

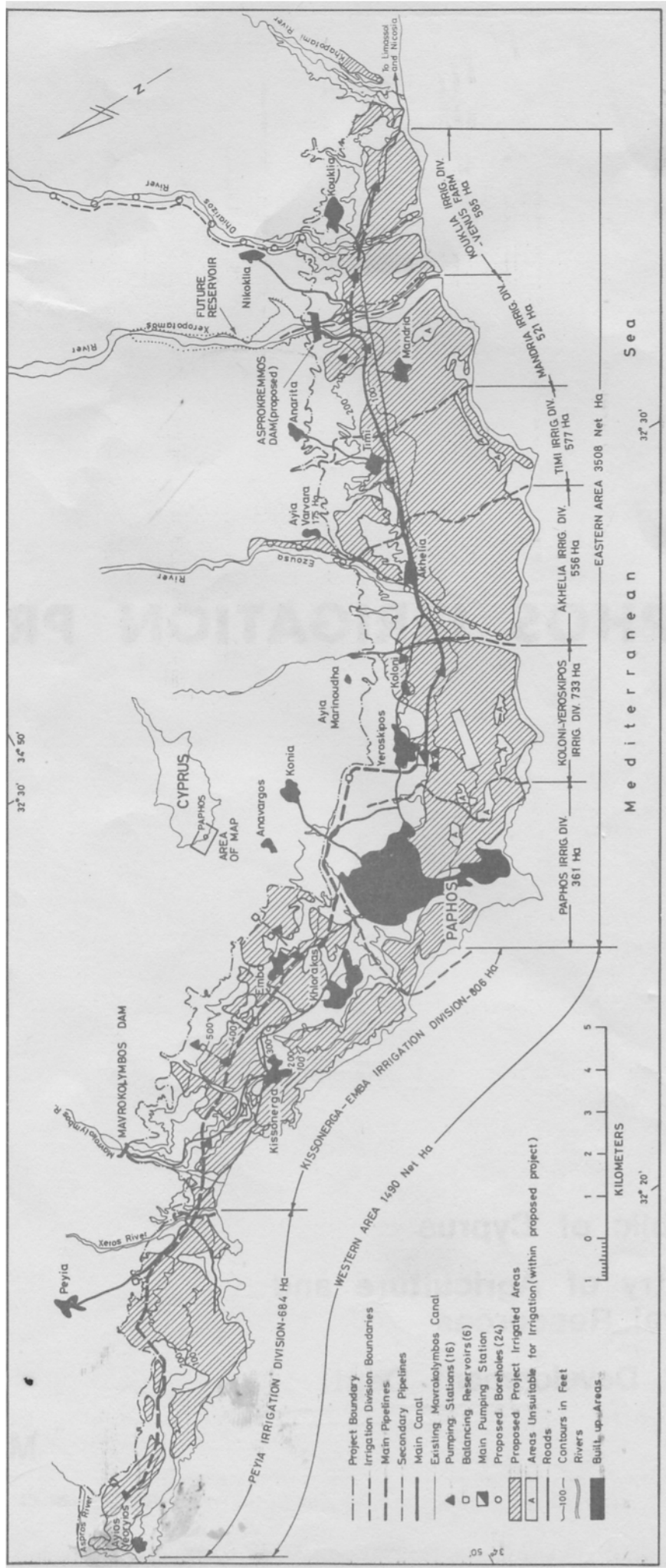


PAPHOS IRRIGATION PROJECT

Republic of Cyprus
Ministry of Agriculture and
Natural Resources
Water Development Dept.

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PAPHOS IRRIGATION PROJECT PROJECT AREA



1. INTRODUCTION

The Paphos Irrigation Project is the largest and most important Project in its kind ever undertaken by the Government of Cyprus. Its aim is to irrigate about 5,000 ha of net irrigable area lying in the south-western coastal plain of Cyprus on both sides of the town of Paphos. The water requirements for the irrigation of this area are estimated to be 36 Mm³/year and will be provided by the Xeropotamos flow (22 Mm³), regulated at Asprokremmos, where an earth dam will be erected and the alluvial aquifers in the main river beds east of Paphos: Dhiarizos, Xeropotamos (lower reach only) and Ezousa (10Mm³) and coastal calcarenite aquifer (4Mm³).

