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UNITED NATIONS
DEPARTMENT OF TECHNICAL
CO-OPERATION FOR DEVELOPMENT

NATIONAL WATER RESOURCES
MASTER PLAN
PHASE II

Project Findings and Recommendations

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DEPARTMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT

NATIONAL WATER RESOURCES MASTER PLAN
PHASE II
MALAWI

Project findings and recommendations

Prepared for the Government of the Republic of Malawi
by the United Nations
Department of Technical Co-operation for Development
acting as Executing Agency for the
United Nations Development Programme

New York, 1987

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NOTES

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The monetary unit in Malawi is the kwacha (K). As of February 1987, the value of the kwacha in relation to the United States dollar was \$US 1 = K1.86.

Abbreviations used:

ADB	African Development Bank
ADF	African Development Fund
DTCD	United Nations Department of Technical Co-operation for Development
DW	Department of Water
EEC	European Economic Community
ESCOM	Electricity Supply Commission of Malawi
IDA	International Development Association
IBRD	International Bank for Reconstruction and Development
MOA	Ministry of Agriculture
MOWS	Ministry of Works and Supplies
MW	megawatt(s)
ODA	Overseas Development Administration of U.K.
RGS	river gauging station
UNCDF	United Nations Capital Development Fund
UNDP	United Nations Development Programme
UNICEF	United Nations Children Fund
UK	United Kingdom
USA	United States of America
WRA	water resources area

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ABSTRACT WITH KEY WORDS

This project was to ensure that Malawi's water resources be used for economic development and benefit of the people. At the request of the Government of Malawi, the United Nations agreed to assist by preparation of a National Water Resources Master Plan. The project commenced in 1981. Phase I entailed the review and processing of all hydrologic data and establishment of a data bank. Phase II commenced in October 1984 and the Master Plan was completed. The following immediate objectives were met: (i) appraisal of water resources and studies of river basins, (ii) identification and appraisal of promising projects, (iii) preparation of a Master Plan with development proposals, (iv) introduction of microcomputers, development of programmes and training in the establishment of a permanent hydrologic analyses, information storage and retrieval system, and (v) preparation of water resources legislation. Goals on organization, manpower and training were essentially completed. The National Water Resources Master Plan report was printed; each set comprises

- (i) Summary and Recommendations
- (ii) Report and Appendices
- (iii) Annexes 1, 2A, 2B, 2C, 3, 4, 5, 6 and 7 as separate volumes on the various objectives.

INTRODUCTION

Malawi, in south central Africa, has an area of 118,485 km² of which the land area is 94,276 km² and the remaining 24,209 km² is occupied by lakes. Lake Malawi is the largest with an area of 28,760 km². The population in 1985 was estimated to be about 7.06 million with a national density of 75 persons per km². The population is estimated to rise to 8.33 million by 1990 and 13.66 million by 2005.

The country is rich in water resources with a good network of river systems. The mean annual rainfall is around 1037 mm and the surface-water runoff is around 196 mm.

To meet the water demands of the growing population, particularly in the water supply and sewerage sector, a five member mission under the WHO/IBRD Co-operative Programme headed by Mr. Jackson, an engineer of WHO, visited Malawi during October and November 1977, at the invitation of the Government of Malawi. The mission gave its report in April 1978 and this was accepted by the Government.

One of the main recommendations was to prepare a Water Master Plan for management of the country's water resources. The main objectives of this Plan were to be consolidation and analysis of available data; study of the availability of water resources both in time and space; establishment of a basis for continued compilation of data; quantification of existing water demands and projection of future demands over 10 to 20 years; and presentation of a plan for use of the resources to meet future demand.

In 1979, the Government integrated all water-related activities in one department, the Department of Lands, Valuation and Water. In 1984, the Water Division in this department was made the Department of Water (DW) and shifted to the Ministry of Works and Supplies.

To implement the main recommendations, the Government requested the United Nations Development Programme (UNDP) for assistance in preparation of a Water Master Plan for the country. Accordingly, a

project document was formed and finalized in 1980. Phase I of the National Water Resources Master Plan Project (MLW-79-015) was started in March 1981 with the United Nations Department of Technical Co-operation for Development (DTCD) as the executing agency, and the DW as the Government implementing agency.

