045.20 SR from a one hectare farm (chapter 1, p. 86) and 30,990.95 SR from a nine hectare farm (chapter 1, p. 93) is promising, but the marketing situation (chapter 1, pp. 60-62) makes this profit impossible and even causes losses.

Labour input for the agricultural production of the three farm types requires the permanent presence of two labour units for a four hectare farm (chapter 1, pp. 81-82), one labour unit for a one hectare farm (chapter 1, p. 85) and four labour units for a nine hectare farm (chapter 1, pp. 89-90). For an agricultural community such as that in Al Hassa this would not create any problems, but for the future farmers of Haradh, with their traditional background, difficulties would most probably be encountered. Nevertheless, the situation would improve as the settlement progressed, provided the settlers stayed long enough.

One of the most important needs would have been to employ the right supervisors. The ideal would be a Saudi with agricultural education, but these men are rare and it was almost impossible to engage them for Haradh: during the construction period only one of the five supervisors was a Saudi. Thus the supervisors for the project would most probably be Palestinians, who are excellent farmers but not respected by the Al Murrah and thus their ability would not be utilized properly.

Al Hassa

Here the number of inhabitants (chapter 2, p. 114) does not create any problems. Even if the movement of the people to the oil-fields and other places of employment continues there will be enough people to cultivate the land, provided a regrouping of the properties is carried out, thus assuring an adequate family income.

The people cultivating the farms and gardens are farmers by tradition and education. Their nutrition is adequate and would improve as more crops are introduced (chapter 2, pp. 7-16).

About two thirds of the soil is suitable for cultivation (half of this needing amelioration), whereas one third creates serious problems, (chapter 2, pp. 124-126). This would need heavy investment, but even then part will be completely unusable.

Cultivation of the oasis has been adapted to the climate for centuries and since no great changes will occur climate will not exert negative influence (chapter 2, pp. 127-129).

Through the new irrigation and drainage scheme the water quality has been improved (chapter 2, p. 133) and the increase in quantity (chapter 2, p. 149) would make possible expansion of the oasis to 20,000 ha. However, two problems could endanger the water supply of many of the farms.

Firstly, the projected irrigation time of 24 hours daily (chapter 2, p. 134), which implies 20 hours actual irrigation time, clashes with the customs of the farmers, who, until now, have only irrigated during daytime.

Secondly, access to the water in the new scheme is problematical. Of the total area of 17.091 ha. (Flah 1 and Flah 3), only 7.451 ha., or 43.6 per cent, were irrigated. This area was irrigated using four different systems:

1. Correctly, using the new irrigation network.
2. The water supplied by the new irrigation system, but taken from the canal intended to serve neighbouring fields, which meant that the water had to be led across drainage canals.
3. The water was pumped out of the old irrigation and drainage network by means of motor pumps.
4. Using the old network, the water being lifted by Shadufs.

The sizes of the areas served by each of the four systems are shown in the following table.

Table No. 2

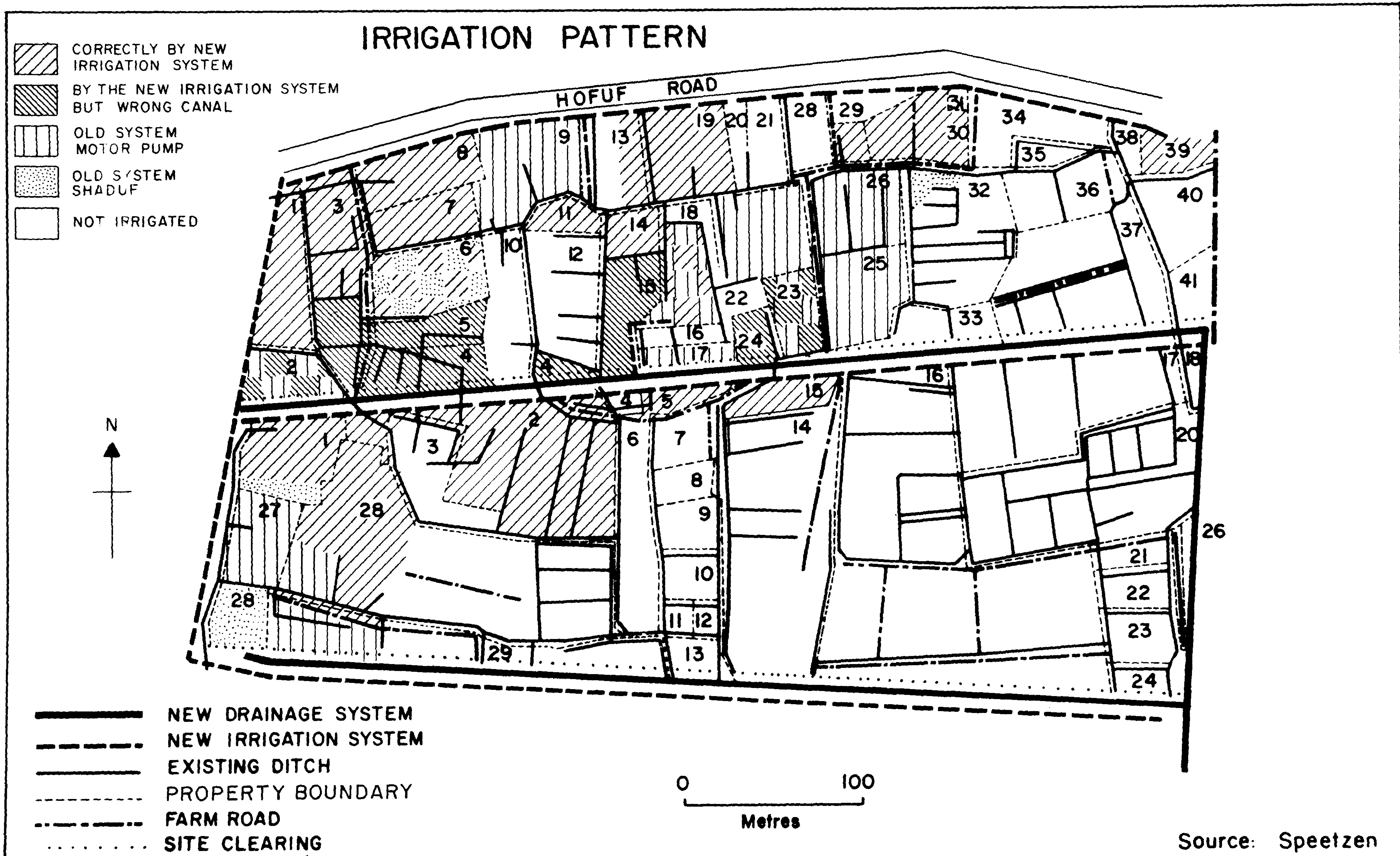
Irrigation systems and the extent of their use[2]

SYSTEM	HECTARES	PERCENTAGE OF TOTAL
New system, correctly	4.686	27.42
New system, wrong canal	0.804	4.71
Old system, motor pump	1.616	9.46
Old system, Shaduf	0.345	2.02
Total	7.451	43.60

This pattern is also illustrated in Map No. 1.

This map shows that, with the exception of one case, all those farmers who do not use the new irrigation system at all, or use it incorrectly, have no other choice, as their fields do not border on new

Map No. 1


IRRIGATION PATTERN
CORRECTLY BY NEW IRRIGATION SYSTEM
BY THE NEW IRRIGATION SYSTEM BUT WRONG CANAL
OLD SYSTEM MOTOR PUMP
OLD SYSTEM SHADUF
NOT IRRIGATED
HOFUF ROAD
N
NEW DRAINAGE SYSTEM
NEW IRRIGATION SYSTEM
EXISTING DITCH
PROPERTY BOUNDARY
FARM ROAD
SITE CLEARING
0
100
Metres
Source: Speetzen

irrigation canals. During the investigation of Flah the author repeatedly observed that farmers refused to let the irrigation water for their neighbours' fields cross their farms. This means that many of the farmers cannot utilize the new scheme at all.

The irrigation of 7.451 ha., or 43.6 per cent, was only possible when the old system was in operation, that is, until 1972. In fact, only 5.490 ha., or 32.13 per cent, of the total of 17.091 ha. has ever been irrigated by the new scheme.

Topography is generally favourable for agricultural production, both in the Old Oasis and the newly developed land. (Chapter 2, p. 129)

No money has been spent on resettlement undertakings as nearly all of the money was allocated for the improvement of the irrigation and drainage facilities (chapter 5, p.460). Surprisingly, a general improvement of living conditions was not included in the overall development plan. However, separate plans for the improvement of housing conditions have been drawn up. But the future effect of these later plans upon the community cannot be estimated at present.

Access to the Al Hassa Oasis is easy since it lies on the main Riyadh - Gulf road and the Riyadh - Dammam railway. The conditions for road transport within the oasis are also good.

Under the present system of land tenure the possibilities of earning an adequate income on farms within the Old Oasis are limited. On a 1.808 ha. farm, which is the largest unit found in Flah, the most probable income which can be gained is about 120.00 SR (chapter 2, p. 116) per labour unit per month, and on smaller farms not even this much can be earned. As a result the farmers look for employment elsewhere.

Assuming that the farms to be established on the newly developed land will have an area of 5.00 ha. each, a monthly income of about 400.00 SR per labour unit could be achieved (chapter 2, p. 206). This, together with the supply of vegetables and meat for his family free of charge, makes farming in Al Hassa very attractive to the farmers, who will thus be discouraged from seeking work elsewhere.

The labour input required for a 1.808 ha. farm is not enough even to employ one labour unit fully (chapter 2, pp. 180-181). This leads to a gradual abandonment of farming. The projected labour demand for the 5.00 ha. farms (chapter 2, pp. 196-197) on the new land will require the permanent employment of one full-time labourer. This man will thus be encouraged to remain on the farm.

The marketing situation (chapter 2, pp. 165-166) is favourable; only some of the vegetables needing to be transported to distant markets. This is an important condition for the maintenance of the farmers' income.

Supervisors do not create the same problem as in Haradh: (1) not so many supervisors are needed, (2) Hofuf and Mubarraz and the villages in Al Hassa are pleasant enough to attract supervisors, and (3) foreigners, i.e. Palestinians, are better accepted.

Avu Keta

The number of inhabitants (chapter 3, p. 269) in the area favours agricultural development as it enables the selection of the best suitable for farming. Moreover, tradition and education (chapter 3, p. 221 and p. 309) encourage agricultural progress and with increased output of agricultural products an improvement of diet can be expected (chapter 3, p. 225) and thus the farmers would be more able to do the hard farm work.

The soils of the plots selected for agricultural production should support good crops after the land improvement has been completed in the initial phase (chapter 3, pp. 232-237). Nevertheless, further research should be conducted in order to find out how the soils will react to this land improvement.

Climate does not exert any negative influence. The problem of low precipitation is accentuated when applying an intensive cropping pattern, but can easily be overcome by irrigation (chapter 3, pp. 237-243).

Water quality (chapter 3, pp. 268-269) and water quantity (chapter 3, pp. 255-256, 267 and 298) are adequate for the project. The design of the irrigation (chapter 3, pp. 251-256) and drainage system (chapter 3, pp. 256-263) is based on the water requirements envisaged in the development programme, and the access to the water (chapter 3, p. 255) favours agricultural production.

From the topographical point of view the area is ideal for agriculture, being almost flat with a slope of less than 0.1 per thousand, (chapter 3, p. 244).

The recommended resettlement plans (chapter 3, pp. 268-272) should enable the settlers to improve their living conditions.

The opening up of the area by means of the planned road network will facilitate traffic to and within the area (chapter 3, pp. 276-279).

Because of the favourable market situation (chapter 3, pp. 309-312) the planned yearly family income (chapter 3, p. 316) will not be reduced significantly by the demands of transport costs. This income would be for area I and 75 per cent of area II about £G 165, and for 25 per cent of area II and area III about £G 390.

Comparable incomes which male Ewes could earn outside the area are as follows: £G 300 per year from a six acre farm in the new Volta Resettlement Scheme[3] and in Accra[4] about £G 130 yearly as a factory or construction worker, about £G 84 per year as a labourer in transport, about £G 600 yearly as a manager in commerce, £G 90 to 2,250 per year for personal services and about £G 60 to 170 in public and other services. Thus area III and 25 per cent of area II promise a comparatively good income whereas the income from area I and 75 per cent of area II will only equal the income of a semi-skilled labourer.

However, as shown in chapter 3, p. 317, with a modified cropping pattern on farms in area I and 75 per cent of area II an income of about £G 545 could be achieved, which means, that farmers in these areas would not need leave their villages for higher salaries elsewhere.

Furthermore, the cropping pattern for both farm sizes has a peak labour demand twice a year which exceeds the working power of the family, that is, for farms in area I and 75 per cent of area II 219.94 per cent and 163.69 per cent (chapter 3, pp. 290-291) in July and January respectively, and for area III and 25 per cent of area II (chapter 3, pp. 304-305) 310.63 per cent and 301.00 per cent in August and January respectively. Since all farms will work according to the same model it will not be possible to get any help from neighbours during these periods. Thus, either the necessary work will not be done, which would lead to a reduction in yields, or workers would have to be hired at a cost of 23[5] to 40[6] pence per day per worker.

It would be ideal to keep the available family workers occupied at a constant rate throughout the whole year, but the planned cropping pattern for the Avu Keta project does not allow this. Therefore, in order to achieve continuous equal employment for each worker throughout the year, an entirely different cropping pattern would be necessary. However, this would require a totally different planning of the project, which is beyond the scope of this study.

The labour input figures (chapter 3, pp. 290-291 and pp. 304-305) are based on the assumption that the farmers will work eight hours daily per labour unit on their farms. But it is uncertain whether the farmers will be able to afford this time.

According to the traditional working pattern[7] the rural population is engaged in four different activities:

1. agricultural production,
2. production of non-agricultural goods (houses, roads, cloth, tools, etc.),
3. ceremonies, funerals, marriages, market days, etc., and
4. social security (the maintenance of the contact between members of extended families, which requires a great deal of time).

