NIVAREPORT

International Activities

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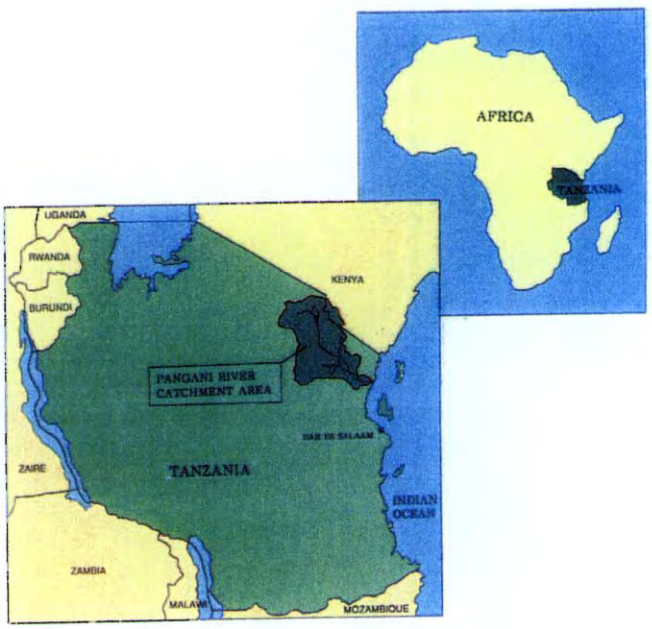
Water resources management in Tanzania

Pangani river catchment



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Abstract: The need for a well functioning water resources management system in Tanzania is essential for further development of the country. The poorly developed water resources management combined with a fast growing population and industry, increased agriculture- and hydropower production cause uncertainty and conflicts for the potential use of the water in the future both with respect to quantity and quality. NIVA has carried out a project in Tanzania, with a focus on Pangani Basin, to study 1) the water resources management at the central, regional and local level and 2) the water quality- and pollution problems, user interests and conflicts among the user groups. The major conflict in Pangani is between irrigation and hydropower production. The abstracted water for different purposes is far exceeding the demands, due to low efficiency in the traditional furrows and misuse of water. The users impact on the environment are also causing conflicts in the basin. Outlets of municipal waste water and waste water from industry are in conflict with downstream users and makes the water unsuitable for other purposes, especially for drinking water, irrigation of crop and food and beverage industry. A cost efficient pollution action plan should be prepared, and there is need for a regular water quality monitoring program. Re-organising of the water recources management is necessary for clear responsibility, avoid double work and to improve co-operation and co-ordination between departments which are involved. Other accompanying measures can also be implemented in the Tanzanian Water Resourses Mangement system to reduce the conflicts between the user groups.

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For the Administration

Dag Berge

Preface

Two researchers at the Norwegian Institute for Water Research (NIVA), Kjersti Dagestad and Leif Lien, have undertaken a study in Tanzania with focus on Pangani Basin. The study was carried out during a mission to Tanzania in May 1995. The main objectives of the study have been to: 1)investigate the water resources management at the central, regional and local level and 2)study, water quality- and pollution problems, user interests and conflicts among the users.

The project has been financed by a scholarship provided by the Norwegian Research Council (NRC) and NIVA, in order to improve the competence of Norwegian Environmental Scientists with regard to development aid co-operation. We thank the NRC and NIVA for this opportunity to improve our knowledge in this field, but we also hope that this study can contribute in increasing the knowledge of environmental impact and to solve some of the problems in Pangani Basin.

The project idea originated at a seminar in September 1993, based on a presentation held by Professor Terje Simensen working at The University of Trondheim/Centre for Environment and Development. The project proposal was prepared by Hans Olav Ibrekk, who at that time was working at NIVA.

We want to give special credit to Ove Rusten, Brian Glover, Are Bjørn Ovanger and Sten Hernes working at Norplan's offices in Norway, Dar es Salaam and in Pangani Falls, for being very helpful and generous to us in carrying out this study. Alf Adler at NORAD in Dar es Salaam has also helped us with the organising of the study, provided us with the necessary information, and taken his valuable time to patiently answer all our questions.

We are also very grateful and we convey a special and personal thank to the employees at Pangani Basin Water Office; B.A.S. Luhumbika, S.M.Kamugisha, J.Z. Riwa, Y.M.K. Ngoma and Senior Advisor Jon Einar Værnes. They have all been very co-operative from the start of the project, and gave us a lot of practical help and increased our knowledge of the problems in Pangani. This study could not have been carried out without their assistance.

The support from the Acting Principal Water Officer G.K.M. Shirima and the recently appointed PWO, J.M.Kobalyenda, have also been very valuable. G.K.M Shirima very efficiently arranged meetings with central authorities, and J.M. Kobalyenda gave us a lot of useful information and comments on a preliminary draft of the report.

Finally our thanks go to J.A.Mukumwa, J. Sarmett and J. Nasari at the Regional Water Engineer offices in Tanga, Kilimanjaro and Arusha for arranging field trips to the pollution sources sites in the regions, and all others we met during our mission and who shared their knowledge with us.

Oslo, August, 1995

Kjersti Dagestad
Leif Lien

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LIST OF ABBREVIATIONS

BOD-Biological Oxygen Demand

COD-Chemical Oxygen Demand

DANIDA-Danish International Development Agency
DC-District Commissioner
DED-District Executive Director

EIA-Environmental Impact Assessment

LAC-Land Advisory committees

MALD- Ministry of Agriculture and Livestock Development
MH-Ministry of Health
MLHUD-Ministry of Lands, Housing and Urban Development
MTNE-Ministry of Tourism, Natural Resources and Environment
MWEM-Ministry of Water Energy and Minerals

NEMC- National Environmental Management Council
NGO-Non Governmental Organisations
NIVA. Norwegian Institute for Water Research
NLUPC- The National Land Use Planning Commission
NOK- Norwegian Kroner
NORAD-Norwegian Agency for International Development
NyM- Nyumba ya Mungu reservoir

PBWB-Pangani Basin Water Board
PBWO-Pangani Basin Water Office
PFRP-Pangani Falls Redevelopment Project
PWO-Principal Water Officer

RC-Regional Commissioner
RH - Regional Hydrologist
RIE-Regional Irrigation Engineer
RWE-Regional Water Engineer
RWRA-Rapid Water Resources Assessment

TANESCO-Tanzania Electric Supply Company
TOC-Total Organic Carbon
Tsh-Tanzanian shilling

WB- World Bank
WRM-Water Resources Management
WW-Waste Water
WWTP-Waste Water Treatment Plant
WUA- Water Ultilization Act

ZID-Zonal Irrigation Department
ZIE- Zonal Irrigation Engineer

Executive Summary

The need for a well functioning water resources management in Tanzania is essential for further development of the country. The poorly developed water resources management combined with a fast growing population and industry, increased agriculture- and hydropower production cause uncertainty and conflicts for the potential use of the water in the future both with respect to quantity and quality.

NIVA has carried out a project in Tanzania, with a focus on Pangani Basin, to study 1) the water resources management on a central, regional and local level and 2) the water quality- and pollution problems, user interests and conflicts among the users.

The Pangani Basin is situated in north east of the country and drains into the Indian Ocean. Pangani river is the major river in the basin with a catchment area of 42 000 km^2. There are extreme variations in rainfall, surface runoff and water flow within the catchment, which are accelerating the conflicts between the users of water.

There are more than 2000 identified water users in Pangani river, and a major part of these have been abstracting water illegally. The number of illegal abstractions has decreased in the last years, and several water rights have been issued. Installation of control gates have also regulated the total amount abstracted water, but this is still considerable compared to the water flow in Pangani river, and the amount is far exceeding the actual demands due to low efficiency in the irrigation system and the misuse of water.

The major conflict in Pangani river is between irrigation and hydropower production, and this has also been the driving force in establishing Pangani Water Office (PBWO). Water for irrigation is abstracted upstream in the catchment, and the irrigation peaks are in the dry periods when the available water is at the lowest. This is not only causing conflict for hydropower production in the catchment, but also for other downstream users like; fisheries, other farmers and for water supply for domestic and industrial purposes. Both irrigation and hydropower interests want do develop the potential for further production, and the water demand for the fast growing population and industry will also increase. To be able to cope up with the present conflicts, to reduce the conflicts in the future, and to optimise the utilisation of water, it is necessary to control the existing abstractions and to develop tools for an efficient water resources management:

- The work which has already been undertaken very efficiently by PBWO and which has reduced the abstractions considerably, must continue like building of control gates, rehabilitation of traditional furrows, develop programs to improve the efficiency of irrigation schemes, creating awareness among farmers etc.

- A water resources management plan should also be prepared, and serve as a basis for issuing of new separate water rights.

The different users impact on the environment are also causing conflicts in the basin. Monitoring of the water quality in Pangani river has been scarce and ad hoc, but the few measurements taken together with the impression from the site visits, indicate an alarming situation due to polluted water. The pollution from municipal and industrial sources are dominant, and the total load from the agriculture sector seems to be rather low due to low consumption of fertilisers and pesticides. Local pollution from agriculture do however occur. The major pollution from agriculture is increased erosion. The main pollution of Pangani occurs in the upper part of the river in Moshi and Arusha, and the local effects on ecology and human health from industrial and municipal sources are obvious. The regional effects may be slightly less due to selfpurification in NyM and the

swamps. Outlets of municipal waste water and waste water from industry are in conflict with other downstream users and makes the water unsuitable for other purposes, especially for drinking water, irrigation of crop and food and beverage industry. Waste handling in the urban centres is also unacceptable. The fast growing population and the uncontrolled establishment of industries will be a major challenge in the future. Fertiliser and pesticide consumption can also increase, and one should be aware of the problems which may occur.

Other environmental impacts from the agriculture sector, are the impacts caused by irrigation. Salination of the soil and increased ground water level, have already been observed for big irrigation projects in the basin. Both the hydropower production and irrigation change the natural flow in the rivers, leaving little to no water left in the river during dry periods. This influence severely on both flora and fauna in the watershed and at the river bank.

To reduce the environmental impacts in Pangani river the following should be done:

- Prepare and implement a cost-efficient water pollution action plan (Some of the Hot spots in the region are; Sisal industry, untreated sewage from Moshi and Arusha, tanning industry, paper mill, match fabric, pesticide fabric, textile industry, fibre board production and brewery.
- Establish waste policies; separation of industrial and municipal waste and treatment of leakages.
- Pay an extra attention to drainage at the existing irrigation schemes, and incorporated environmental impacts in the planning of new projects in order to reduce the environmental problems.
- Establish regulations regarding minimum water flow in the rivers.

The technical measures to reduce the environmental impacts must be adapted to the local conditions, and be based on technology which can easily be operated and maintained in the area.

There are also some accompanying measures which can be implemented in order to reduce the conflicts in the basin and to improve the water management like:

- Establish discharge permits, regulating both flow and concentration according to downstream users, and implement emergency plans to use in case of accidents.
- Instruct the polluters to periodically control their effluent
- Establish control procedures for the authorities to check that discharges are kept within permission limits (both regular and unexpected)
- Establish stricter control at municipal waste water treatment plants for industrial effluent and impose pre treatment of industrial effluent.
- Review and update the Water Utilisation Act aiming at more efficient procedures regarding the process of fining polluters.
- Establish appeal procedures, allowing polluters to consult MWEM if they feel the Basin Board is acting unfairly.
- Establish EIA procedures, and secure that minimising of environmental impacts are a part of the total costs for new projects
- Increase the water user fees in order get an efficient tool against misuse of water
- Increase the pollution fines, and implement pollution fees.
- Develop water resources management plans with a strong connection to land use plans
- Establish processes for public participation in government decision making, including requirements of notification and an option to comment on plans and new projects.
- Increase environmental education and public awareness

- Undertake research to investigate the environmental impacts of different activities in the basin
- Establish a regular water quality monitoring program, the level of water quality monitoring is at present totally unacceptable.
- Improve laboratory facilities and procedures.
- Establish a program for collection and updating of necessary data, and improve the gathering and distribution of environmental data or other relevant information from the ministerial data base to regions and districts. Strengthen the co-ordination to avoid duplication of work.
- Improve the organisation of the water resources management (institutional strengthening), and improve the co-operation and co-ordination (see below).

The water resources management is fragmented, and many departments at many administrative levels are involved depending on the use of the water. The Ministry of Water Energy and Minerals (MWEM) has the overall responsibility for water issues, but the Ministry of Agriculture and Livestock Development (MALD), Ministry of Natural Resources, Tourism and Environment(MNTE), Ministry of Lands Housing and Urban Development(MLHUD) and Ministry of Health(MH) with their regional and district units are also involved.

The sectoral approach to the water management issues is resulting in unclear roles, overlapping responsibilities and a lack of co-ordination and co-operation. These problems both exists between MWEM and the other ministries, but also within MWEM. There is need for reorganising the water resources management system. PWO and PBWO are important in the work of clarifying the responsibilities in the water resources management system, but The Ministry of Tourism, Natural Resources and Environment has a cross sectoral approach to the management of the natural resources and should also be involved in this work.

Conflicts easily arise when the main responsibility for water resources management is organised within the Ministry where some of the biggest user interests are organised. To secure an independent and integrated approach, focusing on the water resources instead of the user interests, it may be more convenient to organise the water resources management within a "Ministry of Resources and Environment" and with a stronger connection to land use planning. The shift in responsibility is however a political question, and the study reported here has not been extensive enough to propose this type of changes.

At the present MWEM shall carry the overall responsibility for the water resource management in Tanzania. The Principal Water Officer position (under MWEM) should be strengthened to reflect its crucial role and status in the Government structure. The present "independent" or direct organisational link to the Principal Secretary should be maintained. Improved co-ordination and co-operation are however needed in the present system within MWEM and the other ministries. There should especially be a better co-ordination and co-operation with the MTNE(environmental policy and research), MLHUD (land use and water use planning), but also with the MH (rural sanitation) and MALD (improved efficiency for irrigation and creating of awareness of farmers).

Some of the water resources management problems mentioned above seems to have been solved by establishing basin boards and offices. The basin board and the basin office co-ordinate the activities in the basin and secure an integrated water resources management. In Pangani Basin, the office function well in their role of undertaking the overall responsibility for the water resources management. The institution is however young, and there is inadequate financial support from the Tanzanian Government, which has not fulfilled its obligations. This is causing some problems for the office to undertake the task they are suppose to, and the lack of funding has made the long term planning difficult. The office needs financial support, and need capacity building within water resource management, nature conservation, pollution and irrigation.

PBWO has a close co-operation and co-ordination with the regional water offices and their political leaders. PBWO do also co-operate very efficiently with the regional irrigation engineers, the zonal irrigation engineer, the regional hydrologists, district offices with their political leaders, local governments and users. The co-operation with the universities and NEMC should be encouraged.

1 Background

1.1 Need for improved Water Resources Management in Tanzania

The rainfall and runoff in Tanzania varies considerably, and the scarcity of water for different users has so far been the main concern and caused big conflicts among the user interests. Lack of water is not only a climatic problem, but it is also a result of poor water management and misuse.

There are also great variations in the water quality, due to the geological conditions and the activities in the areas. It has however been paid less attention to the water quality problems (except for water borne diseases), and the extent of the problems are not very well known. The existing data indicate however that the situation is alarming due to insufficient treated waste water from municipalities and industries. Agriculture is also a source to pollution.