Phase I was to be essentially data collection and documentation with effort concentrated mainly on gathering and processing river-flow data from about 300 river gauging stations (RGS) amounting to about 4,000 station years. This huge task was accomplished by the end of 1983. As for ground-water data and details, the input was agreed to be provided by the Ground-water Section of the DW together with experts of the Overseas Development Administration of U.K. (ODA) then working in the DW. Some studies, such as population projections, preliminary studies on water sector legislation, manpower needs and training, were also done under Phase I.

As most of the main activity and output of the proposed Water Resources Master Plan could not be undertaken in Phase I, a tripartite review meeting was held in September 1983 when it was agreed that the programme should continue as Phase II, but a new project, to accomplish the main objectives of preparing the Water Master Plan.

The Phase II project (MLW-84-003) was to commence on 1 January 1984 but owing to administrative delays, it came into effect from 1 October 1984. Printing and distribution of the report, and preparation of a manual on estimation of peak flood for the design of culverts and bridges, etc., was to be completed under supervision of the Water Resources Expert by end of May 1987. The project was essentially complete by November 1986 and the Chief Technical Advisor and the Associate Expert on Water Resources completed their assignments on 30 November 1986.

The contributions by the United Nations Development Programme were:

Phase I	(MLW-79-015)	\$US 634,624
Phase II	(MLW-84-003)	\$US 495,734

The contribution by the Government of Malawi was in kind, covering input by officers and staff of the Department of Water mainly in hydrology and hydrogeology, three full-time staff members, office accommodation and support, and the operation and maintenance of vehicles. The Government contribution amounted to 250,000 kwachas for Phase I and 140,000 kwachas for Phase II.

I. ACTIVITIES AND OUTPUT

A. Activities as planned

The following were the main activities planned for the project:

- (a) Water resources studies
- (b) Identification and appraisal of promising projects selected on the basis of water-resources studies, cost evaluation, map studies and field inspection
- (c) A national strategy for water resources development
- (d) Hydrologic data processing, storage and retrieval system
- (e) Establishment of suitable legislation for water resources control, development, and management
- (f) Manpower and training.

B. Implementation

1. Water resources studies

The water resources studies were to cover appraisal of water resources, availability of water and present use, low-flow and flood characteristics for specific projects, and other aspects of water studies. The country is divided into 17 water resource areas (WRA) and each WRA represents the drainage or catchment area of one river. Some WRAs cover the drainage areas of several small rivers along the lake shore.

The appraisal of surface water resources and associated studies was fully accomplished. The results, and other basic data are documented and included as Annexes 2A, 2B, 2C, 3, 4, and 5 of the Master Plan report.

Briefly, these Annexes are:

- 2A: Surface Water Resources - General (119 pages)
- 2B: Surface Water Resources - Appraisal of Water Resources Areas 1 to 5 (260 pages)
- 2C: Surface Water Resources - Appraisal of Water Resources Areas 6 to 17 (310 pages)
- 3: Hydrological Data - Part I, Water Resources Areas 1 to 3 (220 pages)
- 4: Hydrological Data - Part II, Water Resources Areas 4 to 8 (238 pages)
- 5: Hydrological Data - Part III, Water Resources Areas 9 to 17 (258 pages)

Annex 2A describes the general characteristics of the rivers and river basins and presents data on rainfall, run-off, variations and specific yields. Overall assessment of water resources, general demands, present utilisation, planning and management aspects are also included in Annex 2A.

Annexes 2B and 2C cover detailed water resource studies of the 17 water resource areas of Malawi on water availability and appraisal, demands and future possibilities. The two annexes provide longitudinal profiles of the rivers, histograms of monthly mean, minimum and annual flows, flow-duration curves, and dependability curves based on daily discharge data of dry, average and wet years of selected river gauging stations.

Coefficients of variation, flows at various probabilities are also worked out for the various stations. Availability of water, its appraisal, and present rates and amounts of abstraction are also presented in Annexes 2B and 2C.

Annexes 3, 4 and 5 present the collected and processed monthly mean flows of more than 300 hydrometric stations in the country covering more than 4,000 station-years of data. Brief descriptions of all the *river gauging stations (RGS), gauge history and other particulars* are also included. Further, mean monthly and annual rainfall, temperature, and pan-evaporation data for all the representatives stations are given under each WRA. These are updated versions of the Interim Reports of Phase I.

