

# REPORT



NVE  
NORWEGIAN  
WATER RESOURCES AND  
ENERGY ADMINISTRATION

## RESULTS OF DAM SAFETY AND RESERVOIR SEDIMENTATION WORKSHOP IN TANZANIA

**Executive version**

By

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## **PREFACE**

The Norwegian Water Resources and Energy Administration (NVE) has been contracted by NORPLAN to assess a training programme on supervision covering the fields of "Dam Safety" and "Reservoir Sedimentation" in Tanzania. The background is a request from TANESCO to the Norwegian Agency for Development Cooperation (NORAD) in 1992.

The project was assessed in two phases. The preparatory phase comprised several meetings between TANESCO, MAJI and NVE and site visits to the hydropower reservoirs of Pangani, Nyumba ya Mungu, Mtera and Kidatu. The organization, participation and professional content of a workshop were decided. The "Fact Finding Mission Report (1993) presents the conclusions and recommendations from the meetings.

The workshop was arranged 3-14 October 1994. The participants represented the following institutions in Tanzania: TANESCO, MAJI, Pangani Basin Water Office, University of Dar es Salaam, Ministry of Water Energy and Minerals and Ministry of Agriculture and Livestock Development.

Mr. F.X. Saidi, Mr. D. N'Gula and Mr. K. Luteganya from TANESCO have been the responsible persons for the practical arrangements in Tanzania, as well as organizing the workshop. Mr. J. Joseph from TANESCO and Mr. F. W. Masanja from MAJI made reports during the site visits and group work discussions. Mr. O. Rusten and Mr. A.B. Ovanger from NORPLAN arranged practical details regarding the accomplishment of the workshop as well as necessary contacts between TANESCO and NVE. Mr. A. Adeler from NORAD gave valuable support and contributions, specially during the preparatory phase by participating in meetings and the site visits.

All papers presented at the workshop are enclosed the main report.

The photos in the report are taken by the authors.

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## 1. INTRODUCTION

The content of this report is mainly written by the participants as a result of the work carried out during the two weeks. The reporters have been civil engineer Mr. Joachim Joseph on dam safety and senior hydrologist Mr. Faustin W. Masanja (reservoir sedimentation). This report comprises the presentations, findings during the field exercises, information given in the questionnaires and conclusions gained through the group work discussions.

Based on the findings described in the project report " Dam Safety and Sedimentation in Tanzania " dated Aug. 1993, the workshop was carried out over a two weeks period 3 - 14 October, 1994.

The main objectives of the workshop were:

- \* to bring dam safety on the agenda to a larger extent than now in Tanzania
- \* to discuss a programme for monitoring sedimentation in reservoirs and how it can be initiated and implemented

The background was a meeting in Oslo in 1992, where TANESCO expressed a need for:

- \* an assistance programme in supervision and control during construction and operation of Pangani, and further the possibility of extending the programme to cover all TANESCO's dams above a certain size or with a special risk factor related to possible dam failure
- \* increased know-how in the field of sedimentation in reservoirs and related problems

As pointed out in the fact finding mission report, the situation regarding dam safety and reservoir sedimentation is not satisfactory and must be seriously dealt with in the near future. Some very concrete resolutions/suggestions have been made in chapter 5 in this report. They can serve as a starting point for a broader understanding of these very crucial matters.

Legal framework, organization and competence are keywords for both implementation and quality of the dam safety and sedimentation monitoring programme carried out.

In order to be able to identify areas which need to be improved, the following model was introduced at the beginning of the workshop:

### **Legal framework**

- *Laws*
- *Regulations*

### **Organization**

- *Resources*
- *Responsibilities*
- *Authority*

### **Competence**

- *Knowledge*
- *Experience*
- *Attitude*

*Fig.1*

To get fruitful discussions covering these different fields, the participants of the workshop were invited from organization which are all involved in and play important roles regarding dams, water resources and sedimentation problems in Tanzania. The following organizations were represented:

- TANESCO
- MAJI
- Pangani Basin Water Office
- University of Dar es Salaam
- Ministry of Agriculture and Livestock Development

The two weeks of work were divided into three different phases:

*Presentations (2 days) - Site Visits (5 days) - Group Work (2 days).*

The presentations and the field exercises should give the background for the workshop discussions in describing today's situation on legislation, competence and organization, to motivate the achievement of a necessary monitoring programme



*Day 1 and 2 - Presentations at New Pangani*



*Day 3 - Surveying exercise, total station, at the New Pangani Dam*





*Day 3 - Field demonstrations  
of discharge and sediment  
transport measurements at  
Korogwe.*



*Day 5 - Upstream rock protection at Nyumba ya Mungu Dam*





*Day 5 - Seepage inspection, "hot spring" downstream Nyumba ya Mungu Dam*



*Day 11 and 12 - Group work session in Dar es Salaam*

## 2. PRESENTATIONS

### 2.1 DAM SAFETY

After a short intro. of what the workshop should aim to accomplish during the two next weeks in the field of dam safety in Tanzania, the following presentations were given:

- Legislation in Tanzania w.r.t. dam safety
- Legislation in Norway w.r.t. dam safety
- Dam types
- Dam failures
- Instrumentation of dams
- Surveillance of
  - Mtera dam
  - Kidatu dam
  - Nyumba ya Mungo dam
  - The New Pangani dam

Papers on each topic are included in the appendices.

The time available for presentations was very limited. The topics were therefore carefully selected. It should be noted that the participants of the workshop had different background, some are surveyors, some hydrologists some electro-mechanical engineers etc. as the list of participants indicates. It was therefore important to keep the presentations and discussions on a general level - rather than going into details.

### 2.2 RESERVOIR SEDIMENTATION

Mr. Njombe focused in his opening of the workshop that water stored in the dams in Tanzania is mainly linked to water supply, irrigation, hydro power and flood protection. Except for the narrow coastline, the climate in Tanzania is dry with distinct rainy seasons. Artificial reservoirs are a necessity in a "year around" safe water and energy supply system. The inflow discharge constitutes the natural resource, while the volume of the reservoirs represents the ability of covering the water demand during the dry season.

The objective with the presentations were to elucidate the situation regards legislation, resources and monitoring within Tanzania, in order to give the participants necessary professional background for the later discussions. Due to the limited time available, the subjects were presented on a general level, rather than going into details. The presentations were kept by participants representing different institutions comprising MAJI, TANESCO, the University of Dar es Salaam, the Ministry of Water, Energy and Minerals and the Ministry of Agriculture and Livestock Development and the Norwegian Water Resources and Energy Administration. The papers are attached in Appendices 10 - 20.

### **3. SITE VISITS AND FIELD EXERCISES**

The site visits comprised New Pangani Falls, NyM and Kidatu. The participants were divided into four groups. Each group had to fill in a questionnaire for each site visited. The main objectives with the field exercises were, through site visits and practical demonstrations of instruments and routines, to gain background and understanding of today's situation. Other aspects covered were motivation, the value of interdisciplinary cooperation and to make the participating professionals familiar with each other and the different projects.