In 1991 only 42 % in rural areas and 53.6% in urban areas, had access to safe and potable water supply (The World Bank, 1994). The number was in 1993 increased to 68% in urban areas (MWEM, 1995). It is however not only the drinking water supply which is suffering and will suffer under a bad water quality in the future, but also irrigation (crop production), fisheries, aquaculture, tourism and even hydropower production.

The poorly developed water resources management combined with a fast growing population and industry, increased agriculture- and hydropower production cause uncertainty and conflicts for the potential use of the water in the future, with respect to the quantity and the quality.

The need for a well functioning Water Resources Management System is essential for further development in the area. Organisation of the water resources management, allocation, regulation of water use, control of water pollution, comprehensive planning, registration/information, monitoring, research and education are some of the water management issues which need to be improved.

1.2 Objectives of the study and related studies

1.2.1 Objectives of "WRM in Tanzania-Pangani River catchment"

This study has been financed by a scholarship provided jointly by the Norwegian Research Council and the Norwegian Institute for Water Research (NIVA), in order to improve the competence of Norwegian Environmental Scientists with regard to development aid co-operation.

The main objectives of the study have been to;

1) investigate the water resources management at the central, regional and local level and
2) study , water quality- and pollution problems, different user interests and conflicts among the users (both with respect to water abstractions and water quality)

The Pangani Basin has been used as a case study with a focus on Pangani River.

It has not been within the frame of this project to propose a detailed action plan, but some measures and the need for further investigations are identified. The conclusions and recommendations do especially focus on water quality problems and pollution abatement. There

are however also pointed on several measures in order to improve the water resources management like the organisation of the WRM and institutional strengthening, legal framework (law, standards, criteria and regulations), economic tools and planning tools including monitoring and information. A monitoring program for water quality has been prepared.

The project team has carried out this study during a short time mission to Tanzania (03.May-25.May 1995) and the conclusions in the report are based on:

1) meetings with water resources management authorities (at the central-, regional- and local level), Norwegian Agency for International Development (NORAD) and enterprises (appendix 2),
2) site visits to several locations and several pollution sources sites in Pangani River from Hale to Arusha and,
3) literature from other studies which have been undertaken in the area.

1.2.2 Related studies

There are major conflicts between irrigation and hydropower production in the Pangani basin. Abstraction of water for different use has therefore been addressed the recent years in former studies (see literature list), and mainly as a result of Pangani Falls Redevelopment (PFRP). The PFRP project, with a capacity of 66 MW was constructed in the period 1991-1995 (700 mill NOK) with donor assistance from Norway (42%), Sweden (25%) and Finland (33%). The conflict between hydro power and other users has also been the driving force in establishing a Water Basin Board (Pangani Basin Water Office), and regulation of water use has so far been the main task of the office.

The water quality has not been studied in the whole basin, but as part of the EIA for PFRP (which only concern the new constructions around Hale), some water quality problems were considered (Stevenson, 1994). Otherwise only few reports have been prepared.

After the mission to Tanzania was accomplished and the study half reported we also got access to the report "Rapid Water Resource Assessment" volume I (main report) and II (basin report). The main report gives an assessment of the water resources in the whole country, while volume II addresses each of the basins (9 basins). The Rapid Water Resource Assessment study has been executed by a national team in Tanzania consisting of 11 experts with technical and financial support from the World Bank and DANIDA. RWRA is a comprehensive and cross sectoral study of the water resources management in Tanzania, but it originated as a part of a sector review (water supply and sanitation) within the water division in the Ministry of Water, Energy and Minerals. The project will continue with more detailed studies to improve the WRM in the basins.

The National Environmental Management council has also prepared an Environmental Action Plan which is currently under discussion in the Government and Ministries (MTNE, NEMC, 1994).

The main conclusions in these documents especially the RWRA study, and the main conclusions and problems defined in NIVA's study in Pangani river, are quite similar and call for actions in the area. RWRA and NIVA's study are undertaken independent of each other, but are in a certain extent overlapping. NIVA has however gone into more details in some of the issues in Pangani river, and the study reported here will be complimentary to the continuing of the RWRA project.

2 Brief description of Tanzania

Tanzania in East Africa is bordered by Kenya and Uganda to the north, Rwanda, Burundi, Zaire, and Zambia to the west, Malawi and Mozambique to the south and the Indian Ocean to the east (Figure 1).

The total population of Tanzania is estimated at 27,3 million (1990). With a total land area of 945,000 km^2 this gives a population density of nearly 30 persons /km^2. The population is growing fast and is estimated to 34 million by year 2000. The most heavily populated regions are in the north around lake Victoria and along the coastal belt to the Indian Ocean. 80% of the people live in rural areas and 20% in urban areas.

It is estimated that about 50 000 km^2 of land is under cultivation. Agriculture in Tanzania has played an important economic role, and more than 90% of the total population is considered to be dependent on agriculture either directly or indirectly. Coffee, sisal, cotton and tobacco are the major export crops of Tanzania , counting for about 70 % of the total exports. Maize and rice are the main staple food. Tanzania has not yet become self-sufficient.

The hydrological picture in Tanzania varies between the different regions, with heavy rainfall and a high specific runoff in the coastal areas and in the south western parts of the country. The climate is drier in the north, and the evaporation is much higher. The seasonal variations are also very high, and the rainy seasons are mainly during some of the winter months or in the spring.

Large part of the population live in areas with limited water resources. The main water users are domestic, industrial, irrigation, fisheries and hydropower production. At the end of 1993 about 50% of the whole population had access to clean and potable water supply, and the country's target is to provide the whole population with adequate water supply by the year 2002 (MWEM, 1995).

3 Pangani River Catchment

3.1 Key information

The administrative area of Pangani Basin is situated in the north east of the country and drains into the Indian Ocean. The basin consists of four rivers; Umba, Sigi, Msangazi and Pangani river. The total area of Pangani Basin is 56 300 km^2. Pangani River which is studied in this report dominates the basin with a catchment area of 42 200 km^2.

Figure 1 shows the catchment area to Pangani river. A detailed description of the upper parts of the catchment area is given in figure 3. The catchment covers three regions; Kilimanjaro, Arusha and Tanga. A small part is located in Kenya. The total catchment area in the different regions is shown in figure 2.

The climate in the catchment varies considerably, and the Pangani River Basin comprises several sub catchments of widely different characteristics. The upper parts in the slopes of Kilimanjaro and Mount Meru receive 1200-2000 mm rainfall per year, while the rest of the catchment area only receive about 500 mm/year. There are two distinct rainy seasons, the short one from mid October to December, and the long one from mid March to June.

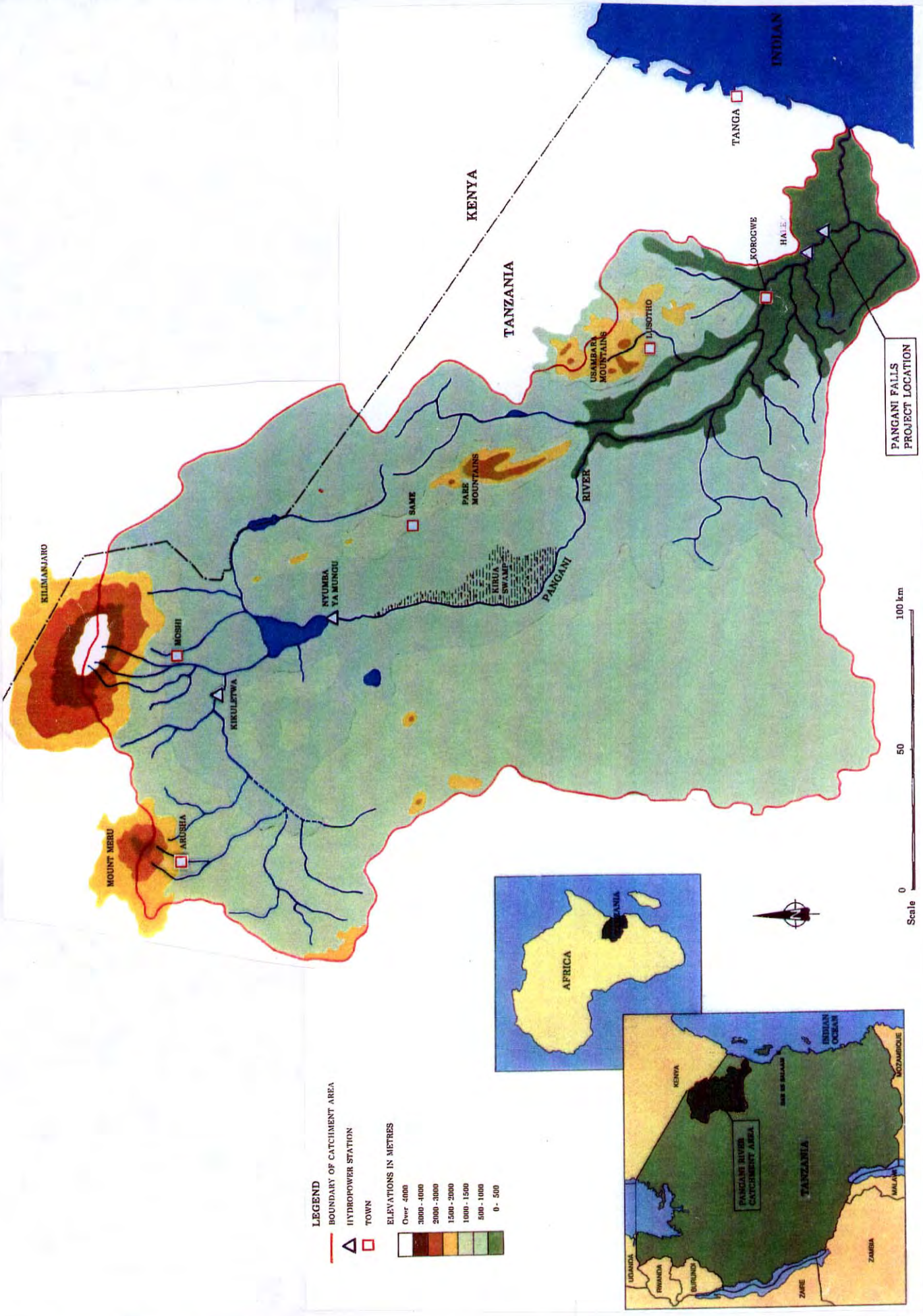

Figure 1: The Pangani River catchment (see also figure 15, chapter 6.5.1)

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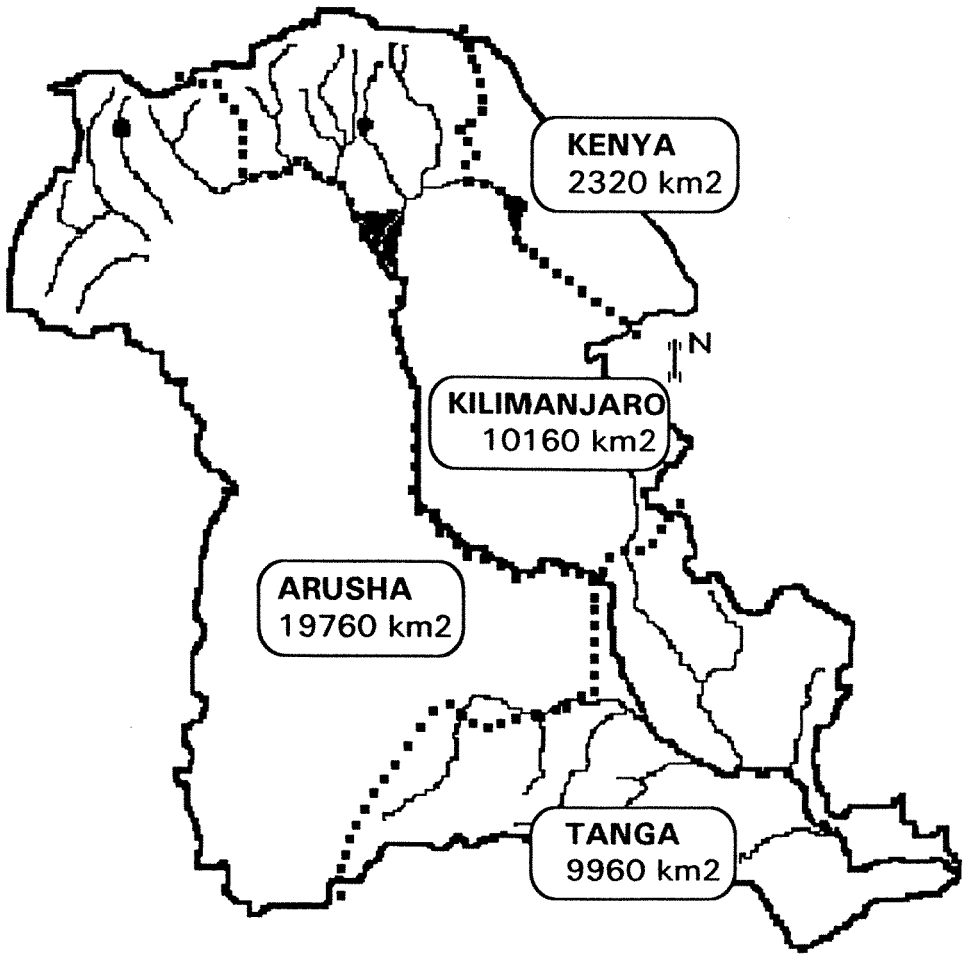

Figure 2: Pangani River's sub catchments

3.2 Water resources

3.2.1 Rivers

The major tributaries to Pangani River are in the Kilimanjaro and Meru mountains; Ruvu (originating from lake Jipe), Weru Weru, Kikuletwa, Rau and Kikafu (see figures 1, 3 and figure 15, in chapter 6.5.1). These rivers mingle together in the great man made reservoir in Nyumba ya Mungu (NyM), where the Pangani river gets its name. Downstream NyM the river is joined by the Mkomazi river from the south Pare and West Usambara mountains, and further east the Luengera river.

Due to the variations in rainfall the surface runoff do also vary considerably. The extreme variations in climate and water flow are shown in table 1, and partly based on information from MWEM, 1995 and The World Bank, 1994 chapter 9. The main part of the catchment area which is located downstream NyM contribute only a small part of the runoff.

Table 1: Variation in rainfall and flow in the sub catchment to Pangani River

Hydrological Zone	Catchm. area (km^2)	Rainfall (mm)	Mean flow (m^3/s)
Kikuletwa (above IDD54)	270	600-1200	14.4
Weru Weru, Kikafu and Karanga	280, south west of Kilimanjaro	800-1600	9.5
Rau & Mue	South of Kilimanjaro	800-2000	6.2
Himo, Ruvu and north Pangani*	East of Kilimanjaro	500-1200	13.3
Total upstream Nyumba ya Mungu (flow corrected for net abstractions) Total loss in NYM Release from NyM (regulated by the power plant)			43.4 ≅10 30.33
Pangani	13000, catchment between NyM and Pangani/ Mkomazi	500	5.0
Mkomazi and Mombo	3600 south Pare and west Usambara	600-1800	6.0
Luengera	845, south Usambara		3.8
Total accumulated downstream NYM without correction of net abstraction			45
Pangani at Hale after 1968			37

(Source; MWEM, 1995 and WB, chapter 9, 1994)

*A large part of the catchment area to Ruvu river is located in Kenya, about 50%, 2320 km^2, and makes Pangani river transboundary.