All the data have been stored in the project microcomputer and can be updated and retrieved as needed. This great volume of data should be most useful in planning and developing for surface-water resources in the future.

Annex 6: Ground-water Resources (162 pages)

Annex 6 was prepared by the Ground-water Section of the Department of Water with ODA assistance in 1983. The report provides hydrogeologic data, aquifer properties, and data on existing boreholes and dug wells and a general idea of the ground-water resources in the country. Data on ground-water use with existing and projected demands are presented. It also deals with water quality and its potential for development of rural and urban water supplies. The report was updated to include 1985 statistics.

2. Identification of promising projects

Independent study by the Master Plan team and study of reports prepared by consultant teams engaged by the Government led to the identification and appraisal of some promising projects. Related cost evaluations, map studies and field inspections were made.

During implementation of Phase II, there were major developments. The Ministries, departments and statutory bodies with the assistance provided by the World Bank, ADF, and other donors initiated the preparation of preliminary studies in various water sectors. The project was involved in most of these studies by identifying and assigning priorities to various projects, and in guiding the investigations in semi-urban rural water-supply projects. Some of the areas not covered by the consultants were taken up by project experts. Independent studies on some priority water supply projects were also taken up.

Briefly, the Consultant Teams were

- (i) The DW, Ministry of Works and Supplies (MOWS), engaged Swiss consultants to prepare feasibility studies on augmentation of existing water supply arrangements for six major urban centres to meet the water demands up to the year 2005. This was accomplished through the African Development Bank (ADB).
- (ii) The DW, MOWS, engaged Danish consultants for preparing feasibility studies for water supply schemes of 44 semi-urban centres, existing and new, to meet the water demands up to 2005.
- (iii) ADB assistance was provided for work on the design and construction of the Mpira-Balaka dam to serve nearly 260,000 rural inhabitants with safe drinking water, apart from meeting the water demands of Balaka urban centre.
- (iv) The Electricity Supply Commission of Malawi (ESCOM) had engaged consultants from the USA, to study and report on the least-cost option of further major hydropower development to meet future needs.
- (v) The Ministry of Agriculture (MOA) engaged consultants from the U.K. under IBRD assistance and initiated studies

on rehabilitation of existing schemes, planning and development of small irrigation schemes, and development of a major irrigation project.

The project made a thorough study of the consultant reports and offered suggestions for their evaluation, appraisal and finalisation. Particular care was taken to ensure that development plans in any one sub-sector would not adversely affect development in other sub-sectors. For example, an alternative development programme for major hydropower has been recommended to ensure that the potential for major irrigation development in the Lower Shire Valley not be affected.

The project made independent studies for the construction of small hydropower schemes in northern Malawi to provide power less expensively than the present diesel generators, a factor which inhibits growth in the area. Similarly, studies were also made to identify and appraise projects to supply water to selected semi-urban centres not covered by the consultants. Another study to pipe water by gravity flow to an area with poor ground-water potential was made to evaluate its technical viability. Details regarding sources of surface water, alignment of pipelines and location of storage and pressure-release tanks were studied and the results incorporated in the Master Plan. In preparation of these appraisals and cost estimates, extensive map studies and field inspections were made and discussions held with Government authorities and statutory Boards.

These and all other details of proposals in the various sectors - water supply, irrigation, and hydropower - are included in the main report of the project, namely:

<u>Appendix</u>	<u>Subject</u>
A	Urban water supply
B	Rural water supply
C	Hydropower development
D	Irrigation

3. Strategy for water-resources development

Preparation of a national strategy for water-resources development was part of the National Water Resources Master Plan. The report has been printed; it comprises nine chapters with appendices and nine annexes.

The main report provides overall information on the availability of surface- and ground-water resources, water use and demands, future needs, strategy and development plans in the various sub-sectors of water. Chapter 5 deals with development proposals, financial outlay, and recommendations. It also covers changes considered necessary in existing water sector laws and regulations for development in the water sector.

Six appendices give details of the various studies and proposals on urban and semi-urban water supply, hydropower, irrigation, water quality, and use of microcomputer in the processing, storage and retrieval of hydrologic and related data.

