NIVA – REPORT

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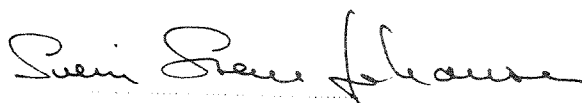| Report title: The Need for Water Research in Zambia. VA-17/83	Date: September 1983
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Abstract:

This report gives an overview over the Water Supply and Sanitation Sector in Zambia, the educational possibilities within this Sector, the on-going water research activities, and NIVA's assessment of the demand for water research and research cooperation with Zambian institutions.

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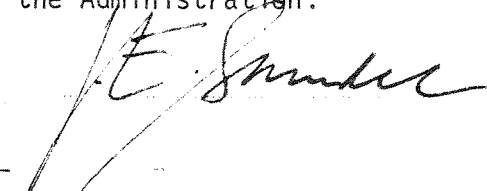
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NORWEGIAN INSTITUTE FOR WATER RESEARCH
OSLO

0-83014

THE NEED FOR WATER RESEARCH IN ZAMBIA

Oslo, September 1983
Author: Svein Stene Johansen

FOREWORD

The Norwegian Institute for Water Research, NIVA, would like to thank the Norwegian Agency for International Development, NORAD, for sponsering NIVA to undertake this study regarding the need for water research and research cooperation in three of the main partner countries of Norway; Zambia, Kenya and Tanzania.

We would also thank the institutions, civil servants and individuals with whom we have had fruitful discussions.

We do feel we have got relevant information of the water research situation in these countries and that we have got a base for recommending cooperation between Norwegian water research institutions and these developing countries in

- *training the scientists and technologists both through the provision of study abroad and through training programmes in developing countries,*
- *the implementation of major research programmes relating to water development,*
- *establishing a direct linkage through cooperation arrangements including joint research and developing programmes.*

Since the water development situations in Zambia, Kenya and Tanzania are different, we have chosen to write separate reports for each country. However, some of the chapters are very similar as these countries have almost the same water research requirements.

Oslo, September, 1983

Svein Stene Johansen
Research Manager

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RECOMMENDATION

This report gives an overview over the Water Supply and Sanitation Sector in Zambia, the educational possibilities within this Sector, the on-going water research activities and NIVA's assessment of the demand for water research and research cooperation with Zambian institutions.

1. There is an accute shortage of skilled staff and professionals. NIVA strongly recommend a "Manpower and Training Study" to be carried out in order to assess the demand for all staff categories. Knowing the demand and the present staff situation, one will be able to evaluate and improve the current education and training programmes.

   The Mongu Training Centre (MTC) for water operators financed by NORAD should be an integrated part of a national programme. Both the MTC and the EEC Training Centre in Lusaka should be integrated.

   One major constraint to day is the lack of Zambian professionals and the low output of Civil Engineers from the University. In connection with NORAD's technical assistances, NIVA recommends that NORAD discuss this very serious situation with Department of Water Affairs, DWA, the University and the National Action Committee for the Decade.

   NIVA further recommends that NORAD should offer scholarships for Zambians to study Public Health Engineering abroad.

2. There is an immediate need for water research activities in order to strengthen the Decade-Programme.

   NIVA thus recommends water research activities which are short and long term in nature.

   The short term research should be carried out on a contract basis using both consulting engineers and water research institutions.

   The short term research projects are listed in table 7.1.

The long term research should be based on cooperation, arrangements during the initial phase in order to build up and strenghten the national institutions.

Direct links should be established between National Council for Scientific Research, N.C.S.R. and Norwegian water research institutions through cooperation arrangements. Such arrangements should provide for the undertaking of joint research and development programmes, including personnel and funds to review the present facilities as well as funds for operating research programmes.

The research and development programmes should be carried out to the maximum extent possible in Zambia.

1. INTRODUCTION

The need for water research as part of water development is fully recognized in the developed countries, and water research institutions are working in close co-operations with the water authorities and ministries. Thus water research results are an important basis for decision-making in water management.

The same applies to the developing countries, but organized water research activities on national basis are only to some degree implemented.

In order to get a review of the situation, The Norwegian Institute for Water Research, NIVA, applied to the Norwegian Agency for International Development, NORAD, for research funds to undertake a study regarding the water research situation in developing countries, particularly in NORAD's main partner countries.

The study was limited to a desk study and was carried out in 1980. The study should investigate

a)   the need for water research in the main partner countries of Norway
b)   current and planned research activities in water development for developing countries including a brief description of the research projects.

The aim of the study was to give NORAD a base for considering a co-operation between Norwegian water research institutions and developing countries in

-   training scientists and technologists both through the provision of study abroad and through training progammes in developing countries,
-   the implementation of major research programmes relating to water developing,
-   establishing a direct linkage through co-operation arrangements including joint research and developing programmes.

In order to carry out the desk survey NIVA sent out questionnaires to organizations, firms and institutions involved in water development programmes in the developing countries.

Based on the desk study, NIVA put forward the following recommendation to NORAD:

1. Direct linkage should be established between the Norwegian research base and institutions in the developing countries. Such arrangements should provide for the undertaking of joint research and developing programmes.

2. The research should to the maximum extent be carried out in the developing countries.

3. The development of human resources is an important part of the research activities. The Norwegian research base should co-operate with developing countries in training their scientists and technologists both through the provision of fellowships for the study in Norway and through training programmes in developing countries involving scientists and technologists from the developing countries.

4. NORAD should devote more resources to water research relevant to the developing countries in connection with the water development programmes financed by NORAD.

    Water development programmes are long term in nature and will always include important water research activities which should be part of the programmes.

In 1982 we were asked by NORAD to follow up the above mentioned desk survy of 1980 by visiting relevant water development institutions in the follwoing three main partner countries of NORAD; Kenya, Tanzania and Zambia.

The findings and recommendations should be reported to NORAD and the report should cover, but not be limited to the following items:

1. Brief description of the current national water development programmes, the related water research activities and educational possibilities within the water sector.

2. The need for water research and social studies in view of paragraph 1 above. Relevant research activities should be listed and given a priority ranking.

3. A list of the relevant institutions and the Governments' interest in co-operation.

4. Detailed description of relevant institutions, especially the part of the organizations for which a co-operation could be possible.

5. Recommendations to NORAD with regards to:

    a) Project related research which could be undertaken on consultancy basis.

    b) Institutional arrangements, i.e. direct linkages between the proposed research systems of the developing countries and the Norwegian research institutions through co-operative arrangements. Such arrangements should provide for the undertaking of joint research and development programmes (a above) and the development and strenghtening of the process of restructuring and improving existing systems to meet the water research requirements.

This study was carried out during February and March, 1983.

2. CURRENT NATIONAL WATER DEVELOPMENT PROGRAMMES

2.1 Responsibility of National Water Supply Schemes

The present principles of responsibilities for development, coordination, construction, operation and maintenance of Public Water Supplies in Zambia is outlined in the Local Decentralization Act of 1980. Before 1980 and even today the policy is based on the "Policy Statement" of December, 1974 made by the Hon. P.J.F. Lusaka, M.P. Ministry of Rural Development.

(a) "The Ministry of Rural Development, in consultation with Cabinet Office and Ministeries of Planning and Finance, Health, Land and Natural Resources, and Tourism, Local Government and Housing and Ministry of Power, Transport and Works and Education, will be responsible for co-ordinating national water resources development and for planning its balanced utilization.

(b) The Department of Water Affairs, DWA of the Ministry of Rural Development will be responsible for executing and/or supervising execution and/or advising on execution of construction, repairs and maintenance of Public Water Schemes and works in the country."

For the financing, construction, operation and maintenance, the following where decided according to the development level of the centres:

The Urban Councils of the Cities (Lusaka, Ndola and Kitwe) and the Municipalities (Livingstone, Kabwe, Chingola and Kalulushi) are responsible for finance, construction, operation and maintenance of the Water Supply Schemes in these centres.

The District Councils are responsible for financing, construction, operation and maintenance of the Water Supply Schemes in the following Townships: Kafue, Mbala, Mansa, Kasama, Chipata, Mazabuka, Mouzei, Choma, Kalamo, Solwezi, Mongu, Kapirimposhi, Pempa and Mpiki.

DWA is assisting in, to different degrees, the construction, operation and maintenance of some of the mentioned Council Schemes.

<u>DWA</u> is responsible of financing, construction, operation and maintenance of 54 Township Water Supply Schemes.

<u>DWA</u> is responsible for financing and construction of Rural Water Supplies (Village Water Supplies).

<u>District Councils</u> are reponsible for operation and maintenance of Rural Water Supplies. However, because of lack of technical manpower in the District Councils, DWA has taken over the responsibilities for some of the supplies.

2.2 Present Level Service

2.2.1 Township Water Supplies

All the 54 Townships have got piped Water Supply Schemes at present.

Eight of these Township Water Supply Schemes require minor modifications or extensions. For the remaining 46 Schemes, new Schemes or large extensions and rehabilitation are required.

There are sketchy records available specifying the degree of coverage of safe water for these Townships.

Both surface water and groundwater are used as source for Township Water Supply Schemes. No statistical data concerning type of source are at the moment available.

For ground water supplies (boreholes) water is normally pumped to the consumers with minor treatment, like chlorination.

For surface water, gravity systems has been constructed in favour of pumping systems. Surface water is normally treated, chlorination is regarded as a minimum. Depending on the quality of the water, slow or rapid sand filtration, in some cases proceeded by sedimentation or chemical precipitation, have been constructed. Due to lack of spares, chemicals, power cuts, capacity of pumps and reticulation system, the quality and quantity of water varies from time to time for each scheme. The

reticulation system includes public stand posts and connections for single and multiple tap houses.

The total population of the Townships is approximately 240 000.

2.2.2 Village Water Supplies

Based on the Rural Population of 1980 of 3.2 million, only about 1.02 million (32 percent) have reasonable access to clean water. This represents about 2000 villages based on 500 people per village. The rest, about 4400 villages don't have access to clean water supply.

Point Supplies
Villages with less than 500 people are normally supplied by point supplies like;

1. Hand dug shallow well equipped with
    i. Handpump
    ii. Windlass and bucket

2. Boreholes equipped with
    i. Handpump
    ii. Windmill and pump

3. Wellpoints equipped with
    i. Handpump

4. Springs

Rivers and dambos are normally regarded as unsafe for direct consumption, but are widely used as the traditional source.

Small piped water supplies
For villages with more than 500 people normally piped water supplies are adopted.

Preferably boreholes are chosen as source in favour of surface water. Surface water is more liable to pollution, at present surface water is

widely used without chlorination.

A piped Water Supply Scheme includes public standsposts and connections for single and multiple tap houses.

2.3 Service Required

2.3.1 Townships Water Supplies

The following are the status of the fiftyfour Townships Water Supply Schemes:

> Thirtysix no's are already planned, but implementation of some depend on the availability of funds.
> Ten no's are to be planned and new schemes are required
> Eight no's are to be planned, but rehabilitations required

2.3.2 Rural Water Supplies

Based on 500 people per village a total of approximately 4400 villages are without access to clean water.