Construction of the civil works of the Project commenced in 1976 and the target date for its full completion was fixed the year 1981 while irrigation supplies from the boreholes in the river aquifers will be available to the adjacent areas of the Project by the years 1978/79. The total cost of the Project is presently estimated to reach up to US\$ 45 million.

2. THE ROLE OF THE UNITED NATIONS

The importance of water development in the national economy of the Republic of Cyprus was stressed out in the report of the first UN Economic Mission financed under the Expanded Technical Assistance Program in 1961 one year after the establishment of Independence. As a result of this report many UN experts have since visited Cyprus on consulting missions and several projects were established. Among these was the Cyprus Water Planning Project (CWPP) which identified Paphos area as one of outstanding potential. Detailed study of the Paphos water development schemes by a contracting consultant was agreed upon in 1967 and was carried out in two phases both of which were financed by UNDP and supervised by FAO as its Executing Agency. Phase A covered detailed assessment of hydrology, hydrogeology, agronomy, dam reconnaissance and overall planning and was carried out between October 1968 and April 1970. Phase B, comprising preparation of the Paphos Irrigation Project feasibility study, was carried out from March 1971 to February 1973. During this period two FAO/IBRD Missions visited Cyprus to carry out interim project evaluation. Final appraisal of the project was carried out by a third Bank mission to Cyprus in May 1973. At that time the estimated cost of the Project was stated as US\$ 36.2 million of which the foreign exchange component was US\$ 18.2 million and 77% of that, i.e. US\$ 14 million, was agreed to be financed by the Bank.

The Loan Agreement between the World Bank and the Government of Cyprus was signed in January 1974 but its application was delayed due to the invasion and occupation of the northern half of the Island by the Turkish Army. Finally, the loan agreement became effective as from October 1975 and from there on the Paphos Irrigation Project entered officially into its implementation phase.

As a further contribution towards the project implementation, FAO released one of its suitably qualified and experienced Senior Irrigation Engineers Mr. Branco Milinusic in order to be employed by the Department of Water Development - the executive body of the Project Works - as a Project Manager for the supervision of all the project activities.

In order to comply with the requirements of World Bank Loan Agreement the Water Development Department engaged the following two Consulting Engineering Firms for the preparation of the final working drawings and specifications for the various supply and construction contracts.

- (i) Sir M. MacDonalds and Partners of Cambridge, U.K. for the Asprokremmos Dam.
- (ii) SOGREAH Consulting Engineers of Grenoble, France for the whole Distribution System and all irrigation works.

3. THE PROJECT AREA

3.1 Location and Geomorphology

The project area is a coastal strip some 38 km long by 3 to 4 km wide with the town of Paphos at its centre. The area to the east of Paphos is a regular coastal plain with uniform seaward slope of 2% and contains the largest area of good soils in the Project; they are made up of old fine deposits between more recent river alluvium. This plain is bounded inland by the Kouklia - Yeroskipos escarpment which at its eastern end reaches the coast at the mouth of the Xeropotami River. It is dissected by three major rivers, the Ezousa, Xeropotamos and Dhiarizos, the resources of which will provide the major irrigation supply.

The topography to the west of Paphos is more irregular with undulating relief of varying slope and higher elevations. A mosaic of different formations is found, particularly spots of red Mediterranean soils overlying limestone crust scattered throughout the area down to the shore line. Two rivers dissect the western area, the Mavrokolymbos and Xeros, both of which have small catchments and incised valleys which merge into a flat coastal enclave.

