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**Special Study on Sediment Discharge
and Its Consequences (SedSS)**

Technical Report Number 13

KIGOMA WATER MASTER PLAN
(NORAD, 1982)-REPORT ON THE VOLUMES
OF THE PLAN HELD BY THE LAKE
TANGANYIKA BIODIVERSITY PROJECT

by
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1998

**Pollution Control and Other Measures to Protect Biodiversity in Lake
Tanganyika (RAF/92/G32)**

**Lutte contre la pollution et autres mesures visant à protéger la biodiversité du
Lac Tanganyika (RAF/92/G32)**

Le Projet sur la diversité biologique du lac Tanganyika a été formulé pour aider les quatre Etats riverains (Burundi, Congo, Tanzanie et Zambie) à élaborer un système efficace et durable pour gérer et conserver la diversité biologique du lac Tanganyika dans un avenir prévisible. Il est financé par le GEF (Fonds pour l'environnement mondial) par le biais du Programme des Nations Unies pour le développement (PNUD)''

The Lake Tanganyika Biodiversity Project has been formulated to help the four riparian states (Burundi, Congo, Tanzania and Zambia) produce an effective and sustainable system for managing and conserving the biodiversity of Lake Tanganyika into the foreseeable future. It is funded by the Global Environmental Facility through the United Nations Development Programme.

Burundi: Institut National pour Environnement et Conservation de la Nature
D R Congo: Ministrie Environnement et Conservation de la Nature
Tanzania: Vice President's Office, Division of Environment
Zambia: Environmental Council of Zambia

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KIGOMA WATER MASTER PLAN (NORAD, 1982)

Report on the volumes of the plan held by the Lake Tanganyika Biodiversity Project

This report is a revision of that produced by the author on behalf of the SedsSS in January 1999, in the light of the acquisition by the Lake Tanganyika Biodiversity Project of additional volumes of the Kigoma Water Master Plan.

The following nine volumes of the final report of the “Kigoma Water Master Plan” (NORAD, 1982) are held by the Lake Tanganyika Biodiversity Project:

‘Part I of the Plan: Plan Overview.’

- Volume 1 – Executive Summary.
- Volume 2- Water Development Atlas.

Intended user groups:

- *Policy/decision makers.*
- *All users.*

‘Part II of the Plan: Plans Proposed for Implementation’.

- Volume 3 - Water Supply Planning, Kigoma District.
- Volume 6- Water Development in Kigoma Region.

Intended user groups:

- *Administrators within aid organisations.*
- *Executive technical staff.*
- *Staff in operational positions at national, regional and district levels.*
- *Village leaders.*

‘Part III of the Plan: Methods, Data, Analyses, Assessments’.

- Volume 7 - Hydrology.
- Volume 8 - Hydrogeology.
- Volume 9 – Water Quality.
- Volume 10 (in two parts) – Water Management and Utilisation.
- Volume 11 - Water Laboratory Operation.

Intended user groups:

- *Professionals.*
- *Others with interests in regional inventory aspects of the whole water field.*

A synopsis of the contents of each volume, with emphasis on those sections thought to be of most relevance to the project, is given below:

Volume 1 – Executive Summary

This volume summarises the main contents of the Kigoma Water Master Plan. It provides easy access to the most important findings, conclusions and recommendations contained in the other 10 volumes of the report. The text is simple and to the point and is illustrated by photographs. It contains summaries of:

- Background to the plan.
- Kigoma Region.
- The people of the region.
- The Water Master Plan.
- Water resources: surface water.
- Water resources: groundwater.
- Water quality.
- Water demand and water balance.
- Today's water supply.
- Water supply planning.
- Priorities for implementation.
- Financing the plans.
- Implementation, operation, maintenance and repair.
- Community participation and sanitation.
- Organisation and training.
- Other development potentials.
- The Water Master plan study team effort.

Volume 2 – Water Development Atlas

This volume compiles 15 high quality, colour maps of A2 size, giving detailed spatial information on:

1. Administrative divisions and infrastructure.
2. Population and livestock.
3. Existing water development (i.e. pre-1982).
4. Hydrological network.
5. Rainfall and evaporation.
6. Runoff.
7. Groundwater potential.
8. Conductivity (surface and groundwaters).
9. Turbidity (surface and groundwaters).
10. Fluoride and nitrate (surface and groundwaters).
11. Fecal coliforms (surface and groundwaters).
12. Fecal streptococci (surface and groundwaters).
13. Planned water supplies.
14. Water availability and demand.
15. Potential water development.