Out of these 4400 about 400 villages have been programmed under the Third National Development Plan (1977-1983).

In addition there are some ongoing Integrated Rural Development Programmes (IRDP) under which some villages are covered for provisions of wells and boreholes.

Of a total of 47 rural districts, rural water supply programmes are under preparation/implementation in 26 districts. The mentioned programmes involve both new supplies and rehabilitation of existing ones. At present the actual number of people that will be provided with safe water is not known.

The following table shows Aid Agencies that are involved in the mentioned programmes.

Province	No of districts included in programme	Aid Agency
Western	6	NORAD (Norwegian)
North Western	3	KFW (German)
		(IRDP Programme)
Eastern	6 (Feasibility study only)	KFW (German)
Central	5 (")	KFW (German)
Luapula)		
Northern)	6	World Bank
Copperbelt)		

2.4 Manpower Requirements in DWA

A long term manpower requirement programme covering all staff categories have so far not been worked out.

The major points that most seriously has to be considered are:

i) Engineering Graduates (B.Sc.)
     About 75 Engineering Graduates are required for furnishing the proposed establishment of DWA. Only 4 Zambian Graduates are working within the system at present.

ii) Engineering Assistants
     About 300 Engineering assistants in the field of Civil Engineering and Mechanical Engineering are required for furnishing the proposed establishment of DWA.

     At present about 50 Zambian Engineering Assistants are working within the system.

iii) <u>Water Development Officers</u>

About 215 Water Development Officers Grade I to Grade III are re-quired for furnishing the present establishment of DWA.

About 50 Water Development Officers, all Zambians, are working within the system at present.

iv) <u>Plant Operators</u>

About 500 plant operators are required to run the township water supply schemes under DWA's responsibility.

At present there is no established posts available in DWA.

3. EDUCATION AND TRAINING PROVISIONS

3.1 Civil Engineers

The School of Engineering at the University of Zambia comprising Civil, Electrical, Mechanical and Minerals Engineering, was established as a separate School by the University Council on 1st May 1969.

The purpose of School of Engineering is the training of professional engineers in Zambia by way of a five-year programme of study leading to the degree of Bachelor of Engineering. Students are admitted to the School of Engineering on a competitive basis after successfully completing the first year in the School of Natural Sciences. The second and third years, providing a background in science and engineering principles, are common to all branches of engineering with the exception of Land Surveying which starts specialization in the third year. Specialization in either Civil, Electrical, or Mechanical Engineering follows in the fourth and fifth years. The academic programme is supplemented by an industrial vacation training scheme which requires the engineering student to spend parts of the vacation periods following the second, third and fourth years in industry. It is expected that by means of this scheme, the student will observe the application of principles taught in the classroom, experience some of the responsibility given to engineers, and learn engineering techniques.

In order to facilitate the growth and maintain relevant engineering education in Zambia, the School of Engineering has developed close associations with industry and Government. Many of the academic staff are members of pertinent governmental committees and commissions. The training officers of the School are directly concerned with industrial training schemes and the placement of the School's graduates. The School of Engineering Advisory Committee draws members from both industry and Government.

The Engineering Institution of Zambia has recognized the B.Sc. as a completely satisfying academic requirement for becoming a Member.

The total number of graduates from the School of Engineering to the end of 1981/82 was expected to be 300. The enrollment at the end of the session was 242.

In average during the last 5 years, 10 B.Sc. in Civil Engineering have graduated from the University of Zambia. It is evident that the present capacity of UNZA is too low. Both increasing the number of graduates per year in Zambia and increasing the number of students abroad will be necessary. In order to specialize in Hydrology and Hydrogeology the graduates from UNZA in Civil Engineering have to go abroad.

3.2 Master of Engineering in Environmental Engineering

Regulations

A. Eligibility

1. The minimum qualification for registration as a candidate for the degree of Master of Engineering is a Bachelor's degree in Engineering of the University of Zambia with an "Upper Credit" having been obtained through the appropriate Department or an equivalent qualification.

    Applicants with additional experience from industrial, teaching or research will be given preference. The stipulation "Upper Credit" may be relaxed in the case of an applicant possessing significant relavant experience.

2. The Board of Studies of the School of Engineering, may also on request from the School of Engineering Postgraduate Studies Committee, accept an applicant on other basis. Such requirement must, however, be approved by the Graduate Studies Committee of Senate.

B. Degree Programmes

    The postgraduate programmes proposed by the School of Engineering aim at training engineers with advanced and in-depth knowledge in

specialized fields. These engineers are needed for creation, use and dissemination of sound technologies, which will be appropriate to local and regional needs and will involve utilization of indigenous resources. A Master of Engineering programme in Environmental Engineering will be available in the 1983/84 session.

C. Structure of the Master's Degree Programmes

1. The Master's Degree Programmes shall consist of two Parts.

2. Part I shall consist of course work equivalent to one academic year of full-time study and part II shall consist entirely of project work carried out over a subsequent period of 6 to 12 months leading to submission of thesis.

3. Under exceptional circumstances, on the recommendation of the School of Engineering Postgraduate Studies Committee and Board of Studies, Senate may grant permission to carry out the entire Master's Degree Programme by research and thesis only.

   There are four senior lecturers to be teaching in environmental engineering one of which is a public health engineer.

   In order to carry out some research work during the M.Sc. studies, funds and equipment must be made available.

   The academic staff also need to be strengthened.

3.3 The National Resources Development College, NRDC

NRDC offers a 3 years Diploma Course in Water Development. This course covers Hydrology, Hydraulic structure, Public Health Engineering, Irrigation and other related Engineering subjects. The average number of students passing out is 12 each year.

The capacity of NRDC is too low to cope with the needs for Engineering Assistants of DWA.

3.4 Zambia Institute of Technology

Department of Technical Education and Vocational Training (DTEVT):
Operate 14 Institutions offering various courses in Engineering Technology.

The awards issued are divided into 4 categories - Diploma, Advanced Certificates, Certificates and Craft Certificates.

None of the Institutions offer exclusive Public Health Engineering Courses or Water Engineering related courses.

The nearest related course is a Diploma course in Civil Technology at Zambia Institute of Technology. One branch of this course could be modified to suit the DWA requirements.

Other courses in DTEVT Institutions have to be modified to suit DWA's requirements for Engineering Assistant.

3.5 Plant Operators

DWA in collaboration with the Trades Training Institute in Lusaka has started a National Training Course for water operators. The course is financed by EEC. The course is of 18 months duration and the first intake (July 1981) was 23 students. The second intake was in October, 1982 with the same number of students. Staff from DWA, Councils and Ministry of Defence are recruited to the course.

The objective of the course is to educate qualified Zambian Plant Operators of Craft man level. A form 3 Certificate is required for entering. Long practice is also considered.

DWA, assisted by NORAD, is running a 4 months plant operator course in Mongu, Western Province. The course is primarily for Water Operators in the Western Province. The sixth training course started in June 1982 with 9 Students. Up to January, 1983, about 50 No's of students have attended the course. DWA's goal is to adapt the curriculum for the course to the EEC Course in Lusaka to obtain recognition as qualifying for entrance to the National Course.

4. RELEVANT INSTITUTIONS FOR COOPERATION

4.1 National Council for Scientific Research (N.C.S.R.)

The National Council for Scientific Research (NCSR) was established by an Act of Parliament in 1967 and operates in accordance with the provisions of Chapter 236 of the Laws of Zambia. One of the major functions of the NCSR is to advise the Government in science and technology research policy. In this regard the NCSR is expected to identify research priorities, promote and coordinate scientific research on a country-wide basis and to maximize the use of results in the socio-economic development activities of the nation. The functions of the NCSR are outlined in Appendix 1.

The NCSR comprises a Governing Council of twenty members appointed by His Excellency the President; an Executive Committee; an Appointments Committee; a Research Advisory Committee; four Research Committees in the fields of agriculture and natural resources, mining and industry, engineering and construction, and medicine and human health; an Administrative Secretariat; and research and technical services units. The structure of the NCSR is outlined in Appendix 2.

The Council is assisted by three administrative and four research committees. The administrative committees are as follows:

(i)   The Executive Committee
(ii) The Appointments Committee
(iii) The Research Advisory Committee

The research committess are as follows:

i)   The Agriculture and Natural Resources
ii)   The Engineering and Construction Committee
iii) The Medical Committee
iv)   The Mining and Industrial Committee

Each of the four research committees comprised a chairman (who is a member of the Council), the NCSR Secretary-General, up to five ex-

officio members representing specific organizations (the Agriculture and Natural Resources Committee represented by eight members, the Mining and Industrial Committee and the Medical Committee represented by seven each) and at least seven other members appointed in their personal capacities.

The terms of reference of the research committees are:

i) To identify and define areas needing scientific and technological research;

ii) To study, coordinate and evaluate scientific and technological research and development activities on a country-wide basis;

iii) To study national plans for social and economic development and advise on the adequacy of the scientific and technological research activities which are planned or in progress with a view to ensuring that the country's development plans are properly supported by scientific research, and that maximum use is made of the results from such research in the implementation of the development plans;

iv) To determine, at a national level, the short and long term research priorities;

v) To indicate scientific and technological manpower, and financial requirements for initiating and sustaining research and development programmes.

The research and experimental development programmes, are exercised by the following units:

i) Agriculture and Natural Resources Research Programmes:
    (a) Animal Productivity Research Unit
    (b) Pest Research Unit
    (c) Tree Improvement Research Centre
    (d) Water Resources Research Unit

ii) Industrial Research Programmes:
    (a) Building and Ceramics Research Unit
    (b) Food Technology Research Unit
    (c) Industrial Minerals Research Laboratory
    (d) Environmental Research Laboratory
    (e) Radioisotopes Research Unit

Funds

The NCSR's activities are depending on the annual Government grants. However, such grants have been inadequate not only to support new programmes, but also to strenghten those being been initiated. Therefore, it was necessary for the NCSR to continue efforts to generate some revenue from its own resources and to seek additional financial support from international organizations.

The estimates for capital and recurrent expenditure for 1980 amounting to K1,923,059 and K2,951,804, respectively, were submitted to the Government in July 1979. The actual grants received from the Government for capital and recurrent expenditure were K750,000 and K2,350,000, respectively. The NCSR was only able to generate about K131,890 from its own resources.

The major capital expenditure included meeting the increased costs on the 1979 construction projects which had been initiated late that year and which extended into 1980. The 1979 construction projects were the construction of a ceramic pilot plant shed, a toxicology laboratory of the pest research programme and a green house for the tree improvement research programme. An amount of K5,931.72 was paid from the 1980 budget to complete these projects. The building projects included in the 1980 budget were the construction of an immunological/microbiological laboratory of the pest research programme; a textile testing laboratory; six residential flats at Waterfalls; and the modification of the Metabolism Laboratory at the Animal Productivity Research Unit. These projects were initiated towards the end of the year due to inevitable delays in completing the preliminaries (i.e. working out tender documents, going to tender, approving tenders, etc.).