The presentations and the field exercises should together give valuable background for the workshop discussions.

#### **3.1 DAM SAFETY**

##### **3.1.1 Field Exercises**

A vital part of the field exercises was to fill in questionnaires by each group. Additionally all the participants could inspect the instruments and the monitoring procedures (if any) at the three sites visited.

##### **3.1.2 Surveillance and Monitoring - Current Practice**

Since the dam at Pangani is just finished and the monitoring of the performance has not started yet the below comments mainly apply to NyM and Kidatu.

The dams were initially equipped with instruments, sufficient for the dam owner to monitor his dam. In the operation manuals for the different dams there are procedures to be followed which would give the dam owner valuable information about each dam's performance.

Provisions for seepage-, settlement- and pore water pressure-monitoring are installed at both dams.

Nevertheless, findings throughout our site visits uncovered a negligence in this field which can lead to serious problems if nothing is done.

The safety of a dam can in general be linked to the three main factors:

- i) Structural safety
- ii) Surveillance - monitoring
- iii) Emergency preparedness

The site visits showed us that the surveillance procedures at both Kidatu and NyM are not at all satisfactory. Systematic recording of data according to the surveillance programmes should be started immediately. A system for analyzing and storing of the data is also required.

The structural safety is apparently satisfactory at NyM, but since the dam is old, a complete

revision of the design criteria and the surveillance procedures should be carried out. Further, it is common practice in many countries that all damowners with dams of a certain category must have an Emergency Action Planning for his dams. Reference is made to TADS( Training Aids for Dam Safety by Burec). Tanesco received a total volume of this Training Aid for Dam Safety as a part of the workshop.

The situation at the Kidatu dam is not satisfactory. Nevertheless, the dam body itself seems to be in good condition. Settlement measurements of the crest were carried out during the site visits. These showed normal behavior. On the contrary, the gates gave a bad impression. Since the operation of these are vital for the safety of the dam, the situation should be improved as quick as possible.

### **3.1.3 General Conclusion**

The dam safety suffers in general from lack of surveillance and maintenance. At Kidatu dam the situation can become critical. Reasons for this were discussed during the groupwork session and is described in chapter 4. See also site visit reports in the appendices.



## **3.2 RESERVOIR SEDIMENTATION**

### **3.2.1 Field Exercises**

The field exercises included practical demonstrations of discharge and sediment transport measurements, levelling by total station and test of an echo sounder. Furthermore, the participants filled in questionnaires and took part in summing up discussions at each site. Themes of interest related to reservoir sedimentation monitoring were:

- \* The necessity of reservoir sedimentation monitoring (evaluation at each project site)
- \* Verification of today's situation related to reservoir sedimentation and runoff monitoring and measurements (routines, instruments, resources and priorities)
- \* How to implement a sustainable monitoring programme and achieve substantial results (available resources, suitable methodologies, background data, motivation, legislation)
- \* Possibilities and benefits to be gained through interdisciplinary knowledge and cooperation

### **3.2.2 Responsibilities Regarding Monitoring**

In Tanzania, the dam owner has the responsibility of maintenance, while MAJI is responsible for hydrological (including sediment transport) monitoring. Reservoir sedimentation monitoring which is in the interest of the dam owner, however seems to be the responsibility of MAJI. Clarification of ownership and related responsibilities were pointed out as one of the most important issues regarding implementation a reservoir sedimentation and runoff monitoring programme.

### **3.2.3 Ownership**

The hydropower reservoirs of Kidatu, Mtera and Pangani are owned by TANESCO while Nyumba ya Mungu and water supply reservoirs like the Mindu dam is owned by MAJI.

### **3.2.4 Status - Reservoir Sedimentation Monitoring in Tanzania**

Reservoir sedimentation monitoring is non-existent in Tanzania, meaning that no hydropower or water supply reservoir volumes are known. Instead of accumulation surveys, the sedimentation rates in use, alter between 0.5 - 1 % of the volume per year. These must be characterized as conservative and rough estimates, most probably too low, not reflecting the real situation. Reservoir sedimentation results from upstream erosion, which will differ in time due to climatic variations and catchment development.

Reservoir sedimentation which has been noticed in several dams, is looked upon as a severe problem. The Hale dam and several smaller water supply reservoirs have already been silted up.

The following main issues were pointed out by the participants during the field exercises:

- \* There exist no exact data regarding today's volume of reservoirs or sedimentation rates in Tanzania
- \* There seems to be no continuous inflow measurements of either discharge or sediment transport to any of the reservoirs.
- \* There should be easier access to hydrological data.
- \* New stage-volume curves should be measured to determine available water volumes and sedimentation rates.

There exist a number of hydrometric stations within the hydro power reservoir catchments. However, great uncertainties about their number, location and condition were expressed by the participants. MAJI is supposed to possess such information, however, insufficient information was available at the sites visited.

TANESCO is registering daily water levels in their reservoirs, however, other kinds of hydrological monitoring is left to MAJI. There is a national hydrometric network in Tanzania, including both run off stations and sediment transport stations. The majority of these stations are either not running or in a bad condition due to priorities and lack of finance within MAJI. The existing hydrological background data, can be of use regarding future monitoring.

### **3.2.5 Why Monitor Reservoir Sedimentation and Runoff**

Reservoir sedimentation directly influences the life time of the reservoir. Another aspect, with special importance in water deficit regions, is the effect on the reservoir's water balance. Sediments accumulated in the active storage have to induce a rise in the reservoir water level, considering the same volume of water available for regulation. Nyumba ya Mungu and Mtera are characterized by large surface areas compared to the depth and low shore gradients. In these reservoirs, where the evaporation rate exceeds 2 000 mm/year, the increase in water loss may be considerable even by small rises in water level.

However, in reservoirs like Kidatu with steep shore gradients, the same rise in water level will cause less increase in surface area, thus inducing a relatively smaller increase in water loss caused by evaporation.

Other aspects of importance regarding the run of a power station is siltation at the gates and sediment flow through the head race creating a danger of turbine abration.

The importance of monitoring reservoir sedimentation and inflow can be illustrated another way. The runoff may be compared with the contribution and the volume of water available for regulation equals the bank account, while evaporation compares the inflation. The importance of these parameters should be quite obvious. Improved knowledge of reservoir sedimentation and runoff are important for the optimum run of the power station as well as the future economy of the same.