3.2 Climate

A typical mediterranean climate prevails in the coastal region of Paphos with hot dry summers from June to September and cool winters from December to March during which much of the annual rainfall occurs with an average record of 425 mm. The uniform and moderate temperatures, attributed to the permanent sea breeze, and the relative humidity are conducive to the production of very early fruit and vegetables for which the reputation of Paphos is well known. Nevertheless, irrigation is indispensable for any appreciable agricultural development in this region.

3.3 Present Agricultural Development

At present agricultural practices are semi-intensive which is rather exceptional considering the deficiency in readily available water and the low population density. Almost 70% of the cultivable project area is used. The range of crops grown shows that the farmers are very receptive to new methods and quickly adapt to market requirements: vegetables under plastic tunnels or greenhouses with drip irrigation etc.

Irrigation supplies are presently obtained from surface water diversions from the major rivers Ezousa, Xeropotamos and Dhiarizos and from extraction by pumping from the gravel aquifers of the same rivers and from calcarenite aquifers. The Project of Mavrokolymbos which covers an area of about 300 ha sustained from the dam reservoir under low reliability of supply will be integrated into the Paphos Project.



Green House for Vegetables with Drip Irrigation System

Current crop distribution over the Project area can be summarised as follows:

1. Perennially irrigated crops 15%
Citrus, deciduous, bananas, table grapes.
2. Seasonally irrigated crops 4%
Vegetables, legumes.
3. Spate irrigated crops 34%
Cereals and legumes.
4. Rainfall crops 37%
Cereals and legumes.
5. Uncultivated land 10%

3.4 The Water Resources

The irrigation supply of the Paphos Project will be provided by:

- (i) The Asprokremmos dam reservoir of 51 Mm³ gross storage on the Xeropotamos river which will supply 22 Mm³ per year.
- (ii) The boreholes drilled in the gravel aquifers of the major riverbeds Dhiarizos, Xeropotamos (lower reach only) and Ezousa which can have a potential extraction of about 10 Mm³/year.
- (iii) The coastal calcarenite aquifer of total supply of 4.5 Mm³/year.

From a combination of the first two water resources the gross annual water requirements of 32 Mm³ (net of calcarenite and Mavrokolymbos dam reservoir supplies) can be met with a reliability factor well above the 92% which is considered as agronomically acceptable.



Banana Plantations with Overhead Sprinkler Irrigation

4. ENGINEERING ASPECTS

4.1 The Overall Engineering Scheme

The water resources mobilisation will be achieved by the erection of the Asprokremmos dam and the drilling of boreholes in the river gravel aquifers.

Conveyance of the water to the irrigation sectors will be done through the following routes:

- (i) The wellfield conveyance system collecting the water extracted from the river wells and supplying the main canal.
- (ii) The Main Canal extending from Asprokremmos to Yeroskipos, supplied by the dam reservoir and the river aquifers and commanding the major portion of the eastern plain.

(iii) The Western Main Pipe Conveyor originating from a large pumping station at the end of the Main Canal; the water will be raised by 100 m, then conveyed by a gravity pipeline over some 19 km to Ayios Yeoryios.

Pressurisation of the water supplied by the main canal and the pipe conveyors will be achieved by automatic pumping plants having a mere pump regulation function (eastern area) or a regulation plus storage function (western area).

Distribution of pressurised water from the pumping plants will be ensured by branched pipe distribution networks.



General View
of
Asprokremmos Damsite

4.2 Asprokremmos Dam

The dam will be of zoned earth fill type with central clay core in the middle and gravel shell at slopes of 2.2 to 1. The dam embankment will be 50 metres high with crest length of 600 metres and total volume 1,75 million cubic metres. Geologically the site provides adequate foundation conditions for the embankment. The principal problem presented by the site is the depth of gravels (30 metres) infilling the riverbed which will require a bentonite slurry cut-off trench some 200 metres long and 30 metres deep.

Construction works on the dam are planned to commence by the end of the year 1977 and its cost is presently estimated to be about CE 4 million.