So as to get settlers to spend most of their time with agricultural production it is essential to make the time-consuming activities (2), (3) and (4) unnecessary. This is easy for activities in category No. 2, as these could be replaced by means of specialisation without any undue problems, whereas activities under category No. 3 will not be abandoned as long as traditions remain. The activities under category No. 4 will not disappear for a long time, if at all. Only after farming has been proved, for a lifetime, to assure adequate returns will the people give up some of the activities necessary to satisfy their demand for this traditional social security.

This means that the labour input is an uncertain factor, which at present, at least, probably has a negative influence on agricultural development.

To find suitable <u>supervisors</u> should not present any serious problems, as the most suitable would be selected from the young people who are now forced to leave the area.

<u>Tauorga</u>

Although the exact <u>number of inhabitants</u> (chapter 4, p. 327) is not known it can be assumed that there are enough families to occupy the 300 farms. This is particularly true since the future farmers will not only be chosen from the former labour force, i.e. the negroid people, but from the total population of the oasis.

Traditionally the oasis dwellers are accustomed to regular work (chapter 4, p. 363). This, combined with a good <u>education</u> which is available for everybody in Libya now, creates the basis for the development of a productive farming community. That is, it can be expected that the settlers will become able farmers after the difficulties of the initial period have been overcome.

However, the <u>diet</u> (chapter 4, p. 327) of the settlers requires improvement, and there are already attempts to achieve this. Nevertheless, the increase to 2,435 calories per day per person, planned for 1970 has not been achieved in the project area yet.

The <u>soils</u> of the area selected for the scheme are capable of supporting cultivation (chapter 4, pp. 331-334).

Although no <u>climatic</u> data for the area is available, from data collected near the project (chapter 4, p. 334) it can be concluded that there will be no negative influence.

The <u>water quality</u> (chapter 4, pp. 341-342) and the <u>quantity</u> (chapter 4, pp. 345-348) are adequate for the recommended cropping pattern, and the <u>irrigation</u> (chapter 4, pp. 349-352) and <u>drainage system</u> (chapter 4, pp. 352-357) are designed to satisfy the water demands of agricultural production under the given circumstances, and to assure <u>access</u> to irrigation water.

The <u>topography</u> of the area (chapter 4, p. 337) favours agricultural production and levelling will only be required in a few places.

The <u>resettlement plans</u> (chapter 4, p. 360), i.e. a village centre for the 288 farms which will be spread over the whole area, takes account of all the needs a scheme such as this will create. Also the dwelling units will be suitable for large families.

The road system within the scheme and the connection to the road network of the country are adequate for the expected traffic (chapter 4, p. 363)

The hypothetical annual family income is 2,814.53 Dinar (chapter 4, p. 388). However, this income can only be achieved with four full-time labourers, but since the families will most probably have only two full-time labourers, two labourers will have to be hired and paid for.

Nevertheless, even after the deduction of these costs the annual family income is still 1,614.35 Dinar, which results in 67.27 Dinar per month per labour unit. Compared with incomes paid in the Misurata district (chapter 4, p. 328) this is a good income, especially as home consumption is supplied free from the farms.

Taking a daily working time of eight hours as desirable, each farm will require four full-time labourers. As it is most unlikely that a family with at most eight members (chapter 4, p. 359) will be able to supply this number the labour demand (chapter 4, pp. 398-399) will exceed the capacity of the family and thus will need to substitute these either by machines or by hired labourers. In either case the profit will be reduced, but these costs are not so great as to reduce the family's income excessively.

The market situation (chapter 4, pp. 385-386) is encouraging for agricultural production as the products which cannot be sold either in the project area itself or in the vicinity of the project area have only to be transported a maximum distance of 260 km. to the markets in Tripoli.

Able men to work as supervisors in the project are available in Tripolitania. However, whether the attraction of the project is strong enough to make these people work and live there is as yet unknown.

Interdependence of factors influencing development

The suitability or otherwise of the factors considered above does not show the complete picture. Their interdependence and - resulting from that - their impact as a "development package" is the criterion. In that way the effectiveness of factors, including some which have not yet been considered, which in themselves do not have any negative or positive value, as for instance the location of the project or the land-ownership, can be illustrated.

The interdependence of all these factors and their contribution towards agricultural development show clearly why in each case success or failure is caused and how failure could be prevented.

The influence of these factors, now considered as interdependent components in the "development package", is judged by their suitability for agricultural development in a whole matrix. That is:

+	improvement of agricultural development (suitable)
-	retardation or prevention of agricultural development (unsuitable)
0	no influence
?	uncertain
i	influence on design, dimension, number, effect on "yes" or "no" decisions, etc.

An example is given below for each case:

For the Haradh project the influence of the new irrigation scheme on the soil is "+" because through irrigation and leaching the soil will be improved.

The influence of tradition in Haradh on labour input is "-", because some jobs and the working times do not suit the attitudes of the future settlers.

When there is no influence at all, as for instance, when the number of inhabitants does not influence the soils, a "0" is shown.

In some areas of the Avu Keta project the influence of the agricultural production on soil is uncertain, that is, "?". The dimension of the drainage canals is influenced by the volume of water to be drained, therefore "i" in all cases.

In these investigations only the direct influence is considered, e.g. in Haradh no income from agriculture is possible without water, but the water does not influence the income directly, and thus is "0". However, all factors necessary to ensure an income are improved by water and are thus "+".

The reasons for no influence being exerted, i.e. "0", or influence being exerted only on specific technical specification (dimensions of canals, etc.), i.e. "i", have been given in the description of the projects and thus further analysis is unnecessary at this stage.

Therefore, in the following analysis only improvements, i.e. "+", impediments, i.e. "-", and uncertain influence, i.e. "?", will be dealt with.

The two decisions as to (a) the desirability of establishing a project or not, and (b) as to its location, are almost always political in nature, based on the three main production factors: water, soil and climate. That is, they are not subject to serious investigation; the question is "yes" or "no" and not at that stage "how". After the location is chosen an investigation of all the other factors involved follows. Thus, the influences affecting the location are in all cases "i".

In the following analysis of the interdependences, the headings of the numbered sections represent the factors which are directly influenced by others specified in the corresponding sections.

Diagram No. 2

HARADH	1 LOCATION OF PROJECT	2 PRESENT LANDUSE	3 NUMBER OF INHABITANTS	4 NUTRITION	5 EDUCATION	6 TRADITION	7 PRESENT SOURCE OF INCOME	8 SOIL	9 CLIMATE	10 SOURCE OF WATER	11 QUANTITY	12 QUALITY	13 TIME OF AVAILABILITY	14 ACCESS TO WATER	15 NEW IRRIGATION	16 NEW DRAINAGE	17 TOPOGRAPHY	18 STATE OF SEDENTARISATION	19 RESETTLEMENT SCHEME	20 MEANS OF ESTABLISHMENT	21 TRANSPORT	22 TRADE	23 SIZE OF FARMS	24 OWNERSHIP	25 AGRIC. PRODUCE	26 LABOUR INPUT	27 INCOME FROM SCHEME	28 MARKETING	29 SUPERVISORS
1 LOCATION OF PROJECT		o	o	o	o	o	i	o	o	i	o	o	o	i	o	o	i	o	o	o	o	o	o	o	o	o	o	o	o
2 PRESENT LAND USE	−		o	o	−	−	+	o	−	+	+	+	?	+	+	+	+	−	+	o	+	+	o	?	+	o	o	o	o
3 NUMBER OF INHABITANTS	o	o		o	o	o	−	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	−	o	o
4 NUTRITION	o	i	o		i	i	i	o	o	o	o	o	o	o	o	o	o	i	i	o	i	i	o	o	o	o	o	o	o
5 EDUCATION	o	−	o	o		−	−	o	o	o	o	o	o	o	o	o	o	−	+	o	o	o	o	o	o	o	o	o	o
6 TRADITION	−	−	o	o	+		+	o	o	o	o	o	o	o	o	o	o	−	+	o	o	o	o	o	+	+	−	o	+
7 PRESENT SOURCE/INCOME	i	−	o	o	−	−		i	−	o	o	o	o	o	o	o	o	−	+	o	−	−	o	o	+	−	−	−	+
8 SOIL	o	o	o	o	o	o	o		o	o	+	+	?	+	+	+	o	o	o	o	o	o	o	o	+	+	o	o	o
9 CLIMATE	o	o	o	o	o	o	o	o		o	+	o	o	o	+	+	o	o	o	o	o	o	o	o	+	o	o	o	o
10 SOURCE OF WATER	o	o	o	o	o	o	o	o	?		o	o	o	o	−	+	o	o	o	o	o	o	o	o	o	o	o	o	o
11 QUANTITY	o	o	o	o	+	+	o	o	o	o		o	−	?	+	o	o	o	o	o	o	o	o	o	o	o	o	o	o
12 QUALITY	o	o	o	o	o	o	o	o	o	i	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
13 TIME OF AVAILABILITY	o	o	o	o	+	−	o	o	o	i	o	o		o	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o
14 ACCES TO WATER	o	o	o	o	o	o	o	o	o	i	o	o	o		i	o	o	o	o	o	o	o	o	o	o	o	o	o	o
15 NEW IRRIGATION	o	o	o	o	o	o	o	i	i	o	i	i	i	i		o	i	o	o	o	o	o	o	o	o	o	o	o	o
16 NEW DRAINAGE	o	o	o	o	o	o	o	i	i	o	o	o	o	o	i		o	o	o	o	o	o	o	o	o	o	o	o	o
17 TOPOGRAPHY	o	o	o	o	o	o	o	o	o	o	o	o	o	o	i	i		o	o	o	o	o	o	o	o	o	o	o	o
18 STATE OF SEDENTARISATION	o	o	o	o	+	−	+	o	o	o	o	o	o	o	o	o	o		+	?	+	+	o	?	+	−	−	−	+
19 RESETTLEMENT SCHEME	o	o	?	o	o	−	+	o	o	o	o	o	−	o	o	o	o	−		−	+	+	o	?	o	−	−	o	o
20 MEANS OF ESTABLISHMENT	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o
21 TRANSPORT	−	−	−	o	o	o	+	o	o	o	o	o	o	o	o	o	o	o	+	o		+	o	o	o	o	o	+	o
22 TRADE	−	−	−	o	o	o	−	o	o	o	o	o	o	o	o	o		−	+	o	+		o	o	+	o	−	+	o
23 SIZE OF FARMS	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o
24 OWNERSHIP	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o
25 AGRIC PRODUCTION	o	−	o	o	+	−	o	+	+	o	+	+	?	+	+	+	+	o	o	o	o	o	i	o		−	−	o	+
26 LABOUR INPUT	o	o	o	o	+	−	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	i	o	i		−	o	+
27 INCOME FROM SCHEME	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	o		−	+
28 MARKETING	−	o	−	o	o	o	o	o	o	o	o	o	o	o	o	o	o	−	+	o	+	+	o	o	o	o	o		o
29 SUPERVISORS	−	o	o	o	+	−	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	o	i	o	o	o	o	o	

Haradh - interdependences

2. Present land use (chapter 1, pp. 15-17)

The degree of (5) education and (6) tradition, i.e. the desire to be a tribesman (chapter 1, p. 23), causes disapproval of any interference which would weaken the tribal society and thus, from this point of view, it is preferable to maintain the present land use.

But with further development of the economy of Saudi Arabia the gap between the (7) present income in the area and elsewhere (chapter 1, pp. 22 and 24, chapter 2, p. 119) will grow wider and tribal members will be tempted to look for employment outside the area, (chapter 1, p. 44).

The extreme (9) climatic conditions (chapter 1, pp. 29-30) until now allowed only the present land use. In order to overcome its crucial influence, enormous capital investment for production units and high salaries for managers and supervisors from outside the area is required.

The (10) source of water (chapter 1, p. 36) in the area, its (11) quantity (chapter 1, p. 37), (12) quality (chapter 1, p. 37) and (14) access (chapter 1, p. 32) made the establishment of an (15) irrigation (chapter 1, pp. 32-36) and (16) drainage scheme (chapter 1, pp. 39-43) possible which will result in the change of the present land use towards more intensive agricultural production. Only the (13) time of availability (chapter 1, p. 37), i.e. 20 irrigation hours, could create drawbacks, since the future settlers are not accustomed to night-work.

The (17) topography (chapter 1, p. 32) of the Wadi as Sabha favours attempts to improve the present land use.

The (19) resettlement scheme (chapter 1, pp. 43-46, and p. 49) is bound to improve the present land use, but the (18) state of sedentarisation (chapter 1, p. 43) tends to maintain it.

By (21) transport (chapter 1, pp. 46 and 48) and (22) trade (chapter 1, p. 23) the first step towards sedentarisation, i.e. from camel to sheep nomadism (chapter 1, p. 44), could be initiated which would lead to change in the present land use.

The question of (24) land-ownership (chapter 1, p. 25) needs more discussion between the parties involved and is as yet an unclear factor.

The recommended cropping pattern for (25) agricultural production (chapter 1, pp. 50, 53, 84 and 88) is a considerable improvement on the present land use.

3. The number of inhabitants (chapter 1, p. 18)

The (7) present source of income (chapter 1, pp. 22-24) does not allow an increase in the number of inhabitants. Neither does the (27) income from the scheme (chapter 1, p. 63) promise any increase.

5. Education (chapter 1, p. 21)

The (2) present land use (chapter 1, pp. 15-17), (6) tradition, the (7) present source of income (chapter 1, pp. 22-24) and the (18) state of sedentarisation (chapter 1, p. 43) make regular attendance at school very difficult whereas in the (19) new resettlement scheme (chapter 1, pp. 43-46) everybody would have the opportunity to be educated. Although the establishment of the villages has been postponed (chapter 1, p. 46) education would be assured since a school is already in operation in Haradh (shanty town).