3.2.2 NyM

Nyumba ya Mungu is a reservoir situated between 679 and 688 m above mean sea level in the upper part of Pangani Basin. The surface area is 148.6 km^2 at the highest water level, and 20.25 km^2 at the lowest level. The volume of the reservoir is about 800 mill m^3. The annual mean inflow to NyM is about 40 m^3/sec, which give a theoretical retention period of 4 months with the reservoir half filled up. The annual average reservoir losses due to evaporation are estimated to 6 mm/day, which corresponds to approximately 10 m^3/s (150 km^2).

3.2.3 Groundwater

The main abstractions are from surface water (about 95%), but the remaining water is taken from groundwater sources. The groundwater is used for domestic, industrial and irrigation purpose. Irrigation is the main ground water user, and account for 80% of the total abstractions. There is a high potential for further abstractions (MWEM, 1995).

3.2.4 Swamps

There are two main swampy areas within the catchment to Pangani river, the Kirua and the Oligarwa Shambarai Swamp. The Oligarwa Shambarai Swamp is situated upstream NyM, and extents from Arusha to the Kilimanjaro area. Kirua swamp is located downstream NyM, and regulate the floods in Pangani river. The evaporation from the swamps is very high.

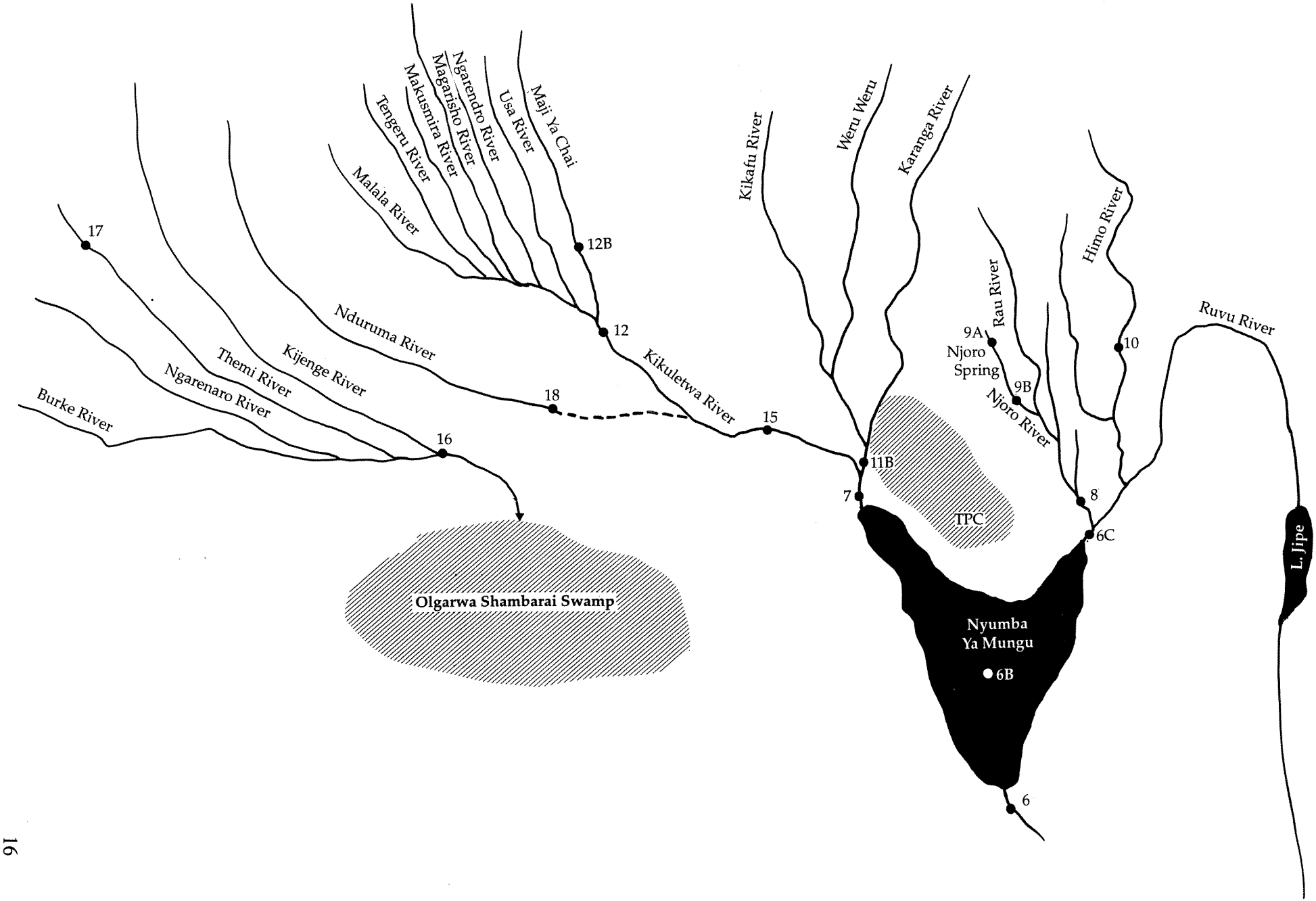

Figure 3: Water resources in the upper parts of the catchment area to Pangani River

3.3 Water quality in surface waters

3.3.1 Availability of data

Water pollution seem to be an increasing problem, and is causing problems both for private and public water supply, irrigation and other user interests. The water quality, do in addition to the activities in the area, also depend on the natural conditions like geology, rainfall and runoff. High concentrations of fluorides for instance, is a big problem in some of the rivers originating from Mt. Meru.

The extent of the water quality problems is not very well known. Monitoring of the water quality in Pangani River has been scarce and ad hoc, and it is only the physical and some basic chemical parameters which have been monitored. Measurements for heavy metals and pesticides do almost not exist. There is not done any comprehensive gathering of water quality data.

Some parameters are analysed in effluents from sisal factories and municipal WWTP together with the recipient quality upstream and downstream the discharges. Data sets do also exist from some of the industries in the catchment, and in addition water quality data from some drinking water supplies are available. Water quality data based on frequent sampling from drinking water sources are however difficult to obtain. The EIA study for Pangani Falls does also contain some water quality data from 1993 which indicate the present situation in the lower parts of the river.

Below is given a brief description of the physical and chemical water quality, based on very few data from Themi River, Njoro River and Pangani River.

3.3.2 Status and possible effects

Table 2 shows the water quality at different locations in the river for some of the parameters. Some of the parameters seem to be rather low, lower than expected with the known influence of pollution sources. This can be an indication of some uncertainty connected to the measurements.

Classification of water quality

The ecological effects of the above mentioned parameters depends very much on the natural water quality, and the natural level which might be expected in surface water (very roughly) are indicated in the table. Guidelines from WHO shows the acceptable level in order to protect humans from negative impacts.

Tanzania has also developed water quality criteria based on the use of the water. The recipient quality according to the use of the water is divided into three categories (The Water Utilisation Act, Amendment NO. 10 of 1981);

Category 1: Water suitable for drinking water supplies, swimming pools, food and beverage industries, pharmaceutical industries or industries requiring water of similar quality.

Category 2: Water suitable for domestic animals, in fisheries, shell cultures, recreation and water contact sports.

Category 3: Water suitable for irrigation and other industrial activities which do not require quality of category 1 and 2.

In table 2 category I in the Tanzanian system is used to indicate the suitability of the water.

Table 2: Water quality data from Themi, Njoro and Pangani River

Parameter	Themi River, up-stream	Themi river after WWTP	Njoro river Up-stream	Njoro River after infl. from WW	Pangani River, after Sisal Infl.	Pangani River, in average down-stream Korogwe	Natural (indi-cation)[2)]	Tanzania Category 1	Human Health (WHO)
pH	7.5	6.8	6.5	6.4	8.4	8.0	7[1)]	6.5-8.5	6.5-8.5
Turbidity(NTU)						479	1-1000		5
BOD_5, mgO_2/l	8	168	2.6	73	512			6	
DO(mg O_2/l)	8.5	4..3	8.7	0	4.2	9.0	8-15	6	
Nitrates (NO_3), mg/l	2.2	2.2				40	<22[3)]	50	44
Nitrites, mg/l						0.33	<0.003-3.3		
Ammonia(NH_4), mg/l						0.10	<0.023-3.9		
Phosphate ($P\text{-}PO_4$), mg/l						0.24		0.16	
Chloride, mg /l	5.3	6.3	8	31		53	<2-10	200	250
Fluoride, mg/l						1.5	0.05-100	8	1.5
Manganese, mg/l						3.8		0.5	0.15
Iron, mg/l						2.2		1	0.3

[(Source: MWEM, (1995), WB, chapter 9, (1994) Stevenson, (1994) and Water Utilisation Act, Amendment No. 10 of 1981)]

1)Unpolluted Rainwater

2)Indicates the natural level in surface water, but this depends very much on the geological conditions.

3)Levels above indicates man made influence, the natural level can be less than 0.4 mg/l

pH

The pH ranges from 6.4-8.4 at the measured sites, with an average of 8.0 at the lowest part of Pangani river. The pH is an important parameter in water quality assessment as it influence on many biological and chemical processes.

Turbidity and Sediment transport

The seasonal variations in rainfall and runoff lead to erosion and sediment transport in the rivers. Rivers originating from Kilimanjaro and Meru Mountain areas carry little sediment. In the Pare and Usambaras, however, severe soil erosion has been caused by land slides (MWEM,1995)

The Pangani river is in general a highly turbid river with an average of 479 NTU, but it can increase to more than 15,000 NTU during the rainy seasons. The high turbidity causes practical problems, for instance at the water treatment plants, but it can also have a negative impact on human health and ecology (especially to fish) if the concentrations are too high.

Fluoride

The fluoride level near the coast zone range from 0.5-1,8 mg/l, and is 1.5 mg/l on the average in the lowest part of the river. This is within the limits set by WHO.

Very high levels of fluorides, far exceeding the WHO guideline value, have however been observed in the upper parts of the catchment area in the Arusha region. The high fluoride level is

caused by the geological conditions, and originate from different types of minerals, including fluoroapatite. These minerals seem to be found in granites.

A sample taken and analysed by NIVA in the Maji ya Chai River (The "Tea river", the most severe polluted river by fluorides in the area) showed a concentration even during the rainy season of 5.35 mg/l. This high level is however within the limits of the Tanzanian temporary standard, which is very liberal to this parameter.

High fluoride content in the drinking water results in brown teeth, and are very common in the Arusha area. Severe effects on the bones (Skeletal and Crippling Fluorosis) have also been reported (Mjengera, 1988).

Organic matter

Organic matter(carbon is the main source) can be dissolved in the water or be present as solids. The organic matters is divided into hardly and easily degradable, soluble and not soluble. A high content of organic matters can be seen visually and discolour the water. Organic matter use oxygen to degrade, and can cause absence of oxygen if the organic matters is high compared to the oxygen available.

Biological oxygen demand indicates the load of easily degradable organic matter, and dissolved oxygen the effect of this decomposing on the oxygen level. High BOD_5 concentrations occur as expected, especially downstream the influence from municipal waste water and sisal.

The dissolved oxygen content in the lowest part of the river is on the average 9.0 mg O_2/l. Dissolved oxygen in freshwater at sea level ranges from 15 mg O_2/l and at $0^{\circ}C$ to 8 mg O_2/l at 25 $^{\circ}C$. Concentrations below 5 mg O_2/l may adversely affect the function and survival of aquatic biota and any level below 2 mg O_2/l kills most fish (Stevenson, 1994). The data in table 2 indicate to low levels in area affected by pollution.

Nutrients

Nutrients can in general lead to an increased primary production (algae and plants) in waters (eutrophication). The eutrophication process in freshwater does mainly depend on phosphorus. The water can as a result of eutrophication have a special odour, and the production of organic matter can cause oxygen problems at a later stage. The nitrogen can result in high contents of nitrates in ground water. Nitrates can cause health problems.

In Pangani river the average nitrate concentration in the lowest part exceed 40 mg/l as NO_3. This indicate pollution from domestic or agriculture sources. The measures in Themi river show however extremely low concentrations.

Nitrite and ammonia concentrations in pristine water is normally very low, but the measured values in Pangani river can be within the natural levels.

Phosphate concentration of Pangani river is in average 0.24 mg/l as phosphorus. In most natural surface water, phosphate concentrations ranges from 0.005 to 0.02 mg P-PO4/l (as phosphorus) (Stevenson, 1994). High concentrations of phosphates origin from agro chemicals or from domestic waste water.

In Norway 20 ug/l of reactive phosphorus is a very high level in natural water, and the surface waters respond to very low concentrations of phosphorus (Water quality class I in the Norwegian system is less than 7 ug/l as Tot-P). 240 ug/l reactive phosphorus which is measured in Pangani river would have caused great eutrophication effects in Norwegian water resources. Even though the conditions are different in Pangani river (both with respect to the natural water quality, but also because of the effects of particles and heavy metal which might reduce the production of algae and plants) it is most likely that these high levels cause eutrophication.

The eutrophication effect is also indicated by the substantial growth of hyacinths (Eichlornia crassipes), an aquatic plant floating on stationary or slow flowing water bodies. The growing of the plant depends on supply of nutrients like phosphorus and nitrogen.

The problems caused by Hyacinths are in general (Herfjord. *et al.*, 1994);

-Increased evaporation because of a big surface of the leaves to the plant
-Increased rate of deoxygenating in water, stressing aquatic flora and fauna
-Reduced navigation and water transport
-Favour the conditions for some water borne diseases like malaria and bilharzia, stagnant water and high organic load.
-Block intakes to hydro power plants, irrigation channels and pipes
-Reduce fishing possibilities.
-Reduce reservoir capacity

The main hyacinth problem in Pangani is the blocking of the intake screen of the power plant, but also the other problems mentioned affect Pangani from Hale and upstream in the river. The hyacinths have not been found in NyM, but the water plants have been observed in the Ruvu and affect Kikuletwa inlets (WB, 1994).

Hyacinth can be removed by mechanical, chemical- and biological methods. In the intake dam to the power station the hyacinth has been removed by simple mechanical measures. Several automatic/ mechanical equipment's are however available for continuously removing of hyacinth (and other items) from intake screens of hydropower stations. So far, it has not been necessary to use these equipment's in Pangani River.

Chloride

A high chloride content is very often associated with sewage, and it is often used in environmental assessments as an indirect indication of possible faecal contamination or a measure of the extent of the dispersal of sewage discharge in water bodies. In pristine water, chloride concentrations are usually lower than 10 mg/l and often less than 2 mg/l. There may be faecal contamination or excessive discharge of untreated sewage into Pangani river which cause the high levels of chlorides (Stevenson, 1994). The high content might also partly be a result of precipitation, while Pangani river is located not very far from the ocean. Saline deposits in the bedrock, e.g. in the Kikuletwa River Basin, also form a major contribution of chloride to the Pangani River.