4.3 Wellfield Conveyance and Equipment

The 24 boreholes to be utilised are distributed in the three river aquifers as follows: 13 in Dhiarizos, 3 in Xeropotamos and 8 in Ezousa. All of them have been already drilled and tested and their total yield was found to be 4,750 m³/hour. They will be equipped with submersible electric pumps which altogether will require a power of about 1,000 KVA. Water pumped from the upper reaches of Dhiarizos and Ezousa will be conveyed to the Main Canal by canaletti flumes and from the lower reaches by buried pipelines.

In order to be able to have the first irrigation supplies from the Project as early as possible construction of the wellfield conveyance system is programmed to start this year and be completed together with the main canal within the year 1978. Its total cost is to reach CE 0.5 million.

4.4 Main Canal

The Main Canal will distribute the water from the dam and wellfields to the Irrigation Sectors. It will extend from Asprokremmos to Yeroskipos along the foot of Kouklia - Yeroskipos escarpment for a distance of 11.8 km. It will have trapezoidal section lined with concrete and provided with necessary structures. Its discharge capacity will be 4.3 m³/sec at the head of the canal and 1.7 m³/sec at its tail. The canal hydraulic regulation will be achieved by three automatic constant downstream lever hydraulic gates which will divide the canal in three reaches.

The contract for its construction has already been awarded to the contracting company GENCO for the amount of nearly CE 1 million and works will be completed by the middle of 1978.

4.5 Western Conveyor and Pumping Stations

Water from the end of the main canal will be pumped to an elevation of about 100 metres and then conveyed by the western main pipeline conveyor over 19 km to Ay. Yeoryios for the supply of the western part of the project area. Altogether 16 pumping Stations will be built along the main conveyance system plus the main pumping station at the end of the canal at Yeroskipou which will entail the

installation of electric power facilities of 5,500 KVA. Associated reservoirs will ensure simply pump pressure regulation for automatic operation. Those in the western area will also provide storage of the order 2,000 to 5,000 m³. The cost of these works is expected to be of the order of C£ 2 million.

4.6 Distribution

Each pumping station will provide pressurised supply to an independent irrigation network. Over the whole project area there will be altogether 16 such irrigation networks. The pipe alignments will conform to future road layout, including farm roads, which has been designed in close cooperation with the Land Consolidation Authority which will undertake the implementation of land consolidation over the project area. Design of the irrigation networks was prepared with the help of a computer program by minimising the total investment and operational costs of pumping + pipe distribution. Water supplies to the farmers will be through hydrants which will ensure constant discharges and pressures not lower than 3.5 atmosphere in order to enable farmers to apply sprinkler or drip irrigation methods. Each hydrant will serve an irrigation farm unit of about 2.5 ha and its supply will be always available on request. The total costs of all irrigation networks will be of the order of C£ 3 million.



Main Canal

Excavation Works

5. AGRICULTURAL ASPECTS

5.1 Soils

The major soil types are alluvial in origin, having been deposited by the five rivers that flow through the area. Due to the calcareous nature of the sediment emanating from the river catchments, a soft calcareous layer called "Havara" is found at varying depths below the surface of these soils. These alluvial soils are fertile, generally medium to heavy texture and relatively low in permeability specially in the eastern coastal plain. River terrace soils are found bordering the rivers Dhiarizos and Xeropotamos and in the areas west of the river Ezousa.

Colluvial soils are found at the foot of steeply sloping areas. They are deep brown soils of clay-loam texture with coarse material and are high in calcium. In the western area most soils are alluvial-colluvial, which are also fertile, as well as red soils overlying a hard limestone crust.

All soils included in the irrigated project area are suitable for sprinkler irrigation.

5.2 Cropping Pattern

The cropping pattern for the Paphos project will not only depend on land suitability but also on market requirements, profitability and labour availability.