Volume 3 - Water Supply Planning, Kigoma District

This volume comprises completed village water supply planning forms without further explanation enclosed. Detailed explanations and information regarding the data presented in Volume 3 are contained in Volume 6. Data are provided for a total of 70 villages in the Rukwa and Kigoma Regions in the general format of:

1. A village information form which includes:
 - Basic village data
 - Physical features
 - Consumer projections
 - Demand estimate of water in m³/d
 - Present water supply/resources
 - Proposals for:
 - (i) New water supply scheme, or
 - (ii) Rehabilitation scheme, or
 - (iii) Augmentation scheme.
2. A form detailing the existing water supply system.
3. A form detailing the new water supply scheme, rehabilitation scheme or augmentation scheme as appropriate.
4. A village map at a scale of 1:50,000 (A4 size, good quality).

Also included is a special study of the Mkongoro Group Gravity Scheme (at time of writing under construction) which is located in the catchment of the River Luiche.

It should be noted that the information collated in Volume 3 represents the situation, “.....found by the WMP Planning Team during brief visits to the villages during 1980-81 as well as the cost and knowledge level existing at the time”.

Of the 70 villages covered in Volume 3, four (Nyamuli, Kaseke, Ilagala and Buhingu) are shown as having existing (i.e. in 1980-81) pumped water supply schemes with Lake Tanganyika as the source. A further eleven villages (Mwakizega, Kirando, Karago, Sunuka, Rukoma, Igalulla, Kalya, Kashagulu, Sibwesa, Zashe and Kigalye) are indicated as having *proposed* schemes to draw their water by pumping from the lake. Whether or not these proposals were implemented is not known.

Volume 6 – Water Development in Kigoma Region

This volume is intended for use with Volumes 3, 4 (not held) and 5 (not held). It is aimed at decision-makers, engineers, planners and technicians involved in the direct process of implementing the Water Master Plan. It is divided into chapters on: Planning of village water supplies, The presented plans and their use, Priority

selection and economic features of planning results, Approach to implementation and training. Financial programme, Community participation, Development needs and potentials, Specific project proposals, Improvements to the hydrometric network and services, Hydrogeological and geophysical services, Water quality surveillance, Sanitation and health.

Volume 7 - Hydrology

This volume is a significant source of hydrological data of relevance to the Lake Tanganyika Biodiversity Project. It is sub-divided into eight chapters and has ten appendices:

Chapter 1 provides a general introduction and emphasises that Volume 7 should be read in conjunction with Volume 2, "Water Development Atlas" (see above) which includes:

- Hydrological Network (Map No. 4)
- Rainfall and Evaporation (Map No. 5)
- Runoff (Map No. 6)
- Water Availability and Demand (Map No. 14)

Chapter 2 gives a short description of the Kigoma Region in terms of: topography, climate and hydrology (drainage network). *Chapter 3*, 'Meteorology', assesses climatological data from the five meteorological stations in Kigoma Region: Kigoma (established 1934), Kibondo, Kagera, Uvinza and Nguruka (all established 1976) and reviews the parameters measured at each (precipitation, radiation, wind, temperature, humidity and evaporation). *Note that several serious deficiencies that reflect on the accuracy of data were noted during the visits by NORAD staff. Generally observers were found to be inadequately trained.* Sub-sections of *Chapter 3* consider 'precipitation' and 'evaporation' in the region. Importantly these include listings of the 37 precipitation stations in Kigoma region [current as at 1981] and their record periods, a distribution map of annual rainfall, a graph showing the trend of annual precipitation with time at three stations and a map of annual potential evaporation. Monthly mean rainfalls for the ten stations having more than 15 years of records are also listed. The full sets of monthly and annual precipitation data are listed in Appendix 7-E (see below).

Chapter 4, 'Discharge', describes the 12 stations of the hydrometric network: six in the Malagarasi catchment, four in the Luiche catchment and one in each of the catchments of the Rivers Luegele and Lugufu. Information is given on the number of water discharge measurements taken during 1980-81 together with remarks on the quality of the rating curves at the various gauging stations. Discussion of extreme discharges and flow duration is incorporated. *Chapter 5* considers water balance and runoff characteristics, providing, *inter alia*, estimates of the mean runoff: mean precipitation ratio (in %) at 11 gauging stations.