Great difficulties were experienced in obtaining foreign exchange for purchasing required equipment from abroad. Therefore, no letter of credit was established during the year, although import licences were obtained and funds were available in local currency. This was a very serious delay because a number of projects could not be carried out due to lack of the required equipment and other supplies.

Grants amounting to about K315,769 were received from bilateral aid programmes and international organizations. This course was made up of K286,032 received from the Swedish Agency for Research Cooperation with Developing Countries (SAREC), K7,496 from the Commonwealth Science Council (CSC) and K3,899 from the World Health Organization (WHO). The SAREC grant was apportioned to support fourteen (14) projects, four of which were being executed by the NCSR and the rest by the University of Zambia, the Department of Fisheries and the Forest Department. The grant from the CSC supported the projects on the development of a more efficient low-cost technology for charcoal production. The WHO grant was for a survey of self-topping aqua privy systems in Zambia.

4.2 University of Zambia, UNZA

4.2.1 School of Engineering, Civil Engineering Department

Reference is made to Chapter 3.1.

Laboratory space is in existence for minor research activities and pilot plants. In order to carry out the M.Sc. course in Environmental Engineering, funds, equipment and facilities are required. However, there is a demand for more funds, equipment and facilities.

4.2.2 Institute for African Studies

The Institute for African Studies is a long-standing institute for research in the social sciences and related disciplines with special reference to contemporary issues affecting national development.

The Institute presently comprises the following five Research Units:

i)   Arts and Communication Studies Unit

ii) Manpower Research Unit (formerly Tracer Project)

iii) Community Health Research Unit (formerly Mental Health Research Unit)

iv) Technology and Industry Research Unit

i)   Urban Community Research Unit.

Founded in 1938 as the Rhodes-Livingstone Institute, the Institute was incorporated in 1965 within the newly established University of Zambia as the Institute for Social Research. It was enlarged in 1971 to encompass the Centre for African Studies (first established in 1966) and in 1977 to include the Manpower Research Unit (first set up as the Tracer Project in 1971).

The Institute's research programme is approved by a joint programme committee of the University Senate which reviews the acitivities of the Institute together with those of the Educational Research Bureau, the Rural Development Studies Bureau and the Institute of Human Relations.

The Institute has an establishment of thirteen academic posts, including that of the Director. In addition to fully-qualified Research Fellows, the Institute is sometimes able to employ recent graduates of the University of Zambia sponsored under the Staff Development Fellowship Scheme. Visiting researchers sponsored by other Institutions whose projects are approved by the Institute are accorded the status of Research Affiliate and work in various degress of association with the Institute's own research programme.

The Institute shares a small campus with the University's Rural Development Studies Bureau and the Institute of Human Relations, located about 3 km from the main University campus. The ancillary staff of the Institute include a small number of trained research assistants as well as secretarial and administrative staff. The physical amenities of the campus include offices, audio and visual recording and reproduction equipment, vehicles and camping equipment, as well as limited residential accommodations. Researchers at the Institute have access to the Library and Computer Centre at the University's Lusaka Campus.

The Institute publishes a journal twice a year, African Social Research, and two annual monograph series, Zambian Papers, and Communications of the Institute, as well as occasional books. In addition, four of the Units issue their own series of limited circulation reports: Manpower Research Reports, Urban Community Reports, Community Health Research Reports and Human Aspects of Technology in Zambia.

The Community Health Research Unit is the most interesting one in connection with water supply and sanitation development.

Community Health Research Unit:

Researchers will be appointed to this Unit in order to carry out both basic theoretical studies and commisioned evaluation studies pertaining to the social, cultural and psychological factors which influence physical and mental health. Specific topics of concern within this area include: conceptions, origins and forms of illness prevalent in Zambia and methods of prevention, diagnosis, cure and rehabilitation; traditional and contemporary patterns of child-rearing and family relationships; social and cultural provisions for the support of persons experiencing physical or mental illness and/or emotional stress, and for the toleration and integration of individuals afflicted by disability or displaying marginal behaviour; community participation in and response to public health measures, e.g. in the context of primary health care, sanitation, immunization, etc.; uses and abuses of alcohol marijuana and other psychotropic drugs; recreational facilities and their relation to the use of chemical stimulants; epidemiological factors in the incidence of various kinds of illness; the roles and interrelationships of traditional health practices and cosmopolitan medical services; opertional research studies on the delivery of health care.

5. CURRENT WATER RESEARCH ACTIVITIES

5.1 National Council for Scientific Research, NCSR / Water Resources Research Unit

(Part of this chapter is quoted from the draft annual report 1982)

5.1.1 Water Resources Inventory Section

Objectives and Main Lines of Research:

The main objective of the Water Resources Inventory Section is evaluation of the existing water resources of the Republic of Zambia in terms of quantity and quality. The inventory of the water resource is being carried out adopting a river basin approach. Luangwa, Chambeshi, Kafue, Zambezi, Luapula and Lake Tanganyika are the major river basins of Zambia. The Water Resources Inventory of the Luangwa basin was done during 1975-78: The period from 1979-81 was devoted to the inventory of the Water Resources of the Chambeshi basin.

Presently, the Kafue river basin is the subject of the Water Resources Inventory. The need for carrying out the water resources inventory of the Kafue river basin stems from considerations of

i) dynamic character of basin in view of large scale mining in the copperbelt, urbanization, agricultural acitivities and forest felling,

ii) pressure on the water of the basin to carter the conflicting needs of present and potential users, cattle herding in the Kafue Flats, domestic and industrial uses and any state farms likely to come in future,

iii) role of Likanga swamps in influencing the hydrology of basin and for augmenting the availability of water resources in the lower Kafue basin,

iv) Exploitation of groundwater resources for supplementing water supplies for domestic, irrigational and industrial uses,

v) pollutions hazards in the wake of mining activities, industrial plants and fertilization and fumigation of chemicals in the agricultural farms.

The Water Resources Inventory Section is also involved in a project directed towards the study of the sediment yields from the Luangwa basin. The Luangwa river poses typical fluvial problems in the wake of wild life and game parks in its basin. The project is being carried out in conjunction with the Department of Water Affairs. Periodic trips are undertaken to the Luangwa valley for collection of the sediment samples. Analyses are done in the NCSR laboratories.

Research Activities

The following research activities are being conducted at the Water Resources Inventory Section:

i)   Water Resources Inventory of the Kafue Basin
ii) Rainfall studies for the Zambezi Basin
iii) Luangwa Sediment Study.

Water Resources Inventory of the Kafue Basin

The role of the Kafue basin in the economy of Zambia, needs not to be mentioned, as the major mining, industrial, agricultural and hydro-electic generation activities take place in the basin. The basin with its catchment area of 154 000 km^2 houses 33 percent population of the country, comprises 20 percent of the total area of the Republic of Zambia and contain large potential agricultural lands in the country. The Kafue, being the main river of the basin, flows through the vast Kafue national park (area 22 600 km^2), and borders the Lochinvar and Blue Lagoon (combined area 840 km^2) national parks. The Kafue flats (area 7 000 km^2, gradient 0.004 percent) present unique and fascinating regions of the basin, where cattle herding and fishing are the main occupations of the local population.

The Kafue flats are well known for the presence of large herds of Lechwe and numerous birds. Another characteristic feature of the basin is Lukanga swamps, which occupy nearly 2 500 km^2 in the flood season. The Kafue catchment has been subject of human encroachment for the last

few decades in form of expansion of mining industry, large scale felling of forests for timber and fuel, large scale pumping from deep mines, abstraction of water for irrigation, domestic and agricultural applications, urbanization in the Copperbelt area, construction of roads, rails, residential dwellings and industrial establishments etc. It is therefore essential to quantify the chagnes in the hydrologic regimes. The parameters associated with the dynamic nature of hydrologic processes should be used for assessing the water resources of the basin.

Therefore, the project activities for evaluation of water resources inventory of the Kafue basin begun with quantification of the changes in the hydrologic environments of the Kafue basin. The data on rainfall runoff and meteorological parameters were obtained from the Department of Meteorology and Department of Water Affairs. The data on groundwater component and quality component of the Water Resources are almost non-existent in the Republic. Therefore, necessary activities for acquiring and analyzing the groundwater level data and water quality data are being initiated for the basin.

Rainfall Studies for the Zambezi Basin

Background Information

The Zambezi river rises in the North Western part of Zambia, winds for nearly 325 Km through Angola before returning to Zambia. It forms the boundary between Zambia, Namibia, Botswana, Zimbabwe and Mozambique. The size of the basin is not accurately known and the differences are incurred by the inclusion or exclusion of the depressions in the north western Kalahari and the area that is partially drained by the river Chobe. Very extensively flooded areas are formed on both sides of the river during the rainy season in the western province of Zambia. The basin is subject to wide variations in temperature and precipitation, because of its huge drainage area. The characteristic features of the basin are

i)   presence of rapids and falls forming cascades, most pronounced at Victoria Falls,

ii) presence of long navigable stretches,

iii) presence of the Kariba reservoir, which is one of the largest man made lakes in the world and produces a tremendous increase in the evaporation loss.

Rainfall is input to a hydrologic system and all hydrologic processes are influenced by it owing to its temporal and spatial variations. It is essential to study the characteristics of the rainfall process in order to generate the information on the water resources and hydrologic processes operating in a basin. Therefore, studies were begun to analyze the monthly and yearly sequences for the Zambezi basin.

Luangwa Sediment Study

Background Information

The Luangwa river basin is a unique system in relation to other major river basins of Zambia. It exhibits typical fluvial characteristics. One can see Luangwa turbid round the year. The sediment concentrations are excessive in the torrential season. The shifting of river course is a regular phenomenon in the Luangwa river and its tributaries. In view of the heavy soil erosional losses, it is essential studying the Luangwa basin for its sediment generating characteristics. The Luangwa sediment study project was, therefore, initiated in 1977 with the following objectives in mind.

i) To establish the sediment regime of the Luangwa valley in relation to land use, topography, wildlife, soil and hydrology of the Luangwa Basin.

ii) To predict the spatial and temporal variations in sediment yield in the Luangwa basin with a view of suggesting the control measures to be taken.

The project activities are being carried out by the joint collaboration of the Department of Water Affairs and Water Resources Research Unit.

Luano Catchments Research

1. Background

Luano Catchments are research facilities for characterizing the hydrologic regimes of head water of Zambian river basins, which are typified by high rainfall conditions and are vegetated with Miabmo trees and Dambo grasses. The studies in Luano Catchments were, therefore, initiated to generate the information on (a) water yield characteristics (b) frequency and height of flood peaks (c) relation of flood peaks to patterns and intensity of rainfall (d) rainfall - runoff - infiltration interactions (e) groundwater flow characteristics (f) soil moisture regimes under pasture, crops and Damboa (g) evapotranspiration characteristics of Miombo treee and Dambo vegetation (h) sediment yield and water quality characteristics (i) changes in the hydrological regimes due to deforestation and settlement on cattle and arable crop economy.