### 3.2.6 Training and Motivation

Reservoir sedimentation monitoring is a new subject within the hydrological field in Tanzania. There are personnel familiar with some of the methodologies which can be used, however, the need for extensive training is obvious. Even if there are hydrologists and field technicians within MAJI, it seems fruitful to include the routines of sediment transport monitoring, runoff monitoring and registration of erosion and sediment sources in a comprehensive training programme. Beside these aspects, emphasis should be put on the planning and organization as well as motivation and utilitarian value of the monitoring. In addition to the professionals, both local and HQ staff should attend the training.

### 3.2.7 Achievement of a Sustainable Monitoring Programme

In order to achieve proper routines on reservoir monitoring and maintenance, the lines of responsibility, financing and ownership to the data are fundamental. The situation today is that TANESCO is in a better financial position than MAJI to carry out the monitoring necessary in order to optimize the run of their power stations. However, MAJI employs hydrologists and field technicians trained in hydrological analyses and measurements. TANESCO and MAJI are organized under the Ministry of Water, Energy and Minerals.

TANESCO is organizing a field unit to handle the necessary measurements and monitoring regarding their reservoirs and dams. The participants found a future cooperation between MAJI and the "field unit" as a realistic solution in order to implement a reservoir sedimentation monitoring programme.

These kinds of measurements are comprehensive and require sufficient resources, infrastructure, logistics and trained personnel. Therefore, it is advisable to make proper and realistic planning including a limited number of high quality monitoring stations in a long term perspective.

Establishment of stage volume curves in the reservoirs is comprehensive and complicated. The same method is perhaps not suitable for all reservoirs. The large surface area and the low shore gradients of Mtera and Nyumba ya Mungu make these reservoirs more complicated to measure than the Kidatu reservoir. The planning therefore has to include a thorough analyses of the objective and how to achieve the goal within a realistic framework. Evaluation of methodologies, available data, personnel, instruments and costs, should build the background in the choice of programme.

The participants pointed out the following issues of importance in establishing a sustainable monitoring programme on reservoir sedimentation and runoff:

- \* Motivation on all levels regarding the importance of reservoir sedimentation and runoff monitoring
- \* Proper routines, responsibilities and financing regarding data collection, storage and analysis should be established.
- \* Data which has been collected and analyzed should be shared within interested ministries or departments.
- \* There should be free accessibility of hydrological data, however, the costs should be covered by the users.

- \* Regarding a monitoring programme, standard routines with emphasis on methodology procedures and quality control must be worked out.

### 3.2.8 Suggested Monitoring Programme on Reservoir Sedimentation to be Implemented within 1996

| Reservoir              | Suggested Methodology  | Location  | Comments  |
|------------------------|--|---|---|
| <i>Pangani</i>         | Echo sounding, sediment transport, erosion potential in the catchment  | Reservoir area, Pangani river at Korogwe  | Topographic mapping of the reservoir bed, Rehabilitation of the monitoring station at Korogwe, sediment transport and runoff                |
| <i>Nyumba ya Mungu</i> | Echo sounding, levelling, fotogrammetry, indirect calculations, sediment transport, erosion potential in the catchment | Inlet areas of the Ruvu and Kikuletwa rivers  | Emphasis on topographic mapping of the reservoir bed, monitoring of runoff and sediment transport in at least one of the major inlet rivers |
| <i>Mtera</i>           | Echo sounding, levelling, fotogrammetry, indirect calculations, sediment transport, erosion potential in the catchment | Inlet areas of the Little Ruaha, Great Ruaha and Fufu rivers  | Emphasis on topographic mapping of the reservoir bed, monitoring of runoff and sediment transport in at least one of the major inlet rivers |
| <i>Kidatu</i>          | Echo sounding, levelling, sediment transport, runoff, erosion potential in the catchment                               | Reservoir area, monitoring in the inlet area of the great Ruaha and major inlet river from south east | Topographic mapping of the reservoir bed, monitoring of runoff and sediment transport in the Great Ruaha river near the inlet               |



## 4. GROUP WORK SESSION

The last two days were set for group work and discussions. The aim was to draw the conclusions and to form suggestions in the fields of legislation, organization and competence. In order to gear the discussions towards key elements there were made questions to be answered and presented. All four groups answered all the questions but each group presented only one question each. The questions are written in skew letters. The following is the essence from all four groups written by the reporter in each group:

### 4.1 DAM SAFETY

#### 4.1.1 Legal Frame Work

*1a) Is the legal framework in Tanzania satisfactory to ensure safe dams? How do you justify your answer?  
If necessary, how can the situation be improved?*

The situation is not satisfactory.

- There is no provision of a law or guidelines, governing the dam design, construction or monitoring of dams as for safety is concerned.
- Dams are designed according to foreign standards. Due to different conditions these foreign standards might not suit our dams.

Proposed action:

An Independent Commission should be established by the government to deal with this problem. It should comprise of professionals from MAJI, ACADEMIC INSTITUTIONS, LAW SOCIETIES etc. it will be responsible for:

- (i) creating laws by appointing sub-committee of competent people
- (ii) Inspecting the dams under construction and under operation.
- (iii) Categorizing the dams within the Country (in terms of size)

*1b) Are the responsibilities and legal authorities between institutions clearly defined?  
If no, make a proposal for improvement.*

The responsibilities and legal authority between institutes are not clearly defined.

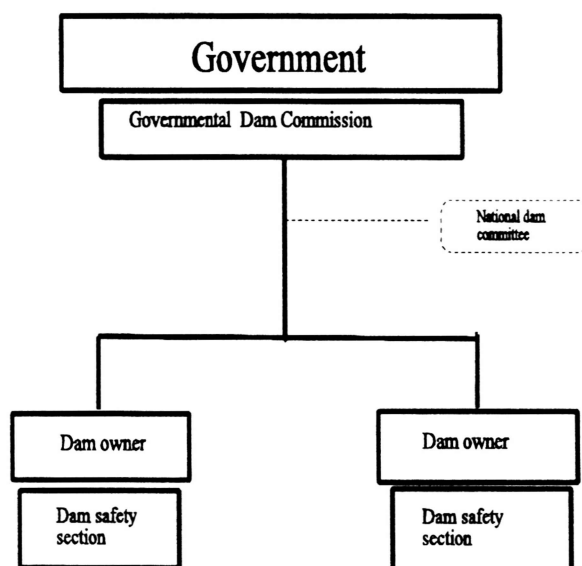
It is proposed that legal provisions on matters of the same nature should be enforceable by the same legal entity.

### 4.1.2 Organization

- 2a) *Make a suggestion for how the surveillance and monitoring of the major dams in Tanzania can be organized in order to ensure the highest possible degree of safety with the resources available in the country.*

*How should these ideas be implemented in Tanzania and Tanesco?*

The following is the proposed organization within Tanzania to improve surveillance and monitoring of major dams in Tanzania and hence the dam safety.



*Fig. 2 Suggested organizational structure to improve the situation w.r.t dam safety .*

#### General Comments:

- An important task for the commission under the Government is to work out and define competence levels for personnel working for the dam owner.