Iron and manganese

Iron and manganese are present in natural water in either dissolved form as iron and manganese (II) or as iron and manganese (III) in colloidal form. The dissolved iron and manganese is stable only in water without oxygen, in aerated water the iron and manganese will be present in suspended form.

Pangani river averages 2.2 mg/l of iron and 3.8 mg/l of manganese. Flowing surface water should not contain more than a few µg/l of uncomplexed dissolved iron at equilibrium in the pH range of 6.6 to 8.5 (Stevenson, 1994). WHO's standard set iron concentrations at 0.3 mg/l Fe and manganese at 0.15 mg/l as maximum levels in drinking water. The high levels in Pangani River will affect the quality of drinking water.

Faecal pollution

There has not been obtained any data on bacteria contents in the surface waters. There has however been some epidemics in the catchment area, and these might have been a result of untreated waste water.

Water related diseases has been and are the most pressing issues regarding water quality in developing countries.

3.4 Water quality in ground water sources

It has not been within the scope of this project to survey the quality in ground water resources. There are however some data from the study "Rapid Water Resources Assessment" which indicate some pollution.

The ground water quality in Pangani river basin varies greatly from high to extremely low concentrations of various elements. High concentrations of fluorides, manganese, iron, salinity and nitrate have been observed in some areas.

4 User interests, conflicts and environmental impact

The major problems and conflicts between different user interests within one basin mainly occur as a result of the limited amount of water available for different demands. This has also been the case for Pangani. The demand for water of a certain quality do however also cause conflicts among the users, and it is not necessary the largest users which result in the most severe pollution.

In the Pangani river catchment area the main water user interests are, domestic, industry, irrigation and hydropower. There are also some fisheries.

Farming is mainly taking place in the areas of Mt. Meru and Mt. Kilimanjaro, and the most densely populated area and the main industry (except for sisal production) are also located in this part of the catchment. Hydropower production is taking place in the whole catchment, but the largest (New Pangani Falls) is located downstream in the catchment at Hale.

The user interests, the conflicts among them and the environmental impacts of the activities with a focus on water quality are described in this chapter.

4.1 Urban and rural water supply, municipal and industrial pollution

4.1.1 Water supply

Domestic

The Pangani river catchment is one of the most densely populated areas in Tanzania. The population in the catchment area is approximately 2.8 million, where 1.3 million are living in Kilimanjaro region, 1.2 million in the Tanga region and 0.3 million in the Arusha region.

The population density is highest in the slopes of Mt. Meru and Mt. Kilimanjaro, Pare and Usambara mountains, with up to 300 persons/km^2. On the lowland plains the density is less, 25-30 persons/km^2.

Table 3: Inhabitants in the regions in the catchment to Pangani river.

Region	Inhabitants, million
Arusha	0.28
Kilimanjaro	1.3
Tanga	1.22
Total	2.8

Table 4 shows the population of Arusha and Moshi towns and the total urban population in the catchment. The numbers in table 3 and 4 are partly based on interviews and partly on literature and can be connected with some uncertainty.

Moshi Town receives drinking water from three different springs. The present supplies satisfy 50% of the water needs in the town (or 60,000 people), which is below the national level in urban areas. The biggest source is Njoro spring which is serving approximately 40,000 people. The water from Njoro spring does not get any treatment except for chlorinating.

Table 4: Inhabitants in urban areas

Towns	Inhabitants
Arusha	135,000
Moshi	123,000
Total in urban areas	500,000

The water to Arusha town is abstracted and distributed from the springs originating from the foot of Mount Meru. The water quality is in general considered as good (except for a high fluoride content), and the coverage percentage for water supply is above the national level.

No information about the coverage percentage in other towns like Same and Lusotho have been obtained, but the municipal water supply is below the national level (MWEM, 1995).

The water for domestic purposes in rural areas are abstracted directly from the river and from deep and shallow ground wells.

The total need for domestic water in the catchment area is estimated in table 5 and based on a specific consumption of 45 litre/person and day. The numbers in table 5 may be overestimated, while the specific consumption in rural areas is normally 25 l/person day.

Table 5: Estimated domestic water supply in the catchment to Pangani River

	Population	Demand, 1995(m^3/s)	Demand, 2010(m^3/s)
Urban areas	500,000	0.3	0.4
Rural Areas	2,300,000	1.2	1.9
Total	2,800,000	1.5	2.3

The population growth rate is 3.3% per year in the Arusha region, and 3% per. year in the other regions. The long term demand is referring to year 2010 and an average growth rate of 3% pr year.

The demand does not correspond with the actual amount abstracted from the river. A large part of the supply is based on traditional furrows with a low efficiency (20%), and the water will leak out in the ground before it reach the user (some of the water will however be transferred back again to the river). The net abstractions for domestic purposes are therefore much higher than 1.5 m^3/s.

Industry

The main industry in the catchment is sisal production, but there also exist breweries, paper mill, tanning industry, match production, textile industry, fibre board production, diaries, beverage production, soap, cosmetic and toothpaste industries and one pesticide factory. Table 6 gives examples of the water demand at some of the visited industries in l/s and in person equivalents.

The water for industry purposes is abstracted from private wells, directly from the river Pangani at its tributaries or via domestic water supply. The total water demand for the industries in the area is not known, but based on the table above which show the water demand in some of the industries, it is assumed to be rather low compared with other sources.

Table 6: Water demand in some of the industry

Industry	Process Water, l/s	Person equivalents
Sisal	20	38,400
Tanning	5.2	10,000
Fibre board	2.7	5,200
Brewery	15	28,800

4.1.2 Municipal and industrial pollution

Domestic waste water

Untreated domestic waste water contains large amounts of organic matter, nutrients and micro-organisms, and can have great negative impacts on both ecology (oxygen depletion, eutrophication etc.) and human health (water borne diseases). The domestic waste water in the catchment of Pangani river is very insufficient treated, and is one of the major pollution sources in the area.

Domestic Waste Water in Kilimanjaro Region
The total population in Kilimanjaro region is approximately 1.3 million. 700,000 are living within Moshi district, and ca 120,000 in Moshi Town. Moshi has one main outlet of sewage located 2-3 km downstream Njoro spring. Waste water from 100,000 people is discharged here together with effluent from industry. 30,000 discharge directly to the river, while 70,000 use septic tanks and the waste from these are collected and transported to the main outlet. The sewage was supposed to be treated biological in a waste water treatment plant, but this has not been in operation for over 15 years. The treatment plant, based on activated sludge, was built in the early sixties and consisted of 4 aeration ponds. The main reason for this being out of operation has been the lack of electricity.

The sewage which today is bypassing the old treatment plant severely affects the water quality, and makes Njoro river extremely polluted and not suitable for any use. The outlet was during the visit estimated to 50-60 l/s, and the water flow in the river to 1.5 m^3/s. The influence of industrial waste water could also be seen visually, and the outlet seemed to be anaerobic. Toilet paper, parts of clothes and other items were floating in the river and hanging in the trees along the river bank. Despite the extremely bad water quality, the water is abstracted 2-3 km downstream the outlet, and used for drinking water as well as for irrigation of crop. The situation during the dry season is approximately the same as in the rainy season, while this river has more or less a constant flow throughout the year. The old treatment plant and the sewage outlet to Njoro river is shown in figure 4.

The remaining population in Moshi town, about 20.000 (15%), use pit latrines. The population in the surroundings and in rural areas in Moshi district and Kilimanjaro region do also use pit latrines. The waste water disposal in Kilimanjaro region is summarised in table 7.

Table 7: Waste water disposal in Kilimanjaro region

Disposal	Number of people
Domestic wastewater (untreated to Njoro river)[1)]	100,000
Pit latrines	1, 200, 000

[1)] 70.000 use septic tanks, but these are emptied in Njoro river→untreated.

Figure 4: The old treatment plant in Moshi, with overgrown ponds and outlet of sewage to Njoro river.

Domestic waste water in Arusha region
Parts of Arusha district (only Arusha town) and the whole of Arumeru district are within the catchment area to Pangani Basin. The total number of people draining to Pangani Basin from Arumeru district including Arusha town is approximately 280,000. The total population in Arusha town is approximately 135,000.

It is only 12.5% (ca 17,000) of the total population in Arusha town who are connected to the municipal waste water treatment plant. The waste water treatment plant discharge to Themi river. The biological WWTP built in 1970 is designed for 4000 m^3/day, and consist of a grit and 5 ponds in series (without mechanical aeration). The waste water has a present flow of 5500 m^3/d, and is heavily overloaded. This is mainly caused by industrial effluent which is not pre treated. The municipal waste water at the treatment plant represents only 20% of the total load (45 l/pd).
The industrial effluent do not only cause problems with the capacity of the treatment plant, but do also inhibit the bacteria's in the biological process. The BOD outlet from the waste water treatment plant is normally 220 mg/l, while the standard is set to 20 mg BOD/l.

When the treatment plant was visited, only three of 5 pond were in operation, the other two were tapped down in order to remove sludge. The sludge was transported to the municipal land fill. The effluent from the plant seemed to be anaerobic, and not properly treated.

The outlet from the waste water treatment plant in Arusha affects villages downstream (ca 15 km), where water is used for irrigation and drinking. The effects on Pangani river is probably small, because the selfpurification in Olgarwa Shambarai Swamp.

The remaining population in Arusha town, ca 110,000, use mainly pit latrines, but some have private sewage systems based on septic tanks (ca 8,000). The partly treated waste water from the septic tanks, are infiltrated in the ground. There was no information regarding sludge handling from these septic tanks.

The population in Arumeru district (ca 145,000) use mainly pit latrines.

The waste water disposal in the part of Arusha region which are within the catchment of Pangani river is summarised in table 8.

Table 8: Waste water disposal in Arusha region

Disposal	**Number of people**
Domestic wastewater via Biological WWTP to Themi river	17,000
Septic tanks	8,000
Pit latrines	255,000

Domestic waste water in Tanga Region
The population living in the catchment area to Pangani river within the Tanga region, mainly use pit latrines.

The information above is summarised in table 9.

Table 9: Waste water disposal in the catchment to Pangani river

Disposal	Number of people
Domestic wastewater, treated biological	17,000
Untreated domestic waste water	100,000
Septic tanks [1)]	8,000
Pit latrines	2.675,000

[1)] 70.000 in Moshi use septic tanks, but the waste is collected and dumped into Njoro River and is therefor in the category of untreated.

Municipal land fills

A municipal dumping site with both municipal and industrial waste mixed together is located in the same area as the municipal sewage outlet in Moshi town. Leakage from this dumping site, draining to Njoro river, probably contain a lot of harmful waste including heavy metals and organic micro pollutants.

The municipal waste dumping site in Arusha is located in a residential area in the centre of the town, and is in conflict with the neighbours. Leakage from the dumping site is draining to Themi river. There are some plans for a new location of the dumping site, but there was no information about these plans or if there existed plans for treatment of leakage. The dumping site in Arusha was not visited during the mission.

Industry

The effects of industrial pollution vary widely with the type of industry. The industrial pollution and the effects are not described in detail in this report, but a short description of some of the industry is given below. Table 10 gives an overview of the major point pollution sources in the catchment.

Sisal-downstream NyM-Pangani River
Sisal is the major industry in the catchment and is mainly located between NyM and Pangani Falls. Sisal production has increased in the last years after a low conjecture in the late eighties. The increased production is mainly a result of the multiple use of the raw material (German paper production, concrete ceiling cover and traditional ropes), but also because sisal can compete with plastic ropes due to the increased oil prices.

The production of sisal includes crushing, washing, drying, brushing and packing of the sisal. It is the leaves of the sisal plant which are used for fibre production. The polluted effluent originates from the washing process, and the amount of pollution depends on the quality of sisal processed. One cubic meter of sisal weighs 1462 kg and produce normally only 50 kg of sisal, giving 1412 kg waste per cubic meter sisal. The effluent from sisal is therefore extremely concentrated and contain a high load of organic matter and nutrients. In the catchment of Pangani river, five sisal industries are located. One of these, Kwamdulu, has built lagoons for treating the effluent, and most of the others are discharging untreated effluent direct to the river.

Kwamdulu was visited during the mission, and total monthly production of fibre on the estate is 140 tonnes. The sisal juice, which was very greenish, was drained to a dumping area where the liquid portion was discharged to a pond. The outlet from the first pond lead to a second pond and then to the last and third pond. A visit to the third pond demonstrated a water body with 5 species of fish (3 tilapia and 2 "cat fish"). Herons, fishermen and earlier observed crocodiles did also indicate a functioning (eco-) system. The outlet of water from the third pond visually gave an impression of clear water. However blue green algae were floating on the pond and the outlet bed had some aufwucks (see figure 5).

Tanning Industry-Moshi-Njoro River

The tanning factory in Moshi has been in operation, but are presently under rehabilitation. The factory is going to produce leather, and there are also some plans to include the finishing process for the final products. The raw material will mainly be sun dried cattle skin, and the process starts with softening (with water), thereafter a lime bath for removing hair and remnants of meat and fat. This process also includes $MgSO_4$ which will be recycled during the process of preparation of leather. The conservation of the skin will include two different methods, chromium tanning or vegetable tanning. The chromium process includes several chromium baths, and the vegetable tanning is based on extracts from various plants (among Memosa species). The chromium solutions can be reused a couple of times, but the excess water has to be treated (chromium is removed by liming baths). The effluent treatment unit at the factory was also under rehabilitation. The colouring of leather will mainly be done by pressure and heat (finished covers will stuck to the surface of the leather), and little to no dyes will be used. Cyanide will not be used in the dying process. The effluent will contain among others organic waste (fat and remnants from hair and meat), $MgSO_4$ and chromium. RWE in Kilimanjaro or PBWO did not have any information about the effluent quality or quantity.

Kibo paper mill-Moshi-Njoro River

The waste water from Kibo paper mill is collected in 4 lagoons/storage tanks with a rather limited treatment efficiency. The outlet from the last pond is discharged into a channel for irrigation purpose. The rice pads which use the water drain to Njoro river. The farmers in this area have complained about skin problems. The water used for irrigation drains to Njoro river in the rainy season. The effluent and treatment facilities at the industry has been studied (Mugulu and Mbaga, 1993), and organic pollution and insufficient treated waste water were observed (high organic loads). The waste water was not analysed with respect to micro pollutants, but in the same report it is mentioned that chemicals like caustic soda, aluminium sulphate and calcium hypo chlorite are used in the production process. The outlet from the factory was also visited during our mission, and the effluent seemed to be very polluted with organic substances.

Kibo Match-Moshi-Karanga River

The effluent from Kibo match flows into three ponds before it is discharged to Karanga river. The project team had only a short stop over during the mission at one of the ponds, and do hardly know anything about the production process or the quality of the outlet. Samples taken by Pangani Basin Water Office (1994) indicate a high organic load. Micro pollutants including heavy metal were not analysed due to lack of facilities and chemicals. Phosphorus may also be high in this type of effluent.

Figure 5: Growing and production of sisal at Kwamdulu sisal estate

(1. the sisal plant with the stem, 2. Sisal leaves, 3.washing of sisal, 4. the third pond before the outlet to Pangani River)

Pesticide factory- Moshi- Karanga River.
The pesticide factory in Moshi has been established lately, but has not yet come into operation (figure 6).There is little to no information about the production and the effluent from the factory, and the RWE in Kilimanjaro has not despite several attempts succeeded in getting any information. It is assumed that the factory will produce copper sulphate, and the waste water will probably be discharge via storage tanks and a tunnel to Karanga river. There has been some objections by the people living in the area, but this has not been taken into consideration.