There are four catchments A, B, G and J (each having an ara of 120 ha) well instrumented with facilities for gauging rainfall, runoff groundwater, and meteorological parameters. Catchments A and G were subject to deforestation and subsistence agriculture - over the period 1974-1978. The forest felling began in November 1973, continued until September 1974 and nearly 90 percent of trees were felled. The area cleared was used for grazing. Maize farming and small scale vegetable gardening was introduced on the Dambos. There were ten small scale farmers, who also reared chickens at their farm houses, on these two catchments for three years and regrowth of the deforested trees emerged. The activities planned in these two catchments could no be pursued for the want of trained manpower and fiancial resources.

2. Research Activities

The studies in the Luano Catchments were carried out in phases. Phase I constituted a period 1968-73, when all the studies were carried out in the natural state of the catchments. Phase II began in 1974 when catchments A and G were deforested and subsistence agriculture introduced. The following hydrometeorological observations are monitored in the catchments.

1. Meteorological parameters - temperature, wind velocity, wind direction, sunshine hours, vapour pressure, and evaporation (Twice a day).

2. Rainfall - 64 raingauges of which 16 are autographic (daily recording).

3. Runoff - 4 flumes and V notches with automatic stage recorders (daily recording).

4. Groundwater level monitoring - 66 observation boreholes (daily recording).

5. Soil moisture - Augering and gravimetric methods (once a week).

6. Water quality of streams (once a month).

7. Sediment concentration (once a week during the rainy season).

5.1.2 Environmental Research Laboratory

1. Introduction

    Environmental Research Laboratory, a section of Water Resources Research Unit, is involved in measuring and enumerating man's impact on ecosystem since its inception in 1973 as Water Quality Laboratory. The main objectives of this laboratory can be summed up as follows:-

    i) Protection, control and evaluation of the status of environmental pollution by monitoring and assessing; the quality of air, surface, underground and used water, pollution problems associated with solid waste, agricultural, municipal and industrial effluents; noise and radiation pollution; land pollution and reclamation, alternate energy sources; the levels of pesticides, toxic contaminants including heavy metals etc. and their toxicological effects on humans, animals and plants, etc.

ii) Assist the government of Republic of Zambia in formulating their policies, programmes, regulations and legislation drafts on Environmental Protection and Pollution Control.

iii) Development of new techniques and conduct research in pollution abatement, analytical and environmental chemistry and biology.

iv) To provide analytical and consultancy services in monitoring air and water quality and also dissemination of information and know how on alternate sources of energy.

v) To impart training and teaching to students, technical and scientific personnel in the field of environmental science.

1.1 Main Lines of Research/Activities:
The research activities of ERL are centred around:

i) Assessment of natural water quality and water pollution by detection and monitoring pollutants in water and sediments through physico-chemical and biological analysis.

ii) Establishment of air pollution nucleus in ERL and monitoring the quality of air.

iii) Development of alternate sources of energy through solid waste pollution abatement.

iv) Establishment of hydrobiological section in ERL to study the biological effects and concentrations of pollutants in fresh-water organisms.

v) Improvement in the existing methods and development of new techniques and methodology in environmental science and pollution abatement.

vi) Academic, advisory and analytical services for requesting individuals, institution and various organizations.

1.2 <u>Achievements during 1982</u>: During 1982, the laboratory's achievements included:

i)   Precipitation study for the 1981-82 rainy season throughout Zambia (20 different stations) has been concluded. The results from the 1980-81 and 1981-82 rainy seasons will be reported early in 1983 in order to highlight the basic issues, sources extent and effects of air pollution.

ii) A biogas plant consisting of a gas distribution system comprised of steel pipes and one stove fabricated at Technical Services Units of NCSR has been installed at Chalimbana. Another biogas plant at Nkumba Piggery has been built up to the stage of construction of the digester.

     Work on utilization of biogas for lightening purposes has also been initiated.

iii) Social, economic, technical and sanitary aspects of self-topping aqua-privy systems in Livingstone and Choma have been investigated.

iv) Survey on fluoride levels in water from various provinces of Zambia, has been done and a report on sources, distribution and effects of fluoride on animals, human beings and plants etc. will be written in 1983.

v)   Assessment on the quality of Chililabombwe underground mine water has been made and a report on it is submitted.

vi) Quality of water and sediments in Kitwe stream has been monitored during three different seasons of the year except for rainy season, in order to assess the pollution trends. After monitoring the pollution levels during rainy season, the findings will be reported.

vii) Preliminary work on assessing the pollution load from various Lusaka wastewater discharges into the Ngwerere/Chongwe river

system has been started. It is too early to conclude by the trends observed during 4-5 sampling times at 25 different sampling stations, but the results indicate that Ngwerere/ Chongwe river offer moderate dilution of the pollution load. The project will continue in 1983 including a wider specter of biological screening of water quality and an enhanced frequency of sampling.

viii) Two Senior Scientific Staff members of ERL contributed significantly in preparing a final draft on Environmental Protection and Pollution Control Act. This exercise initiated in June 1981 was completed in September 1982.

ix) The laboratory continued assisting the National Action Committee of Zambia for UN International Drinking Water Supply & Sanitation Decade (1981-90) in the planning of a water quality monitoring system in Zambia and also holding a National Workshop (planned for early 1983) in order to achieve the goals of this decade.

x) Teaching and laboratory demonstration (facilities) were imparted to students of Natural Resources Development College and University of Zambia, and also to the participants of Fourth UNESCO/NORAD Regional Training Course for Hyrology Technicians from English Speaking Regions of Africa, and to Water Operator's courses (EEC/Department of Water Affairs).

xi) Analytical and advisory services rendered to various individuals, private consulting firms, government and parastatals departments, yielded approximately K4 000 for NCSR.

xii) The output of laboratory in terms of samples analyzed in year 1982 was 756 which is an increase compared to the 1981, 1980 and 1979 when the numbers of samples analyzed were 700,444 and 232 respectively.

1.3 Major Constraints during 1982

The major constraints during 1982 may be summed up as follows:

i) <u>Repairing of the Instruments</u>: Atomic absorption spectro-photometer and UV/visible spectrophotometers had breakdowns 3-4 times during the year and it took long time to get these repaired. One Pye/Unicam UV/visible spectrophotometer is since May 1982, still with Phillips Company, Lusaka for re-pairs. Lack of technical skill and spares are the vital rea-sons.

ii) <u>Non-availability of Chemicals and Media</u>:
Non-availability of specific chemicals and microbiological media hampers the introduction and development of new methods.

iii) <u>Manpower</u>:
There was no technical staff by the hydrobiological and microbiological section except one technical officer transferred from the chemistry section. Three Scientific Officers being supported by one technical officer, is a ridiculous proportion and leads to under-utilization of scientific personnel.

iv) <u>Lack of Funds</u>:
Recurrent and capital budgets were inappropriate for this section. The crunch was felt especially with the establish-ment of the hydrobiological section. There should be provis-ion for extra funding and manpower in such circumstances.

2. <u>Research Activities during 1982</u>:
The activities of environmental research laboratory for the year 1982 can be summed up as follows:

2.1 <u>Air Pollution</u>
Today air pollution has reached new heights as a direct result of increasing urbanization, industrialization, and use of the automo-biles. The world-wide trend is that an pollution is still increas-ing and Zambia is no exception. These man made activities in-cluding the natural ones contribute to a built-up of the pollu-tants in the atmospheric air. Industrial activities in Zambia range from mining of copper, cobalt, coal, lead, zinc and cadmium etc to the manufacture of acgricultural products, asbestos, cement,

chemcials, dairy and food products, plastics, synthetic textiles, paper and pulp and petroleum refining, and its by-products, etc. These industries including the incoming ones if continuing emitting pollutants into the environment unchecked can damage the environment to an irreparable level.

The insidious effects of air pollution lead to grave socio-economic losses by adversely affecting the natural resources and human health.

Air pollution problems range from minor to grave. To identify these problems and to give determined proof of its causes in Zambia, the environmental research laboratory undertook a "precipitation study" as a preliminary study in the 1980-81 rainy season and continued through 1981-82 rainy season.

2.2 Precipitation Study

Air quality assessment by precipitation study for the various pollutants in the atmosphere was initiated in the beginning of the rainy season of 1980-81 and continued till the end of the 1981-82 rainy season. Monthly rainwater samples were obtained from Chipata, Kabwe, Kafue, Polder, Kasama, Kitwe, Livingstone, Lusaka, Mansa, Mbala, Mfuwe, Mongu, Punt Makulu, Mwinilunga, Ndola, Solwezi and Zambezi and analyzed for pH, conductivity, acidity/alkalinity, sulphate, ammonia, nitrate, nitrite, chloride, sodium, potassium, calcium and magnesium. Some areas like Kabwe and Copperbelt etc. were scrutinized for lead, cadmium, copper, cobalt and zinc etc. as well.

2.3 Solid Waste Pollution

Disposal of solid waste, which is called third pollution, has been neglected in comparison to air and water pollution till mid-sixties. Althouth rather late in starting, the movement to control and prevent the pollution of the land has accelerated rapidly in the last decade. Solid wastes comprise domestic, commercial, industrial and agricultural wastes etc.

To protect the environment and prevent any detrimental health effects arising from the disposal of agricultural waste (dung), this laboratory has undertaken a relatively less capital intensive process to abate solid waste pollution and at the same time generate a cheap and alternate source of energy from renewable resources in the form of biogas.

2.4 Biogas Technology Project:

The aim of this project has been to make a feasibility study of biogas generation and its utilization under Zambian conditions. The ultimate goal is to promote the use of biogas in rural areas which have biogas generation requisites. The project was initiated in 1980 and the laboratory investigations were conducted in the environmental research laboratory on optimising the conditions on production of yields of biogas from cowdung. Same exercise was repeated in 1982 employing pig-manure as the raw material for the generation of biogas.

So far under this project, one biogas plant at Chalimbana Farms of the NCSR has been constructed during the year 1981, using cowdung as the feed material. This year work has been completed to make the gas distribution system more efficient and durable by installing galvanized iron pipes to serve as gaslines for the supply of biogas to three houses. At the moment, only one house has so far been supplied with a gas-stove. This gas-stove was fabricated out of mild steel sheets and is of the open mixing type. The other two houses are expected to receive their gas-stoves as soon as they are fabricated. The biogas technology yields fuel (biogas in the form of methane-carbon dioxide) and manure (digested slurry). In order to recover the dry manure, the construction of drying bed along Chalimbana biogas plant was completed in 1982.

Under this project, another biogas plant at Nkumba piggery (Rural Development Corporation) is under-construction. The construction of the pit has been completed and the gas holder is about to be completed. This plant will be using pig-manure as raw feed.