The important topic of sediment transport by rivers in Kigoma Region is considered briefly in *Chapter 6*. This chapter includes a tabulation of suspended sediment concentrations in the River Luiche (data from 19 samples collected between November 1980 and March 1981) with corresponding discharges and sediment transport. Similar data are presented for the Rivers Lugufu (6 samples), Luegele (7 samples) and Mkuti (2 samples). Suspended sediment discharge rating curves (i.e. suspended sediment load v. discharge) are given for the Rivers Lugufu and Luegele and, perhaps of most significance to the project, for the River Luiche at Simbo, Station 4B9, which was reinstated by the project in 1997. In general, the number of samples is considered insufficient to calculate the annual transport for most of the rivers but estimates for the Luiche suggest that its annual transport for the two hydrological years 1978/1979 and 1979/1980, a wet and dry year, respectively, were 530, 000 and 110, 000 MT.

Chapter 7, 'Lake levels', briefly reports on fluctuations in the level of Lake Tanganyika through time, presenting data from Kigoma for the period 1951-1980 in terms of variations of monthly mean water levels. *Chapter 8*, 'Hydrological modelling', outlines the means by which monthly rainfall data can be used to simulate mean monthly runoff on the basis of a Norwegian conceptual model. Simulated and observed mean monthly discharge data for the River Luiche at Simbo (1975-1980) are compared in graphical form and considered to be "acceptable" except for a large deviation in April 1977. The model was consequently used to derive simulated monthly runoff figures for the River Luiche at Simbo and tabulated data from September 1933 to August 1980 are presented.

Volume 7 contains ten appendices, several of which contain data of potential significance to the project:

- 7-A Climatological statistics.
- 7-B Correlations between monthly rainfall totals at different stations
- 7-C Double mass analyses of rainfall
- 7-D Annual rainfall probability
- 7-E Monthly and annual precipitation
- 7-F Discharge rating curves and tables
- 7-G Daily discharges and hydrographs
- 7-H Probability distribution of low flows and high flows of varying duration
- 7-I Flow duration curves
- 7-J References to the literature

The data from the four climatological stations established in 1976 are summarised (until 1980) in Appendix 7-A. Monthly and annual precipitation data for 39 stations are listed in Appendix 7-E. For many of the stations either brief or discontinuous data sets are available. Those ten for which records exceed 15 years are:

Station No. Name

- 93.3000 Kibondo Mission

- 93.3005 Kibondo Agricultural Station
- 94.2900 Mulera Mission
- 94.2902 Ujiji Mission
- 94.2904 Kigoma Meteorological Station
- 94.2906 Heri Mission
- 94.2907 Nkalinzi
- 94.3000 Kasulu
- 95.3000 Uvinza Salt Mines
- 95.3003 Inyonga Mission

Of the above, particularly long (and valuable?) records are available for three stations:

- 94.2904 Kigoma Meteorological Station:
January 1931-December 1980 (continuous monthly data).
- 94.3000 Kasulu:
January 1922-December 1980 (data breaks in some months of 1952, 1957, 1958, 1959, 1962, 1966, 1967, 1969, and 1973; no data for 1960, 1968 or 1971).
- 95.3000 Uvinza Salt Mines:
January 1928-December 1974 (data breaks in some months of 1955, 1956 and 1959; no data for 1954).

Appendix 7-D presents log-normal distribution graphs of annual rainfall probability for six stations: Kigoma Meteorological Station, Kibondo Agricultural Station, Mulera Mission, Kasulu, Uvinza Salt Mines and Inyonga Mission.

The discharge rating curves and tables of Appendix 7-F comprise data from 12 gauging stations (daily discharges and hydrographs are given in Appendix 7-G) including three on the River Malagarasi and two on the River Luiche. Of the latter, that from Station 4B9 at Simbo (reinstated by the project in 1997) is based on 135 discharge measurements between May 1975 and January 1981 and is deemed to be “acceptable”. The graphs of Appendix 7-H, probability of low flows and high flows of varying duration (log-normal distribution), relate to six gauging stations including 4B9 on the River Luiche. Flow duration curves (i.e. daily discharge v. % of time; providing maximum, mean and minimum discharges) are provided for 11 gauging stations (Appendix 7-I) again including 4B9 at Simbo.