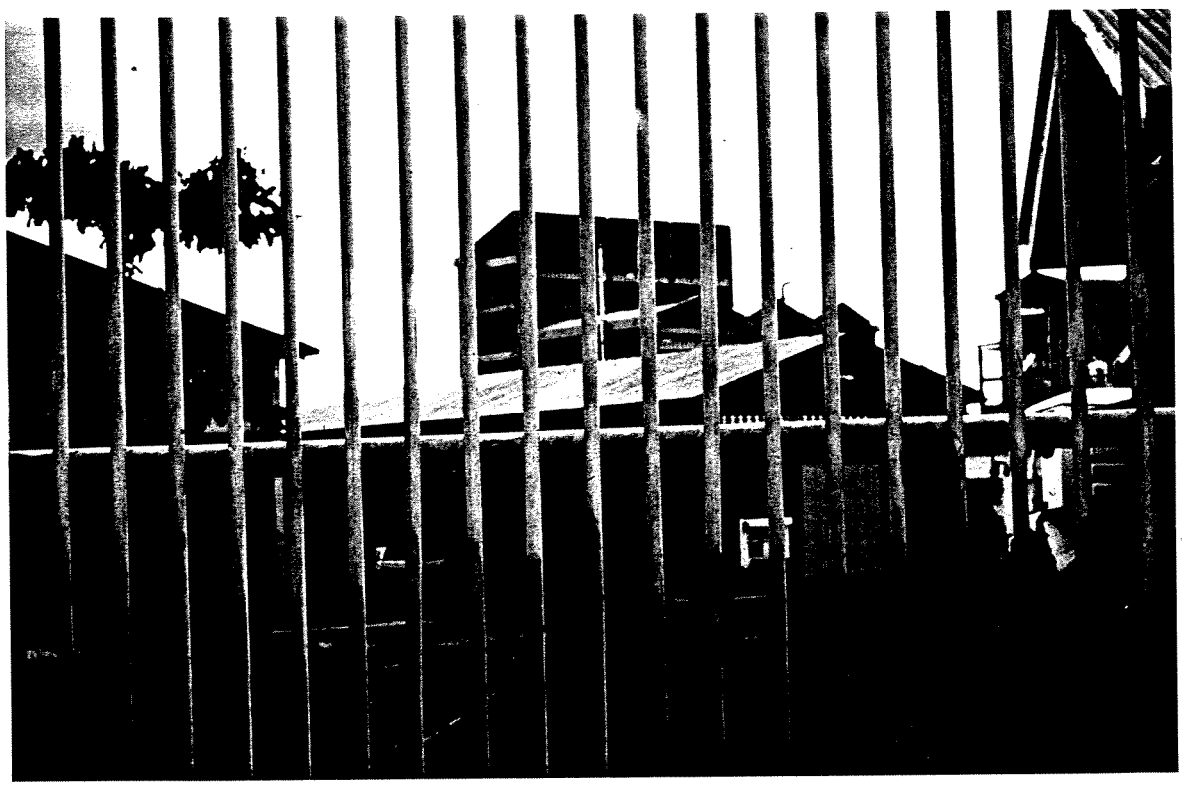

Figure 6: The pesticide factory in Moshi

Textile Industry-Arusha-Themi River via municipal waste water treatment plant
Two main textile factories are operating in Arusha, Sunflag and ATZ-textiles. Sunflag was visited during the mission. The factory has 4000 employees and produce 100-120 tonnes of textiles per month and 35000 T-shirts (mainly for export). For comparison ATZ has a production of 15,000 T-shirts per day. The production process includes washing of fibres, bleaching and dying. The washing is mainly processed with caustic soda and sodium carbonate. The bleaching is undertaken by hydroperchloride, sodium carbonate, sodium hydrosulphate, detergents and organic stabilisators. Two main dying methods are used; polyester dying and cotton dying. Polyester dying is performed with ca 10 dispersed colours. Cotton dying include black colouring with Na_2S (sulphur dying) or a "reactive dying" using chromophorus, Chloroforms, acetic acid, sodium carbonate, agoral naphtalein and other chemicals. The waste water effluent from Sunflag is pumped to ATZ and transferred together with this effluent without pre treatment to the municipal waste water treatment plant in Arusha. There is no effluent data available.

Wall board production-Arusha-Themi River

The fibre board factory in Arusha has four main products; Fibreboards, poles, planks and furniture's. The sawmill produces boards of many different tree species. Little to no waste results from the process. The furniture production has no waste products. Poles from Eucalyptus and Gravelled for electrical- and telephone transmission are produced annually in a number of 10,000. Tanalith, consisting of copper, chromium, and arcen, is used for conservation. The Tanalith bath is not renewed only refilled when necessary, and there are no outlet from the process.

The main waste effluent is from the fibreboard production. 6,000 tonnes of fibreboard's are produced annually, using Cypress, Eucalyptus and Pine. The process includes cutting, heating (using excess wood and oil) and binding of fibre together with pressing. In the heating process parafinwax, emulgate and ammonium are added. No contseptic or gluing components are used. The total water consumption at the factory is 85,500 m3/day, which are distributed over 300 days of operation per year. The waste water from the process is treated in two successive ponds. Both ponds are aerobic with mechanical aeration. The effluent from the wallboard process has a pH of 4.5-5.5. The pH after the treatment ponds is approximately 7. During the mission we did not obtain any data on organic content in the effluent, but there was a high colour on the water and the organic content (hardly degradable) is expected to be high.

The effluent from the factory is partly utilised for fertilising and irrigation of a small area (2-3 da) of maize and beans. The exceeding effluent is transported to Themi river.

Brewery-Arusha-Themi river

The brewery in Arusha produces 30 000 m^3 lager beer annually. The production has increased in the last years with 30-50% annually. The beer production require 300 000 m^3 of water per year (beer/water=1/10), with a certain inlet water quality (soft with a low content of organic matter, dissolved solids, sulphate and chlorine). The process is especially vulnerable to a high content of organic and chlorine while these forms chlororganic compounds which give a raise to smell and taste. The company is served with municipal water, but they also plan to establish their own ground wells. The production of beer at the brewery is traditionally; malting of barley, adding of sugar, yeast and water. The excess malted grain is sold as animal feed. The main effluent is the remaining yeast in the water after production and waste from the washing process. The latter consist of CaCl, NaOH and H_2O in addition to "Oxania" which includes some phosphate. The pH of the effluent varies between 4 and 8. The mean concentration of PO_4 is 25 mg/l and varies between 2-110 mg/l. The content of organic matter is very high at this type of outlet, and COD at the brewery in Arusha is 3000 mg/l.

For the time being the hot effluent (holding approximately 40-50 ^0C) is discharged directly to Themi River without treatment. Estimated (from a field visit) and calculated from the amount of produced beer this gives and outlet of about 15 l/sec. During the visit the discharged water was very hot and turbid, and the colour and transparency of Themi river changed considerably between upstream and downstream the discharge. Themi river had at the time of the visit a water flow of approximately 1 m^3/s (rainy season). The water flow during the dry season is approximately the half.

Samples taken at the effluent and in the recipient in 1994 (Materu, 1994) do also show an alarming situation. The organic content and the content of phosphorus are extremely high.

Figure 7: Mr. J. Nasari (Hydrologist at the RWE-office in Arusha) inspecting the discharge from the brewery to Themi river.

Others

In Moshi town there are some other industries which are not mentioned above like beverage industry and a brewery. Tanganyika Sugar Cane Factory (T.P.C) is also located in Moshi at Kikuletwa river, but there is no outlet from the production process. The only pollution which might occur at the factory is area runoff from the irrigated sugarcane fields (see appendix 2.16).

General Tyre (see appendix 2.19) is located in Arusha and are producing tyres. The factory was visited during the mission, but does not seem to have any significant outlet to water.

In addition to the major polluters mentioned in table 10, the RWRA study has identified some other industries in Arusha discharging to Themi River (MWEM, 1995); Emco Industries (Soap production), Tanzania dairies (milk production), Kiltex (textiles), Tanzania food (biscuits), Halais (cosmetics), Alfi (toothpaste), and Kilima bottlers (beverage).

Major point pollution sources

Table 10 below gives a summary of the major point pollution sources in the catchment area, and the main pollution parameters from the different sources.

Table 10: Major point pollution sources in the catchment area to Pangani River

Pollution Source	Region	Recipients	Type of pollution	Treatm.	Interview (appendix)
Hale- Sisal Industry[1)]	Tanga	Pangani	High concentr. with organic compounds and nutrients	None	
Mruazi- Sisal Industry[1)]	Tanga	Mruazi- Pangani	"	"	
Hale, Makinyumbi- Sisal Industry [1)]	Tanga	Pangani	"	"	
Ngombezi- Sisal Industry[1)]	Tanga	Pangani	"	"	
Kwamdulu- Sisal Industry	Tanga	Pangani	"	Lagoons	2.14
Moshi Town- Municipal Waste Water with influence of Industry	Kilimanjaro	Njoro-Rau-Ruvu-NyM-Pangani	Coliform bacteria, org. matter,nutrients, heavy metals and other micropollutants	None, bypassed old treatment plant	2.9
Moshi-Town Leakage from Municipal Waste dumping	Kilimanjaro	Njoro-Rau-Ruvu-NyM-Pangani	Org. matter,nutrients, heavy metals and other micropoll	No collection of drainage water	2.9
Moshi-Town Kibo Paper Mill	Kilimanjaro	Rice pads-Njoro-Rau-Ruvu-NyM-Pangani	Heavily organic polluted, heavy metals and other micro pollutants. Farmers has complained about skin problems.	Storage and sedimentation tanks, low efficiency	2.9
Moshi Town- Brewery	Kilimanjaro	Njoro-Rau-Ruvu,NyM-Pangani	Organic matter	No treatment, discharge to Municipal sewage	
Moshi Town- Tanning Industry	Kilimanjaro	Njoro-Rau-Ruvu-NyM-Pangani	Organic matter, nutrients, fat, calciumsulphate, cromiumsulphate.	Under planning but not specified	2.15
Moshi Town- Kibo Match	Kilimanjaro	Karanga-WeruWeru-Kikuletwa-NyM Pangani	Organic matter, Phosphorues(?) Micro pollutants	Three sedimentation ponds.	2.9
Moshi Town- Bonito Bottlers	Kilimanjaro	Karanga-WeruWeru-Kikuletwa-NyM Pangani	Nutrients(?) Acid(?)		2.9

Table 10 continoues.

Pollution Source	Region	Recipients	Type of pollution	Treatm.	Interview (appendix)
Moshi Town- Pecticide Fabric	Kilimanjaro	Karanga- WeruWeru- Kikuletwa- NyM Pangani	Micro pollutants coppersulphate(?)	No exact documentation, but probably only via storage tanks to the river	2.9
Arusha Town- Municipal Waste Water with influence of Industry	Arusha	Themi River, Swamps, Kikuletwa	Coliform bacteria, org. matter,nutrients, heavy metals and other micropoll.	Ponds with low treatment efficiency	2.21
Arusha Town- Sunflag Textile Industry	Arusha	Themi River, Swamps, Kikuletwa	Micropollutants	Non, disharge to municipal sewage	2.17
Arusha Town- ATZ Textile Industry	Arusha	Themi River, Swamps, Kikuletwa	Micropollutants	Non, disharge to municipal sewage	
Arusha Town- Tanzania Brewery	Arusha	Themi River, Swamps, Kikuletwa	Organic matter	Non	2.20
Arusha Town- Fiber Board African Ltd.	Arusha	Themi River, Swamps, Kikuletwa	Organic matter....	Aearated ponds	2.18

1) Information based on RWRA study (MWEM, 1995)

4.1.3 Conflicts with other user interests

Water abstracted for urban and rural water supply and for industry do only represent a small part of the total abstractions in the basin, but can cause conflicts with other user interests locally especially where water is abstracted for urban water supply (piped water) and where special water demanding industries are located. The water use can in these cases be considerable compared to other local users.

Almost every major point pollution sources (outlet of domestic waste water and outlet from industry) except for sisal industry are located upstream in the catchment area in Moshi town (Kilimanjaro Region) and in Arusha town (Arusha Region). Outlets from these sources lead to severe local pollution, but will also influence on the water quality in larger parts downstream the outlets.

The outlet of organic matter, nutrients, micro-organism and micro pollutants do not only affect the ecology, but also human health. Outlet of municipal waste water and waste water from industry are therefore in conflict with almost every other user interests in the catchment, especially drinking water interests, irrigation of crop and food and beverage industry.

4.2 Agriculture

4.2.1 Crop production

The main crop production is located in the upper parts of the catchment in the slopes of Mt. Meru and Kilimanjaro, except from sisal production which is mainly located between NYM and Pangani Falls. In the upper parts of the catchment the main crops are cotton, maize, rice, sugar, coffee and vegetables. Kilimanjaro is the largest coffee producing region in the country, counting for about 50 % of the national production.

In the middle and lower parts of the catchment area the crop production is far less than in the upper parts of the catchment area. The crops are mainly rice, maize and sisal. In the Mkomazi valley rice is the main crop with maize and cotton on the higher slopes of the valley.

Increased population in the upper areas has however led to increased pressure on land, and in the recent years this has resulted in more extensive cultivation in the lower areas.

4.2.2 Irrigation

Irrigation practice and water demand

The crop production is extremely depended on irrigation and increase the production from approximately 1 to 4.5 tonnes/hectare in average (depending on crop). The different crops require different amounts of water at different times of the year. Sisal is the only crop which does not need to be irrigated (Sisal does only need water in the washing process in production of sisal fibres, and is grouped under industrial effluent). Table 11 gives an impression of the water requirements for different crops, and table 12 shows the present and potential irrigated area and the water demand.

Table 11: Water requirements for different crops (IVO-NORPLAN, 1990)

Crops	Peak Water Requirement (mm/day)	Main irrigation season
Maize	5-20	Feb.-June
Rice	10-20	June-Nov.
Sugar Cane	15-25	Jan.-Des.
Fruits	10-15	-
Vegetables	7-8	-
Beans	5-15	Sept.-Feb.
Wheat	5-10	Feb.-June

In the upper parts of the catchment area (the Kilimanjaro region) almost 20% of the cultivated area is irrigated (IVO-Norplan, 1990), while the figure for the whole country is 3% (MWEM, 1995). The present irrigated area is however only 0.7% of the total catchment area to Pangani river catchment.

The potential area for irrigation is mainly located downstream NyM, and are mainly for rice production. The total irrigated area will if these schemes are established increase the total irrigated area with 122% and the water demand with 80%.

Table 12: Present and potential irrigated area and water demand (Source, MWEM, 1995)

Catchment	**Present irrigated area (km^2)**	**Potential irrigated area (km^2)**	**Water Demand million m^3/y (m^3/s)**	**Future Water Demand, million m^3/y (m^3/s)**
Arusha region	40		104 (3.3)	104 (3.3)
Kilimanjaro region	164		426 (13.5)	426 (13.5)
Other[1)]	107	382	278 (8.8)	924 (29.3)
Total	311	382	808 (25.6)	1454 (46.1)

[1)]Other catchment referring mainly to areas downstream NYM.