Preliminary work on the use of biogas for lighting purposes, has been carried out. There exist one commercial gas lamp for ligthing purposes and its performance has been recorded as excellent. However, the project, with the assistance of Technical Services Research Unit has designed and constructed a biogas lamp. Laboratory tests have revealed the performance of this lamp to be of standard degree and it is expected to be installed in the field very soon.

This project has been divided into two phases. The first phase, which is in progress, is aimed at the establishment and development of the technical skills and know how needed for proper and efficient biogas generation and utilization. The second phase involved the eventual introduction and promotion of biogas technology in rural areas. This phase will be executed in 1983. The project is receiving financial assistance from the Overseas Development Administration of the United Kingdom through the Commonwealth Science Council.

2.5 Aqua-Privy System Project

This project was first initiated in 1980 and carried out jointly by this laboratory and Building Research Unit. It was, however, sponsored and financed partially by World Health Organization. In 1980 aqua-privy systems were investigated in Lusaka, Kabwe and Ndola. The results were submitted to WHO.

In 1981 the project was abandoned and the work resumed at the end of 1982 after more funds ($4 000) were made available by WHO. This year investigations have been carried out in Livingstone and Choma. The aim of this project has been basically to evaulate the social, economic, technical and sanitary aspects of self-topping aqua-privy systems in Zambia. This project was carried out formly by the Environmental Research Laboratory and the Building Research Unit.

This project is, however, expected to be completed in 1983 after the investigations in Monze, Mazabuka and Kafue township are completed. Specific report for each locality and a final report which

will include accumulative compilation of the data that so far has been collected, will mark the end of this project.

2.6 Natural Water Quality Investigations

The projects mentioned below have been carried out to assess the quality of natural water.

2.6.1 Chiliabombwe Mine Water Quality:

The aim of this project has been to analyze a broad spectrum of water quality parameters of Chililabombwe deep mine water and assess its suitability as mineral table water or as curative mineral water or its possibility for other uses.

Chililabombwe Mine in Konkola Division of Zambia Consolidated Copper Mines is not only the wettest mine in the Copperbelt area of Zambia, but may also be classified as one of the wettest copper mine in the world. It is estimated that for production of every ton of copper ore, nearly 86 tons of water has to be pumped out and that approximately 40 000 m^3 or 90 million gallons of water from this mine flows into Kafue every day. De-watering of the various aquifers which is achieved by drilling boreholes and mining headings into the aquifers, is very crucial and vital for the operation of the mine. Water from the following three aquifers from the main source of Chililabombwe mine's underground water, is pumped through shafts No 1 and 3 to the Lubengele stream, a major tributary of Kafue river.

i)   Hangingwall Aquifer (Interbedded dolomite and argillite)

ii) Foodwall Aquifer (Interbedded feldspathic), quartzose sandstone and conglomerate-all porous.

iii) Footwall Quartzite Aquifer (Conglomerate with quartzite matrix).

Therefore the quality of this underground water will reflect on: the type of above mentioned aquifers, or host rocks that yields the water as the rock materials through which the water has pass-

ed, the temperatures along the route of subterranean travel, and volume of water circulating, past and present. The term "Water Quality" is used to define those chemical, physical and biological characteristics by which a given water is evaluated for its acceptability for the desired usage.

The present investigations were carried out to determine the mineral contents of Chililabombwe underground mine water in order to evaluate its suitability as mineral water or for other uses. Classifications of mineral water is based on the balneological criteria and also on the levels and nature of total dissolved solids or gases and that it can be used for drinking or curative purposes depending upon its chemical constitutional and physical properties.

Natural mineral table water is defined as one which is either naturally or artificially impregnated with at least 1.0 g of total dissolved solids or the same amount of carbon dioxide in 1.0 litre quantity and should have suitable physico-chemical and aesthetic properties as a refreshing without any pharmacological effects. Whereas curative water may be defined as water with specific physico-chemical constitution which cures human health.

2.6.2 Fluoride Levels in Zambian Waters:

This project initiated in 1981 is aimed at assessing the fluoride content in Zambian waters and has initially been restricted to drinking water due to the fact that ministry of health need basic data on fluoride levels in various water supplies of the country. This will assist the Ministry of Health to take appropriate measures to bring the fluoride to optimal levels in drinking water by fluoridation.

Surface and underground water samples from different parts of Eastern, Lusaka, Central, Copperbelt, Northern, Luapula, Southern Provinces and very few from Western Province has been collected and analyzed. The fluoride levels in surface and underground water samples varied from less than 0.02 to 8.0 ppm. In general, surface water has very low levels of fluoride and underground

water has relatively higher fluoride levels as expected. In Luangwa district especially Ghitope, Mwavi and Kaulungu stream levels of fluoride are unusually high and varies from 1.3 to 4.0 ppm. Chinyunyu spring water has large variations in fluoride levels. One time it was found to be 1.4 ppm and a second time 21 ppm, but these analyses need to be reconfirmed.

In general, fluoride levels in Zambian waters are inadequate which can be one of the factors leading to dental caries or decay and fluorosis or mottling of teeth. There is evidently a need to fluoridate most of the water supplies in the country that have been scrutinized so far by this laboratory. For those places where fluoride level in water is more than 1.0 ppm (for Zambian climatic conditions), there is need to bring the fluoride level to required concentrations.

A comprehensive assessment of the cumulative impact of fluorides on man's environment, requires considerations of total fluoride contributed by multiple sources. These sources include natural sources such as volcanic gases and soluble fluorides in the earth's crust. However, the preponderance of pollution problems, have been caused by modern-day man-made sources which singly, or in combination, occassionally lead to the presence of harmful levels of fluoride compounds in air, water, food and forage.

For future planning, there is need to investigate total fluoride uptake by man and gross effects of fluoride on plants and animals. The laboratory will continue the survey on fluoride levels in Zambian water and some investigations on the quality control and recovery experiments.An ion selective electrode method is employed for fluoride determination.

i) Water Pollution

Major water pollution in Zambia like any other country, can be attributed to agricultural, domestic and industrial wastewater discharges. More industrialization, urbanization and the accompanying high standard of living, without appropriate pollution control, wastewater treatment technology and legislation, leads to

increasing pollution problems. The environment research laboratory is assessing the present status of pollution in various wasteways of Zambia by monitoring the quality of water, sediments and fresh water organism and also pollution load from different sources. This should form baseline data for enumerating future pollution trends in the country and in formulating policies, programmes regulations and legislation for the abatement of water pollution.

ii) Water Pollution Monitoring in the Copperbelt

Kitwe stands on a watershed of many streams and rivers, which receive effluents from agricultural, domestic, mining and other industrial activities. A surveillance of water and sediments quality have been carried out on Kitwe stream, Mwambashi river, Inciphe stream, Uchi stream, Wusakili stream and part of Kafue river between confluence of Mwabashi Kafue river and Ndola bridge in South of Kitwe city.

The objective of this study is to assess the pollution load of mine effluents, sewage effluents, other non-point pollution sources and agricultural waste and also create reference points in the form of measured parameters for future comparisons. In future, this will show the trends and variations of data by scrutinizing water and sediments samples.

iii) Ngwerere - Chongwe River System

This project was initiated in 1973/74 to assess the physico-chemical characteristics of Ngwerere-Chongwe river water which receives wastewater discharges from different Lusaka sewage plants, commercial farms and village dwellers in the east of Lusaka. Monitoring of this river system has been re-initiated, with the inclusion of microbiological tests. This river system is economically important to the farmers and village dwellers living near and on the river banks.

Twenty-five sampling sites have been established on the Ngwerere-Chongwe river system. Sampling has been done four times for each sampling point, this year March, April, October and November. It is certainly too early to make conclusive statements regarding the

extent or nature of pollution in this river system from the average of four results, especially when none of these results were obtained in the rainy season (1982-83). But the results indicate that Ngwerere being the immediate recipient of wastewater discharges, is more polluted than Chongwe which offers moderate dilution to the pollutants.

During 1983, it is planned to monitor water quality of this river system more frequently and to include hydrobiological parameters.

iv) Toxic Metals Pollution in Kabwe

The Kabwe mine formerly known as Broken Hill mine is renowned for the mining of large ore deposits for zinc (Zn) and lead (Pb). Among these ores cadmium and lead are toxic metals if ingested by man or animals through any environmental media. A preliminary screening of mine effluent, sediments, soil and plants from different sections of the town of Kabwe was carried out.

Tap water, soil, grass, maize, mine canal effluent and its sediments samples were collected twice in 1982 and processed by the routine processes and analyzed for sodium, potassium, calcium, magnesium, lead, zinc, cadmium, iron, manganese and copper on the atomic absorption spectrophotometer.

High levels of zinc, lead and cadmium were noted at Kasanda sampling point although these metals also were found in most other sampling points like soil, maize, canal effluent and mud at Chowa stage 1 (each of mine), grass and soil samples from 2 km north of mine at Police Station, soil and maize samples from Rural Council, 2 km south of mine.

6. THE NEED FOR WATER RESEARCH AND SOCIAL STUDIES

6.1 General

In the industrialized countries water research is orientated towards their own needs. Thus it is imperative that developing countries should develop their own expertise. To be self-sufficient in water research require positive moves to invest. Since the governments are the largest investors in the water sector in developing countries, the governments should also bear the major costs.

There is a need for action on the part of developed countries to support and facilitate the internal costs of developing countries to achieve development through establishment of endogenous scientific and technological capacities.

However, it will take time to achieve research potential in new water institutions in developing countries, and it will in the meantime be necessary to contract-out water research projects. It will probably take more than a decade to establish sufficient self operation activities on water management.

There are no obvious institutions to handle water research in the developing countries visited. Normally the Universities have the skilled manpower and the basic facilities. This is not always the case in developing countries. The Universities in developing countries are mostly short of qualified staff, funds and facilities.

The type of water research which is needed in developing countries is at present definitely applied research rather than pure basic research. The application of known technological principles and techniques to existing problems is the approach needed.

Water research projects supporting the national water programmes for the Decade should in our opinion have the highest priority and start immediately. These kind of R & D-projects are likely on an ad-hoc basis. This type of projects could be contracted out to project teams consisting of researchers and consulting engineers, but in close cooper-

ation with the clients, local technical and scientific staff.

Water research is, however, long term in nature and it is important to build up competent local staff in order to make continuous evaluations and revisions to the research policy and priorities. Both research establishments and Government must constantly be evaluating effectiveness of research investments by measuring the impact of research findings on water and sanitation development.

One major problem is the translation of successful research into practice. <u>The researchers should do a continuously "state of the art review"</u>.

6.2 Water Resources

Water Resources Assessment requires knowledge of suitable water resources, surface water supplies as well as ground water resources. In order to assess these resources for human and livestock consumption, small-scale gardening supply, fishing, as well as for other user categories, it is important to;

a)   study and evaluate existing hydrological and hydrogeological data,
b)   identify and execute possible additional field investigation required in order to assess the water resources,
c)   assess the suitability of the water resources,
d)   prepare hydrological and hydrogeological maps of the country,
e)   evaluate continuously existing data collection system in respect of water resources and propose, if necessary,improvements of the system,
f)   to make suggestions with regard to the improvements in the control of water quality by setting up and implementing adequate water monitoring systems.