Eg.) Level 1 - competence requirements for personnel working on site.

Level 2 - competence requirements for head office personnel who analyze the monitoring data from the head office.

- When the National dam committee is established, Tanzania should apply for membership in ICOLD, International Commission on Large Dams. This will give access to very useful international information and a society with long experience within the field. Due to Tanzania's relatively small amount of dams, the annual fee will also be small.
- Tanesco as an owner of dams should have a dam safety section which can be placed within the Directorate of Research. This sections main goal will be to raise the

awareness of people responsible for the dams at site and at the Head Office.

#### 4.1.3 Current Dam Safety Level

2b) *Why is the situation w.r.t. dam safety not satisfactory?*

*What should be done?*

The situation at KIDATU is not at all satisfactory as far as safety of the dam and people is concerned. The situation is unsatisfactory due for the following:-

- (i) Poor maintenance of spillway gates
- (ii) Surveillance programme not at all followed.
- (iii) No Emergency Plan nor auxiliary power for operation of gates.
- (iv) Lack of awareness on impending crisis hence leading to do nothing by the management.

To save Kidatu from impending dangers the following should be done:

- (i) The gates should immediately be serviced
- (ii) A possibility of having another spillway may be looked into. e.g. side channels at left side abutment to reduce the risk of dam failure due to malfunctioning of the gates.
- (iii) The monitoring programme should be closely followed as given in the operation manuals.
- (iv) Tests should be carried out to detect possible aggregate-alkaline reactions in the concrete pillars.

2c) *The surveillance programme for Mtera is handed out to you*

*What is in your opinion the main features to be monitored in order to evaluate the state of the dam? Why?*

*Make a suggestion for how the surveillance programme can be reduced, simplified (maybe altered) but still give adequate information? Bear in mind the resources available.*

(c) Surveillance programme at Mtera:

There are several instruments provided at Mtera for monitoring the dam performance. Of these the critical features that should be closely monitored and be adequate to give the necessary information are:

- (i) Visual inspections
- (ii) Deformations
- (iii) Seepage
- (iv) Water level

For a concrete dam of this nature the above features should suffice.

2d) *Make a brief surveillance programme for NyM and describe how it should be implemented, resources required, where to get resources etc.*

The main features to be monitored at Nyumba ya Mungu are:

(i) Visual Inspection

- to be done daily by level 1 of competence (personnel at site)
- to be done every 3 months level 2 of competence (owner's head office).

(ii) Seepage

- Readings to be taken daily

(iii) Water levels

- Readings to be observed daily

(iv) Deformations

- Readings should be taken every three months.

(v) Water Inflow

- readings should be taken daily

It is proposed that for a smooth monitoring of NYM dam TANESCO should own the dam and thus be responsible for all monitoring works. The resources are available within TANESCO. Alternatively, Maji can buy this service from TANESCO.

#### **4.1.4 Need for Training**

3a) *Is there a need for more extensive training of personnel than practiced today? If yes, how should this be organized?*

3b) *What can be done by local staff members and HQ staff? Is there a need for external training? If yes, how can this be organized?*

There is a need for more extensive training. This should be organized in the form of short courses, site visits etc., conducted both internally and externally.

In the construction of new dams and rehabilitation of existing dams, people should be deliberately trained, so that they can smoothly take over during operation and maintenance period.

Both local and HQ staff need to coordinate their activities and hence more understanding of each other's activities.

The local staff should be highly motivated. The motivations should include:

- ◆ More awareness on their activities i.e. through seminars, workshops etc.
- ◆ Increased appreciation of what they are doing.
- ◆ Equip the local staffs with proper and necessary working facilities



## 4.2 RESERVOIR SEDIMENTATION

During the group work discussions, the participants came up with the following views and descriptions and conclusions:

### 4.2.1 Legal Framework

#### *Situation today*

No legislation related to reservoir sedimentation or hydrological monitoring, i.e. the development of water resources require no follow up monitoring.

#### *Improvements*

Establishment of a legal framework which defines responsibilities and monitoring requirements regarding development of water resources. The utilization of a natural resource should oblige relevant monitoring in order to secure the optimal management of the resource (on behalf of the public and the environment).

The legislation clearly should define duties and responsibilities regarding a hydrology and sedimentation monitoring programme in order to implement optimal utilization of the water resources

### 4.2.2 Competence

#### *Situation today*

There are competent people on reservoir sedimentation and hydrology, however, they lack experience, motivation, instruments, facilities, logistics, quality control and regularly payment

There is minimal utilization of the academic institutions and resources

#### *Improvements*

Increase motivation and knowledge at all levels, training and quality control of field technicians

Increase the utilization of national academic institutions and resources, rather than foreign experts

Make contacts with relevant international professional organizations

Establish training programmes

### 4.2.3 Organization

#### *Situation today*

Insufficient funds are allocated for programmes on monitoring reservoir sedimentation and hydrology

The lines of responsibility are unclear and not defined

The participants all agreed about the value of national hydrological data collection and presentation. The Hydrological Section at MAJI, which in fact has the role of a national hydrological centre, is working on a system for national data presentation. However, the participants pointed out, this section suffers from lack of financial resources.

In principal, all kind of hydrological data should be available at MAJI. The Hydrological Section is working on a system to improve the database, thus simplify the access to the data and the utilitarian value of the data. However, at hydro power sites, few if any, hydrological data were available. There also seemed to be some confusion about data available at the Regional Water Offices and how to get access to them.

#### *Improvements*

There are many potential users of hydrological data in Tanzania. The overview concluded there is a potential market for hydrological monitoring and data within a variety of fields comprising several Ministries, parastatals, academic institutions and private firms (see Appendix 9). A system of cooperation and cost shearing to improve the resource situation should be initiated.

Top management (TANESCO/MAJI) must understand the importance and value of both reservoir sedimentation monitoring and hydrological monitoring as an integral part of the reservoir economy and the electricity production/water supply

The organization(s) needed, should be initiated and established

The implementation should be financed by allocation of funds based on the income from "water user's fees"

Establish sufficient funding routines

Introduce and establish field units with clear responsibility lines

Support simple, but good quality instruments, improve the infrastructure and logistics

Introduce monitoring routines including quality control and lines of responsibility (people at all levels must feel responsibility)

Introduce of good reporting routines

#### 4.2.4 Implementation

##### *Situation today*

The actual volumes as well as the life time of all the hydro power reservoirs are unknown.

Even if water perhaps is the most important natural resource in Tanzania, there is a lack of motivation and understanding among the decision makers and field technicians regarding the significance of monitoring.

Experiences in Tanzania have shown that comprehensive hydrological monitoring programmes are difficult to run.

There are no monitoring or measurements of either sediment transport or reservoir sedimentation in any of Tanzania's hydro power reservoirs. The water budget and the water balance is unknown in all the reservoirs.