The water demand for crop production will not be constant over the year. Irrigation takes place throughout the whole year, but the various areas are irrigated in different seasons resulting in large variations. The requirement is highest in the dry periods from June-September, but it is also quite high in the other dry period in January-February. The average water demand in m3/s can therefore be much higher in periods when the available water for irrigation is rather limited.

The total water demand for crop production in table 12 is lower than previously estimated by Norplan 1990, where the total irrigated area was estimated to 400 km^2 and the water demand to 400-480 million m^3/year.

The number of abstractions

There is a great number of abstractions for irrigation in the Pangani river catchment. Based on numbers from Swedpower (1993) about 2000 abstractions are for irrigation and domestic purposes. The main part of these are only for irrigation purposes or for irrigation combined with domestic purpose. Only a part of the irrigation users have been issued water rights (see chapter 6.1.1).

The amount of water abstracted for irrigation

The traditional irrigation furrows, also used for domestic purpose, have been in operation for hundreds of years. The furrows are based upon an extensive network (approximately 1800 km) of canals. The canals are mostly unlined and have normally no facilities to regulate the water flow. This is resulting in wasting of water, and much more water than actually needed is abstracted. The efficiency of the traditional furrows can be as low as 20%. PBWO has installed control gates and introduced coat lining at some of the furrows, resulting in an improvement of the efficiency aimed to reach about 50%.

The water for irrigation is not only abstracted from the traditional furrows, but over the last decades a number of modern, large scale irrigation schemes have been established in the river with donor assistance. The largest is the lower Moshi irrigation scheme which was finished with the Japanese assistance in 1986. The project includes, 40 traditional furrows and villages. These

large scales irrigation projects are based on modern technology like sprinkling equipment with small holes, and are in general operating with a high efficiency and according to the water rights which are given. The large scale irrigation projects do however account for a large net abstraction. 10 large irrigation schemes in the basin account for more than 9 m^3/s (Swedpower, 1993).

The total amount of water abstracted for irrigation is as mentioned much higher than the water demand in table 12, but the project team was not able to obtain the exact quantity number. Previous reports indicate that the abstraction for irrigation in Kilimanjaro region, can be as much as 80% of the total water abstracted. The main part of the abstractions are also located in Kilimanjaro region, and 80% can therefore be a representative number for the whole basin. The total net abstraction in the basin is in the order of 50-70 m^3/s, (see chapter 6.1.1) which give a net abstraction for irrigation in the order of 40-56 l/s. There are indications on that these numbers might be lower. It is however a fact that irrigation abstraction can on an average year account for 30-40% of the annual run off in some rivers, and there have been water shortages for some of the irrigation schemes during the dry season.

The total demand for irrigation compared with the net abstraction indicate an overall efficiency of 35-50% for all irrigation schemes (both traditional furrows and larger irrigation schemes).

Environmental impacts

Irrigation can in general have a negative impact on the environment, and some of the problems caused by irrigation are listed below. They are very similar to the problems caused by hydropower projects (see chapter 4.5.2)

- Irrigation can lead to higher evaporation and stagnant water (especially if a reservoir is built). Stagnant water increase health problems related to water borne diseases.

- Irrigation can change the natural runoff in the river and may directly affect the flora and fauna, and indirectly affect the flora and fauna by changing the water quality (dilution capacity). The change in the flow pattern to a more constant flow, do also reduce the floods. Flood plains are very often fertilised by the sediments from the river and are essential for flora, fauna and agriculture. Reduced floods will also influenced the ground water level and the amount of water which is transferred back to the river in dry periods.

- In areas with irrigation the crops normally require intensive farm production /mechanical production, insect pesticides and fertilisers. This cause higher erosion and give a higher load of pollution (nutrients, micro pollutants and particles) (see chapter 4.2.3).

- The most obviously effects of large scale irrigation project are normally the increased ground water level and salination of the soil. If the water used for irrigation is not effectively drained back to the river, the ground water level will increase and may reach the root zone and reduce the production. High salinity can occur as a combination of high salt content in the water, intensive irrigation, bad drainage and high evaporation.

Environmental impacts of irrigation in Pangani:

Environmental impacts of large scale irrigation projects in Pangani river have not been addressed properly. There have been registered some problems with saline soil, and increased ground water levels have also been observed in some schemes due to poor drainage

Areas affected by salinity includes TPC, Kahe, Lower Mkomazi, Naururu, Marwa and areas along Umba valley on the foot of Usambara mountain (MWEM, 1995). The salinitation of the soil in Pangani is not only caused by a bad drainage, but the water especially in Kikuletwa is influenced by some saline springs and is unsuitable for irrigation.

The abstraction for irrigation purposes have also left less water available in the river downstream, and the water level have reached a critical point in many rivers (Mkomazi, Rau, Mue, WeruWeru) (IVO-Norplan, 1990). The irrigation thus effect the fish in dry season

Conflicts with other user interests

The irrigation in Pangani river require extensive amounts of water, and the activity is in conflict with downstream users, especially hydropower production. Irrigation is mainly located in the upper parts of the catchment, while hydropower is a downstream user. This makes the conflict between irrigation and hydropower even worse. Another fact causing problem is that the requirement for irrigation is highest in the dry periods, when the available water in the river is rather limited. Fishery is as mentioned above is also suffering at some of the sites due to the abstraction for irrigation.

Based on table 12 the potential area for irrigation downstream NyM is large and will if coming into operation increase the net average abstraction with at least 20 m^3/s (100% efficiency). This will have a great net effect on Pangani Falls while the potential areas are located downstream NyM, and will probably, despite a good water management, not be in compliance with the hydro power production.

4.2.3 Area runoff and pollution from husbandry

Applied amounts and pollution produced

The main pollution from agriculture is in general nutrients (phosphorus, nitrogen), organic waste and pesticides.

The pollution from agriculture can be divided into point and non point pollution. The most common point pollution sources in the agriculture sector are leakage from green fodder's, manure storage and waste water from milking parlours and washing rooms. Traditionally husbandry exist in the catchment, but the units are relatively few. The pollution from these point sources are therefore rather limited in the catchment.

Non point pollution (area runoff) depend on the size of cultivated area, applied amount of fertiliser and coefficients for nutrients runoff. In the catchment of Pangani river it is the most intensively cultivated areas which use pesticides and fertilisers. The rate of application varies from 20-80 kgN/ha and 14-28 kg P/ha depending on the altitude (Chiza, 1995). Manure is not used.
The total amount of fertiliser used in the catchment is rather low, because the farmers cannot afford to buy it. The applied amount of fertiliser in 1990 (MWEM, 1995), the calculated amount

of nitrogen and phosphorus based on these numbers and the corresponding person equivalents using 12 g N/pd and 2.5 g P/pd are shown in table 13 (The number in the table do only indicate the consumption of fertiliser, and the loads if everything had reach the watershed).

Table 13: Fertiliser consumption and pollution

Region	**Fertiliser**	**N**	**P**	**Applied amount 1990,**	**Nitrogen 2)**		**Phosphorus2)**	
		(%)	(%)	(tonnes)	(tonnes)	Pe (1000)	tonnes	Pe (1000)
Arusha	Ammonia Sulphate S/A	21		1754	368.3	84		
Kilimanjaro Tanga	1)	30		2009 400	602.7	138		
Arusha Kilimanjaro Tanga	Calcium Ammonium nitrate (CAN)	26		956 2120 42	248.6 551.2 10.9	57 126 2.5		
Arusha Kilimanjaro Tanga	Urea	46		- 2812 749	 1293.5 344,5	 295 79		
Arusha Kilimanjaro Tanga	Triple super phosphate (TSP)		21	95 404 52			20 84.8 10.9	22 93 12
Sum Arusha Sum Kilimanjaro Sum Tanga Total					616.9 2447.4 355.4 3419.7	141 295 82 518	20 84.8 10.9 115.7	22 93 12 127

1) There is no information about the type of fertiliser used, and an average of 30% N is assumed

2)The total pollution load based on the consumption of feriliser, it is only a small amount of this which will enter the waters.

The total applied fertiliser in the catchment represent about 520,000 person equivalents regarding nitrogen and only 130,000 person regarding phosphorus. The pollution is concentrated in Kilimanjaro region, but it is also in this region representing a relatively small amount of pollution compared with the domestic pollution from the 1.3 million people living in the region (21% of the nitrogen pollution and 7% of the phosphorus pollution from the population).

It is only a small amount of the fertilisers which is used that will enter the watershed, and depend on the coefficients for nutrient runoff. The nutrient runoff coefficients in the Pangani River catchment are assumed to be rather low, while the application rate of nutrients is extremely low The present load of nutrients to the watershed from agriculture seems therefore at the moment to be low compared with other sources. Agriculture can however have local environmental impacts.

The pollution from fertilisers can increase in the future as a result of increased agriculture production, or/and if the expensive fertiliser is subsidised. To increase the production of maize from a medium level of production 5 tonnes/ha to 25 tonnes/ha will for instance require an increase of fertiliser use from 30 kg N/ha and 25 kg P/ha to 100 kg N/ha and 40 kg P/ha (information received from Chiza, 1995).

The application of pesticides is not a common practice in the catchment, but is expected to increase as modern crop production techniques are introduced. There are nine different types of pesticides which are used in the basin (information received from Chiza, 1995).

Environmental impact

General

Nutrients (especially phosphorus) can as explained in chapter 3.3.2 increase the primary production, and nitrogen runoff can result in high contents of nitrates in ground water, which may cause health problems. These effects will not only be a result of agriculture pollution, but can also be caused by other sources (especially domestic sources).

Pesticides are micro pollutants and can cause toxic effects in relatively small amounts. Several of these compounds can impose stress on the ecosystem, but the overall ecosystems consequences are not known. The residence time is long, and when these chemical first have entered the hydrological cycle, little break down is taken place.

Another environmental impact from the agriculture can be the effect of increased erosion caused by the use of more intensive agriculture methods or by cattles. The Ministry of Agriculture is concerned with erosion, and are investigating how much an area can bear of cattle's with respect to water use and runoff.

Effects in Pangani;

Based on the above information above the total pollution from agriculture seems to be rather low. Local problems in small tributaries can however occur, and PBWO has also reported about agriculture pollution in some areas in Arusha and Kilimanjaro, due to extensive use of agrochemical such as fertilisers, herbicides and pesticides (WB, chapter 9, 1994).

The catchment of Pangani has as mentioned a relatively low number of cattle, but some local areas have a big number, and in the dry seasons these cattle are drinking water directly from the river. This has caused problems with erosion and health problems for the population who abstract water for drinking. The problem has increased in the latest years because of prolonged drought in the Masailand (The Masais have been forced to move closer to the river).

Conflicts with other user interests

The conflicts the agriculture cause with other users are mainly as described earlier, a result of irrigation. Pollution from agriculture including erosion seems to be a local problem at the moment. Fertiliser consumption and pesticide consumption can however increase, and one should be aware of the problems which might occur in the near future.

4.3 Forestry

4.3.1 Forestry in the catchment to Pangani River

Forests are mainly located in the mountain areas, east and west Usambaras, Kilimanjaro and Meru.

Deforestation is mainly resulting from overcutting of forests, woodlands and bushes which are used for energy purpose. Wood fuel is the dominant energy producer in the basin, and accounts for more than 90% of the primary energy supply.

Deforestation is also caused by the expansion of livestock and agriculture. Tanzania is losing 2% of the forest every year. There are no figures on the deforestation rate in Pangani, only that deforestation is taking place (IVO-Norplan, 1990).

There has been worked out a Forestry Action Plan which includes several projects to be undertaken to decrease the deforestation and increase afforestation. In the catchment of Pangani an area of 1332 km^2 is included in this plan (3% of the total catchment area to Pangani river).

4.3.2 Environmental impact

General

Deforestation can in general lead to negative ecological impact on wildlife and flora, and cause soil erosion (siltation and increased nutrients transport which may cause eutrophication). Deforestation can also influence on the stability of the catchment regarding run off (more run off leading to greater flood peaks and reduced low flow), and the water balance (storing of water, decreased evaporation and change in local climate) etc.

Impact of deforestation in Pangani

The annual runoff volume in Pangani river and NyM is not expected to not have been changed significantly because of deforestation, but deforestation might have influenced on the distribution of flows (IVO-Norplan, 1990). However, a reduction of water level in NyM started in the seventies, but this reduction is expected to be caused by increased abstractions of the water for irrigation upstream the reservoir. An extensive control of these abstractions, together with introduction of control water gates and water fees, and heavy rain in 1995 have lead to a (temporarily) increase of the water level in NyM.

The problem of soil erosion is however severe on the mountain slope, and to a lesser extent in the plains. The degree of siltation of NyM reservoir is unknown, but the loss of reservoir volume has probably not exceeded more than a few percent since the reservoir came into operation in 1968. The stable situation is caused by reduced evaporation because of siltation (IVO-Norplan, 1990). How much of the siltation which is caused by deforestation is not known.

The Pangani Basin Water Office has identified a need for research on the effects of deforestation within the basin.

4.4 Fisheries (and aqua culture)

4.4.1 Fisheries (and aqua culture) in Pangani river

The main fisheries in the Pangani Basin takes place in the Nyumba ya Mungu reservoir. Minor catches are taken in the intake dam to Pangani Falls Power Station and the Pangani river. The limited fishing activity at Pangani Falls area might increase in the intake dam.

The NyM dam was built in 1965, and it was filled with water in 1968. High catches of fish were observed shortly after. This is well known as "short time effect", and takes place after filling up reservoirs both in temperate- and tropical regions. The "short time effect" is explained by washing out of nutrients from the flooded area of the reservoir providing increased production possibilities in this aquatic environment. The high catches of more than 20,000 metric tons per year sustained for many years (at least 10 years), but from the late seventies the catches decreased considerably. However, in NyM the "short time effect" lasted for unusual many years. This might be caused by the deforestation and the subsequent soil erosion that took place in the near surroundings of NyM (washing out of nutrients).

The last years the catches have fluctuated between two and five thousand tonnes. The recent reduction of fish catch is explained by the decrease of the "short time effect". However, at the same time the water level of NyM was drastically reduced, and an over fishing probably also took place in the same period.

A rough calculation of fish yield per surface area of NyM gives figures of about 1500 kg/ha/year during the period of "short time effect" with the reservoir almost filled with water. This is a very high yield. During the latest years with low water level the annual yield has been about 500 kg/ha/year which is also a good yield.

Fish stocks are not well known, but the main fish species landed from the reservoir are tilapia species: *Oreochromis esculenta, O. jipe, O. pangani* together with *Clarias mossambicus and Synodontis spp.* The main fishing gears used are gillnets, beach seines, traps and hooks and lines.

Aqua culture is for the time being of minor interest in the Pangani Basin. However, many ponds and other facilities could make the area attractive for aqua culture, if the water quality of the various part of Pangani are found to be suitable for aqua culture.

4.4.2 Pollution and Environmental impact, conflicts with other users

Before establishing aqua culture in the basin, the environmental impacts must be investigated. Aqua culture can lead to pollution problems and unwanted growth of algae and water plants, increase spread of water borne diseases and lead to a major increase in the demand for clean water or energy.