The paragraphs above could be part of a Master Water Plan. The drawback is, however, that a Master Water Plan is normally done on an ad-hoc basis which in the long term, is not sufficient for a proper management and the utilization of the water resources.

6.3 Standardization

6.3.1 Introduction

Norwegian Institute for Water Research, NIVA, has years ago applied to NORAD for R & D funds in order to assist the Water Authorities in the Main Partner Countries of NORAD to enable them to develop necessary standards.

The need for design standardization has increased considerably due to the prevailing economic situation which calls for more economical designs and more effective utilization of the design resources which are available in the developing countries.

6.3.2 Criteria and Guidelines

It is pertinuent to look into the present set of criteria and guidelines for the design of water supplies and sanitation schemes. These need to undergo frequent revisions in order;

- to incorporate new policy decisions in particular regarding the service level and relevant new technology,
- to introduce criteria for more appropriate and cheaper technology,
- to make changes of the criteria or guidelines shown necessary from experience of design construction and operation & maintenance during the last years.

6.3.3 Design Manuals

The manuals shall contain general and detailed criteria and guidelines necessary for the design of water supply and sewerage projects.

It is envisaged that in the future more design work will be taken over by the developing countries and that the number of projects designed by expatriate consulting engineers will be reduced. A pre-requisite for such a development is that a number of type and standard drawings and descriptions are available, such as intake structures, various treatment units, storage tanks, staff houses, office buildings, etc. and a

large number of detail drawings of various structures. Without such drawings it will not be possible to keep an acceptably high design standard at the same time as the work load of the design offices increases.

The current trend towards the use of appropriate technology for rural water supplies and sanitation will increase the need for drawings of simple structures such as wells, springs or rainwater catchment installations, etc. which can be used direct by the people building the structures without the assistance of a design engineer. Much effort has to be put into this kind of standard drawings to make them easy to understand for the laymen.

Standard Drawings and Type Drawings should be included in the Design Manual or appended to it. The Standard Drawings shall be used whenever applicable while the Type Drawings will only give examples of recommended solutions.

6.4 Water Supply Engineering

6.4.1 Operation and Maintenance Research

Operation and Maintenance (O & M) create crusial problems in developing countries. The reasons are manifold, thus not limited to only lack of skillded local manpower and funds.

Proper O & M-routines have to be worked out and implemented. This will, however, require major training programmes.

Some water works will require special attention in order to get an effective operation. Improvements to the present design will be necessary in order to solve the problems.

Some water works need rehabilitation, augementation or up-grading. During NIVA's visites to water supplies in Africa, we have many times experienced that consulting engineers have proposed new supplies in stead of improving the existing systems. The local water authorities have not got the manpower required to critically examine the proposals or to suggest other solutions.

O & M-research will in this respect be of greatest importance in respect of up-dating and rehabilitating existing supplies.

O & M-research will most probably result in proposals which in term lower the O & M-costs tremendously. Many water supplies are, f.ex. based on coagulation by dosing chemicals into the water. Without proper dosing, a huge amount of chemicals are wasted.

6.4.2 Materials

The choice of materials in the different components of a water supply may be accidental or based on other criteria than the water quality. Choice of the materials of the pipes used for water distribution will similarly depend on the quality of soil. One has experienced many catastrophical examples of the consequences by neglecting the importance to consider the water quality when selecting the materials.

Some components may be manufactured in the developing countries, however, proper test-procedures are of outmost importance, independently the country of manufacture.

6.4.3 Distribution

Some of the problems related to distribution are mentioned in the above paragraph 6.3.1 - 6.3.3.

A distribution system may depend on intake structures, pumps, pipes, storage tanks, etc. or buckets to be carried home.

Pumps

A world-wide research programme with regard to handpumps is going on. It is important that each country is selecting a limited number of different handpumps for their future requirements. The selection must be based on a proper test-programme. The programme is presently mostly carried out by expatriates because of lack of local research staff.

Pumps based on solar energy are under development. These pumps are still very costly, and a lot of research will be needed before these pumpes are competative.

Pumps based on windmills have been in operation for years, but through research, the efficiency of these pumps have been improved during the last year. However, the use of windmills depends on the local situation and must be adapted accordingly.

Pumping systems which use human power more efficiently should be developed further, besides improvements to existing animal lift systems need more research.

6.4.4 Treatment

i) General

New trends in water treatment needs to be evaluated in respect to existing plants. Studies of the breakdowns may indicate that other systems and processes should have been chosen in the first place. Learning from mistakes is of major importance.

Up to date knowledge of existing low cost, appropriate technology will be another important aspect. The most promising systems should be followed up through pilot plant studies.

The possibilities of using local available media in filters, and local available coagulation and disinfection chemicals should be given high priority.

Realistic criteria or guidelines for drinking water quality should be worked out, based on health aspects, technical options and economy.

ii) Electrocoagulation

The project deals with the basic ideas and preliminary results from a developing project "Development of a Package Plant for Potable Water Treatment in Developing Countries" developed at NIVA. The treatment processes included in the package plant are; coagulation, flotation, alkalization, filtration and UV-disinfection, in other words, advanced potable water treatment. The coagulation, flotation and alkalization process is combined in one unit, the electrocoagulation process, which has proved effective for removal

of organic matter and which is being tested with other parameters. This method is a simplification of the traditional coagulation process. The maintenance and operation of this system is simple. No handling of chemicals is required by the operator, and the change of the electrodes used in the unit is necessary only once a year.

The electrodes must be connected to a power supply, only 24 V are required. If the treatment plant is located far from an electricity distribution system small solar cells should be used.

In order to simplify the conventional coagulation method, electro-coagulation using soluble aluminium electrodes could be used (Vik, 1982). The quality of the water available as source of supply varies considerably. In areas where only surface water is available, the water quality is often poor with great impurity. The sources can be shallow wells, streams or ponds. These sources are dependent on rainfall and surface runoff, and the water quality has enormous seasonal variations.

The coagulation process removes effectively various impurities from water. The objective of the research is to simplify the conventional coagulation process. A simplification of the conventional coagulation process will have a great potential in developing countries where the water must be treated to provide safe drinking water. Avoiding chemical handling is of major importance. A combination of electrocoagulation, granual-media filtration, and disinfection is studied in order to develop a package plant producing adequate water quality. UV-disinfection is used instead of the conventional chlorination process. This simple operating disinfection process (UV lamps must be changed once a year) can only be used for treated water or water with low turbidity and colour. The objective of this development project is to simplify the operation and maintenance of small scale treatment plants.

iii) Desalination

Hundreds of boreholes in East Africa have got saline water and can not be used for human and livestock consumption.

Saline groundwater may be the only reliable water source in many
areas. Many lakes are also saline. Thus it is of greatest impor-
tance to develop low-cost methods for renovation of saline waters
for various uses.

NIVA proposed to NORAD some years ago to develop desalination
cells based on solar energy. The development should take into
consideration local manufacturing.

We are still of the opinion that the development of desalination
cells should have high priority.

We also propose to use water hyacinths to remove chlorides. De-
salination and purification of slightly saline waters or
wastewaters can be accomplished effectively by water hyacinth
ponds.

iv) Development of Low Technology Defluoridation Systems

In special areas in Africa ground water and surface water have got
a too high content of fluorides which make the water unsuitable as
drinking water.

The limit set by WHO for acceptable fluoride concentratins in
drinking water range from 0.7-1.5 mg/1. It is thought that human
beings consuming water of fluoride concentration greater than 1.5
mg/1 during the first 8 years of their life, suffer from dental
fluoration or mottled enamel.

The actual effects of consuming water containing fluoride is not
just restricted to the teeth. The effects go deeper into the
whole skeletal framework and in particular the backbone, resulting
in backaches, bending and weakness of the skeleton.

Many African states are not in a position to adopt the WHO figure
as they have no other alternative than using the water sources
available. The development of low technolgoy defluoridaton sys-
tems is thus of greatest importance. The first stage in such a
research and development project will be as follows:

Laboratory investigations should be done to identify an absorbent which can be used in a low technology defluoridation system suitable for household or small community use in developing countries. The effectiveness of a variety of materials, including locally available plant and soil materials, will initially be tested using jar tests. Substances which exhibit ability to remove fluoride will then be tested in columns to determine removal capacity in water of various composition. Components to be varied will include fluoride, alkalinity, turbidity, organics, and salinity, with the test concentrations to be based on maximum and minimum concentrations occurring in the target area.

Suitability of a defluoridation system will be evaluated based on the following criteria:

- Reduction of fluoride concentration from 10-20 mg/l to less than 1 mg/l.
- Fluoride removal capacity of media
- Operation and maintenance of system by local people possible.
- Capital and operation/maintenance costs low
- Increase in toxicity of water due to improper operation of system unlikely.

During the evaluation of a proposed defluoridation system, media regeneration and disposal of waste products will also be considered.

v) Pre-treatment - Slow Sand Filtration
Slow Sand Filtration is used throughout Zambia and is a simple but efficient treatment process to produce a hygienically safe drinking water. However, its application is limited and depends on the turbidity and suspended solid concentration in the raw water.

During the execution of the Water Pricing Study in Zambia, one experienced that of all the slow sandfilters visited no one was in a proper working condition. There was no pre-treatment, the sand was dirty and so was the "clean water".

The objective of this proposal is to develop a simple, selfreliant pre-treatment method for use in connection with the existing slow sand filters.

vi) Low-Cost Household Water Treatment

Until public water supply systems actually deliver safe water to the consumer, it may be advisable to encourage the use of household water treatment.

In parts of the developing world one has used traditional water treatment methods for decades. These methods need to be further developed and improved. Due to the introduction of piped supplies, the traditional water treatment methods have been neglected without considering the water quality in the new supplies which may not be satisfactory.

Household water treatment units should be developed. The following options should be looked into:

1. Modified slow sand filter followed by disinfection by copper ions. The filtered water may be stored in a clean copper container for 24-48 hours. Alternatively cheaper specially designed copper-plate elements may be used along with other types of containers which are cheaper and locally produced.

   Zambia as the world's biggest copper producer makes this project very attractive.

   Clay pots are traditionally used as containers for transporting and storing water. Experiments carried out with clay pots shows that clay has a purificational effect. Further investigations should be carried out.

2. Optimal Storage Tanks designed for households should be developed. During Storage, two main processes occur which improve water quality. These are the death of micro-organisms and sedimentation of solid particles. These particles may be the eggs or cysts of parasites or inorganic particles. The mineral

particles will absorb a significant proportion of the bacteria and viruses and thus remove them as they sediment out.

3. The use of Rainwater Cisterns as a catchment system should be designed, developed and operated as an alternative or supplemental water supply. The cisterns should be designed with screens, sandfilters, activated carbon or membrans.

4. The principal disinfection agents used in water treatment are chlorine, chloramine, chlorine dioxide, silver and ozone. Chlorination remains the most widely used process at the present time.