Volume 8 - Hydrogeology

This volume describes the hydrogeology of the Kigoma Region by means of a geological review of the area. It should ideally be read with Map No. 7 “Groundwater Potential”, which is included in Volume 2 of the Kigoma Water Master Plan (not held). Volume 8 fulfils two objectives: (i) a synthesis of all findings into a single map with quantification of the groundwater occurrences giving both the hydrogeologist and the planner ready access to knowledge (as at 1980/81) of the hydrogeological

conditions in Kigoma Region, and (ii) presents all collated data. There are five chapters in Volume 8:

Chapter 1 describes the geology of the area: the age and structure of the Lake Tanganyika rift, relationships between tectonics and drainage, and details the stratigraphic succession. Useful diagrams are included. *Chapter 2*, 'Water well drilling: discussion of data and methods', incorporates a review of drilling methodology. Significantly, it includes a table (Table 8-2.1) presenting a Borehole Catalogue of the Kigoma Region, 1933-1981 (this lists borehole number, bedrock or overburden type, locality, total depth, static water level, yield, drawdown and total dissolved solids in the water). Details of drilling investigations in the various parts of the Kigoma region are presented. *Chapter 3* reviews the aquifers of the study area (bedrock and overburden) and their distribution, dividing the area into 'hydrogeological provinces'. Useful maps and cross-sections are included. Appropriate drilling methods for each of the defined provinces are discussed together with programmes of groundwater monitoring. Landsat imagery (as compared with aerial photographs) is briefly considered as a tool for groundwater prospecting. *Chapter 4*, 'Field investigations', considers applied geophysical methods in groundwater exploration (resistivity, seismic refraction and well logging) and water well drilling using light and heavy equipment. *Chapter 5* provides supplementary information, in particular explanatory notes for the Groundwater Potential Map, a useful glossary of terms used in the volume and a good bibliography.

A series of five appendices to Volume 8 includes: borehole logs, location maps (1:50,000 Scale, A4 size, good quality) and pump test data (Appendix 8-B) and shallow investigation logs and location maps (Appendix 8-C).

Volume 9 – Water Quality

This volume is a comprehensive collation of the water quality data and provides a characterisation of the water resources of the Kigoma Region, together with recommendations for the application of water quality standards and treatment procedures. It should be consulted in conjunction with Volume II, which includes (see above) illustrative maps showing quality characteristics of the Kigoma Region's water resources.

Volume 10 – Water Management and Utilisation

This volume is largely concerned with 'non-water resources' aspects. It synthesises the technical potential of the Kigoma Region and the likely results of the envisaged water developments outlined in Part II of the plan. The subdivision by chapters is as follows: Introduction, Socio-economic aspects, Population, Livestock, Institutions, industry and infrastructure, Water supply in Kigoma Region, Background to water supply development proposals, The regional organisation, Manpower and training, Proposed operation, maintenance and repair organisation, Agriculture and irrigation, Hydropower and energy, Water control and miscellaneous water users, water demands, allocations and balances, Limnological features of lakes. The latter chapter,

though not apparently part of the brief of the NORAD project, is brief but useful. It principally collates limnological information about Lake Tanganyika relating to water quality. It reviews the literature on these aspects and reports on a limited programme of water quality sampling.

Volume 11 - Water Laboratory Operation

This volume is the final of the series of reports in the Kigoma Water Master Plan. It takes the form of a 'handbook' of analytical techniques for laboratory personnel in Rukwa and Kigoma regional laboratories. Most of the references cited are Norwegian publications but the methods described (see below) are usually in accordance with the Standard Methods for the Examination of Water and Wastewater. Five chapters are incorporated which cover the following:

1. General laboratory routines:
 - Day-to-day routines.
 - Rinsing of water sample bottles and glassware in a laboratory.
2. Sampling:
 - Sampling techniques for chemical, physical and bacteriological examinations of water.
3. Analytical procedures:
 - Chemical and physical analyses (pH, colour, EC, turbidity, permanganate value, total hardness, suspended solids).
 - Bacteriological examination of water.
4. Analytical quality control (precision, accuracy etc.).
5. The Sumbawanga and Kigoma laboratories.

R W Duck (revised August 1999)