Figure 8: Young Fishermen in Pangani river

4.5 Hydropower

4.5.1 Hydropower production in Pangani river

Hydropower is one of the main users in the basin, and there are four hydropower plants in operation. Table 14 shows the location, the production capacity and also the planned production for hydropower plants in the basin.

Existing plants

Kikuletwa power station is not operating at the moment, and a redevelopment of the power station with a projected capacity of 1.5 MW is planned.

NyM power station has been in operation since 1967, and is producing 8 MW at the maximum..

Hale Power station has been operating since 1964, with a production of 21 MW, and the Old Pangani Falls powerstation has 17,5 MW at maximum since 1930.

After the New Pangani Falls power station came in operation in January in 1995 with a production of 66 MW, the old power station will only produce electricity during the high flood periods. The redevelopment of Pangani Falls has involved rehabilitation of the Old Pangani Falls hydropower plant, construction of a hydropower station and a transmission line from Hale to Tanga. The project with total investment costs 700 mill NOK, has been financed jointly by the Governments of Norway (42%), Sweden (25%) and Finland (33%) in developing aid.

The total hydropower production in Pangani River accounts for approximately 2.5% of the total hydroelectric potential in Tanzania after the new Pangani hydropower plant came into operation at Pangani Falls at Hale.

Potential

Tanesco want to undertake a comprehensive study to investigate the total potential for hydro-electric power production in the whole Pangani Basin. A prefeasibility study already undertaken for the area downstream Kikuletwa within the Kilimanjaro Region, has shown a hydroelectric production potential of 11 MW. Between NyM and Hale Power station there has been estimated a hydroelectric production potential of 15 to 20 MW.

Table 14: Planned and existing hydropower production in Pangani

Location	**Established**	**Existing -(planned production) MW**	**Remarks**
Kikuletwa		0 (1.5)	Not operating at the moment
Kilimanjaro Region, downstream Kikuletwa		0 (11)	Prefeasibilty study, bigger fall head
Outlet of NyM	1967	8	Bypass possibilities of water to Pangani
Mandera, Downstream NyM		0 (15-20)	
Hale	1964	21	
Old Pangani Falls	1930	17.5	Temporarily operating in periods with exceeding of full capacity at Pangani
New Pangani Falls	1995	66	
Total		95	

4.5.2 Environmental impact and conflicts with other user interests

General

Electricity is fundamental in the development of the living standard in Tanzania, and is a cheap and renewable source of energy.

Hydropower production do however cause environmental impacts with the physical constructions like reservoirs, intake dams, transmission lines, power plants etc., and do also change the natural flow pattern.

Some environmental concerns related to hydropower production are briefly listed below:

- Loss of land resulting in re-settlement
- Deforestation leading to increased erosion
- Change in biological diversity, both regarding flora and fauna
  Hydropower project can influence on the flora and fauna in many ways. The building of a reservoir will for example very often have negative impacts on fish because of change in condition for migration and reproduction, but also because of change in water flow and the change in chemical substances in the water (dilution capacity).
- The change in flow pattern can also reduce the ground water level, and the water which is transferred back to the river in dry periods.
- The reservoir can store sediment rich of nutrients and reduce floods.
  This will influence on natural nutrient transport to agriculture fields. The increased nutrient content in the reservoir can also lead to eutrophication and growing of e.g. hyacinth which has a large specific surface area. It is a known problem that these water plants increase the evaporation
- Big reservoirs do also increase the evaporation because of a larger surface area, and stagnant water favour the living conditions for snails and mosquitoes and can increase the problems with water borne diseases like Bilharzia, malaria etc.

Hydropower production does also normally cause conflicts with other user interests because of the scarcity of water.

Consequences of hydropower production in Pangani and the EIA for PFRP

Hydropower production is also in conflict with other user interests in Pangani, because of the scarcity of water, and 30 m^3/s is needed for the production at Hale. The fact that the main production is located downstream in the catchment area, is as explained earlier accelerating the conflicts with other user interests especially the irrigation sector. The net abstractions for irrigation before the water reach the power station are considerable, and it is also the conflicts between these two user interests which has been the driving force in establishing Pangani Basin Water Office.

The environmental impact of hydropower production in Pangani has mainly been studied for the PFRP (see below), but other environmental impact worth mentioning has been the creation of NyM reservoir (1968) which has increased the total evaporation losses in the river by maintaining a large open water surface. To some extent this has probably been balanced by reduced evaporation in the Kirua Swamps (Swedpower, 1993)

EIA for New Pangani Falls
The redevelopment of Pangani Falls has included extensive construction work. There has been carried out an EIA to describe the consequences (Stevenson, 1994). The report has covered the essential impacts in the project between Hale and the outlet of the tailrace tunnel. The study has been comprehensive and contains a lot of detailed information. The EIA on the upper parts of Pangani river is however not included.

New Pangani falls was also visited during NIVA's mission. The visit included the washing facilities which had been established for the local population, the intake dam, the upper section of the former falls, the old English power station (Old Pangani Falls), a major part of the dry stretch of the riverine gorge, the tailrace channel, a few hundred meters down stream the conjunction of the tailrace tunnel and the river and finally the new power station.

The new intake pond cover the former river bed and a former swamp area. This swamp has now a stable annual water level compared to the situation before the regulation, though the possible daily variation can even today be ca 2 meters. The daily variations will not be regularly used. The new water level of the pond favour rice production throughout the whole year in a significant part of the plain.

The surface water of the intake dam showed an extensive growth of water hyacinths. Up to now the hyacinths have been mechanically removed and stored on the "banks". A further utilisation of this waste can be favourable (animal food, fertiliser, soil improvement etc.).

Washing facilities which has been established and located at the intake dam, ensure a constant outflow of 50 l/sec from the dam to the former falls throughout the whole year (day and night). This is, so far, the only minimum release of water to the dried river gorge.

The old English power station in the former falls is now used only during high flood periods (this rainy season, 1995, with high precipitation, the station had only been used for a short period). A short trip downstream the old power station to the moist forest in the river gorge showed that the black and white colobus still are present in the area (they were also observed in the area downstream the conjunction of the tailrace channel and the river). The African Violet, Saint paulia tong Wensis, which has been claimed to be endemic to Pangani Falls, was observed in the steep slope of the gorge (a similar or an identical violet was also later on our trip observed in the lime caves of Amboni near Tanga). The forest did not show any signs of drying, but our "safari" took place at the end of the rainy season and only some months after the new power station came in operation. The long terms effects or the situation in the dry season may be worse. The river bed, in the vicinity of the old power station had several rock pools. This part of the former river had also several small falls and rapids. A constant flow of 20 l/sec (which was suppose to be permanent through the year) throughout this pools prevented a visual impression of stagnating water. Invertebrates and tadpoles was observed in most of the pools.

Further downstream from the old power station, rapids had existed but the water was now running smoother. In this part of the river bed, thresholds had been constructed (see figure 9). These thresholds gave especially a good impression of the river bed, and the water quality seemed to be acceptable for permanent fish populations.

Downstream the tailrace tunnel a foot path had been constructed. Due to topography, the west river bank was set by concrete cover. The visual impression of this area will probably be improved by natural re vegetation within a few years.

Conclusion

In general the way the rehabilitation has been done gave a very good authentic impression. The thresholds in the river bed have increased the surface of the water substantially, and the ravine forest looked healthy at present (rainy season). However regularly visits to the forest by a skilful person will reveal changes of the biota. A minimum release or short flushes of water from the intake dam might be considered as necessary if decisions are made to protect this forest.

Figure 9: Thresholds in the river bed at PFRP, Hale

5 Water resources management

5.1 Organisation and institutions involved

5.1.1 General on regional and local administration in Tanzania

The Tanzanian system of government consists of three tiers. At the centre is the central government organised around a ministerial system including independent departments, commissions and standing committees. The second tier consists of the central government regional administration reaching also districts and even lower levels. The third tier comprises local authorities like the district and urban councils (NORAD, 1991).

There are three administrative structures of relevance to regional and local administration (see figure 10):

- The central government structure
- the local government structure
- the ruling party structure

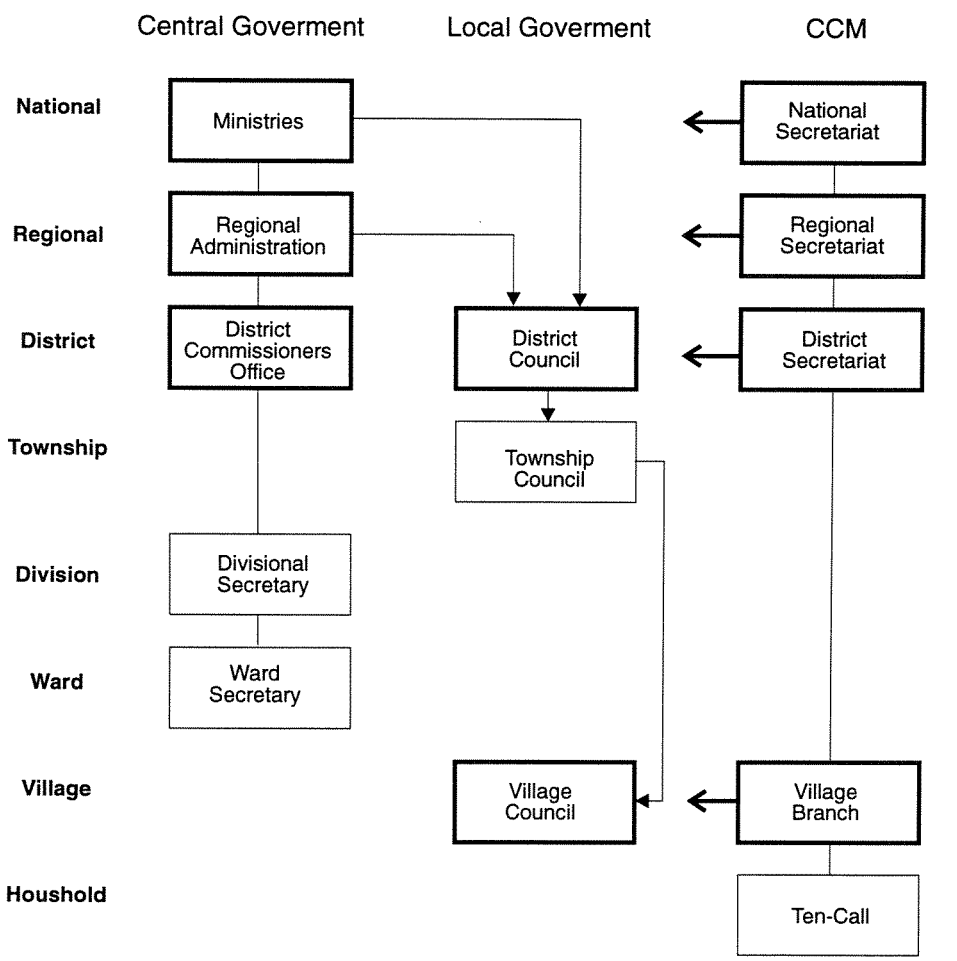

Figure 10: Simplified structure of central and local government and the ruling party (NORAD,1991)

The regional administration is headed by a Regional Commissioner (RC) who is the representative of the Central Government. He is assisted by a Regional Development Director (RDD) who controls all development activities and leads the administration. Below the regional level, the central government is represented by a District Commissioner in each district, a divisional secretary in each division and a ward secretary in every ward (see figure 11). The Departments of Engineering and The Department of Agriculture & Livestock are organised directly under the respective Ministry, and are only administratively responsible to the regional administration.

The local government structure consists of both districts and village councils. Each has an elected body (District council) and an administrative staff (headed by the District Executive Director). The departmental structure is similar to that of the central governments regional structure (see figure 12).