Although land use practices upstream of dam are changing e.g. livestock settlements, cultivation and deforestation, no attempt to measure their effect on soil erosion and sediment transport have been carried out. Catchment erosion is the major input factor for the magnitude of reservoir sedimentation.

There is no frequent monitoring of the inflow to any of the hydro power reservoirs in Tanzania. However, there exist several stations, but these are not working. Old hydrological data records can be turned to account in combination with new records.

##### *Improvements*

The participants concluded motivation at all levels as, perhaps, the most important issue in order to establish a sustainable programme on reservoir sedimentation and hydrological monitoring. There are several benefits to gain by establishing a monitoring programme:

- \* Improve the background for optimal run of the power stations i.e. optimize the power production and, thus, increase the generation of financial income
- \* Ability to influence on land use practices in the catchment in order to reduce the erosion rates and thereby increase the life time of the reservoirs

Knowledge achieved through monitoring will optimize the operation of the power plants, thus, reduce the load shedding. The general management of the water resources will improve by accomplish better knowledge of:

- \* exact volume of water in the reservoir available for power production at all times
- \* the water budget (seasonal inflow, water abstraction etc.) and the sediment budget (erosion and sedimentation rates)
- \* the water balance
- \* the life time of the reservoir (active storage)
- \* hydrological trends and changes

### 4.2.5 Monitoring Programme

Based on the presentations and the field exercises, all participants agreed that a monitoring programme on reservoir sedimentation and hydrology should be implemented at Kidatu as well as the other hydro power reservoirs in Tanzania.

For Kidatu, the participants suggested the following monitoring programme:

- \* Establish sediment transport monitoring (combined with the hydrometric stations); measurements specially during the rainy season
- \* Establish stage-volume curve to get the actual volumes (dead storage, active storage) and sedimentation rates (to be compared with the previous curves)
- \* Establish river gauging station(s) to measure inflow and outflow on a regularly basis
- \* Establish a gauge plate at the reservoir; to be read at fixed intervals
- \* Establish a meteorological station to measure parameters like evaporation and rainfall

### 4.2.6 Establishment of a Field Unit

The participants concluded that establishment of a field unit probably was the best way of implementing a reservoir sedimentation and hydrology monitoring programme. Reservoir sedimentation monitoring requires special instruments and competence and the measurements are not repeated every year. A field unit, therefore, would reduce the costs and optimize the utilization of instruments and professional competence among the field technicians. Furthermore, the administration of the programme would be easier and less time consuming.

The workshop noted that it may be difficult to establish such a unit within MAJI due to lack of financial resources. However, it would be possible to cooperate with parastatals such as TANESCO, which is under way establishing their own field unit. MAJI and TANESCO is administrated under the same ministry and the participants looked quite positive on the cooperation between the two. TANESCO has better financial and logistic opportunities, while MAJI employs the majority of the professional hydrologists and is in possession of the analyses facilities.

### 4.2.7 National Measures

The participants discussed the need of national measures to secure satisfactory management of the water resources in Tanzania. The majority of reservoirs in Tanzania are constructed for water supply, however, the largest reservoirs are the heart of the national electricity production.

In order to improve the management of the water resources, introduction of water user's fee was looked upon as a useful tool. In principal, this should lead to more awareness among industries and the public, thus reducing their abstraction of water. Pangani Water Basin Office is an example where such a system is under introduction.

To secure satisfactory professional monitoring and allocation of funds, the participants concluded that:



- i The legislation clearly should define duties and responsibilities regarding a hydrology and sedimentation monitoring programme in order to implement optimal utilization of the water resources
- ii The organization(s) needed, should be initiated and established
- iii The implementation should be financed by allocation of funds based on the income from "water user's fees"

#### **4.2.8 Training**

The workshop noted the need for training in the field of monitoring reservoir sedimentation. Issues of importance are the motivation of trainees in understanding the mechanics of sediment production, sediment transport and deposition (sediment budget). Furthermore, the trainees should gain practical experiences, be able to maintain and operate equipment used for reservoir sedimentation monitoring and sediment transport measurements. The administration, infrastructure, instrumentation, methodology and analyses are other fields of importance to be included in a training programme.

#### **4.2.9 Combination of Reservoir Sedimentation and Dam Safety Monitoring**

The workshop saw the possibility and advantages in combining reservoir sedimentation monitoring with dam safety surveillance. However, the discussion demonstrated different opinions whether or not this was a good idea. The main arguments pro et contra are listed below:

- i Sharing of information regarding concurrence of parameters without much problem
- ii Same location, easier to train
- iii Specialization of equipment
- iv Reduced running cost
- v Routine measurements could be done by the same staff
- vi The two fields requires different kinds of professionals
- vii The lines of responsibilities are different
- viii Different financial resources

The workshop discussed on who to be responsible and agreed the team of experts should look into the matter and deliberate on it.

## 5. RESOLUTIONS AND CONCLUSIONS

### 5.1 DAM SAFETY

| Item no. | Item(goal)  | Proposed activity no | Proposed activity  | Responsible institution | Deadline |
|----------|---|----------------------|--|-------------------------|----------|
| 1.       | <b>Establishment of legal framework to ensure safe dams</b> | 1.1                  | Establishment of commission in the Ministry  | Maji                    | 1995     |
|          |   | 1.2                  | Adapt laws, regulations and guidelines for planning, construction, and operation of dams in Tanzania | Maji                    | 1996     |
|          |   | 1.3                  | Make an organization within Tanzania which improve the lack of dam safety provisions.                | Maji                    | 1995     |
| 2.       | <b>To ensure the required competence within Tanzania</b>    | 2.1                  | Set up a National dam committee  | Maji                    | 1995     |
|          |   | 2.2                  | Apply for membership in the International Commission on Large Dams (ICOLD)                           | Maji/TanESCO            | 1995     |
|          |   |                      |  |                         |          |

|    |   |     |  |                                       |      |
|----|---|-----|--|---------------------------------------|------|
|    |   | 2.3 | Start training at all levels within the Ministry and the dam owners organization   | Maji/TanESCO/ Ministry of Agriculture | 1995 |
|    |   | 2.4 | Implement training with the training modules TADS (Training Aid for Dam Safety)  | TanESCO                               | 1995 |
|    |   | 2.5 | Certification procedures of dam safety personnel at all levels implemented   | Maji                                  | 1995 |
| 3. | <b>Kidatu - emergent improvement of the safety of the dam</b> | 3.1 | Gates must immediately be repaired due to severe lack of maintenance which threatens the safety of the dam   | TanESCO                               | 1995 |
|    |   | 3.2 | Check concrete for possible Alkali - Aggregate reaction  | TanESCO                               | 1995 |
|    |   | 3.3 | A total revision of the design criteria with respect to hydrology, operation, seismicity, emergency preparedness etc. pointing out the current situation | TanESCO                               | 1995 |
|    |   | 3.4 | The surveillance programme must be carried out as suggested in the operation manual.   | TanESCO                               | 1995 |