6. Tradition (chapter 1, p. 23)

The isolation caused by the (1) location of the project (chapter 1, p.15) and the (18) state of sedentarisation (chapter 1, p. 43) preserve tradition with all its impeding elements. However, the (7) present source of income (chapter 1, pp. 22-24) indicates that the first step away from the traditional society is already completed (chapter 1, p. 20), thus initiating a development which will be continued by the (19) new resettlement scheme (chapter 1, pp. 43-46) itself requiring the introduction of new techniques for (25) agricultural production (chapter 1, pp. 49-95) and a new approach towards (26) labour input (chapter 1, pp. 63-82). In addition to this, the (29) supervisors (chapter 5, p. 409) will gradually try to overcome the impeding influence of traditions. Nevertheless, all their efforts will be defeated by the expected low (27) income from the scheme (chapter 1, p. 62).

7. Present source of income (chapter 1, pp. 22-24)

The (2) present land use (chapter 1, pp. 15-17) forces the people to live mainly from their herds. The above-mentioned non-agricultural jobs (chapter 1, p. 20) are not in the area and consequently people would have to emigrate in order to utilize them. These people would normally be the most able and (5) education (chapter 1, p. 21) accelerates this movement. Or they may be engaged in (21) transport (chapter 1, pp. 46-48) or (22) trade (chapter 1, p. 23) in the area, which again means that those with initiative are lost to agriculture, since (9) climate (chapter 1, pp. 29-30) and the (28) marketing situation (chapter 1, pp. 60-61) do not allow an extension of the present source of income. The (19) resettlement scheme (chapter 1, pp. 43-46) including a different (25) agricultural production (chapter 1, pp. 49-95) under (29) supervision (chapter 5, p. 409) would improve the income considerably, but the permanently high (26) labour input required (chapter 1, pp. 63-82) and the expected low (27) income from the scheme (chapter 1, p. 63) after the transport costs have been deducted, will make this improvement impossible.

8. Soil (chapter 1, pp. 25-29)

The hard-pans in parts of the project will be destroyed through (26) labour input (chapter 1, pp. 63-82) as soon as the (25) agricultural production (chapter 1, pp. 49-95) starts. A removal from the soil of all depositions is assured due to (14) access to water (chapter 1, p. 32), the new (15) irrigation (chapter 1, pp. 32-36) and (16) drainage scheme (chapter 1, pp. 39-43), based on the adequate (12) quality (chapter 1, p. 37) of the water and a (11) quantity (chapter 1, p. 37) which includes 35 per cent for leaching purposes. However, the (13) time of availability (chapter 1, p. 37) could hinder full use of the possibilities since it demands night-work.

9. Climate (chapter 1, pp. 29-30)

There is no way of influencing the climate. However, the near absence of precipitation can be made good by an adequate (11) quantity of water (chapter 1, p. 37) provided by the (15) irrigation (chapter 1, pp. 32-36) and (16) drainage scheme (chapter 1, pp. 39-43). Furthermore, in the (25) agricultural production plan (chapter 1, pp. 49-50) only parts of the area are under cultivation during the hottest period.

10. Source of water (chapter 1, p. 36)

Water sufficient to supply the (15) irrigation system (chapter 1, pp. 32-36) for 100 years is stored in the Umm er Radhuma stratum and this period will be extended even when only part of the water used for irrigation is replaced by precipitation (chapter 1, pp. 29-30) falling in the catchment area and by recycled (16) drainage water (chapter 1, pp. 39-43).

11. Quantity of water (chapter 1, p. 37)

The new (15) irrigation system (chapter 1, pp. 32-36) will distribute sufficient water to ensure agricultural production. (5) education will enable the future farmers to apply the correct amount to the fields and this can be taught to them relatively easily since they like to deal with water. But the fact that there will be almost unlimited (14) access (chapter 1, p. 32) to the water could lead to over-irrigation and losses; the (13) time of availability (chapter 1, p. 37), i.e. night irrigation, will certainly cause this.

13. Time of availability (chapter 1, p. 37)

(5) education (chapter 1, p. 21) of the future farmers would ensure that they would make the best use of the water when it is available, but their (6) tradition (chapter 1, p. 23) will discourage them from doing night-work and thus the water will not be used properly all the time.

18. State of sedentarisation (chapter 1, p. 43)

In order to achieve any agricultural development, altering the degree of sedentarisation is unavoidable.

The (7) present source of income (chapter 1, pp. 22-24), i.e. 66 per cent from animal sale, mainly camels whose market value is diminishing, and about 26 per cent from cash donations which could stop any time, is one of the main reasons for altering this state. The necessity to achieve a higher, more reliable income requires increased (25) agricultural production (chapter 1, pp. 49-95) which together with (19) resettlement scheme (chapter 1, pp. 43-46) and with simultaneous (5) education (chapter 1, p. 21) and (29) supervision (chapter 5, p. 409) would lead to sedentarisation. This trend will be emphasized by the enlightening influence of increased (21) transport (chapter 1, pp. 46-48) and (22) trade (chapter 1, p. 23). But (6) tradition (chapter 1, p. 23), the expected low (27) income from the scheme (chapter 1, p. 63), the permanently high (26) labour demand (chapter 1, pp. 63-82) and the unfavourable (28) market situation (chapter 1, pp. 60-61) do not make a change towards sedentarisation desirable.

Furthermore, the open points concerning (24) ownership (chapter 1, p.25) of the homesteads and the (20) means of establishment, about which the latest recommendation is to let the future settlers live in their tents during the initial period, do not encourage any change in the state of sedentarisation.

19. Resettlement scheme (chapter 1, pp. 43-46)

The unreliability of the (7) present source of income (chapter 1, pp. 22-24) which could be recognized by the inhabitants because of increased contact with other people, established the desire for security which would be represented by the resettlement scheme. But the (18) state of sedentarisation (chapter 1, p. 43), (6) tradition (chapter 1, p. 23), the (20) means of establishment, the permanently required (26) labour input (chapter 1, pp. 62-82), low family income (chapter 1, p. 63) and an unclear (24) land tenure situation (chapter 1, p. 25) lessen this desire and the fact that it is actually unknown who finally will be settled, which results in an unspecified (3) number of inhabitants (chapter 1, p. 18) and thus uncertainty about the future, suggest the same conclusion.

21. Transport (chapter 1, pp. 46-48)

The isolation caused by the (1) location of the project (chapter 1, p. 15), the small (3) number of inhabitants (chapter 1, p. 18) distributed over a large area and the negligible output from the (2) present land use (chapter 1, pp. 15-17) do not require a well developed traffic system. But the (7) present source of income (chapter 1, pp. 22-24) necessitates a change, thus initiating the establishment of a project which will lead to increased (22) <u>trade</u> (chapter 1, p. 23) requiring a developed traffic system.

22. <u>Trade</u> (chapter 1, p. 23)

The (1) <u>location of the project</u> (chapter 1, p. 15), the (2) <u>present land use</u> (chapter 1, pp. 15-17), the small (3) <u>number of inhabitants</u> (chapter 1, p. 18), the (7) <u>present source of income</u> (chapter 1, pp. 22-24) and the (18) <u>state of sedentarisation</u> (chapter 1, p. 43) limit demand and thus trade is severely restricted.

The (19) <u>resettlement scheme</u> (chapter 1, pp. 43-46) with increased (25) <u>agricultural production</u> (chapter 1, pp. 49-95) and (28) <u>marketing</u> (chapter 1, pp. 60-61) and increased (21) <u>transport</u> (chapter 1, pp. 46-48) inside and outside the area could increase the demand. However, the (27) <u>income from the scheme</u> (chapter 1, p. 63) will not result in a higher purchasing power, and thus trade will remain limited.

25. <u>Agricultural production</u> (chapter 1, pp. 49-95)

Agricultural production will be made possible by a combination of (5) <u>education</u> (chapter 1, p. 21) and (29) <u>supervision</u> (chapter 5, p. 409) based on improved (8) <u>soil</u> (chapter 1, pp. 25-29), (9) <u>climate</u> (chapter 1, pp. 29-30), (11) <u>water quantity</u> (chapter 1, p. 37) and (12) <u>quality</u> (chapter 1, p. 37), (14) <u>access</u> to water (chapter 1, p. 32), a new (15) <u>irrigation</u> (chapter 1, pp. 32-36) and (16) <u>drainage system</u> (chapter 1, pp. 39-43) and a (17) <u>topography</u> (chapter 1, p. 32) which allows cultivation.

A drawback will be the (13) <u>time of availability</u> (chapter 1, p. 37) of the water, since the correct amount of water will probably not be applied during night irrigation.

To make agricultural production successful it is vital to overcome the negative influence of (6) <u>tradition</u> (chapter 1, p. 23) and to increase the knowledge of the farmers, which at present only allows them to exploit the pastures extensively. But the psychological drive, necessary for any successful agricultural production will be lacking, as the high (26) labour input (chapter 1, pp. 63-82) and the low (27) income from the scheme (chapter 1, p. 63) will result in frustration.

26. Labour input (chapter 1, pp. 63-82)

Only through improved (5) education (chapter 1, p. 21) and (29) supervision (chapter 5, p. 409) could the farmers be persuaded to fulfill the labour demand of the scheme. However, the low (27) income from the scheme (chapter 1, p. 63) will not reward these efforts.

27. Income from the scheme (chapter 1, p. 63)

Based on the recommended (25) agricultural production (chapter 1, pp. 49-95) under (29) supervision (chapter 5, p. 409) an adequate family income be achieved, but the (28) market situation (chapter 1, pp. 60-61) will lower all estimates.

28. Market situation (chapter 1, pp. 60-61)

The market situation is most strongly influenced by the (1) location of the project (chapter 1, p. 15) at a great distance from the markets. The market within the area is very limited because of the small (3) number of inhabitants (chapter 1, p. 18) and their (18) state of sedentarisation (chapter 1, p. 43). Even the new (19) resettlement scheme (chapter 1, pp. 43-46) and increased (12) trade (chapter 1, p. 23) within the area could not create any considerable increase in demand.

The (11) transport conditions (chapter 1, pp. 46-48), even when improved, would not bring any monetary savings, and thus profits could still not be achieved.

Diagram No. 3

AL— HASSA	1 LOCATION OF PROJECT	2 PRESENT LANDUSE	3 NUMBER OF INHABITANTS	4 NUTRITION	5 EDUCATION	6 TRADITION	7 PRESENT SOURCE OF INCOME	8 SOIL	9 CLIMATE	10 SOURCE OF WATER	11 QUANTITY	12 QUALITY	13 TIME OF AVAILABILITY	14 ACCESS TO WATER	15 NEW IRRIGATION	16 NEW DRAINAGE	17 TOPOGRAPHY	18 STATE OF SEDENTARISATION	19 RESETTLEMENT SCHEME	20 MEANS OF ESTABLISHMENT	21 TRANSPORT	22 TRADE	23 SIZE OF FARMS	24 OWNERSHIP	25 AGRIC. PRODUCE	26 LABOUR INPUT	27 INCOME FROM SCHEME	28 MARKETING	29 SUPERVISORS
1 LOCATION OF PROJECT	■	i	i	o	o	o	i	i	i	i	i	i	i	i	i	i	i	i	o	o	o	o	o	o	o	o	o	o	o
2 PRESENT LAND USE	o	■	o	i	+	+	—	i	i	i	i	i	i	_	+	+	+	l	?	o	o	o	o	o	o	-+	-+	+	o
3 NUMBER OF INHABITANTS	o	—	■	o	o	o	—	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	—	o	o	o	o	o
4 NUTRITION	o	l	o	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	o	+	o	o
5 EDUCATION	o	o	o	o	■	i	o	o	o	o	o	o	o	o	o	o	o	i	o	o	o	o	o	o	o	o	o	o	o
6 TRADITION	o	i	o	o	o	■	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
7 PRESENT SOURCE/INCOME	o	i	o	o	o	i	■	i	i	i	o	i	i	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+
8 SOIL	o	o	o	o	o	o	o	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
9 CLIMATE	o	o	o	o	o	o	o	o	■	o	+	+	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	o	o
10 SOURCE OF WATER	o	o	o	o	o	o	o	o	o	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
11 QUANTITY	o	o	o	o	o	o	o	i	o	o	■		—	—	i	—	o	o	o	o	o	o	o	o	o	o	o	o	o
12 QUALITY	o	o	o	o	o	o	o	o	o	o	o	■	o	o	+	+	o	o	o	o	o	o	o	o	o	o	o	o	o
13 TIME OF AVAILABILITY	o	o	o	o	o	o	o	o	o	o	o	o	■	—	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o
14 ACCES TO WATER	o	o	o	o	o	_	o	o	o	o	o	o	o	■	_	_	o	o	o	o	o	o	—	—	o	o	o	o	o
15 NEW IRRIGATION	o	o	o	o	+	+	o	o	o	o	i	o	—	—	■	i	i	+	o	o	o	o	o	o	o	o	o	o	o
16 NEW DRAINAGE	o	o	o	o	o	o	o	i	i	o	i	o	i	o	i	■	i	o	o	o	o	o	o	o	o	o	o	o	o
17 TOPOGRAPHY	o	o	o	o	o	o	o	o	o	o	o	o	o	i	i	o	■	o	o	o	o	o	o	o	o	o	o	o	o
18 STATE OF SEDENTARISATION	o	o	o	o	o	+	o	o	o	o	o	o	o	o	o	o	o	■	o	o	o	o	_	_	o	o	_	o	o
19 RESETTLEMENT SCHEME	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■	o	o	o	o	o	o	o	o	o	o
20 MEANS OF ESTABLISHMENT	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■	o	o	o	o	o	o	o	o	o
21 TRANSPORT	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■	i	o	o	i	o	o	i	o
22 TRADE	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	1	■	o	o	+	o		o	o
23 SIZE OF FARMS	o	o	o	o	o	—	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■		o	o	o	o	o
24 OWNERSHIP	o	o	o	o	o	—	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■	o	o	o	o	o
25 AGRIC PRODUCTION	i	+	o	o	+	+	+	+	+	o	+	+	—	—	+	+	+	+	o	o	o	o	—	o	■	+	o	+	+
26 LABOUR INPUT	o	o	o	i	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	l	■	o	o	+
27 INCOME FROM SCHEME	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	7	.i	_	_	+	+	■	+	+
28 MARKETING	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	+	o	o	o	o	o	■	o
29 SUPERVISORS	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■

29. Supervision (chapter 5, p. 409)

The great distance between the urban centres and the project discourages able men from taking a job as supervisor. This could be improved by better (11) transport conditions, so that they could commute to the area without having to drive along tracks for hours.