4. Information storage, and retrieval system

The project introduced microcomputers in the national hydrologic data processing, storage and retrieval system. In 1983, a Radio Shack TRS 80 Model II microcomputer was installed and fully used during Phase II. Further, all the analyses of data for water resources studies were done through this microcomputer. Several computer programmes were developed. All the monthly mean discharges, and relevant results of data analyses have been stored in the computer for retrieval as necessary. Besides these, details of all rain-gauge stations, river gauging stations, length of data available, licensed water abstractions, and listing of about 750 impoundments, were stored in machine-readable form. Further, the microcomputer was extensively used for word processing in preparation of project documents and the Master Plan, covering more than 2,200 pages. On-the-job training in use of the microcomputer was given to five officers of the Department of Water.

By the end of the project, it was becoming obvious that the Radio Shack RTS-80 Model II microcomputer lacked sufficient memory, speed and functions to meet the growing needs of the Department of Water and would need soon to be augmented or replaced.

In view of these, the Tripartite Review meeting held in February 1986, recommended purchase of another microcomputer with better capability and larger memory which could be used by the Department for processing storage of daily flow and other data, and for conducting studies for planning of water resources and use. It was decided to make the purchase locally so that essential back-up-service within the country would be assured. An IBM Personal Computer complete with display screen, keyboard and disk drive, and some essential software, was purchased in September 1986. The IBM-PC-AT is not compatible with the Radio Shack microcomputer but transfer of data to the new computer is possible. The training of local staff in use of the new computer was extended to April 1987, to ensure that sufficient personnel are available to program and operate it.

In fact, during the project, the computer needs of various sections of the Department of Water were examined in detail. It is felt that more microcomputers will be necessary if all the hydrogeologic (boreholes) and water quality data are to be adequately stored and updated.

The two microcomputers, a daisy-wheel printer, and a line printer were interconnected. Some software and such expendable accessories as diskettes were procured. Future maintenance of the equipment and procurement of supplies (ribbons, diskettes, etc.) will be by the DW. Thus, a permanent information storage and retrieval system to process hydrologic data has been established in Malawi. The entire 'National Water Resources Master Plan Report, and all Annexes' is in machine-readable form for retrieval and analysis by the microcomputer.

5. Legislation

Recommendations for legislation on water-resources control, development and management are included in Annex 7, "Water Resources Law and Administration" (81 pages) of the Master Plan report. The water law consultant visited Malawi twice during Phase I and prepared a draft bill for water legislation to replace existing law so that suitable legal protection would be provided for existing and future developments in the water sector.

The draft bill was studied by the Government which recommended that, instead of a new bill, regulations within the framework of existing law should be drafted. The regulations are comparatively easy to introduce as they do not require the approval of parliament, but require assent of the Minister responsible for water resources.

The water law consultant, again visited Malawi twice in 1986 and drafted regulations to encompass all aspects of water and pollution control. These were finalized after discussion with members of the Water Resources Board and other concerned agencies. These regulations were submitted for consideration by the Government.

6. Organization, manpower and training

Although the original assignment was to cover manpower and training only, organizational aspects of the Department of Water were later included in 1986. The consultant on manpower and training visited Malawi during Phase I of the project and submitted an interim report. Models for manpower requirements depending on the size of development plans in the various sections of the DW were outlined, but subsequent needs rendered the models inadequate. Other consultant reports on the subject confirmed the need for fresh recommendations.

Accordingly, the consultant made another visit in December 1986 and January 1987 when considerable progress was made. Another visit was planned to finalise the recommendations after obtaining the views

and comments of the DW and MOWS. A final set of recommendations was to be made by May 1987, and was to form Annex 8 of the Master Plan.

C. Output as planned

The anticipated output of the project was to include:

- (i) Assessment of surface water availability, potential, and associated aspects
- (ii) Appraisal of promising projects
- (iii) Preparation of a National Water Resources Master Plan for various time horizons and scenarios
- (iv) Reliable hydrologic data, storage, retrieval and updating system using microcomputers
- (v) Revision of water laws and drafting of additional regulations
- (vi) Organization, manpower, and training
- (vii) On-the-job training.