|    |   |     |   |                               |         |
|----|---|-----|---|-------------------------------|---------|
|    |   | 3.5 | Instruments out of function must be repaired  | TanESCO                       | 1995    |
|    |   | 3.6 | Procedures for presentation of recorded data and analysis of the results must be established  | TanESCO                       | 1995    |
| 4. | <b>Mtera - improved surveillance</b>                  | 4.1 | Revision and implementation of surveillance programme   | TanESCO                       | 1995    |
| 5. | <b>Nyumba ya Mungu - improved safety</b>              | 5.1 | The ownership of the dam must be decided in order to establish a clear responsibility for the surveillance and maintenance of the dam | Maji/TanESCO                  | 1995    |
|    |   | 5.2 | The instruments recording settlements/deflections and seepage must be repaired  | Maji/TanESCO                  | 1995    |
|    |   | 5.3 | New surveillance and monitoring routines must be established  | Maji/TanESCO                  | 1995    |
| 6. | <b>Improved motivation for surveillance personnel</b> | 6.1 | Increase awareness through training   | TanESCO/Maji (all dam owners) | 1995/96 |
|    |   | 6.2 | Supply them with proper uniforms, boots and facilities  | TanESCO/Maji (all dam owners) | 1995/96 |



|  |  |     |   |                               |      |
|--|--|-----|---|-------------------------------|------|
|  |  | 6.3 | Give them a defined address for further analysis of their findings and recordings | TanESCO/Maji (all dam owners) | 1995 |
|--|--|-----|---|-------------------------------|------|

### Comments:

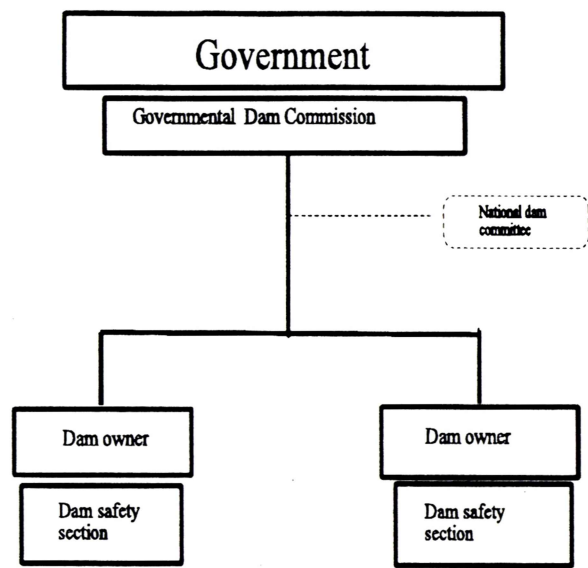
Dam safety in Tanzania is not satisfactory. If no action is taken now we can expect catastrophes soon or later!

**Remarks item 1.0** It was observed that there is no legal framework in Tanzania to ensure safe dams. Dams are designed, constructed and operated in accordance with specifications the designers may wish to apply. No laws or regulations binding designers and dam owners to consider dam safety within the Tanzanian context. Workshop therefore proposed measures in subsequent items to be taken:

- Activity 1.1**
- \* The Government appoint this commission which should be built up of professionals from the Government itself, institutions and dam owners.
  - \* The Commission is rested with following main tasks:
  - \* Create groundwork for establishing a legal framework that will ensure safe dams.
  - \* The commission will be a temporary one and will cease to exist once its task is completed; it will culminate in the formation of permanent bodies.
  - \* Formation of a National Dam Committee which shall deal with all technical matters regarding dams.
  - \* Formation of an inspectorate section in the Ministry that will enforce dam safety laws, e.g. regulations and guidelines
  - \* Passing of laws, regulations through legislation bodies, e.g. Parliament

**Activity 1.2** In the process of establishing legal framework, reference to those applicable in other countries and/or in other sectors should be made, for sake of completeness. The frame work should contain laws, regulations and guidelines covering planning, construction and operation phases.

Activity 1.3                      The legal framework should in essence entail a kind of organization that shall ensure proper practice as far as dams safety is concerned. The following organization is foreseen to be appropriate:



Clear tasks and responsibility shall be given to all those involved in dam safety work.

**Remarks item 2**                      The workshop observed that there is qualified manpower in Tanzania to undertake dam safety works; it only need to be organized. Some recommendations on this are as follows:

Activity 2.1                      This committee shall be a technical body, that deals with technical issues in respect of dams; this will be established by law and will draw members from Govt., professional institutions and dam owners.

Activity 2.2                      Efforts shall be made to join international organizations which have concern on dams, e.g. ICOLD. These serve as forums for up to date information on developments in fields related to dams. Membership is normally possible, once a National Committee is legally formed/or assumes a legal status.

Activity 2.3                      To ensure proper monitoring and surveillance of dams. It is proposed that the following competence levels be established within an organization:

- \* Local staff - Local staff should be trained and assigned to do routine work which is clearly defined.
  
- \* Head Office Section -

- to do special surveillance and monitoring works;
- to analyze data from site and decide on any steps that might be required to be taken.
- to decide on problems that must be referred to specialists outside the organization.
- to update programmes depending on observed developments

Activity 2.4      A complete version of Training Aid for Dam Safety ( TADS ) was handed over to Tanesco during the workshop including videos. This enables Tanesco to carry out training in all relevant dam safety topics. A systematic utilization of TADS should start as soon as possible.

Activity 2.5      Certification of safety personnel at all levels within the dam owners organizations should start as soon as possible. This will serve as a motivation factor as well as a increased awareness and quality of work.

**Items 3.0, 4.0 and 5.0 See reports from site visits/presentations**

#### **Remarks item 6**

Activity 6.1      It was generally recommended that training internally (utilizing Tanzanian resources) and abroad (through internationally organized workshop) is needed, at different competence levels to improve efficiency and also motivate the workers who are responsible for dams.

- When new dams are planned, involvement of personnel who shall take care of such dams should be from the early beginning (esp. for large dams).

Activity 6.2      Proper working gear and facilities are needed to motivate workers; through motivation people can feel the importance of their work/responsibility and hence strive to do it well.

Activity 6.3      Procedure must be established for communicating information, e.g. observations from site have to be sent to a higher level (known). Proper storing facilities for drawings, reports, surveillance data must also be established. At NyM this is ergant.



## 5.2 RESERVOIR SEDIMENTATION

### Summary

The most important finding is that there is no monitoring of either reservoir volumes or sedimentation rates in any of the larger and important reservoirs in Tanzania. This means that the present volume of the hydro power reservoirs and water supply dams and their life time is unknown. This must be characterized as a serious situation regarding both today's and future water resources management and planning. Another issue of great concern is the lack of systematic and good quality discharge and sediment transport monitoring.