Since most of the supervisors would be foreigners who are not tribesmen, the traditional reluctance of the inhabitants of the area to accept them must be overcome by educational efforts.

Al Hassa - interdependences

2. Present land use (chapter 2, pp. 100-108)

The inhabitants of the oasis are settled farmers because of their (5) education (chapter 2, p. 113) and (6) tradition (chapter 2, pp. 111-112). For this reason a part of the oasis is still under cultivation in spite of the relatively low (7) income (chapter 2, p. 166) which is earned at present from farming.

The proportion of cultivated land is becoming progressively smaller as, even with the new irrigation and drainage scheme, an increasing number of farmers give up farming because the farms do not require enough (26) labour input (chapter 2, pp. 166-181) and do not supply the families with adequate incomes (chapter 2, p. 166). However, as the (28) marketing situation (chapter 2, pp. 165-166) is good, for the farmers who continue farming, an outlet for products is assured.

3. Number of inhabitants (chapter 2, p. 114)

The (2) present land use (chapter 2, pp. 100-108), i.e. small scale farming means that (7) present incomes (chapter 2, p. 166) are low and this causes a decrease in population in the villages.

This process is accelerated further as land tenure is based on the Moslem law of succession, that is, gavelkind, and the land units, or at least the profits from these units, are getting continuously smaller.

4. Nutrition (chapter 2, pp. 120-121)

(2) present land use (chapter 2, pp. 100-108) and the planned (25) agricultural production (chapter 2, pp. 182-183), which are in fact similar but at different levels of intensity, provide at present, and will provide in future, an adequate diet. If larger farms are established, the resulting higher (27) income from the scheme (chapter 2, p. 206) could be used to buy food with which to supplement the diet.

7. Present source of income (chapter 2, p. 166)

By means of intensified (25) agricultural production (chapter 2, pp. 182-183) the present income could be improved considerably. This presupposes an enlargement of the farms, but the prevailing traditional law of succession militates against larger farm sizes.

8. Soil (chapter 2, pp. 124-126)

The new (16) drainage scheme (chapter 2, pp. 141-146) contributes to an improvement in the soil as some areas with stagnant water are now being drained properly. Furthermore, only with a sufficient drainage system can effective leaching be carried out. The intensified (25) agricultural production (chapter 2, pp. 182-183) and the required (26) labour input (chapter 2, pp. 196-197) will also result in an improvement in the soil, assuming that it will be economic to cultivate the land.

9. Climate (chapter 2, pp. 127-129)

The new (15) irrigation (chapter 2, pp. 134-141) and (16) drainage scheme (chapter 2, pp. 141-146) is necessary because of the arid climate. The success of this scheme was assured by the availability of an adequate (11) quantity (chapter 2, p. 149) of water, of an adequate (12) quality (chapter 2, p. 133), available at the (13) required times (chapter 2, p. 134). However, it is not assured that all farmers have (14) access (chapter 5, p. 417) to the irrigation water and new regulations to ensure this are essential. As long as such rules are absent the success of the newly established scheme will be at stake.

11. Quantity of water (chapter 2, p. 149)

The calculations on which the water requirements are based indicate that there is an adequate water supply. But the (13) time of availability (chapter 2, p. 134), i.e. an irrigation time of 20 hours daily, is not suitable, as it necessitates night irrigation which will most probably not be acceptable to the farmers.* Furthermore, (14) access to the water (chapter 5, p. 417) is not guaranteed for a number of farmers, who, consequently, cannot cultivate their land properly.

12. Quality of water (chapter 2, p. 133)

Whilst the old irrigation and drainage system was in operation the irrigation water became increasingly saline because the same water was used by successive farms. By means of the new (15) irrigation (chapter 2, pp. 134-141) and (16) drainage system (chapter 2, pp. 141-146) every farm is now theoretically provided with fresh irrigation water (but see (11) above).

13. Time of availability (chapter 2, p. 134)

For some farmers who do not have (14) access to the water

* Verbal communication with a number of farmers during the investigation of Flah.

(chapter 5, p. 417) because their farms do not border irrigation canals, the water is not necessarily available when required.

14. Access to the water (chapter 5, p. 417)

The (6) traditional law of succession is causing the farms to become continuously smaller in (23) size. This fact did not create such serious problems whilst the old irrigation and drainage system was operating, but now that the oasis is being irrigated by means of the new system, the old irrigation network has been destroyed. This means that a number of farm owners cannot obtain any water for irrigating their fields.

15. New irrigation scheme (chapter 2, pp. 134-141)

Because of their (6) traditions (chapter 2, pp. 111-112), (5) education (chapter 2, p. 113), and their being a (18) settled community, the farmers of Al Hassa are able and willing to make the best use of the new irrigation system. However, the (13) time of availability (chapter 2, p. 134) and (14) access to the water (chapter 5, p. 417) hinder this.

18. State of sedentarisation (chapter 2, pp. 111-113)

(6) traditionally (chapter 2, pp. 111-113) the inhabitants of Al Hassa are sedentary. However, the (23) size of the farms (chapter 2, p. 107) in the Old Oasis, the ruinous (24) pattern of ownership (chapter 2, pp. 121-124) and the resulting small (27) incomes (chapter 2, p. 166) force them to move to places with better employment opportunities. This could be prevented for future farmers cultivating the new land by providing farms of an adequate size and a system of land tenure which would replace the old laws of succession; no decision has as yet been made regarding this problem.

22. Trade (chapter 2, p. 148)

An increase in trade can be expected after the establishment of intensified (25) agricultural production (chapter 2, pp. 182-183), provided that the (27) income from the scheme (chapter 2, p. 206) is high enough to enable the farmers to purchase goods.

23. Size of farms (chapter 2, pp. 107 and 153-154)

(6) tradition causes a progressive decrease of the farms' sizes, thus preventing agricultural development. This problem could be circumvented only by the establishment of a different land tenure system. However, no plans for this exist.

24. Ownership (chapter 2, pp. 121-124)

The application of (6) traditional laws of inheritance has caused parcellation of holdings in the entire oasis, this, together with other factors, being instrumental in the decline of the oasis.

25. Agricultural production (chapter 2, pp. 155-156 and 182-183)

(2) present land use (chapter 2, pp. 100-108), (5) education (chapter 2, p. 113), (6) tradition (chapter 2, pp. 111-112), the (18) state of sedentarisation (chapter 2, pp. 111-113) and the (7) present source of income (chapter 2, p. 166) are an excellent basis for future agricultural production in the oasis. The natural resources, that is, (8) soil (chapter 2, pp. 124-126), water (11) quantity (chapter 2, p. 149) and (12) quality (chapter 2, p. 133), and (9) climate (chapter 2, pp. 127-129) also favour agricultural production, but the (13) time of water availability (chapter 2, p. 134) and (14) access to the water (chapter 5, p. 417) implied by the new scheme, make this production impossible in some places.

The new (15) irrigation (chapter 2, pp. 134-141) and (16) drainage scheme (chapter 2, pp. 141-146) is generally an improvement on the old agricultural production system. The (17) topography (chapter 2, pp. 129-130) does not create serious problems, but levelling is required in some places.

The (23) size of the farms (chapter 2, p. 107 and pp. 153-154) in the Old Oasis does not favour agricultural production, and no farm size has yet been decided for the new land.

The (26) labour demand (chapter 2, pp. 180-181 and 196-197) will be covered easily by family members, supported by able (29) supervisors (chapter 5, p. 409).

The (28) marketing situation (chapter 2, pp. 165-166) is good as all of the products, with the exception of a proportion of the vegetables, can be sold in Al Hassa.

26. Labour input (chapter 2, pp. 180-181 and 196-197)

The general willingness to supply the required labour input will be supported by able (29) supervisors (chapter 5, p. 409)

27. Income from the scheme (chapter 2, p. 206)

(25) agricultural production (chapter 2, pp. 155-156 and 182-183), supply of the (26) labour input required (chapter 2, pp. 180-181 and 196-197), the (28) marketing situation (chapter 2, pp. 165-166) and the availability of able (29) supervisors (chapter 5, p. 409) favour agricultural production. However, the pattern of (24) ownership (chapter 2, pp. 121-124) and the resulting (23) size of the farms (chapter 2, p. 107) in the Old Oasis will nullify all efforts.

28. Marketing situation (chapter 2, pp. 165-166)

(21) transport (chapter 2, pp. 146-148) and (22) trade (chapter 2, p. 148) are improving the marketing situation.

Diagram No. 4

AVU — KETA	1 LOCATION OF PROJECT	2 PRESENT LANDUSE	3 NUMBER OF INHABITANTS	4 NUTRITION	5 EDUCATION	6 TRADITION	7 PRESENT SOURCE OF INCOME	8 SOIL	9 CLIMATE	10 SOURCE OF WATER	11 QUANTITY	12 QUALITY	13 TIME OF AVAILABILITY	14 ACCESS TO WATER	15 NEW IRRIGATION	16 NEW DRAINAGE	17 TOPOGRAPHY	18 STATE OF SEDENTARISATION	19 RESETTLEMENT SCHEME	20 MEANS OF ESTABLISHMENT	21 TRANSPORT	22 TRADE	23 SIZE OF FARMS	24 OWNERSHIP	25 AGRIC. PRODUCE	26 LABOUR INPUT	27 INCOME FROM SCHEME	28 MARKETING	29 SUPERVISORS
1 LOCATION OF PROJECT	■	i	i	o	i	i	i	i	i	i	i	i	i	i	o	o	i	i	o	o	i	i	o	o	o	o	o	o	o
2 PRESENT LAND USE	o	■	i	i	–	+	o	i	i	i	+	i	+	+	+	+	+	+	+	o	+	+	o	o	o	–	±	+	o
3 NUMBER OF INHABITANTS	o	–	■	–	–	–	–	o	o	o	o	o	o	o	o	o	o	o	+	o	o	o	o	o	+	?	±	o	o
4 NUTRITION	o	–	o	■	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	o	+	o	o
5 EDUCATION	o	o	o	o	■	o	o	o	o	o	o	o	o	o	o	o	o	o	+	o	+	o	o	o	o	o	o	o	o
6 TRADITION	i	o	o	o	i	■	o	o	o	o	o	o	o	o	o	o	o	o	i	o	o	o	o	o	o	o	o	o	i
7 PRESENT SOURCE/INCOME	i	i	i	o	o	i	■	o	o	o	o	o	o	o	o	o	o	o	+	o	+	+	o	o	+	o	o	o	o
8 SOIL	o	o	o	o	o	o	o	■	o	o	o	o	o	o	+	+	o	o	o	o	o	o	o	o	+?	+?	o	o	+
9 CLIMATE	o	o	o	o	o	o	o	o	■	o	+	o	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	o	o
10 SOURCE OF WATER	o	o	o	o	o	o	o	o	o	■	o	o	o	o	i	i	o	o	o	o	o	o	o	o	o	o	o	o	o
11 QUANTITY	o	o	o	o	o	o	o	o	o	o	■	o	i	i	i	i	o	o	o	o	o	o	o	o	o	i	o	o	o
12 QUALITY	o	o	o	o	o	o	o	o	o	o	o	■	o	o	i	i	o	o	o	o	o	o	o	o	o	i	o	o	o
13 TIME OF AVAILABILITY	o	o	o	o	o	o	o	o	o	o	o	o	■	i	i	i	o	o	o	o	o	o	o	o	o	o	o	o	i
14 ACCES TO WATER	o	o	o	o	o	o	o	o	o	o	o	o	o	■	i	i	o	o	o	o	o	o	o	o	o	o	o	o	o
15 NEW IRRIGATION	o	o	o	o	+	+	o	o	o	o	o	o	i	i	■	i	i	+	o	o	o	o	o	o	o	+	o	o	+
16 NEW DRAINAGE	o	o	o	o	o	o	o	i	i	i	i	o	i	i	i	■	i	o	o	o	o	o	o	o	o	o	o	o	o
17 TOPOGRAPHY	o	o	o	o	o	o	o	o	o	o	o	o	o	o	i	i	■	o	o	o	o	o	o	o	o	o	o	o	o
18 STATE OF SEDENTARISATION	o	o	o	o	o	+	o	o	o	o	o	o	o	o	o	o	o	■	+	o	o	o	o	o	+	o	±	o	o
19 RESETTLEMENT SCHEME	o	–	+	+	+	+	+	i	i	i	i	i	i	i	i	i	i	+	■	o	+	+	o	o	+	?	±	+	o
20 MEANS OF ESTABLISHMENT	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■	o	o	o	o	o	o	o	o	o
21 TRANSPORT	i	–	o	o	o	o	o	o	o	–	i	o	i	i	i	i	i	o	i	o	■	i	o	o	i	o	o	o	o
22 TRADE	o	o	i	i	o	o	–	o	o	o	o	o	o	o	o	o	o	o	+	o	+	■	o	o	+	o	±	o	o
23 SIZE OF FARMS	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■	o	o	o	o	o	o
24 OWNERSHIP	o	o	o	o	o	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■	o	o	o	o	o
25 AGRIC PRODUCTION	o	o	o	o	+	+	+	+	+	o	+	o	+	+	+	+	+	+	+	o	+	+	o	o	■	?	±	+	+
26 LABOUR INPUT	o	o	o	o	i	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	i	■	o	o	+
27 INCOME FROM SCHEME	i	i	o	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	i	i	±	–	■	+	o
28 MARKETING	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	+	o	o	o	o	o	■	o
29 SUPERVISORS	o	o	o	o	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	■

Avu Keta - interdependences

2. Present land use (chapter 3, pp. 226-230)

Under the present circumstances (5) education (chapter 3, p. 221) does not contribute anything to agricultural development, since the people with the best education and most initiative leave the area to seek employment elsewhere. (6) traditionally (chapter 3, p. 222), the inhabitants of Avu Keta are agriculturalists and should thus be able to undertake improved agriculture. However, it is possible that the change from shifting cultivation to sophisticated cultivation under irrigation could create some problems.