D. Accomplishments

All the planned output was achieved. A brief review follows.

Studies regarding assessment of availability of surface water resources of major river basins, water balance in major areas and suitable options for meeting the future water demands and hydrologic analyses of low flows were completed.

Besides making comments on the projects recommended by consultants in the field of urban water supply, irrigation and hydropower, some promising projects in the northern region of the country were

identified for generation of hydropower to serve the growing power demands of Karonga, Chitipa and Chilumba towns. The projects are financially viable and promise high rates of return when compared with diesel power stations. Further detailed studies were recommended. Similarly in the urban water supply sector, studies were made for Ntaja and Euthini towns, both of which are expected to grow rapidly. These towns had not been included in studies by the consultants. One of the schemes, Ntaja, is definitely considered viable and is recommended for inclusion as a high priority scheme. Another recommended scheme would pipe water to rural areas, but additional study is necessary to identify specific sources.

Preparatory and feasibility studies for a major gravity-flow irrigation project in the Lower Shire Valley were recommended.

The Master Plan presents a list of priority projects in various sub-sectors of water which should be implemented in a phased development over the next 20 years (1985 - 2005). The extent of capital investment needed in the various phases is also indicated so that the development plans in various sub-sectors can be tailored to the funds provided by financial agencies or donors.

Of the 51 urban and semi-urban water supply schemes studied by the consultants and the project, 39 are considered as high-priority schemes which should be taken up during the initial phase of development (to 1995). Some additional studies for ground-water assessment and feasibility studies leading to preparation of detailed designs were recommended for these schemes.

Draft regulations within the framework of the existing water laws were recommended to ensure the development of water supply programmes without legal drawbacks.

The Master Plan report in 11 volumes was printed. It provides a data bank and results of water resources analyses which should be an invaluable asset in future planning. The data bank should be

continually updated with future hydrologic data and results of any analyses.

E. Factors helping implementation

1. The project received continuous support and assistance from UNDP, DTCD, DW and the MOWS. The working conditions provided by the DW were excellent.

2. The Statutory Boards, Commissions, concerned Government ministries and other Government agencies took part in the discussions and expressed their views and comments.

3. Toward fulfilment of the activity of the project to propose promising projects, the proposals by consultant teams on urban and semi-urban water supply, and other sectors of water utilisation helped extensively. The project supplemented the recommendations of the consultant teams. With the limited staff and time, the Master Plan project could not independently have covered all the proposals made by both the project and consultants.

4. Procurement of the Radio Shack TRS 80 Model II microcomputer and the subsequent joining of a full time associate expert on computer sciences went a long way toward completion of the water-resources studies, and word processing for the Master Plan report.

5. Purchase of the IBM PC-AT and accessories helped in the training of local officers and staff. This IBM Personal Computer, with the Radio Shack computer, facilitated the establishment of a data bank, and a continuing system for data processing, storage and retrieval amenable to easy updating and modification.

6. There was a high level of expertise available to meet the challenge and pressure of work.

7. The Manager and staff of Montfort Press, Limbe (Blantyre) made possible the major task of printing in good time all 11 volumes of the Master Plan.

F. Factors hindering implementation

Like nearly any major project of this magnitude, covering many technical and administrative disciplines and the preparation of a Water Resources Master Plan, delays were experienced; some of the more troublesome were:

1. The positioning of the Civil Engineer (Hydraulic structures), due on 1 January 1985, was actually toward the end of October 1985.
2. The Associate Expert in computer sciences could not join the project until the end of October 1985, instead of January 1985 as planned.
3. Delays in the submission of several technical reports by the consultant teams, the results of which were essential, delayed preparation of the Water Master Plan.

II. ACHIEVEMENT OF IMMEDIATE OBJECTIVES

A. Proposals

The immediate objectives of the project were to provide a blueprint for development of the country's water resources by preparing a National Water Resources Master Plan along the following lines:

1. Determine the extent of water resources of major river basins,
2. Identify and appraise a few promising projects in the various sectors, including water supply, irrigation and hydropower,
3. Complete a Water Resources Master Plan, with development proposals for various time horizons,
4. Assist in establishing a computer-based system of data processing, and information storage and retrieval,
5. Rationalize the hydrometric network, and
6. Establish suitable legislation for water resources control, development and management.