   However, the use of chlorine in household water supply is for the time being not practiced in the developing countries. Electrolytical chlorination should be evaluated.

5. Artificial ultraviolet radiation (UV) is an effective way of disinfecting drinking water. (In combination with oxydants UV also removes organic matter). The use of natural UV as a disinfectant on tanked water (possibly in combination with oxydant) should be investigated.

6.4.5 Water Consumption Restricting Devices

In connection with NIVA's Water Pricing Study for Zambia, one has experienced great problems with regard to reading, operation and maintenance of water meeters. In addition comes the problems of billing, collecting revenue and in many cases the disconnection procedure.

To simplify the revenue collection and to avoid the problems mentioned above, a water consumption restricting device (wcrd) should be developed.

The wcrd should allow a certain amount of water to the consumer equal to i.e. one months average consumption. When that amount of water has been used, the wcrd has to be replaced by a new one to be bought from a store, public office, etc.

The wcrd must be cheap, reliable and easy to replace.

6.5 Sanitation

6.5.1 Water Borne Sanitation

i) Sewage Quantities and Composition

The need for information regarding the quantities and composition of the sewage is obvious.

Without a proper metering and sampling programme, further planning, design or cost estimates will be speculative and is not recommended.

Quantities

To get information of the sewage quantities - total and per capita - water measuring programmes should be implemented. Gauging stations should be installed on the inlet of existing waste-water treatment plants and the flow recorded continuously. The measuring will take place during a typical dry-season period and a typical wet season period.

To calculate the per capita flow a counting of the houses and inhabitants within the connected area has to be done.

Composition

To find out the composition of the sewage, samples will be taken and analyzed. It is recommended to gather composite samples - both on incoming and outgoing flow - during the same periods as mentioned above and analyze them on the following parameters:

- BOD_7 (Biochemical Oxygen Demand)
- COD   (Chemical Oxygen Demand)
- TS   (Total Solids)
- TVS   (Total Volatile Solids)
- TSS   (Total Suspended Solids)
- TVSS   (Total Volatile Suspended Solids)
- N   (Total Nitrogen)

- NH_4-N   (Ammonia Nitrogen)
- P   (Total Phosphorus)

In addition it is recommended to analyze the samples on some bacteria, viruses and hook worms.

ii) Aquaculture System for Waste Water Treatment in Developing Countries

Introduction

Aquatic systems employing plants and animals are proposed as alternatives to conventional wastewater treatment systems. The fundamental difference between conventional and aquatic systems is that in the former, wastewater is treated rapidly in highly managed environments, whereas in the latter, natural self-purification processes are utilized by establishing suitable combinations of aquatic organisms in more or less unmanaged natural environments. The consequences of this difference are

1) conventional systems require more construction and mechanization but less land than aquatic systems
2) conventional processes are subject to greater operational control and less environmental influence than aquatic processes.

The major stimulus for further research into the fundamentals, design, and management of aquatic systems is the potential for reducing the construction and operation and maintenance costs for wastewater treatment. Furthermore aquaculture systems may provide protein or other exploitable products.

These aspects are very promising with regards to the utilization in developing countries. The general concepts involved in the design and use of aquatic systems are presented and the implications are discussed in the following.

Wastewater characteristics and treatment (see also i) above)
The characteristics of the wastewater to be treated are of funda-

mental importance in the selection of design of treatment systems whether conventional or aquatic, employing plants and animals. Further, the performance, reliability, and cost of conventional treatment systems have become the standard against which other treatment systems must be compared. For these reasons, each of these topics is considered in the following discussion.

The principal contaminants of concern in wastewater are shown in paragraph i) above.

At the concentrations found in domestic wastewater, the contaminants of greatest concern are biodegradable organics, suspended solids, and pathogens. Problems stemming from the other contaminants are of a more subtle, long-term nature and are neither well understood nor closely regulated at this time.

The principal removal mechanisms for the contaminants of concern in wastewater in aquatic systems employing plants and animals are known. The removal mechanisms have been identified on the basis of observations of

- natural systems such as marshes and wetlands
- laboratory and pilot scale studies of aquatic systems employing one or more plant and/or animal species.

An understanding of these mechanisms is important because the selection of plants and animals for use in aquatic systems will depend on the contaminants to be removed and the removal mechanisms that must be used for their removal.

The major treatment effect of an aquatic plant/animal treatment system is accomplished by bacterial metabolism. In effect water hyacinth or wetland systems are similar to large, slow-rate trickling filters with built-in secondary clarification. In addition the aquatic plants effectively remove nutrients (phosphorus and nitrogen) and toxic substances (eg. heavy metals and phenols) from the wastewater.

Aquatic Processing Units: A Conceptual Model

An aquatic processing unit (APU) is defined as the assemblage of aquatic plants and animals grouped together to achieve a specific treatment objective (e.g. removal of nutrients and heavy metals). In this context, an APU is a definable physical entity that represents some discrete steps in the treatment of a wastewater. For example, one or more APU's could be used in conjunction with conventional treatment methods to achieve a desired degree of wastewater treatment or several APU's could be used together to form an entirely aquatic treatment system.

The Need for Research

At present, very little is known about the use of plants and animals for the treatment of wastewater. Our knowledge is primarily related to the removal of nutrients, refactory organics and heavy metals.

Research is needed to define the conditions under which various types and combinations of aquatic species may be used in the tropics, and with special regards to the O & M aspects in developing countries.

6.5.2 Low Cost Sanitation

i) "State of the Art Review"

As complement to the sanitation programmes that are being carried out in developing countries, a number of multilateral and bilateral agencies have done and continue to do research in the sanitation sector. This is especially motivated by the "Water and Sanitation Decade". A State of the Art Review is highly recommended, and agencies of special interest are:

- The World Bank Technology Advisory Group (TAG)
- The International Development Research Centre of Canada
- UNICEF
- WHO/International Reference Centre
- USAID - Water and Sanitation for Health Programme (WASH)

- Asian Institute for Technology Bangkok/ENSIC (Environmental Sanitation Information Centre)
- B.I.E. - Bouwcentrum for International Education, Netherlands
- Intermediate Technology Group, London
  etc.

ii) Composting of human wastes

General and experiences gained

Composting the wastes is an old method of reclaming the substances in the wastes. Very little, however, has been done on composting fecal material in a container. During the last 10 years more than 25 different methods for composting fecal material have been developed in Scandinavia.

A biological toilet consists of a container that collects the feces and urine. This container is ventilated above the roof. After a certain period the composted material may be removed. During the composting, microorganisms decompose the organic materials into "soil" and CO_2. The compost contains a harmless "soil flora".

The Department of Microbiology at the Agricultural University of Norway has tested all the biological toilets on the Scandinavian market (45 tests) in their laboratory. They were tested with regards to capacity, strength and hygiene. From this experiment a few models were chosen for further testing in practical use. The Department of Microbiology has installed and continuously controlled about 150 toilets in different parts of Norway.

Research requirements

The climate, price and method of use make it impossible to transfer our technology directly. We know that some experiments have been done in this field in Africa, and a number of problems have emerged:

- Many of the users are reluctant to handle excreta even in its composted form.
- The users have difficulty in providing the necessary mainten-

ance inputs of adding carbonaeous material and thereby maintaining the correct carbon nitrogen ration required which results in the compostos becoming aerobic.

To resolve these problems it is proposed that the composting latrines constructed in Tanzania and in Botswana during the middle 70's be visited to assess the operational difficulties before embarking on better development work in other African countries. Experience from the very successful biological latrine programmes that operate in Thailand and Vietnam should be made use of in the process of developing systems applicable to Africa.

iii) The Ventilated Improved Pit Latrine (VIP)

General

The major problems associated with a traditionally constructed pit latrine are usually:

1) Short lift due to the pit collapsing and/or the pit becoming full.

2) They are mal odorous

3) They are a focus of insect breeding especially flies which are a major vector of fecal oral disease transmission links and also in some instances are a focus of mosquito breeding.

4) The squatting plate is often foulded with feces and is difficult to clean and can be reservoir of hook worm larvae.

Over the past few years research projects in Botswana and Zimbabwe have developed on improved pit latrine in order to overcome these problems. The main features of the improved pit latrine are that it is relatively easier to clean, foul odours and fly breeding is controlled.

Permanence is ensured by providing a structural lining of the pit either for the full depth or partially. Also sufficient volume is provided to give a useful life of 10 years or more.

The most important modification is the addition of a ventilation pipe or chimney, screened at the top with a mosquito gauze. This has the effect of controlled both odour and fly breeding which are inter linked.

Wind shear across the top of the chimney or ventilated pipe creates a strong updraft which vents out the foul odours. Gravid or egg laying flies who are attracted to their egg laying site by foul odour, follow the smell to the top of the vent. pipe, but cannot enter into the pit because of the gauze. Secondarily the few flies that do emerge from larvae in the pit are strongly phototactic and fly toward light, the greatest source of light into the pits is via the vent.pipe therefore the young emergent flies travel up the vent, but are prevented from leaving by the gauze. The flies remain trapped until they dehydrate die and fall back into the pit. This mechanism is reinforced by adopting a superstructure design that provides low light intensity in the interior of the superstructure.

The odour/fly control mechanism in ventilated pit latrines is well researched and established. A variety of materials may be used to construct the superstructure. We suggest the following options to be included in a Pilot Project:

a) Concrete blocks, with tile or corrugated iron or asbestos cement roof.
b) Mud and water walls with thatch roof.
c) Thatch walls with thatch roof.

A variety of materials can be used to construct the squatting plate. We suggest the following to be included in a Pilot Project:

a) Timber with plastic cover
b) Reinforced concrete
c) Glass reinforced plastic
d) Ferrocement.

Pit Lining

It is not unusual that the pits collapse after 5-6 months in average due to the soil condition.

The pits have to be protected and different solutions should be considered.

The following options should be tested in a Pilot Project:

a)   Timber used in the same way as framework for pillars.
b)   Framework in basked material and produced by local basket-makers.
c)   Cement/grass sheets.
d)   Concrete or sand/cement blocks.

6.6   Water Related Research - Social Studies

6.6.1   General

Improvements to health through water supply and sanitation is a long term goal whose effectiveness is not easily measured. The provision of appropriate technology is in itself insufficient to achieve this aim.

The main requirements for a good water supply and sanitation programme are a full understanding of local conditions and practices, promotion and provision of appropriate facilities combined with a health education programme that can bring about behavioural changes in order to gain full benefit from the improved facilities.

In connection with Water Supply and Sanitation Development Programmes, it is recommended to undertake series of indepth studies that will enable the correct implementation strategy to be formulated.

6.6.2   Anthropological Study

Indepth national or regional studies to determine behavioural patterns to personal and domestic hygiene, water use and sanitary practices is recommended.

Specific regards shall be given to traditional customs and attitudes concerning excreta disposal and knowledge of disease transmission.

Such surveys will provide basic information as to what (if any) improvements can be made in domestic and sanitation practices in order to improve health.