The (17) topography (chapter 3, pp. 244-246), the new (15) irrigation (chapter 3, pp. 251-255) and (16) drainage system (chapter 3, pp. 256-264), (11) water quantity (chapter 3, pp. 248-251), (14) access to water (chapter 3, p. 255) and the (13) time of availability (chapter 3, pp. 255-256) favour agricultural development.

The (18) state of sedentarisation (chapter 3, p. 221), the (19) resettlement scheme (chapter 3, pp. 268-275) and the (27) income from farms in area III and 25 per cent of area II (chapter 3, p. 316) would encourage progress on this land. The (27) income from area I and 75 per cent of area II, however, is so low that it would be better to maintain the present land use and to seek alternative employment elsewhere than agricultural development, particularly since the required (26) labour input (chapter 3, pp. 290-291 and 304-305) considerably exceeds the capability of the families during the peak periods.

The (28) market situation (chapter 3, pp. 309-312) and (22) trade (chapter 3, pp. 279-280) when supported by an improved (21) transport system (chapter 3, pp. 276-279) will favour increased production.

3. Number of inhabitants (chapter 3, p. 220)

The number of inhabitants has most probably fallen considerably during the last three decades. This was caused by the (2) present land use (chapter 3, pp. 226-230), insufficient (4) nutrition (chapter 3, pp. 225-226), (5) education (chapter 3, p. 221) which, the better it was, the greater was the desire to move to town and which furthermore supported long-term migration,[8] (6) tradition (chapter 3, p. 222) and the (7) present source of income (chapter 3, p. 224). The following three tables illustrate the overall situation in detail.

Response to the question "More people are going to big towns (e.g. Accra, Kumasi) now. Why do you think this is so?"[9]

Responses	Rural Survey No.	Rural Survey %	Urban Survey No.	Urban Survey %
To obtain jobs, money, consumer goods	1,567	88	479	82
Preference for town life, preference for town husband	166	9	48	8
To become "civilized", sophisticated, for prestige	79	4	45	8
Desire to travel and enjoy new experiences	61	3	44	7
To gain education or training	60	3	44	7
To join immediate relatives	31	2	31	5
Problems of the villages:				
Land shortage	13	1	2	0
Poor rural facilities	36	2	13	2
Village or family difficulties	40	2	6	1
Trading purposes	124	7	71	12
Other	6	0	8	1
Total: responses	2,183	121*	791	133*
respondent households	1,782		585	

* Adds to over 100 per cent because of multiple response.

Response to the question "Tell me three or four things which sometimes make village life unpleasant"[10]

Responses	Rural Survey No.	Rural Survey %	Urban Survey No.	Urban Survey %
Economic				
No work or no suitable work, especially for the educated	577	32	131	22
Crop failures	117	7	51	9
Facilities				
Lack of facilities or amenities	312	18	119	20
Inadequate water supply	662	37	216	37
Shortage of consumer goods	584	33	93	16
Bad roads, poor transport, poor communications	549	31	114	20
Poor preventive medical and health facilities	384	21	118	20
Much disease and sickness	324	18	107	18
Lack of electricity	338	19	134	23
Poor educational facilities	94	5	28	5
Entertainment				
No night-clubs, bars, dances, etc.	552	31	129	22
No cinema	128	7	14	2
Way of life				
Life is dull or uncivilized	289	16	108	19
Laziness, disobedience, lack of respect	118	7	28	5
Social				
Family pressure or troubles (conflicts about traditional religion, practice of witchcraft)	91	5	28	5
Total: respondents	5,117	287*	1,418	243*
respondent households	1,782		585	

* Adds to over 100 per cent because of multiple response.

Summary of certain responses to questions on rural push and urban pull[11]

Response	Percentage of households giving specified response: Rural Survey	Percentage of households giving specified response: Urban Survey
Motives for migration:		
Migrants are going for economic reasons	88	82
Family members went for economic reasons	77	77
Motives for not migrating:		
Non-migrant remaining for		
economic reasons	65	55
non-economic reasons	45	50
Family members remain for		
economic reasons	62	44
non-economic reasons	36	48
Villagers would be very poor if there were no migration	46	39
Village life is more "manageable" than town life	84	80
Town life corrupts	65	64
Male migration is a good thing	83	85
Female migration:		
is a good thing	52	68
may lead to prostitution	40	27

(Continued)

Response	Percentage of households giving specified response* Rural Survey	Urban Survey
Attraction of:		
Town life		
facilities	150	114
entertainment	103	118
Village life		
simple economic conditions	140	108
family and village way of life	96	74
Disadvantage of:		
Town life		
complex economic conditions	138	115
social problems	49	39
way of life	47	24
Village life		
lack of facilities	182	159
lack of entertainment	38	24

The (19) resettlement scheme (chapter 3, pp. 268-275) with an increased (25) agricultural production (chapter 3, pp. 282-316) and the (27) income from nearly half of the farms (chapter 3, p. 316) would encourage the people to stay, but (26) labour input (chapter 3, pp. 290-291 and 304-305) and the (27) income from the other farms (chapter 3, p. 316) could not convince the people of the advantages of rural life.

* In some cases the figures add to over 100 per cent because of multiple response.

4. Nutrition (chapter 3, pp. 225-226)

The (2) present land use (chapter 3, pp. 226-230) prevents any improvements of the diet. Only home-grown food-stuff from increased (25) agricultural production (chapter 3, p. 295 and 310) and food-stuff bought with the (27) income from the farms (chapter 3, p. 316) make improvements possible.

5. Education (chapter 3, p. 221)

Although school attendance is high the (19) resettlement scheme (chapter 3, pp. 268-275) and an improved (21) traffic system (chapter 3, pp. 276-279) would increase it still further. Moreover, as most of the people will stay in the area after the project is completed, education will be for the benefit of agricultural development.

7. Present source of income (chapter 3, p. 224)

The main sources of income, i.e. agriculture, (22) trade (chapter 3, pp. 279-280) and fishery (chapter 3, pp. 280-281), would be improved by the (19) resettlement scheme (chapter 3, pp. 268-275), increased (25) agricultural production (chapter 3, pp. 282-316) and an improved (21) road network (chapter 3, pp. 276-279).

8. Soil (chapter 3, pp. 232-237)

The (15) irrigation (chapter 3, pp. 251-255) and (16) drainage system (chapter 3, pp. 256-264) could contribute to the improvement of the soil, and in addition one would expect that the (26) labour input (chapter 3, pp. 290-291 and 304-305) required for (25) agricultural production (chapter 3, pp. 282-308) would improve soil conditions. Nevertheless, more research should be conducted in order to give the (29) supervisors (chapter 5, p. 409) valid guidelines.

9. Climate (chapter 3, pp. 232-243)

Although a change of climate is impossible, environmental adjustments through changes in (11) water quantity (chapter 3, pp. 248-251), (13) time of availability (chapter 3, pp. 255-256), (14) access to water (chapter 3, p. 255), in short, changes resulting from the new (15) irrigation (chapter 3, pp. 251-255) and (16) drainage scheme (chapter 3, pp. 256-264) are feasible.

15. New irrigation scheme (chapter 3, pp. 251-255)

Because of their (5) education (chapter 3, p. 221), (6) tradition (chapter 3, p. 222) and (18) state of sedentarisation (chapter 3, p. 221) the future farmers will probably be able to use the new irrigation system to its full capacity through (29) supervised (chapter 5, p. 409) (26) labour input (chapter 3, pp. 290-291 and 304-305).

18. State of sedentarisation (chapter 3, p. 221)

By (6) tradition (chapter 3, p. 222) the inhabitants are settled and the (19) resettlement scheme (chapter 3, pp. 268-275) with increased (25) agricultural production (chapter 3, pp. 282-316) will thus not interfere with their way of life. The only problem will be that an adequate (27) income (chapter 3, p. 316) cannot be achieved from all farms.

19. Resettlement scheme (chapter 3, pp. 268-275)

The (2) present land use (chapter 3, pp. 226-230), strongly influenced by annual floods, does not favour any resettlement efforts, and only after the land improvement is completed would this be possible.

The inhabitants of the area are suited for settlement because of their (3) number (chapter 3, p. 220), which allows selection, (4) nutrition (chapter 3, pp. 225-226), (5) education (chapter 3, p. 221),

(6) tradition (chapter 3, p. 222) and their (7) present source of income (chapter 3, p. 224). An adequate (27) income (chapter 3, p. 316) from (25) agricultural production (chapter 3, pp. 282-318) from nearly half of the farms would reward their effort. Furthermore, an improved (21) traffic system (chapter 3, pp. 276-279) would open the area for (22) trade (chapter 3, pp. 279-280) which would improve the (28) market facilities (chapter 3, pp. 309-312) considerably. Drawbacks could arise from the peak (26) labour demand (chapter 3, pp. 290-291 and 304-305) and the fact that half of the farms will not supply an adequate family income.

21. Transport (chapter 3, pp. 276-279)

Several rivers flood the area and only after this is prevented will a development of the traffic system be possible.

22. Trade (chapter 3, pp. 279-280)

Until now expansion of trade was impossible because of the low (7) present income (chapter 3, p. 224) and the bad (21) transport conditions (chapter 3, pp. 276-279). However, since these conditions will be improved and the (19) resettlement scheme (chapter 3, pp. 268-275) will include (25) agricultural production (chapter 3, pp. 282-318) which will result in an adequate (27) income from the scheme (chapter 3, p. 316) for nearly half of the farms, trade will expand.

25. Agricultural production (chapter 3, pp. 282-318)

Agricultural production is favoured by: (5) education (chapter 3, p. 221), (6) tradition (chapter 3, p. 222), (7) the present source of income (chapter 3, p. 224), (8) the soil (chapter 3, pp. 232-237), (9) the climate (chapter 3, pp. 237-243), (11) the quality of water (chapter 3, pp. 267-268), the (13) time of availability (chapter 3, pp. 255-256), (14) access (chapter 3, p. 255), (15) the new irrigation system (chapter 3, pp. 251-255), (19) the resettlement scheme (chapter 3, pp. 268-275), improved (21) transport (chapter 3, pp. 276-279), (22) trade (chapter 3, pp. 279-280) and (29) supervision (chapter 5, p. 409).

Only the inadequate (27) income from the farms in area I and 75 per cent of area II (chapter 3, p. 316) based on the old cropping pattern and the peak (26) labour demand (chapter 3, pp. 290-291 and 304-305) could jeopardize the success of agricultural production.

26. Labour input (chapter 3, pp. 290-291 and 304-305)

Through able (29) supervisors (chapter 5, p. 409) it is feasible to improve the skill of the future farmers.

27. Income from the scheme (chapter 3, p. 316)

The (28) market situation (chapter 3, pp. 309-312) encourages agricultural production, but the farms of area I and 75 per cent of area II will have a cropping pattern (chapter 3, pp. 283-284) which will make an adequate income impossible. However, the income based on the modified cropping pattern would make farming in these areas desirable. The peak (26) labour demand (chapter 3, pp. 290-291 and 304-305) will require hired labourers which will lower the income.

28. Marketing (chapter 3, pp. 309-312)

Improved (21) transport (chapter 3, pp. 276-279) and (22) trade (chapter 3, pp. 279-280) conditions will contribute to a better market situation.

29. Supervision (chapter 5, p. 409)

The situation for supervisors, who should be preferably be chosen from the Ewe, is dealt with on p. 409.

Diagram No. 5

TAUORGA	1 LOCATION OF PROJECT	2 PRESENT LANDUSE	3 NUMBER OF INHABITANTS	4 NUTRITION	5 EDUCATION	6 TRADITION	7 PRESENT SOURCE OF INCOME	8 SOIL	9 CLIMATE	10 SOURCE OF WATER	11 QUANTITY	12 QUALITY	13 TIME OF AVAILABILITY	14 ACCESS TO WATER	15 NEW IRRIGATION	16 NEW DRAINAGE	17 TOPOGRAPHY	18 STATE OF SEDENTARISATION	19 RESETTLEMENT SCHEME	20 MEANS OF ESTABLISHMENT	21 TRANSPORT	22 TRADE	23 SIZE OF FARMS	24 OWNERSHIP	25 AGRIC PRODUCE	26 LABOUR INPUT	27 INCOME FROM SCHEME	28 MARKETING	29 SUPERVISORS
1 LOCATION OF PROJECT		i	i	o	o	o	i	i	i	i	i	i	i	i	o	o	i	i	o	o	i	i	o	o	o	o	o	o	o
2 PRESENT LAND USE	o		i	+	+	?	o	i	i	i	i	i	i	i	+	+	i	+	+	o	i	i	o	o	+	o	o	o	o
3 NUMBER OF INHABITANTS	o	o		o	–	–	–	o	o	o	o	o	o	o	o	o	o	o	+	o	o	o	o	o	o	o	o	o	o
4 NUTRITION	o	o	o		o	o	–	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	o	o	o	o
5 EDUCATION	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	o	o	o	+
6 TRADITION	i	o	o	o	i		i	o	o	o	o	o	o	o	o	o	o	o	i	i	i	i	o	o	i	i	i	i	i
7 PRESENT SOURCE/INCOME	+	–	o	o	o	o		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
8 SOIL	o	o	o	o	o	o	o		o	o	+	+	o	o	+	+	o	o	o	o	o	o	o	o	+	+	o	o	o
9 CLIMATE	o	o	o	o	o	o	o	o		o	+	o	+	+	+	+	o	o	o	o	o	o	o	o	o	o	o	o	o
10 SOURCE OF WATER	o	o	o	o	o	o	o	o	o		o	o	o	o	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o
11 QUANTITY	o	o	o	o	o	o	o	o	o	o			i	i	i	i	o	o	o	o	o	o	o	o	o	i	o	o	o
12 QUALITY	o	o	o	o	o	o	o	o	o	o	o		o	o	i	i	o	o	o	o	o	o	o	o	o	i	o	o	o
13 TIME OF AVAILABILITY	o	o	o	o	o	o	o	o	o	o	o	o		i	i	i	o	o	o	o	o	o	o	o	o	i	o	o	i
14 ACCES TO WATER	o	o	o	o	o	o	o	o	o	o	o	o	o		i	i	o	o	o	o	o	o	o	o	o	o	o	o	o
15 NEW IRRIGATION	o	o	o	o	+	+	o	o	o	o	i	i	i	i		i	i	o	o	o	o	o	o	o	o	o	o	o	+
16 NEW DRAINAGE	o	o	o	o	o	o	o	i	i	o	i	o	i	i	i		i	o	o	o	o	o	o	o	o	o	o	o	o
17 TOPOGRAPHY	o	o	o	o	o	o	o	o	o	o	o	o	o	o	i	i		o	o	o	o	o	o	o	o	o	o	o	o
18 STATE OF SEDENTARISATION	o	o	o	o	o	+	o	o	o	o	o	o	o	o	o	o	o		+	o	o	o	o	o	o	o	+	o	o
19 RESETTLEMENT SCHEME	o	o	+	+	+	+	o	i	i	i	i	i	i	i	i	i	i	i		o	o	o	o	o	o	o	+	o	o
20 MEANS OF ESTABLISHMENT	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o	o
21 TRANSPORT	i	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o	o	o
22 TRADE	+	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	+	o	o
23 SIZE OF FARMS	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o
24 OWNERSHIP	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o	o	o
25 AGRIC PRODUCTION	o	o	i	i	+	+	+	i	i	o	i	i	i	i	i	i	i	i	o	o	o	o	i	o		i	+	o	+
26 LABOUR INPUT	o	o	o	+	+	+	o	i	i	o	i	i	i	o	i	o	o	+	+	o	o	o	i	?	i		i	o	+
27 INCOME FROM SCHEME	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	+		+	o
28 MARKETING	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	+	o	o	o	o	o		o
29 SUPERVISORS	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	