B. Results

With but one exception (objective 5) the immediate objectives were reached. Details were given in section I.B., Implementation, above. Although originally specified an immediate objective, Rationalization of the hydrometric network (5 above) was later decided to be included as a responsibility of the Hydrology Section of the DW.

III. UTILIZATION OF PROJECT RESULTS

A. Type and application

1. Data documentation

Annexes 3, 4, and 5 of the Master Plan include the collected and processed hydrologic data, associated particulars, history of river gauging stations and related information. All past data, generally up to 1983, are included. Annex 6 contains all ground-water details.

These basic data were of much use during the project and the various consultant teams on water supply projects. Further, all this information has permanent value and should be of great use in the future by those planning and designing water projects. Additional data from 1982-83 should be progressively included by the DW to keep the data base current.

2. Availability studies

The water resources availability studies and results are also of basic nature and the results pertaining to all the river basins are valid for future continuing use. Additional data and further analyses will update the record but the basic results are not likely to change significantly as all the past data are sufficiently long-term to establish validity of the results.

Some of the results have already been utilized by the concerned agencies and the DW and would be of immense value to water-use planning for single purpose or for multipurpose benefits.

3. Present and future water demands

The Master Plan report includes all the present withdrawals for water supply, irrigation, generation of hydropower and has also

indicated the availability to meet the future water demands. The population growth and water requirements have been indicated. These would be progressively utilized.

4. Field inspections and project proposals

For a few promising projects on urban and rural water supply, detailed field inspections were made, locations on rivers for withdrawal of water were indicated and preliminary feasibility and financial studies included. The results have already (1987) been drawn upon by the DW.

On the development of small and micro-hydropower projects, extensive map studies, field inspections and suitability of sites and preliminary feasibility studies were made. General design criteria, cost evaluation, economic analysis were also detailed in addition to load growth and demands. After inspecting and identifying ten sites for hydropower development in the northern region of Malawi, some schemes were detailed for meeting the energy demands of Karonga, Chitipa, and Chilumba areas.

The results were, in general, discussed with the Electricity Supply Commission of Malawi (ESCOM) and all the studies and projects proposals are geared to meet their future requirements. The preliminary studies and analyses made are of much use to ESCOM. These projects cover areas outside the national power grid.

The consultant's Report on the least-cost option for major power development was studied and commented upon.

On irrigation development, the Master Plan provides an overall picture of past projects, past and present studies by consultant teams, present extent of irrigation, rehabilitation of small-holder schemes and other aspects. Comments on the latest studies are included and the Master Plan report makes recommendations for future development.

All these are included in Appendices A, B, C, and D of the Master Plan report.

B. Master Plan report

The purpose of the Master Plan is to identify all available water resources, present and future water demands in all the sectors such as rural, semi-urban and urban water supply, irrigation, hydropower, and other aspects such as floods and drainage, water resources management, and to outline the means to meet the growing demands of the future for different time horizons.

The nature of the subject is such that the Master Plan provides a broad-based outline for development of water resources. Use of the Master Plan report in its entirety will be progressive. Changes and updating of findings are in the nature of any Master Plan.

A manual on 'Estimation of Peak Floods' for the design of culverts and bridges for village access roads was begun and scheduled for completion by May 1987. This manual would be used primarily by civil engineers in designing roadways.

C. Proposed Water Resources (National) Regulations

After discussions and meetings with the DW, the Water Resources Board, Statutory Water Boards, concerned Government and non-governmental agencies, the project finalized, in August 1986, a draft on 'Water Resources (National) Regulations'. These proposed regulations would assist and strengthen implementation of the existing Water Resources Act of 1969 and subsequent regulations.

The Water Resources regulations are in accordance with the requirements of the Government of Malawi, as determined from numerous meetings and discussions. The regulations were submitted for consideration by the Government for necessary further action. They are covered in Annex 7 of the Master Plan report.

D. Organization, Manpower and Training

Several discussions have already (1987) been held with the Department of Water and other agencies on organization, manpower and training. A draft report was prepared, which when accepted should be of much utility to the DW.

E. Changing factors on future utilization

The results of the Master Plan study were such that some are already (1987) being utilized, some are of permanent value for progressive future use and some require further study and field investigations.