It is important that such a study also provide data that will determine the form and level of education.

a)   in rural populations
b)   in health personnel

required to bring about these changes and improvements.

Such studies could be carried out on a sample basis by enumerators in both rural and peri urban areas supervised and trained by social-anthropologists.

6.6.3 Socio-Economic Study

Indepth socio-economic studies to determine social and economic opportunity of the rural people and rural communities i.e. the money, skill, time available and willingness to participate in a sanitation programme is recommended.

Such studies shall provide data and information as to the most appropriate strategy to be accepted during physical implementation, minimum standards, and the scale of technical and/or financial subsidy that may be required and to what degree self help and self reliance may be utilized. Data collection will be part of the anthropological study.

6.6.4 Health Education and Promotion

In the educational/promotional sector there are three major initiatives to be undertaken:

i)   A promotion campaign to persuade communities and individuals to

provide for themselves (perhaps with assistance) good water supply and sanitation facilities.

ii) A demonstration/technical help campaign to show how to build and help communities construct these facilities.

iii) A health education programme to support and reinforce the above investments by ensuring proper use and associated good hygiene practice.

The study shall propose and design the most effective methods, "media mixes", and programmes for delivering these messages. Emphasis will be placed on utilizing existing institutions and organizations within the country.

6.6.5 Community Participation and Implementation Strategy

The key to success in projects which demand social and behavioural change is to promote willing and active community and individual participation in both planning and implementing a project. This creates a sense of ownership and pride which reinforces continued use, operation and maintenance of any facility thereby provided.

Community participation strategies that have been successfully used in other countries undertaking similar projects are:

i) The community assists in planning and organizing a project (and perhaps provides some materials).

ii) The individual provides labour (and perhaps provides some materials).

iii) The donor/investigator provides financial or material assistance, technical assistance, education and training.

6.7 Development of Human Resources

Zambia should co-operate with Norway in training their scientists and

technologists both through the provision of fellowships for study in Norway and through training programmes in Zambia involving Norwegian scientists and technologists. Such exposure and training should be undertaken in conformity with the needs, priorites and specific conditions agreed upon and proposed in this report.

Counterpart staff will be of greatest importance in order to strenghten N.C.S.R., the University and DWA.

7. PROPOSED WATER RESEARCH PRIORITIES FOR ZAMBIA

7.1 General

NIVA is not in a position to give firm recommendations with regard to priorities on water research projects as the selection of projects depends to a great extent on the availability of economic and human resources.

The priority list NIVA is suggesting is divided into two parts.

The first part contains research activities which are long term in nature and require proper planning.

The second part contains R & D-projects which initially should be done on an ad-hoc basis by contracting out the work. These projects are directly linked to the International Decade for Drinking Water Supply and Sanitation and should have immediate priorities. It would of course be a great advantage if the activities of these two levels could advance in close contact.

7.2 Long Term Water Research Activities

The National Council for Scientific Research, N.C.S.R., should be strengthened by a multidisciplinary water research team consisting of

     1 hydrochemist
     1 hydrobiologist
     2 public health engineers/sampling engineers
     1 hydrologist

and funds to upgrade existing facilities and to renew equipment.

N.C.S.R. has a good relationship to the University and DWA. All institutions are represented in the National Action Committee for the Decade. N.C.S.R. has several common projects with DWA and has assisted the University by providing part-time lectures.

N.C.S.R. will cover all relevant aspects of water research if strengthened. The water research activities may be divided into

1)   Public Health Engineering Research
2)   Water Resources Research

i)   <u>Public Health Engineering Research</u>:

The short term water research projects mentioned in chapter 7.3 need to be followed up and revised from time to time. Some of the proposed projects may prove to be long term in nature and will require considerable time to complete. It is important to have continuation in research and to develop human resources for research. A continuous state of the art review should be undertaken.

The choice of materials based on proper test-procedure will be of great importance. The demand for low cost and appropriate technology will be a main subject of interest. New trends in water treatment and disinfection should be followed up through pilot plant research.

ii)   <u>Water Resources Research</u>

N.C.S.R. have detail proposals for Water Resources Research Projects. Below we have given a brief description of some of their proposals.

WATER RESOURCES INVENTORY OF ZAMBIA

<u>Introduction</u>
N.C.S.R. has initiated a project titled "Water Resources Inventory of Zambia" since 1975. The project activities began with assistance of UNESCO from funds-in-trust donated by NORAD. The surface water inventory of the Luangwa river basin was carried out under the auspices of the project and a report titled "Water Resources Inventory of the Luangwa River Basin" was brought out in 1977. The project assistance also offered opportunities for carrying out the inventory of the ground water resources of Zambia, and a preliminary report on Ground Water Resources Inventory of Zambia was produced. The project assistance ended in 1978.

While credible progress on the project and good preliminary results were achieved, especially with regard to ground water inventory, certain unforeseen constraints adversely affected the progress of the water resources inventory project, particularly with regard to development of local capacity adequate to sustain the project. After the termination of UNESCO-NORAD assistance, the project activities continued with the meagre resources of N.C.S.R. Zambia in 1979. Swedish Agency for Research Co-operation (SAREC) was requested to provide assistance for funding the project over the years 1980 and 1981. The objectives of the SAREC assisted project were: -

i) To strengthen the water resources inventory section in terms of hydrological equipments and hydrological literature for carrying out the activities associated with the water resources inventory project.

ii) To carry out the investigations regarding the temporal and spatial variations of quantity and quality of surface and ground water resources of the Chambesi river basin. The Chambesi basin was chosen in view of its potentials for agricultural development in near future.

iii) To train the local staff in the area of hydrogeology and surface hydrology for strengthening the manpower component of the Water Resources Research Unit.

Water Resources Inventory of Zambia is, however, a huge task. It was possible to carry out the water resources inventory of the Chambesi basin through funding from SAREC. However, the hydrologic characterization and water resources inventory of the Zambezi, Luapula, Lake Tanganyika and Kafue river basins is yet to be carried out.

Justification for the Project

Zambia has six months of dry weather per annum. Therefore, a rational and efficient development of her water resources is a pre-requisite for dynamic development of the social, agricultural and industrial conditions.

The main objectives of the project are: -

a) To determine the hydrological charateristics of river catchment area in relation to land use;

b) To observe general hydrological features of a given region through a network of representative river basins, and their variations over larger natural zones under relatively stable natural conditions;

c) To make a complete assessment of all the water resources of the watershed, both surface and ground water, and

d) To monitor and assess the quality of natural water bodies, sewage and industrial effluents, and to determine their effect on the general environment.

e) To make an inventory of existing and potential future water users.

f) To undertake applied research on special problems and projects related to the development of the nation's water resources.

STUDY OF ECONOMIC MANAGEMENT AND EXPLOITATION OF LARGE MAN-MADE INLAND LAKES OF ZAMBIA

ITEZHI-TEZHI DAM

Introduction

1. Construction of the Itezhi-tezhi dam started in 1973 and the reservoir was finally filled in 1977. The reservoir covers an area of about 370 square kilometres and extends from Kafue River to Musak River, a distance of about 30 km. The dam was constructed to generate hydroelectric power at Kafue Gorge. About 90 percent of the Itezhi-tezhi reservoir lies in the Kafue National Park. The lake created had provided fishing facility for hundreds of fishermen. Fish production from the lake is expected to increase considerably from the present 200 metric tonnes per year. The esti-

mated potential yield of the reservoir is 1 800 metric tonnes per year.

2. The creation of any reservoir brings about drastic environmental changes (lotic to lentic) which are associated with changes in the qualitative and quantitative distribution of flora and fauna including fish. Since the creation of the reservoir there has been no meaningful post impoundment studies undertaken on the limnology of the reservoir. In order to properly manage the fishery of the lake in depth limnological studies of the lake should be undertaken. Such studies will provide information upon which the development and exploitation of the fishery should be based.

Objective

The objective of the Itezhi-tezhi limnological study is to increase total fish yield of the lake. The limnological study is a primary phase intended to provide vital information:

a) The physico-chemical changes that may have taken place as a result of creation of the reservoir;

b) Changes in biological production that may have resulted from the impondment;

c) To yield any limnological information important for the better exploitation and management of the fishery resources of the lake;

d) To identify and study new aspects within this environment, if any, and to gather ecological information on such habitats with a view to assessing suitability for transplanting fish species from other water bodies.

Collaboration

Liaison and collaboration between the Environmental Research Laboratory of the N.C.S.R. and the Fisheries Department shall be necessarily maintained througout the course of the project. This is desirable because the Fisheries Department is going to be the end user of whatever information which is going to be generated by the project.

7.3 Short Term R & D-projects

In the table below we have identified some R & D-projects which are very important to have carried out at our early stage of the Decade in order to select the best technical options taken into consideration aspects like economy, health, benefits, etc.

In the table we have given a brief description of the projects and proposed teams to carry them out. Terms of reference for these projects will be forwarded at a later stage.

Social studies should be part of the planning and implementation strategies for both water supply and sanitation.

With regard to Western Province, social studies should have a major part of the Mongu Sanitation Programme.

Table 7.1. SHORT TERM R & D-PROJECTS.

No	Brief description of water research projects to be contracted out.	Ref. to chapter in this report	To be carried out by	Remarks
I	Development of design criteria and guidelines i) Water supply engineering ii) High cost sanitation iii) Low cost sanitation		CE/R/SA	The research projects I-III are all very important at an early state of development. Based on experience the criteria will have to be revized from time to time.
II	Standardization and the development of Design Manuals including Standard and Type Drawings for the items listed under I above.		CE/R	
III	Drinking water quality criteria or guidelines.		R	
IV	Pilot Project on Low Cost Sanitation.		CE/SA/R	Mongu Pilot Project
V	Pilot Project on the development of low cost water supply projects in the rural areas.		CF/R/SA	Should be part of the NORAD financed Water Supply Programme in Western Province.
VI	Testing of handpumps in order to select and/or to manufacture locally		CE	
VII	Operation and maintenance research in order to up-grade existing facilities and to solve current O & M-problems including the reduction of costs.		R/CE	During the execution of the Water Tariff Study in Zambia, the NIVA-team experienced that many water supplies needed rehabilitation, augmentation or up-grading. For some of these projects Consulting Engineers had proposed new expensive designs which in some cases could have been avoided.
VIII	Treatment Electrocoagulation	6.4.4	R	The research projects listed under VIII are all very important as they are appropriate and cheap. They have all a great potential.
	Low-Cost Household Water Treatment	"	R	
	Optimal Storage Tanks Design	"	R/CF	
	Disinfection by using natural UV-radiation	"	R	
IX	Water Consumption Restricting Devices (wcrd)	6.4.5	R	The development of a wcrd which could simplify the revenue collection would be of great benefit.
X	Pre-treatment - Slow Sand Filtration	6.4.4	R	The development of a pre-treatment plant to use in connection with existing slow sand filters would be of greatest importance.

CE = Consulting Engineers
SA = Socialanthropologist
R = Researcher