In order to achieve proper routines on reservoir monitoring and maintenance, the lines of responsibility and finance are fundamental. In Tanzania, the dam owner has the responsibility of maintenance, while MAJI is responsible for hydrological (including sediment transport) monitoring. The hydropower reservoirs of Kidatu, Mtera and Pangani are owned by TANESCO while Nyumba ya Mungu is owned by MAJI. TANESCO is registering daily water levels in their reservoirs, however, other kinds of hydrological monitoring is left to MAJI.

Even if TANESCO and MAJI both are organized under the Ministry of Water, Energy and Minerals, MAJI seems to be in a bad financial situation to carry out their hydrological assignments in a satisfactory way.

There is a hydrometric network in Tanzania, including both run off stations and sediment transport stations. The majority of these stations are either not running or in a bad condition due to priorities and lack of finance within MAJI. However, there exist hydrological background data, which could be of use regarding future monitoring.

The situation today is that TANESCO is in a better position than MAJI to carry out the monitoring necessary in order to optimize the run of their powerplants. However, MAJI employs the hydrologists and the field technicians trained in hydrological measurements.

Reservoir sedimentation monitoring is non existent in Tanzania, including the large amount of water supply reservoirs. Instead of accumulation surveys, the sedimentation rates in use alter between 0.5 - 1 % of the volume per year. This must be characterized as a conservative and rough estimate, most probably not reflecting the real situation. Reservoir sedimentation results from upstream erosion, which will differ in time due to climatic variations and catchment management.

The table below, which presents the resolutions, summarizes the main conclusions and the recommended activity plan in order to improve the situation.

| Item no. | Item (goal)   | Proposed Activity no. | Proposed Activity  | Proposed Responsible institution(s)                              |
|----------|---|-----------------------|--|--|
| 1.       | <b>Legal framework to establish guidelines for Reservoir sedimentation, inflow and water balance monitoring</b> | 1.1                   | Establishment of a Commission in the Ministry  | * MAJI<br>* The Ministry of Water, Energy and Minerals           |
|          |   | 1.2                   | Accommodate laws, regulations and guidelines for sustainable and environmentally sound planning, approval and operation of artificial water reservoirs | * The Ministry of Water, Energy and Minerals<br>* The Commission |
|          |   | 1.3                   | Establish an independent governmental body to approve the applications, control the regulations and give supervision                                   | * The Ministry of Water, Energy and Minerals<br>* The Commission |
|          |   | 1.4                   | Approval of the laws, regulations and the guidelines   | * The Government of Tanzania                                     |
| 2.       | <b>To ensure the required competence within Tanzania</b>  | 2.1                   | Establish a national hydrological competence centre  | MAJI   |
|          |   | 2.2                   | Start training at all levels within MAJI and TANESCO   | MAJI/TANESCO   |
|          |   | 2.3                   | Improve the monitoring and analyses routines within MAJI   | MAJI   |
|          |   | 2.4                   | Make MAJI financially in the position of handling their hydrological obligations   | MAJI/The Ministry of Treasure                                    |
|          |   | 2.5                   | Establish contacts and cooperation with relevant national institutions   | MAJI   |
|          |   | 2.6                   | Establish international contacts   | MAJI   |

| Item no. | Item (goal)   | Proposed Activity no. | Proposed Activity  | Proposed Responsible institution(s) |
|----------|---|-----------------------|--|-------------------------------------|
| 3.       | Improve the organization in order to implement satisfactory monitoring of the water resources | 3.1                   | Establish field units  | MAJI/TANESCO                        |
|          |   | 3.2                   | Establish clear lines of responsibilities                                  | MAJI/TANESCO                        |
|          |   | 3.3                   | Establish quality control system   | MAJI/TANESCO                        |
|          |   | 3.4                   | Establish systems to ensure financial income                               | MAJI/Ministry of Treasure           |
|          |   | 3.5                   | Allocation of sufficient financial resources to the local/regional offices | MAJI/TANESCO/Ministry of Treasure   |
| 4.       | Implementation of a programme on reservoir sedimentation and water balance monitoring         | 4.1                   | Establish a programme on reservoir sedimentation                           | TANESCO/MAJI/Damowner               |
|          |   | 4.2                   | Establish a monitoring programme on sediment transport                     | TANESCO/MAJI/Damowner               |
|          |   | 4.3                   | Establish a programme on water balance                                     | TANESCO/MAJI/Damowner               |
|          |   | 4.4                   | Upgrade and renew instruments and equipment                                | MAJI/TANESCO/Damowner               |

### Remarks Item 1

- Activity 1.1      The Commission should be established as soon as possible in 1995. The objective is to suggest legislation regarding hydrological and reservoir sedimentation monitoring in order to improve the management of the water resources. Members of the Commission should include the most important water users as well as the Ministry.
- Activity 1.2      The Commission should start this work as soon as possible in 1995 and finish within 1996. The assignment must include clarification of responsibilities regarding reservoirs on sedimentation and hydrological monitoring - MAJI or Damowner. Should be possible to get inputs from other countries.
- Activity 1.3      The Commission has to include the subject in their work and come up with a suggestion within 1996.
- Activity 1.4      As soon as possible when the Commission come up with their recommendations. Due to the critical water resources and energy situation in Tanzania, the legislation should be approved within June 1997.

**Remarks Item 2**

- Activity 2.1 This organization should be established within MAJI, and the planning should start immediately. Hydrological data collection, analyses, services and supervision are the main objectives.
- Activity 2.2 To start immediately in 1995. Important issues are: motivation and understanding of the value of monitoring, hydrological and technical training.
- Activity 2.3 To start immediately in 1995. All monitoring routines should be evaluated in order to improve the organization
- Activity 2.4 The work should start immediately in 1995 by calculating cost/benefits of MAJI's assignments in order to come up with sources of sufficient financing. Put a price on hydrological services from "the hydrological centre". Part of this work can be assigned the Commission
- Activity 2.5 Immediate contact should be made to educational institutions, technical schools and universities in order to utilize common resources
- Activity 2.6 Improve the possibilities of international contacts by membership in organizations like IAHS, UNESCO, WMO etc.

**Remarks Item 3**

- Activity 3.1 TANESCO is under way establishing a unit. Possibilities of MAJI to cooperate or establish their own field units should be evaluated within 1995.
- Activity 3.2 Legislation and regulations will draw the superior lines. Additionally, there should be worked out clear lines of responsibilities at all levels within the organizations. This work should start immediately in 1995.
- Activity 3.3 Internal and external quality control systems should be established as soon as possible.
- Activity 3.4 Introduction of i.e. "payment for hydrological services" and "water user's fee" requires organizations to: monitor and calculate the abstraction of water, decide the size of the fees, control the payments and the cash flow. There are systems collecting fees i.e. PBWO, Mindu dam - water supply.
- Activity 3.5 A working group should be appointed early in 1995, handling 3.4 and 3.5.