In the studies so far on average the following cropping pattern has been anticipated:

Citrus fruit	35%
Avocado-pears	5%
Vineyards	35%
Bananas	10%
Vegetables	12%
Summer crops	3%

5.3 Yields and Benefits

The current levels of crop yields in the project area are as high as can be achieved under the scanty and seasonally concentrated rainfall and inadequate irrigation. Without the project, therefore, any further increase in production is unlikely. With commencement of irrigation under the project in 1978/79 a rapid shift from low-value cereal crops, currently raised over about 70% of the project area, to high-value fruit crops and vegetables is envisaged. In the areas irrigated now by groundwater the latter are grown with admirable skill and success. At full development of the project the annual crop production in comparison with the present one would be as follows:

<u>Crop</u>	<u>Production in 1000 tons</u>	
	<u>Present</u>	<u>Future</u>
Cereals	7.0	-
Citrus fruit	4.0	65.0
Table grapes	4.0	27.0
Vegetables	7.0	20.0
Bananas	1.0	7.0
Avocado	-	2.0
Total	23.0	121.0

The economic benefits from the project will be the significant increase of gross value of yearly production from the present US\$ 2.9 million to US\$ 19.4 million. The foreign exchange earnings from the exportable crops would be about US\$ 7.3 million. The project's economic rate of return was estimated at 19%.

The project beneficiaries include 3,500 farm families most of which with small ownerships, 1,300 landless families in the project area and about 350 refugee farm families who will receive economically viable farm units in the project area.

5.4 Land Tenure and Consolidation

There are four types of ownership in the total project area, with the following distribution:

<u>Ownership</u>	<u>Percentage of Area</u>
Private, individually owned	45%
Private, community owned	34%
Government owned	16%
Owned by Religious Institutions	5%

As it generally occurs in most privately owned areas all over the Island the plots within the project area have irregular shape and their size has been reduced considerably over the years due to the continuous fragmentation of the private holdings under the laws of dividing the land into several shares if it is requested so. Statistics indicate that the average number of plots per holding, for the whole project area, is 3.2, each of 0.57 ha. Under these conditions it has been decided that land consolidation is absolutely essential in order to achieve: (a) aggregation of scattered plots (b) elimination of ownerships of below 0.27 ha or in undivided shares and (c) provision of farm access roads the layout of which will be compatible with the layout of a modern economical irrigation network and which will also form regular blocks of land within which it will be possible to obtain consolidated plots of optimum shape for on-farm water management.

Depending on the quality of the land the economically viable plot sizes have been decided to be 1.2, 1.6 and 2.4 ha with widths always kept as near as possible to 100 metres.

Design of the future road network which will constitute the framework of land consolidation has already been prepared by the Consultants SOGREAH in close cooperation with Land Consolidation Authority. The land consolidation procedure is now in progress in the village sectors of Akhelia, Koloni, Yeroskipos, Emba and Kissonerga and will soon be initiated in the sectors of Peyia, Ayios Yeoryios, Paphos and Ayia Varvara. In the predominately Turkish owned areas of Mandria and Timi the Government under the present political situation will not enforce land consolidation but the layout of the irrigation network to be constructed in these areas was designed to fit in with the requirements of possible future land consolidation.

The land development works such as land levelling, road construction, drainage etc. which are essential part of land consolidation are planned to be carried out concurrently with the installation of the irrigation pipes.

5.5 Agricultural Research

The Agricultural Research Institute, which was established in 1961 with UNDP assistance is the centre of research activities in Cyprus. Through its substation at Akhelia, the Agricultural Research Institute will be responsible for carrying out all necessary research work for providing services to the farmers in the project area. This substation has been in operation since 1966 covering 7 ha and its major activities were concerned with vegetable, fruit culture and water use. Strengthening of its facilities and staff under the project is now in progress. A soils and water testing laboratory was added to enable determination of exact suitability of various soils to the proposed crops, and an area of 20 ha within the project area was allocated to the substation for the purpose of carrying out experimental field work.