Tauorga - interdependences

2. Present land use (chapter 4, pp. 328-330)

When examining present land use, two areas have to be distinguished: the Old Oasis and the project area. There will be no planned improvement in the Oasis, whereas in the project area the improvement will be considerable. Apart from being the location where the future settlers now live, the oasis is not connected with the project. Therefore, the present land use in the Old Oasis has not been considered.

After agricultural production in the new project has started (4) nutrition (chapter 4, p. 327) will most probably be adequate for the settlers to do the hard farm work. The impact of (5) education (chapter 5, p. 423) is difficult to estimate. The inhabitants of the Old Oasis are unable to run their farms properly at the moment for various reasons, and it is uncertain how fast they will be able to adjust their lives to the changed circumstances. Their agricultural (6) tradition (chapter 4, pp. 363 and 388) would aid agricultural production. However, the decay of the oasis which forced them to do handicraft work and the subsequent decline of this latter source of income, makes it difficult to assess the influence of tradition. Nevertheless, it is the author's belief that after they have become accustomed to the new way of life, their tradition and education will assist agricultural production in the project.

With the new (15) irrigation (chapter 4, pp. 348-352) and (16) drainage scheme (chapter 4, pp. 352-357) an improvement in the present land use is virtually guaranteed.

The (18) state of sedentarisation (chapter 4, p. 327) and the new (19) resettlement scheme (chapter 4, pp. 360-362) will be instrumental in the success of agricultural development.

3. Number of inhabitants (chapter 4, p. 327)

The (7) present source of income (chapter 4, p. 363) forces the inhabitants to leave the oasis, especially the (5) educated (chapter 5, p. 423) ones, who (6) traditionally (chapter 4, p. 363) are sent to earn money elsewhere.

As soon as the new (19) resettlement scheme (chapter 4, pp. 360-362) is functioning properly many additional opportunities for employment will become available and this will lead to an increase in population in the area.

4. Nutrition (chapter 4, p. 327)

The (7) present source of income (chapter 4, p. 363) does not assure a diet which is adequate for hard farm work, but the (25) agricultural production (chapter 4, pp. 364-388) planned for the project will at least supply a better diet, even if it should fail to provide an adequate income.

5. Education (chapter 5, p. 423)

The existing general level of education is quite adequate for the present situation. However, the additional knowledge which will be necessary to run the new farms successfully could be gained during the process of (25) agricultural production (chapter 4, pp. 364-400) under good (29) supervision (chapter 5, p. 409).

7. Present source of income (chapter 4, p. 363)

The present source of income is dependant on the (1) location of the project (chapter 4, p. 324) which allows easy access to the markets. (2) present land use (chapter 4, pp. 328-330) in the oasis and the project area, however, hinders agricultural expansion and thus an increase in income.

8. Soil (chapter 4, pp. 331-334)

The (11) quantity (chapter 4, pp. 342 and 345-348) and (12) quality of the irrigation water (chapter 4, p. 341) are such that by leaching a decrease in salinity and thus an increase in the suitability of the soil for agricultural production can be expected. The (25) agricultural production (chapter 4, pp. 364-400) and the (26) labour input (chapter 4, pp. 388-400) will lead to a further improvement.

9. Climate (chapter 4, pp. 334-337)

An improvement in the climate is not possible. However, the problem of low precipitation can be overcome by irrigation, as the (11) quantity of irrigation water (chapter 4, pp. 342 and 345-348) is sufficient, the (13) time of availability (chapter 4, p. 348) is correct, and the (15) irrigation (chapter 4, pp. 348-352) and (16) drainage scheme (chapter 4, pp. 352-357) will function properly.

15. New irrigation scheme (chapter 4, pp. 348-352)

Their (5) education (chapter 5, p. 423) and (6) tradition (chapter 4, pp. 363 and 388) will enable the settlers, guided by able (29) supervisors (chapter 5, p. 409) to use the irrigation facilities to their full capacity.

18. State of sedentarisation (chapter 4, p. 327)

(6) traditionally (chapter 4, p. 327) the inhabitants of Tauorga are settled, and the (19) resettlement scheme (chapter 4, pp. 360-362) means that they will remain a settled community. The (27) income (chapter 4, p. 388) which can be achieved on farms in the project makes the settled life even more attractive.

19. Resettlement scheme (chapter 4, pp. 360-362)

The (3) number of inhabitants (chapter 4, p. 327), their (4) nutrition (chapter 4, p. 327), (5) education (chapter 5, p. 423) and (6) <u>tradition</u> (chapter 4, pp. 363 and 388) enable the settlers to make the best use of the scheme and the relative high (27) <u>income</u> (chapter 4, p. 388) projected would encourage them to stay.

22. <u>Trade</u> (chapter 4, p. 363)

The (1) <u>location of the project</u> (chapter 4, p. 324) guarantees easy access to the markets for the products from the project. The (27) <u>income from the scheme</u> (chapter 4, p. 388) would enable the settlers to buy goods from these markets, thus assuring a flow in both directions.

25. <u>Agricultural production</u> (chapter 4, pp. 364-400)

The (4) <u>nutrition</u> (chapter 4, p. 327), (5) <u>education</u> (chapter 5, p. 423) and (6) <u>tradition</u> (chapter 4, pp. 363 and 388) of the inhabitants would eventually favour agricultural production. Furthermore, the (7) <u>present source of income</u> (chapter 4, p. 363) is very low while the (27) <u>income from the scheme</u> (chapter 4, p. 388) would be much higher, thus ensuring a satisfied work force, and a permanent maintenance of agricultural production. But this would only be possible with able (29) <u>supervisors</u> (chapter 5, p. 409).

26. <u>Labour input</u> (chapter 4, pp. 388-400)

Adequate (4) <u>nutrition</u> (chapter 4, p. 327), the farmer's (5) <u>education</u> (chapter 5, p. 423), (6) <u>tradition</u> (chapter 4, pp. 363 and 388), (18) <u>state of sedentarisation</u> (chapter 4, p. 327), and the availability of able (29) <u>supervisors</u> (chapter 5, p. 409) favour the supply of the required labour input.

As the (27) <u>income from the scheme</u> (chapter 4, p. 388) would be comparatively high and living conditions in the (19) <u>resettlement scheme</u> (chapter 4, pp. 360-362) would make life on the farms desirable, all requirements for a permanent adequate labour input are present.

27. Income from the scheme (chapter 4, p. 388)

The output from the farms based on an effective (25) agricultural production (chapter 4, pp. 364-388), and the favourable (28) marketing situation (chapter 4, pp. 385-386) would result in a relatively high family income. The (26) labour input required (chapter 4, pp. 388-400) could not be covered solely by family members and, therefore, labourers from outside the family would have to be hired. However, the resulting expenses would not be so great that the high family income would be threatened.

28. Marketing situation (chapter 4, pp. 385-386)

(21) transport (chapter 4, pp. 363 and 387) and (22) trade (chapter 4, p. 363) would create a favourable marketing situation for the products from the project.

Pattern of expenditure in the "Development Package"

In the previous section we made individual factor analyses for each project but within what may be called the total "development package" there appear some critical situations.

The impact of a "development package" depends upon the combination of existing factors and those introduced by the development project.

The pattern of expenditure of any project is the tool for guiding the development to the chosen goal at the correct speed. These patterns differ for each project and for the four cases are detailed below.

Faisal Settlement Project, Haradh

The pattern of expenditure for the establishment of the new scheme in Haradh is as follows:

Item	Percentage of provided money[12]
Drilling of wells	7.60
Delivery of pumps and installation of pumps	4.60
Power station and electricity distribution system, inspection work for the power station	29.00
Irrigation and drainage scheme	45.80
Roads	11.00
Fences	1.30
Windbreak trees*	0.70
	100.00

Originally it was planned to erect seven villages along the wadi, but these plans have been cancelled. Furthermore, the establishment of a well equipped education and training centre for the Bedouins' settlement has been cancelled.

Thus, in this case, all capital has been used for the technical establishment of an agricultural production unit without any consideration for the needs of the future settlers or for socio-economic incentives.

Al Hassa

The total capital for the improvement of agricultural production in the Al Hassa Oasis has been used completely for the establishment of the irrigation and drainage scheme. That is, 93.64 per cent of total capital for earthwork, production and installation of concrete canals and for necessary buildings, such as power and pump houses; and 6.36 per cent

* These trees are still in the nursery since because of lack of electricity for pumps they could not be planted around the fields.

for electrical and mechanical equipment and its installation. The establishment of an electricity and telephone network for the oasis, which would have amounted to 4.55 per cent of total capital has been postponed.[13]

Avu Keta

The input in percentage of the investment is shown below.

Item	Percentage of total expenditures
Irrigation and drainage scheme, structures for flood control, necessary buildings.	52.02[14]
Farmhouses	13.58[15]
Drinking water	10.11[16]
Roads	24.29[17]
Power supply for the villages	?
	100.00

The capital input for the production unit itself is only 52.02 per cent. The other 47.98 per cent will be used for directly improving the standard of living. In addition the money to be spent for the power supply must be considered, but this should not exceed about two per cent of total capital. Thus, about 50 per cent will be spent for the production unit and about 50 per cent for the improvement of the standard of living, and for the provision of socio-economic incentives to self-sustained further growth.

Tauorga

The pattern of expenditure for the Tauorga Project is detailed in the following:[18]

Item	Percentage of provided money
Irrigation and drainage scheme	83.64
Windbreak trees	0.09
Farmhouses	9.14
Equipment for drinking water supply for the farms	1.14
Electrical equipment for supply of the farm area	3.60
Establishment of the village centre	2.38
	100.00

In this case 83.73 per cent, i.e. 83.64 per cent for the irrigation and drainage scheme and 0.09 per cent for the windbreak trees, of the total capital is allocated for the production unit. The remaining 16.27 per cent, which will be spent for farmhouses, drinking water, electrification and the Village Centre, will help to improve the standard of living without bringing any primary benefits.

In each of these projects some expenditure sections, e.g. social improvement, are marked either by their presence or by their absence. Thus in Avu Keta approximately 50 per cent of project expenditure is planned to go directly to consumption in the shape of housing, water-supply etc., while at Haradh all expenditure is devoted to production technology. What becomes important is whether in any project the "development package" balance is arrived at by deliberate policy decision or whether it appears as an unplanned and unrecognised product of design.

CONCLUSION

In general, the need for development as perceived by any community is created by three basic factors:[19] (1) the possibility of comparing the conditions under which one is living with conditions which seem to be better. (2) the dissatisfaction with one's own conditions. (3) the realisation of the possibility of improvement and thus a rejection of submission to fate.

These factors had similar effects on the inhabitants of the four project areas, i.e. the people abandoned, or will abandon, the old source of income.

In Haradh the Bedouins are changing from camel to sheep nomadism and are looking for alternative employment within and outside the area. In Al Hassa the farmers and farm-labourers are leaving the farms and are moving to the oil-fields and towns. In Avu Keta emigration to the industrial centres is under way. In Tauorga the former agricultural population is now partly engaged in handicrafts, but most of it is idle.

(1) material improvement and (2) social justice will be demanded as a result of the above-mentioned factors. The interrelation of the two demands is made clear in the following quotation by Tothill, the initiator of the Zande Scheme:[20]

" ... the sociological side of the scheme transcends the economic side, but the economic side must be sound as it forms an essential foundation of the scheme."

Profits are an important factor for the decision as to the establishment or non-establishment of a project and they are an essential part of planning as they indicate whether a project can become a commercial success or not. Therefore, an exact calculation of profits must be made.

When an amelioration only brings social improvement and not the necessary profits to cover at least the interest of the invested capital, no person or administrative body with a sense of responsibility, especially in developing countries with their enormous shortage of capital, should be willing to support its establishment. However, the need for support sometimes is so great that these objections are overruled and the project is used as a form of relief. Wherever this has proved to be unavoidable, real development efforts have been merely postponed, but remained necessary. Only a solid economic basis enables long-term self-sustained progress: an investment which has to be repeated frequently without creating progress only leads to exhaustion of financial resources and human interest.