In the future, the main aspects should be updating the data bank, study of the changing costs and financial scenarios, adjustment and revised planning in accordance with national policies and priorities of development.

IV. RECOMMENDATIONS

A. General

The country is rich in water resources and in general can meet the requirements of the growing population in all water sectors.

Lake Malawi (28,760 km²), with its vast volume of water, is a great asset in maintaining the water balance and in acting as a great natural reservoir to meet the requirements of hydropower generation along the Shire River, the only outlet to the lake.

There have been great strides in the economic development of the country and in harnessing the water resources for the benefit of the population - including water supply, irrigation, hydropower, fish culture and recreation. The Master Plan assists in evaluating further uses of the water resources.

The DW and other concerned agencies are equipped to continue the Master Plan objectives and to contribute to the progressive national requirements. For undertaking specific projects there are external agencies to meet both the technical and funding needs. There were and are grants, aids, and loans for the development of water projects by many countries and organizations, e.g., Canada, Denmark, EEC, Federal Republic of Germany, United Kingdom, USA and by international banks and agencies such as the Christian Service Committee, ADB, ADF, IBRD, IDA, UNCDF, UNDP, and UNICEF. It is most gratifying to note the extensive overall development in all sectors. This basic document, the Master Plan, has, in fact, set in motion a chain of development in water and related sectors contributing to overall development of the country.

B. Specific

The following are the main recommendations to facilitate continuing and progressive development in the water sector.

1. Continuation of project activities

The activities of the Master Plan project should be continued to meet changing requirements.

2. Updating data bank and use of microcomputers

Hydrologic data from the hydrometric stations should be kept updated by regular collection, processing and publishing of water year books. The use of microcomputers is advocated for the processing, storage and retrieval of hydrologic data. In fact, wider use of microcomputers should be made through acquisition of additional computers and setting up of a computer section in the DW. The section should be responsible for storing hydrologic, hydrogeologic and water-quality data and for keeping them updated from time to time. A data-base system also needs to be developed.

3. Improved instrumentation

Instruments for recording water levels, and for flow observations at the hydrometric stations need to be calibrated and replaced as necessary. The operational side also needs strengthening to ensure regular and reliable field observations including low and high flows. Periodic training of field staff should be organized.

4. Water laws and regulations

The draft regulations on control and development of water resources drawn within the framework of the existing water laws, require further action.

5. Development of water supply

Phased development in the urban water supply and rural water supply should be continued. Augmentation of existing schemes which are not able to meet the demands, such as Kasungu, Ntcheu, Mzuzu and Karonga, should be given high priority. With development of the Afridev pump which can be manufactured locally and maintained at village level, the borehole and dug-wells programme should receive the necessary boost to serve the growing demand of safe water for the rural population. Potential rural piped water schemes should be studied and feasible projects implemented. Such programmes in the past achieved remarkable success, attracted donors with long-term grants, and should be continued.

6. Upgrading of Ground-water Section

The Ground-water Section should be upgraded to Branch level so that it can be geared to take up the accelerated programme of construction of new, and rehabilitation of existing, boreholes and dug wells.

7. Small hydropower schemes

Some small hydropower schemes, North Rukuru and Wowve to serve Karonga, Chitipa and Chilumba towns respectively should be taken up for detailed feasibility study. These schemes, if found feasible, would provide comparatively cheap and dependable source of electricity in areas currently depending on diesel power stations. The schemes require modest investments and could be implemented within two or three years of inception.

The next most economic option for generating major hydropower is at Kapichira Falls on the Shire River where a dam is proposed which could generate 100-125 MW. Future power development on the Shire River should be planned for firm flow of $136 \text{ m}^3/\text{s}$ (not $170 \text{ m}^3/\text{s}$ as

calculated hitherto). The Kapichira dam must provide a canal regulator of $40 \text{ m}^3/\text{s}$ for future construction of a major irrigation project in the Lower Shire Valley.

8. Shire River irrigation project

Preparatory and feasibility studies for constructing a major gravity flow irrigation project to irrigate 20,000 ha of new area and 9,000 ha of existing estate area should be taken up early. The project could be constructed in stages and is considered financially viable.