**Remarks Item 4**

- Activity 4.1      Start planning and implementation of a programme covering the hydro power reservoirs within 1995. Key words are: Choice of methodology, proper planning, training, field unit, documentation and reporting.
- Activity 4.2      Start planning and implementation of a programme covering the hydro power reservoirs within 1995. The programme must concentrate on a few and high quality stations. Number and location must be decided in concurrence with 4.1. Suspended and bed load should be measured on a regularly basis over at least a 5-years period.
- Activity 4.3      Start planning and implementation of a programme covering the hydro power reservoirs within 1995. The programme must concentrate on a few and high quality stations. Number and location must be decided in concurrence with 4.2. Inflow in the major rivers, evaporation and runoff through the power station and the spillway must be included.
- Activity 4.4      A rehabilitation programme should be started up as soon as possible in 1995. Maintenance and calibration should preferably be done by domestic resources like universities, private or public firms/institutions.

# APPENDICES

## APPENDIX 1

TOPIC: WORKSHOP PARTICIPANTS

## APPENDIX 1; WORKSHOP PARTICIPANTS

| PARTICIPANTS      | ORGANIZATION        | JOB TITLE/PROFESSION              |
|-------------------|---------------------|-----------------------------------|
| BOBY, M.H.        | PFRP/HALE           | LAND SURVEYOR                     |
| CHAGGAMA, Y.N.K.  | TANESCO/DPDC        | CIVIL ENGINEER                    |
| FARAJI, S.        | MAJI                | SENIOR HYDROLOGIST                |
| HUSEBYE, S.       | NVE                 | SENIOR WATER RESOURCES ENG.       |
| IKWASA, A.O.      | TANESCO/MTERA       | C. W. SUPERVISOR/CIVIL TECHNICIAN |
| JOSEPH, J.        | TANESCO/DCPR        | RESEARCH ENG/CIVIL ENG.           |
| KABADI, J.I.      | TANESCO/DCPR        | MECHANICAL ENGINEER               |
| KABAKA, K.        | TANESCO/PFRP        | SEN. GEOLOGIST                    |
| KAMANGA, A.G.     | TANESCO/NYM         | GENERATIONS SUPT.                 |
| KAMUGISHA, S.M.   | MWEM/PBWO           | HYDROLOGIST                       |
| LEMA, F.M.        | TANESCO/HALE        | GENERATION SUPT.                  |
| LUHUMBIKA, B.A.S. | PBWO                | PROFESSOR                         |
| LUTEGANYA, K.     | TANESCO             | CHIEF CIVIL ENGINEER              |
| LYARUU, J.M.      | TANESCO/KIDATU      | MAINTENANCE MANAGER/EL.ENG.       |
| MAKUNGANYA, S.M.  | PFRP/HALE           | CIVIL TECHNICIAN                  |
| MASANJA, F.W.     | MAJI                | SEN. HYDROLOGIST                  |
| MDIBALEMA, G.H.   | TANESCO/DPDC        | QUANTITY SURVEYOR                 |
| MINDE, V.B.       | TANESCO/KIDATU      | QUANTITY SURVEYOR                 |
| MKUCHU, S.G.      | MWEM-DSM            | PRINCIPAL W. OFFICER/C. ENGINEER  |
| MSINDAI, K.A.     | GEOLOGY/UDSM        | DR./ENGINEERING GEOLOGY           |
| MTALO, F.         | UDSM                | WATER OFFICER                     |
| MUHAMBA, O.K.     | PFRP/HALE           | LAND SURVEYOR                     |
| MULABA, D.        | IRRIGATION DIVISION | IRRIGATION ENGINEER               |
| MWASHA, D.        | IRRIGATION          | IRRIGATION ENGINEER               |
| N'GULA, D.        | TANESCO/DCPR        | MANAGER RESEARCH/HYDROLOGIST      |
| NDESYAMOKI, M.    | TANESCO/DPDC        | QUALITY SURVEYOR                  |
| NGAIZA, A.M.      | TANESCO/MTERA       | SENIOR ELECTR. SUPERVISOR         |
| RJMTEMU, E.       | M.A./IRR.DEPT.      | CIVIL/EXECUTIVE ENGINEER          |
| RWEYEMAMU, F.     | MAJI                | ASSISTANT EXECUTIVE ENG. (CIVIL)  |
| RYBAGOMYA, C.L.   | TANESCO/PHS.PFRP    | CIVIL ENGINEER                    |
| TORBLAA, E.J.     | NVE                 | CIVIL ENG.                        |

## APPENDIX 2

TOPIC: PRESENTATION PROGRAMME



## APPENDIX 2; PRESENTATIONS

| Topic/Activity   | Speaker |
|--|---------|
| General Introduction (Day 1)                               | DN      |
| Welcome Address  | BN      |
| Intro. Dam Safety  | KL/ET   |
| <i>DAM SAFETY (Day 1)</i>                                  |         |
| Legislation in Tanzania                                    | SM      |
| Legislation in Norway                                      | ET      |
| Dam types  | FM      |
| Dam failures   | ET      |
| Instrumentation of dams                                    | ET      |
| Surveillance program - Mtera                               | AI      |
| Surveillance program - Kidatu                              | JL      |
| Surveillance program - NyM                                 | CR      |
| Surveillance program - P/Falls                             | CR      |
| <i>RESERVOIR SEDIMENTATION (Day 2)</i>                     |         |
| Introduction   | DN/SH   |
| Reservoir sedimentation - importance of monitoring         | SH      |
| Sediment Monitoring in TZ - network                        | SF      |
| Sediment Monitoring in TZ - competence                     | FM      |
| Sediment Monitoring in TZ - situation in dams              | SF      |
| Sediment Monitoring - Methodologies                        | SH      |
| Irrigation Dams  | DM      |
| Pangani River Basin Water Management                       | BL/SK   |
| Field trip to Korogwe - river flow & sediment measurements | PBW()   |

### ABBREVIATIONS:

AI: A. IKWASA - TANESCO  
 BL: B. LUHUMBIKA - MAJI, PBWO  
 BN: B. NJOMBE - TANESCO  
 CR: C. RYBAGOMYA - TANESCO  
 DN: D. NGULA - TANESCO  
 DM: D. MWASHA - MA&LD, IRR. DEP.  
 ET: E. TORBLAA - NVE  
 FM: F. MTALO - UNIVERSITY OF DAR ES SALAAM

JL: J. LYARUU - TANESCO  
 KL: K. LUTEGANYA - TANESCO  
 SF: S. FARAJI - MAJI  
 SH: S. HUSEBYE - NVE  
 SK: S. KAMUGISHA - MAJI, PBWO  
 SM: S. MKUCHU - MAJI