As proved in the past, neither through investment in monocultural plantation, nor through capital intensive economies has development been achieved since these efforts were only made to facilitate resource exploitation. Whether this exploitation was carried out by a colonial power or by natives has made no difference. Permanent material improvement for the whole community, without close control, requires social justice. Only when this is achieved can a permanently adequate family income be assured. However, this presupposes a development programme, i.e. systematic efforts tailored to a particular case, to achieve growth in productivity and purchasing power for as many people as possible. But this does not only mean an increase in production but also the creation of a new socio-economic order and the destruction of the old static society where necessary. Only in this way can a snowballing effect be obtained, resulting in the creation of new jobs for which little or no investment is necessary. That is, when production units for 60 per cent of the population have been established, the remaining 40 per cent will also profit from the improved conditions.

All efforts aimed at the permanent settlement of a rural population require a long-term engagement since being a farmer does not only mean producing agricultural products, but is also a way of life. In fact, in the initial phase even successful schemes are sometimes far from having a settling influence. On the contrary, they are often rather disturbing.

As shown above, in the four cases under consideration not all of the factors encourage development. The technical part is sound in all of them, i.e. the irrigation and drainage schemes were planned according to the natural resource endowment. However, there are other factors which at least slow down, if not prevent, any development. The results which will probably be achieved in the projects will be dealt with in the following sections.

Haradh

The Faisal Settlement Project is a sound technical unit perfectly adapted to the natural resources available, but has been created for the wrong people in an area uneconomically remote from the markets.

A population, too small in number, grown up under a tradition which makes the required labour input impossible, and with an educational level which intensifies the traditional outlook still further, cannot be expected to operate such a complicated scheme, even if intensive supervision could be assured.

This situation is further aggravated by the postponement of the construction of the villages. Men who work during the day with such a sophisticated scheme cannot be expected to be satisfied when living in their tents under primitive conditions. Nevertheless, agricultural production based on natural resources and the new irrigation and drainage scheme would allow an adequate hypothetical family income. But since the project is so remote from the markets no profit at all can be realized. On the contrary, the transport costs and capital costs would cause considerable losses.

Under the above-mentioned circumstances even present life, with its relatively low and insecure income, appears to be more desirable than life in the new scheme. The present living conditions create the desire for settlement and development, but the project cannot satisfy this desire since material improvement and security will not be achieved by participation.

In conclusion it can be said that the Faisal Settlement Project, economically at least, is a failure.

However, as the sources of income of the Bedouins are diminishing and the scheme is already completed, it appears to be worthwhile to use it as it was intended but without any expectation of monitary profit. On the contrary, the Government must be prepared to bear the losses and the capital costs. Nevertheless, the long-term aim of giving the nomads a means of earning money in a sedentary society, given that their traditional society is doomed, arguably makes the investment worthwhile.

Furthermore, the project could be used for breeding Nejdi sheep and improving their performance. As there is an ever increasing demand for sheep of this breed this would be a rewarding undertaking. In particular, since there is no other breeding centre for Nejdi sheep (with the exception of Hofuf where a small herd is kept), and the genetic potential of this breed is virtually unknown.

Al Hassa

The new irrigation and drainage scheme could be the basis for sound agricultural production in Al Hassa. The scheme is designed for the needs of the agricultural community, is based on natural resources, and is a great engineering achievement.

However, in the present situation in Al Hassa the scheme does not represent any improvement.

The land units found in Flah, which in this study are assumed to be valid for the entire oasis, are far too small to assure an adequate family income and, consequently, must be enlarged. But this requires that most of the farmers give up farming, as the smallest feasible unit capable of supplying an adequate family income, based on the size of the family labour force, is about 5.00 ha. If the sole purpose of the farms was to supply an income, this lost income could be replaced by financial inputs, but in addition to this, the farms also serve as a place of recreation and the value of this cannot be overestimated. The aggravating factor is that the farms are becoming successively smaller after each inheritance.

Furthermore, the old canal and road system was destroyed with the establishment of the new irrigation and drainage network. This was foreseeable, and it is therefore surprising that no follow-up measures were planned. As mentioned before, it is virtually impossible for some farmers to reach their land or to gain access to irrigation water.

Moreover, the conflict between Shiites and Sunnites living side by side in the oasis, while its influence should not be overestimated, does not contribute to the solution of these problems.

In order to achieve the greatest possible profit, monetary and otherwise, it is imperative to alter the Moslem law of succession or to prevent its application in its present form. But this necessitates a revolutionary approach towards religion, with results which are immense and immeasurable. However, the whole question of land tenure is such a delicate and difficult matter that its handling needs the greatest possible care and information. Here the most important requirement, knowledge of the present land-ownership situation, is not met and, therefore, any interference in land tenure must be postponed until the requisite knowledge is obtained.

The easiest and quickest solution to all of the problems would be to have the entire oasis bought by the Government and to apply a land tenure system which does not lead to the destruction of the production units. However, the author does not believe that this is possible.

In any case, the above paragraphs are only valid for the 8,000 ha. of the Old Oasis and not for the 12,000 ha. of newly developed land. Successful agriculture is possible on the new land, provided that farms of at least 5.00 ha. are established and held in State ownership so that the Moslem law of succession would not apply. Only in this way can a destruction of the farms be prevented and the planned agricultural development be achieved.

Avu Keta

As shown in Table No. 1, all factors, with the exception of soil and the labour demand of both farm types, favour agricultural development.

The soil will most probably not create any problems after it has been under cultivation, but further research should not be neglected.

The labour demand which cannot be covered by family members will lead to a reduction of the family income. However, even after this reduction, the income will remain comparatively high, assuming that the old cropping pattern in area I and 75 per cent of area II is abandoned and the modified one is applied.

Therefore, it can be assumed that the project could be the basis for a successful settlement programme.

One way to find out how the people would respond to a resettlement programme, and whether such a programme would stop migration, is to investigate the motives for migration. The main reasons, i.e. the economic ones, would disappear after the scheme had been established.

In addition to economic reasons the improvement of facilities was a strong motive for the scheme, and the desire of the people could be fulfilled. As shown above, given a modified cropping pattern and resulting incomes, the farms will bring an adequate income to the inhabitants and consequently they would spend more on entertainment which should make the establishment of an entertainment business worthwhile.

Consequently, by means of the scheme, everything for which the inhabitants are moving to the industrial centres would be available in the area itself, and the reasons for migration would no longer be valid.

A halt to migration is strongly desirable as the urban centres are increasingly unable to cater for the social and economic demands of large numbers of migrants. Moreover, the introduction of greater stability and wealth into the area makes possible at least further locally based growth.

Tauorga

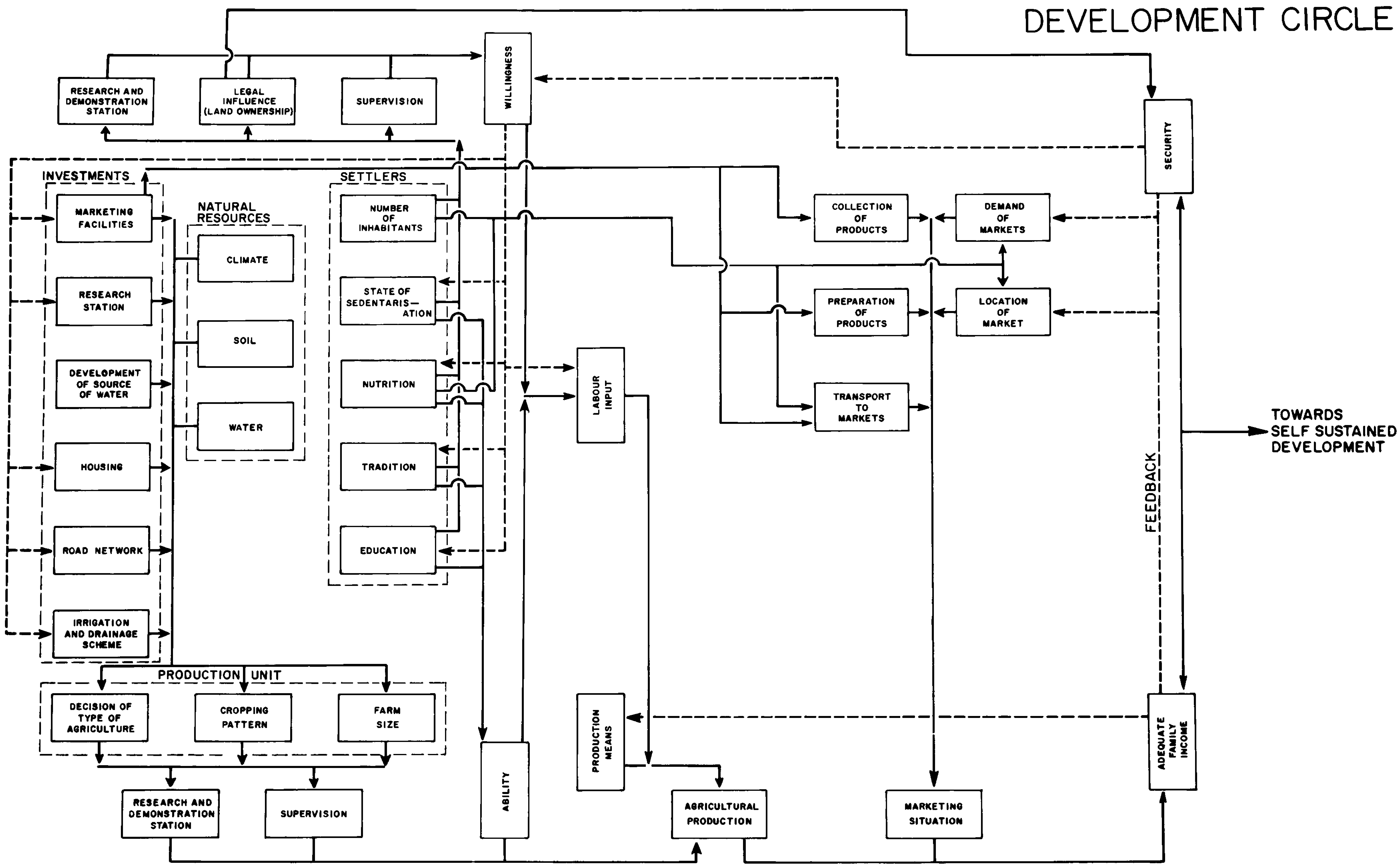
Of the four projects under consideration in this study the Tauorga Project appears to be the one which will most probably become a success without the introduction of additional measures.

However, there are several weak points which could cause temporary minor problems. These are:

1. Although it is believed that enough people are living in the area, their exact number is not known.
2. At present, the diet of the future settlers is not adequate for hard farm work, but can easily be improved as soon as agricultural production has started in the project.
3. The employment of able supervisors may prove to be difficult as large towns are more attractive as a place of work to these men.

The only factor which could really hinder agricultural development is the working ability of the future settlers. However, this, too, appears to be only a temporary matter. The future settlers are traditionally farmers and only adverse circumstances forced them to

Diagram No. 6


DEVELOPMENT CIRCLE
RESEARCH AND DEMONSTRATION STATION
LEGAL INFLUENCE (LAND OWNERSHIP)
SUPERVISION
WILLINGNESS
SECURITY
INVESTMENTS
MARKETING FACILITIES
RESEARCH STATION
DEVELOPMENT OF SOURCE OF WATER
HOUSING
ROAD NETWORK
IRRIGATION AND DRAINAGE SCHEME
NATURAL RESOURCES
CLIMATE
SOIL
WATER
SETTLERS
NUMBER OF INHABITANTS
STATE OF SEDENTARIS— ATION
NUTRITION
TRADITION
EDUCATION
LABOUR INPUT
COLLECTION OF PRODUCTS
PREPARATION OF PRODUCTS
TRANSPORT TO MARKETS
DEMAND OF MARKETS
LOCATION OF MARKET
FEEDBACK
TOWARDS SELF SUSTAINED DEVELOPMENT
PRODUCTION UNIT
DECISION OF TYPE OF AGRICULTURE
CROPPING PATTERN
FARM SIZE
RESEARCH AND DEMONSTRATION STATION
SUPERVISION
ABILITY
PRODUCTION MEANS
AGRICULTURAL PRODUCTION
MARKETING SITUATION
ADEQUATE FAMILY INCOME

give up farming. Therefore, it is expected that after an acclimatisation process they will be able and willing to cultivate the land efficiently. In return their efforts will be rewarded by an adequate income and good living conditions.

Thus, it can be assumed that, after initial slight difficulties, the project will be a success. That is, in this case self-sustained growth is expected to be secured far sooner and more smoothly than in the other projects dealt with in this study.

The "Development Circle" or Critical Sequence (see Diagram No. 6)

We can take, finally, our examination of critical factors and their interdependences to the point where their feed-in, feed-back significances in the critical sequence of events leading successfully to development can be plotted in what here is termed a "Development Circle".

In order to have a successful development process leading to self-sustained development, all the factors which make up the "development package" must exert their influence. This means that material inputs as well as inputs of know-how, willingness, and legal advice, to name just a few, must be actively present. For example, it is not enough that the adequate know-how is available, because, before it becomes useful, it must be applied.

The basic requirements for settlement projects based on irrigated agriculture are the knowledge about, and ability to manipulate, the following factors:

1. Natural resources (water, soil, climate)
2. Settlers (number of settlers, their state of sedentarisation, nutrition, tradition, education)
3. Investments (irrigation and drainage scheme, road network, housing facilities, development of water resources, research station, and marketing facilities)

These three basic factors are the visible components of any project of this type. However, as shown above, a far more complicated network of factors influence development, some of which are only imagined but, nevertheless, are just as important and "real" as, for instance, buildings.

The decision regarding the type of agriculture, the farm size and cropping pattern to be introduced should be based on a consideration of these three main factors. This decision should also be influenced by experience gained in the research unit.