Research efforts will be primarily directed towards (a) growing practices of all project crops with special emphasis on further advancing maturity, (b) crop varieties best suited to various project conditions and (c) efficiency in water use.

5.6 Agricultural Extension

The present establishment within the Department of Agriculture will be expanded to project requirements for extension services. The existing extension staff will be increased by three agriculturists and three assistants to work on cultural techniques, by two more agriculturists specialised on irrigation and by four agricultural assistants to work on water use problems. Besides giving advice to the project farmers on technical matters, the extension officers will assist them in preparation of farm plans required to support their requests to Cooperative Central Bank for credit to finance on-farm development.

Three experts, specialized in the fields of sprinkler irrigation and the growing and marketing of out of season and early vegetables, quality citrus and early maturing table grapes will be employed for a total period of 36 man-months in order to organize the extension service and to train the local staff. In addition, a number of local qualified personnel will be given overseas training in project-related fields.

One of the main features in extension work is the Agricultural Educational Center at Yeroskipos which has been put in operation from last January. A programme of 40 courses has been prepared to cover the period 1st January - 31st December 1977 and the total number of participants is expected to be 1,000 approximately. During the first 3 months of the center's operation 15 courses were held by specialists of the Department of Agriculture with a total number of 374 participants.

Works for the establishment of two nursery gardens in the project area have been also completed. These nursery gardens will cover the needs of the project area for seedlings of citrus and avocado budded with suitable and recommended varieties.

6. ORGANISATION AND MANAGEMENT FOR PROJECT IMPLEMENTATION

The institutional framework for the complete project organisation and management including the composition of the concerned committees is illustrated in the attached chart. Its main instruments are shortly described below:

6.1 Policy Level

Project policy and coordination of the activities of all Government Departments concerned is achieved by a high level body called the Project Policy and Coordination Committee (PPCC) with the Minister of Agriculture and Natural Resources as chairman, the Director of Water Development Department as secretary and other members from other contributing Departments.

6.2 Executive Level

The main executive body of the Project during its implementation, operation and maintenance is the Water Development Department. The services of some other Departments are also utilised. The Agricultural Department will be responsible for the on-farm development works and together with the Agricultural Research Institute will provide agricultural extensions and research services. Other Departments involved are the Geological Survey Department for drilling works, Land and Survey Department for land acquisition, Land Consolidation Authority, Planning Bureau, Tender Board and Ministry of Finance.

7. OPERATION AND MAINTENANCE

For the operation and maintenance of the Project after its implementation the following institutional set up is envisaged:

7.1 Policy Level

As described under para 6.1

7.2 Executive Level

The executive body for the Project Management will be the Department of Water Development through a Project Manager at Paphos properly assisted by the Agricultural Department.

All water legislation will be controlled by the Director of Water Development both for the Project Area as well as for all water catchment areas upstream.

The Department of Water Development through its Paphos Office will be responsible also for selling the water either in bulk to the Irrigation Divisions or to private consumers. The charges per cubic meter of water used will be sufficient to pay for all operation and maintenance costs as well as to recover the investment costs over the project life of 50 years at 4% annual interest.

7.3 Advisory Level

An advisory body at regional level with knowledge of local affairs representing all interested disciplines has been established under the chairmanship of the Paphos District Officer. This body is called the Project Advisory Committee and advises directly the Project Manager on local developments affecting the project and problems faced by the farmers and also explains to the farmers the project objectives and advises them about the efficient use of the water resources.

Consumer Level

The project area is divided into 9 Irrigation Sub-divisions which are selected mainly on village administrative grounds. Each Sub-division will have its farmers' representation in a Water Committee consisting of the District Officer as chairman, the Deputy Project Manager as secretary and the District Agricultural Officer, the District Engineer of W.D.D. and the farmers' representatives as members. This committee will deal with problems concerning operation and maintenance of the project as will be delegated by the Director of Water Development.



Mavrokolymbos Dam