It is fundamental that all processes are understood by the settlers and that the legal aspects, for instance ownership, are clear. Only then can the settlers develop the willingness which, combined with their ability, can assure the required labour input. The latter is, together with the production means and the production unit, indispensable for agricultural production.

The hypothetical results of agricultural production, however large, could be nullified by inadequate marketing possibilities. Only when there is a suitable reliable outlet for the products from the project can an adequate income be achieved.

Only in cases where this income can be achieved over a long period or, where the people involved can be convinced that the adequate income is a lasting achievement, can a feeling of security grow. This is the main goal, because the feedback can only occur after the feeling of security, through an adequate income, has been achieved. Where this has been obtained the feedback itself can cause the following:

1. The ability to afford the production means.
2. A shifting of the markets; that is, home consumption increases, which results in a higher standard of living.
3. The stimulation of the willingness to participate in the project. This makes the farmers willing to reinvest in their production units

and maintain them. Through a change in their way of life, that is, settling where required, better diet, break with hindering traditions, and better education, their working ability is increased considerably.

These feed-back results cause a strengthening of the "Development circle" as shown in Diagram No. 6, thus speeding up and assuring the development process. In such a case self-sustained, long lasting development is certain.

But in the four cases under consideration feed-back cannot always be achieved.

The development circle of the Faisal Settlement Project, Haradh, is interrupted so often that it needs much additional input. In fact an entirely new re-planning of the project and a rethinking of the ideas which originally led to the establishment of the project are required. With the project in its present state no progress at all will be achieved.

Superficially, the situation in Al Hassa seems to be more favourable, as the development circle is only interrupted twice, that is, by the unsuitable "farm size" and the "legal influence and ownership pattern". But since the farm size is caused by the legal conditions, in fact, only one factor interrupts the circle. However, in order to improve this situation a break with the law of succession, which is based on the Koran, is required. But this, at least at present, is impossible. Consequently, no full circle can be achieved and self-sustained growth cannot be obtained.

In the case of Avu Keta the development circle is closed, which means that agricultural development is possible, but needs strengthening at several points in order to secure progress. The points in question are the "cropping pattern" and the resulting "labour input" required. The project would probably be a success even without any changes, but this could not be certain. Therefore, an alteration of the cropping pattern would appear to be worthwhile so that the labour input required, or at least most of it, could be covered by family members. Thus, the farmers would be more independent of rising labour costs, and the maintenance of self-sustained growth would be more likely.

The development circle of the Tauorga Project is completely closed and, after the initial difficulties have been overcome, is strong enough to secure self-sustained growth. However, this fact does not mean that less vigilance and effort is required, because it is necessary to adapt the project to continuously changing circumstances, thus ensuring that the progress achieved is not lost.

In a material sense, development progress must imply the attaining of satisfying levels of income, not by a project nor by the State but by specific families on specific land-holdings or through specific occupations.

Agricultural development is a very slow undertaking with the result that during the initial phase the planned income cannot be achieved. Therefore, during this period the settlers will either have to be paid for their work or their products will have to be subsidized in order to assure an adequate income. But it must be made clear to the settlers that this is only a temporary arrangement, otherwise they would expect this payment to be permanent.

Under the circumstances described in the four projects a ratio of agricultural to non-agricultural jobs of about 60:40 can be expected and it should be the aim to assure an adequate income for all families involved. However, as development within the project areas and the countries continues the income in industry and trade will probably rise faster than those in agriculture and thus the situation of inequality would be restored. This applies particularly to countries like Saudi

Arabia and Libya with their enormous wealth. In order to avoid this, horizontal or vertical expansion must be possible, i.e. it must be feasible, to increase the farm size or to intensify production or a combination of these measures.

There are two possibilities when choosing to increase the size of the farms: either more land will have to be redeveloped or controlled migration will have to be started in order to have less people on the already developed land.

But these solutions are not suitable for the Faisal Settlement Project, Haradh, as the increase in farm sizes would only concentrate the losses to a smaller number of families and an increased output based on intensified agriculture would only lead to increased losses because of the high transport costs as the project is so remote from the markets. However, whether any development at all will be achieved is doubtful as it has not yet been decided finally how to use the project.

In Al Hassa a change towards non-agricultural jobs may be a solution to the problem, but the legal aspects could prove too difficult to overcome and thus it is probably that only migration will occur without making the abandoned fields available for the remaining farmers.

In addition to the above-mentioned solutions engagement in industrialized farming, as for instance egg production and broiler production based on bought feed, might be worthwhile. At present there are still possibilities for expansion in this field, but whether these chances will always be available is questionable as competition is already fierce. Nevertheless, a great proportion of the chicken and egg consumption is still imported.

For the Avu Keta project both possibilities could lead to a solution, alone or combined.

With the growth of Accra-Tema and the other industrial centres migration to these places could become desirable in future as this growth would lead to a higher demand of labour. If this migration was carried out under supervision so as to ensure that whole families migrate and farms were made available for the remaining families the basis for a higher income would be provided. However, it is questionable whether this is workable as the traditional ties to the tribal area are still strong.

The use of an intensive cropping pattern would also make a higher income possible, as has been shown in the modified cropping pattern.

Nevertheless, both solutions will most probably have to be based on hired labour, as the labour demand of the production units planned for a family income which is at present adequate, already exceeds the capacities of the families.

As it is not possible to enlarge the farms in the Tauorga project without migration of several families, the inclusion of industrialized farming into the production programme seems to be appropriate to increase the family income. That is, egg and broiler production which is independent of local land resources and based on bought food-stuff will have to be introduced.

At the moment, 10 chicken farmers with 25,000 layers produce about 18,000 eggs daily; furthermore, they produce 1,200 kg. chicken meat daily. Even so, the present demand is still not entirely covered.

As 50 per cent of the costs of the food-stuff for chickens is paid by the Government and the health service is entirely free, and, furthermore, the market is not saturated[21] this branch of agriculture offers good opportunities to redress the balance of income between the urban and rural population.

However, this intensive production technique demands much skill from the farmers and thus cannot be included immediately into the production programme. Furthermore, if included, this branch will require hired and paid labourers from outside the families.

When planning the development of an area has become unavoidable, it is essential to evaluate the natural resources, to consider the human and technical possibilities, i.e. the production means, to decide on farm size and cropping pattern, and to check the returns, nationally and for the farmers. Furthermore, one has to know the relationship between traditional customs and the new scheme, that is the capability and the willingness of the people concerned to adapt the scheme. If there is sufficient evidence that the people involved are able, based on their education, and, furthermore, willing to support development, all other obstacles can be overcome.

After an investigation of the natural resources in all four cases under consideration in this study the establishment of an irrigation and drainage scheme was recommended as the basis for agricultural development in each case.

In the case of Al Hassa this was just a continuation of the traditional, now decaying, way of life as the plan meant the redevelopment of the old production units. That is, the same resources would be exploited.

This is only partly true for the Tauorga Project as the inhabitants have given up agriculture. They were engaged in handicraft work for a while, however, due to the rapidly increasing availability of cheaper imported products, this has been abandoned too. At the moment most of the people are unemployed.

The case of the Avu Keta project differs somewhat, in that only a section of the population is involved in cash crop production. The others practise shifting cultivation, and new resources will have to be developed for the scheme. For at least a part of the community this means a change in the way of life. However, since there are no other known natural resources, the scheme appears to be the only means of development.

In Haradh the situation is obviously different as two natural resources are available: firstly there is the traditional exploitation of the pastures through nomadism, and secondly there is the possibility of establishing an irrigation and drainage scheme based on the ground-water found in the Wadi as Sabha. As this study shows the decision to establish a highly sophisticated scheme at Haradh was not a really wise one, as the wrong resources were chosen as the basis for a development programme. The scheme is rendered economically unsuccessful by many factors. Furthermore, the scheme will accelerate the abandonment of the pastures, which have proved to be a poor but, with a few exceptions, reliable source of income for a great number of people in Saudi Arabia. This is not meant to be a plea for the "good old days" but a warning for development at any price.

When investigating resources great care is necessary. Even simple resources should be considered, and not only those which, based on a sophisticated system, seem to promise the highest increase in production. Whenever possible the wishes and ability of the people involved should be the basis for decisions. The resources whose development would cause the smallest change in the way of life should be preferred when traditional, i.e. static,societies are involved as traditional outlooks can seriously hinder or delay the introduction of new sophisticated techniques. For societies where the old traditional pattern is already destroyed, it is sometimes good policy to accelerate the speed of change by a new scheme in order to destroy the remainder of the old establishment completely and thus make way for a new society.

The establishment of technical units in places endowed with natural resources, with the sole aim of exploiting these resources as thoroughly as possible does not necessarily lead to true development, for as soon as the need for exploitation disappears so does the scheme decay, eventually to disappear bearing no long-term benefits.

After the natural resources have been investigated with a view to agricultural development, and it is decided which resources should be exploited the people involved should be studied as to their suitability, and if it is found that they are lacking in ability or willingness, another solution has to be looked for.

Every development programme interferes in the way of life of the people involved. The degree of this interference can vary from 0.00 per cent, i.e. no interference at all, to 100 per cent, i.e. the way of life is changed completely. However, as shown in the case studies, the best results will appear where no change in the way of life is required. Furthermore, where slight changes are unavoidable and the population is convinced of the necessity of the scheme, and where the other production factors do not create any problems, a smooth change towards the new way of life can be expected. But where the scheme brings changes which go against everything the people believe in, even the highest expectation of increased production cannot be the determining factor.

Apart from the human factor, the production means are the major determinant factors of projects' success. The most important production means, the irrigation and drainage schemes, have experienced very few failures. These systems and the other production, e.g. seeds, fertilizer, plant protection, agricultural machinery etc., depend upon the availability of capital. Investment for the irrigation and drainage scheme requires the availability of capital only once. In contrast, money for running costs must be permanently available and for this more reliance is placed on returns from the production. That is, when establishing a project one should be able to afford to run it after it has been established.

Where the running costs cannot be covered by the income from the project, long-term subsidies are required. Apart from the fact that these subsidies may stop any time, there is another more serious side-effect in that there is no feeling of security among the participants, thus, self-sustained development is impossible.

The four case studies provide evidence for the widespread existence of a trend for irrigation projects per se, i.e. where the whole range of factors influencing agricultural development is ignored and where the scheme, while over-emphasizing its value, is a justification in itself.

Planning conducted from industrialized countries, based on experience gained in those countries, often erroneously assumes that all people, regardless of cultural background, are able and willing to undertake hard, time-consuming work, as is normal in such economically advanced countries. That is, such planning ignores the problems which could arise from the human element in developing countries, and assumes that to simply create the production unit is enough. It is quite common for the technical part of a project to be undertaken by a foreign firm whereas the human part is managed by local authorities, and very seldom is one group interested in the problems of the other; mainly because each group has only the specialized personnel necessary for their job.

It is often overlooked that these pre-industrial societies have a different attitude towards development, that is, they prefer leisure time, whereas industrialized societies prefer an increased income enabling higher consumption.[22] This means that the population of areas to be developed does not necessarily regard economic development as an advantage as it results in shorter leisure time.[23] It is only with the decline of the social structure that the inhabitants may change their attitude towards labour. This process is a gradual one, which reaches culmination when the people spend their leisure time passively. At this point they have become "consumers" and need a secure income and thus become willing to gear their lives towards longer working time.

Both extremes, i.e. being either completely consumption or leisure time orientated, hinders the formation of capital with the result that the settlers would not be able to repay investments or maintenance directly. Therefore, a balance of consumption and leisure is necessary.

The ability of the planners from industrial countries has improved and is still improving as can be seen by the increasingly more appropriate forms of development aid. With longer involvement and more experience better results will no doubt be achieved.

At present planners are in the process of recognizing the importance of the different factors involved in development. However, the decision makers, that is politicians, are still the ultimate determining factor, as the planners are only allowed to act within the framework given by politicians. Thus, success or failure is often already decided even before the planners start working.

Only when the outcome of the foregoing investigation is positive should a detailed development programme be planned.

After the decision has been taken with regard to the cropping pattern, the farm size has to be decided in order to assure an adequate family income for the settlers.

On newly developed land the farm size is only influenced by the level of returns and this size will be decided according to the necessary income. Problems only arise when the ownership of land is already established and it is found that (1) the farms are too small and (2) the lay-out does not allow access for all farmers to their farms and the canals. Such problems are not covered by tradition or customary laws. In such cases all development plans should be postponed until these questions are solved.

If development is started in spite of these problems, then new schemes come to be identified with them and are regarded as sources of trouble and not as improvements. Thus it could be expected that the invested capital will not bring any progress. On the contrary, in such a case it will destroy the established systems and make retreat impossible and advance improbable.

Should all preconditions favour engagement in agricultural development, investment is worthwhile. If conditions are not conducive to development, investment should be avoided, or at least postponed, in order to make the necessary pre-investment changes; it is very difficult to find money for the redevelopment of an already developed site. Furthermore, when a project's failure has once destroyed belief in progress, it is nearly impossible to revive enthusiasm for development, especially when the participants are daily confronted, in the course of their work, with the failed enterprise.

The most favourable solution would certainly be the exploitation of all natural resources at the highest possible level. However, this requires all the other production factors to be of high quality, and if they are not, even the best scheme will not bring significant improvement, because the least developed factor usually determines the degree of development.

The ultimate aim of long-term agricultural development programmes has been succinctly stated by Tothill[24] as being

" ... to bring about the emergence of happy and prosperous rural communities rapidly becoming fully literate, financially able and mentally wishing to participate in the advance of civilisation and taking an ever-increasing interest in the management of their own affairs."

Unless there is a reasonable prospect of achieving such a situation it would be best not to proceed at all. Since, however, in the real world the decisions whether or not to move into development are not necessarily taken on such full and national grounds, projects with inbuilt weaknesses will be mounted. It then becomes doubly necessary for those responsible for development to make rigorous evaluations of the kind considered have not only to minimise the effects of inherent weaknesses but also to expose to the decision makers the consequential implications which such weaknesses may have for the future.

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