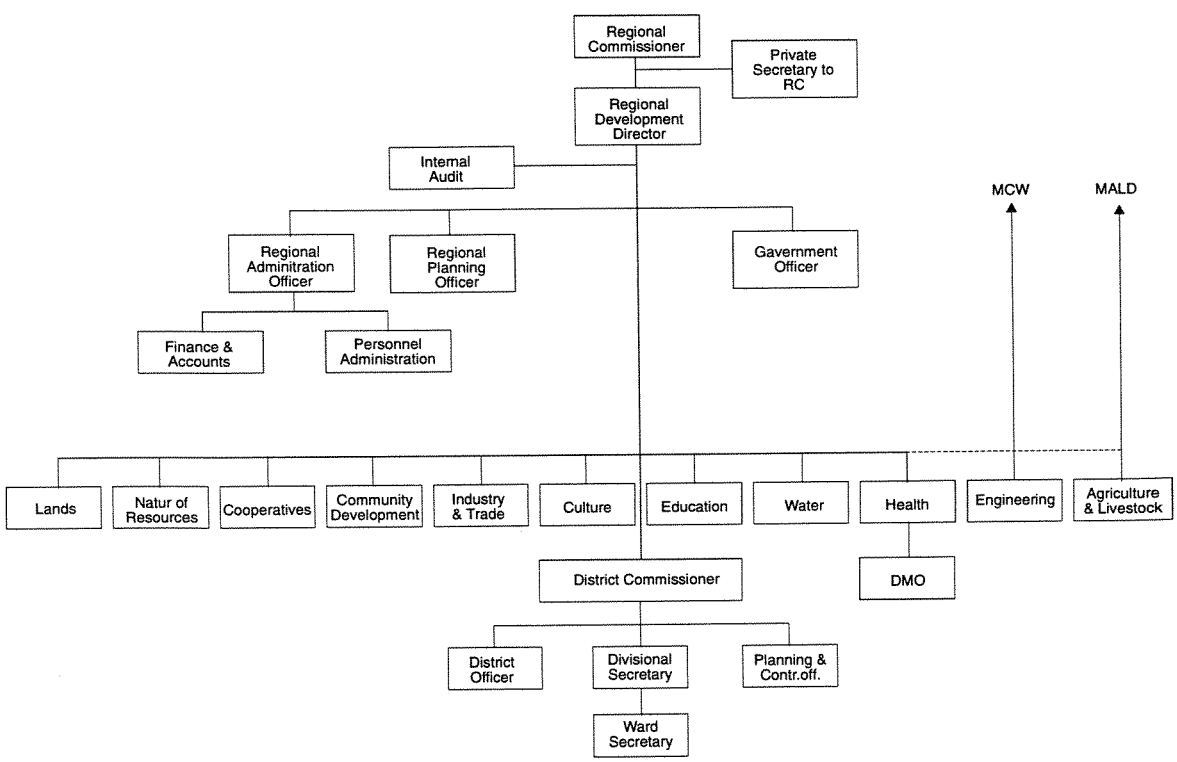

Figure 11: Organisation of the regional administration

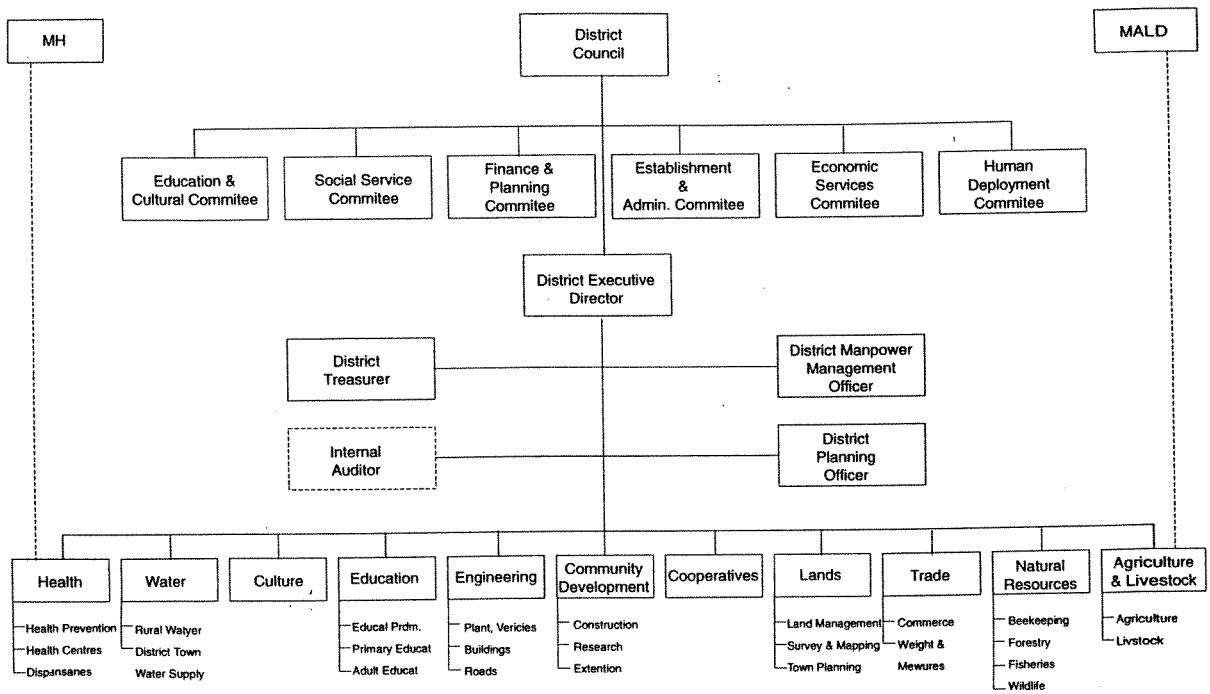

Figure 12: The structure of a District Council

5.1.2 An overview of central governments involved in WRM

It has not been possible to go in detail and understand completely how the Water Resources Management functions in Tanzania within the short time available in this study.

Figure 13 gives a rough overview of the important ministries (including independent departments and commissions) and the regional representatives of the ministries involved in the WRM. The chapters below give a more detail description of tasks, personnel, co-ordination and co-operation in the different departments and institutions.

5.1.3 Ministry of Water, Energy and Minerals

The water management regarding the use of water is regulated by the Water Utilisation Act No.42 of 1974, with amendment regarding control of water quality (1981) and water fine (1989).

The central authority and mandate given by the Water Utilisation Act is the Ministry of Water, Energy and Minerals (MWEM), which is solely responsible for the activities related to use of water, issuing of water rights, regulation and control, water constructions and pollution control.

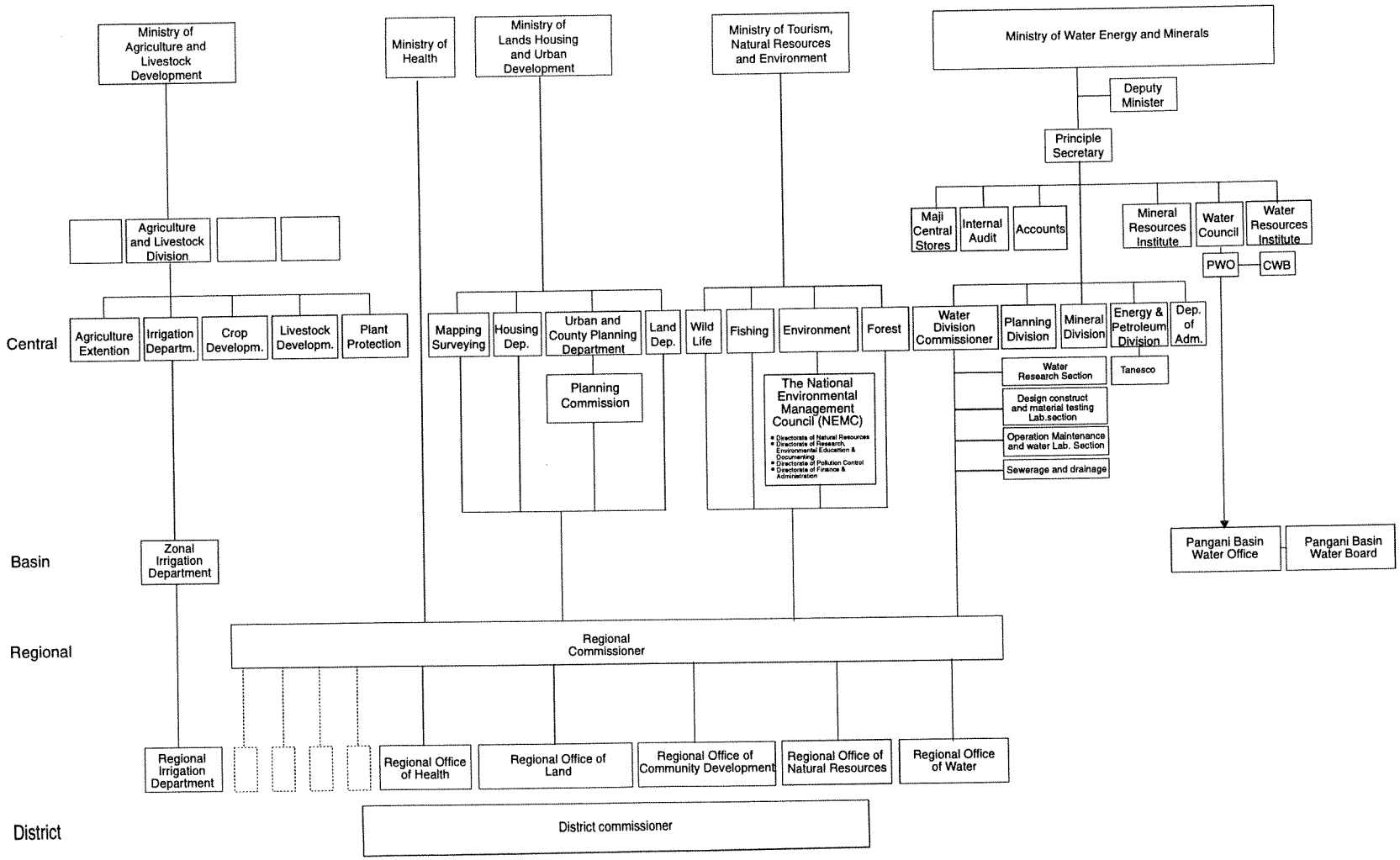

Figure 13: Organisation of the central water management in Tanzania

According to section 8 of Act No. 42 of 1974 all water in Tanzania is vested in the United Republic, in this case MWEM. Water as a precious national resource is, according to the law, is administrated by the Principal Water Officer (PWO), the Central Board and the Basin Boards. These are at the moment organised under the "Water council" (see figure 13), which are one of the six Departments reporting to the Principal Secretary. The organising of PWO directly under the water council is meant to secure an independent approach with respect to the different users of water (within their own Ministry; hydropower production and water supply/sewerage and within other Ministries responsible for irrigation, fisheries, aqua culture etc.). See also chapter 5.1.4 for further information.

The law gives also provision for establishing Basin Boards and Basin Water offices (BWO) as these basins are declared as national. For the time being 9 basins have been declared, but only two are in operation (Pangani and Rufiji). The administration of the basins is delegated from PWO to BWO, and the Basin Boards are given the same authority as the Central Board (see chapter 5.1.5).

If a river is not declared as national, the management has so far been delegated to the regions represented by the Regional Water Engineers. The RWE is normally reporting to the Water Division Commissioner (one of the users, in charge of water supply and sewage), but has in these cases reported directly to the PWO (see chapter 5.1.7).

5.1.4 Principal Water officer and the Central Water Board

Tasks and responsibilities of the Central Water Board

The Central Water Board is given executive power on pollution, but act as an advisor to PWO with respect to the utilisation of the water, regulation and control. Other issues include water rights (determination, modification etc.) and regulation of discharges of effluents to national declared water sources.

Members of the central Water Board

The Central Water Board consists at the moment of 14 members from different ministries and institutions:
-The Chairman of the Central Water Board is appointed by the President.
-The PWO (MWEM)(Secretary):
-The Commissioner for Water Research (MWEM)
-The Assistant Commissioner for water (MWEM)
-The Assistant Commissioner for Electricity (MWEM)
-The Principal Health Officer (Ministry of Health)
-The Irrigation department (MALD)
-The Ministry of Industry and Trade
-The Ministry of Lands, Housing and Urban Development
-The Planning Commission, The Director of Natural Resources
-The Ministry of Tourism, Natural Resources and Environment
-The Ministry of Justice
-Director of Technical Service in the Ministry of Community Development, Woman and Children.
-Institute of Resource Assessment (University of Dar es Salaam)

Tasks and responsibilities of the Principal Water Officer

The Principal Water Officer administers important rivers, lakes and reservoirs which are declared as national (at the moment 155). Some of the power as explained earlier have been delegated to the basins which have been established.

The PWO is also responsible for co-ordinating the tasks which are delegated to the regional authorities or to the basin authorities, and to co-ordinate the activities with other institutions involved in water management.

PWO is responsible for:

- Registration of Water Rights applications and discharge consent
- Undertake a sound water resource development, co-ordinate and optimise the use of the water in Tanzania.
- Facilitate, promote and regulate the water use in Tanzania, give water rights in order to avoid shortages and conflicts. To protect water rights for all legitimate users.
- Undertake pollution control in compliance with, Act No. 42(1974), Act No.10 (1981), Act no 17 (1989)
- Protect the water resources and the environment.
- Co-ordination of Water Basin Offices' activities.
- To attend and inspect 155 national water sources abstractions at intakes.

5.1.5 Pangani Basin Water Office and Pangani Basin Water Board

The organisation of the water management has undergone changes and PBWO is no the executive authority within Pangani Basin according to the WUA. PBWO co-ordinates the activities in the basin, and shall secure a comprehensive management of the water resources in the basin and avoid sector planning. The office has got support from the MWEM (Moshi meeting, 1994) to undertake this role, but has had some problems in executing its duties due to lack of funds from the Central Government. PBWO is reporting to the Principal Secretary through the Principal Water Officer.

The Office is located in Hale and the administrative unit consists of the three regions Kilimanjaro, Arusha and Tanga. The basin consists of 4 rivers; Pangani, Umba, Sigi and Msangazi. Pangani river dominates the catchment area of the basin (about 50%).

As for the Water Board the Basin Board is given executive power on pollution, but act as an advisor to PBWO with respect to the utilisation of the water, regulation and control.

The responsibilities of the Pangani Basin Board and Pangani Basin Water Office were summarised in a meeting held in Tanesco in 1990 and are listed below:

Tasks and responsibilities of the Pangani Basin Water Board (Meeting at Tanesco 30 June, 1990)

- Advice PBWO on all matters concerning the utilisation of Pangani basin water;
  -water rights (determination, diminution or modification),
  -measures to be taken in case of drought,
  -priorities to be given from time to time, for the different purposes for which the water is required in any area of Pangani Basin, in accordance with the prevailing circumstances .
  -methods and measures to be taken to distribute the water among the various users in the most optimum and efficient way including the operation of major water schemes in the basin..

- Promote research and investigations and propose measures for efficient prevention and control of water pollution.

- Regulate discharge of effluents by industrial, trade and other categories of users of water.

Members of Pangani Basin Water Board

The former Pangani Basin Water Board consisted of a chairman and one member from the following authorities:

- Ministry of Water Energy and Minerals
- Ministry of Agriculture and Livestock Development
- NEMC (Ministry of Natural Resources, Tourism and Environment)
- Ministry of Industry
- The Planning Commission
- Tanesco
- RDD-Offices in the regions; Kilimanjaro, Arusha and Tanga

The Regional Water Engineers and Hydrologists in the regions have been invited to attend the Board meetings.

The current PBWB is under the chairmanship of the Deputy Minister (MWEM) and the following 9 members:

- Water Officer (PBWO), Secretary
- Zonal Irrigation Engineer (Moshi)
- Chief Hydrologist (Tanesco)
- PWO as a resource person
- DC (Lusotho, Same, Hai, Mwakga, Moshi and Arumeru Districts)

Tasks and responsibilities of the Pangani Basin Water Office (Meeting at Tanesco 30 June, 1990)

- Execute water resources management and control according to the utilisation of the water in the basin, and consider the advice of the Pangani Basin Water Board before deciding on the operation of major schemes in the basin, before granting or refusing any application for a water right, before determining revising, diminishing or modifying any water right or existing rights and before specifying a quality of water.

- On behalf of Pangani Basin Water Board, carry out Research and investigations, control the discharge of pollution and propose measures to prevent water pollution.

- Advise Pangani Basin Water Board as needed in order for them to carry out their duties.

Staff of Pangani Basin Water Office (planned and present)

The Pangani Basin water office shall in addition to the Pangani Basin Water Officer, consist of members with the following expertise and tasks:

- Hydrology
  Water balance computation, basin data bank, field monitoring
- Pollution
  Water pollution investigation and control measures, water quality budgeting and accounting.
- Irrigation
  Water rights, optimum (economic) use of water for irrigation, field monitoring
- Water Resources Management
  Optimum water management, operation of major dams/reservoirs and water schemes, economical and socio-economical aspects of existing and proposed water schemes.
- Nature Conservation
  Impact on nature on major existing and proposed water schemes, measures of improving forestry, wildlife and fishery.
- Law
  Prosecuting abuse of given water rights and water pollution above given levels.
- Technical
  Field control of monitoring system and technical installation

The office does not have the necessary competence to cover all aspects or fields, and consists at the moment of a Water Officer, a Senior Hydrologist, an Accountant, four Technicians and two Office Attendants. The donors for the Pangani Falls Redevelopment have in addition supported the office with a Senior Advisor.

Water Officer: Mr. B.A.S. Luhumbika
Senior Hydrologist: Mr. S.M Kamugisha
Technican II: Mr. Basso
Technican II: Mr. Riwa
Technican II: Mr. Mbaga
Senior Advisor: J.E.Værnes

To be able to handle questions regarding the law, the office has close contact with PWO. They have also a close contact with NEMC concerning pollution and the Zonal and Regional irrigation engineers regarding optimum use of water for irrigation.

Work accomplished by the office (1991-1995)

The activities carried out by the office have so far been related to the use of water, but they have also in some extent controlled and fined polluters. The activities undertaken by the office is listed below:

- All abstraction of water (about 2000) in the Pangani River Basin have been registered, mapped and stored in a data base. Some of the registered users had water rights, but a great number of the abstractions were illegal. The inspections have resulted in issuing of 1000 water rights.

- The furrows used for irrigation and drinking water supply have so far been operating very inefficiently (20%), and one main task has been to rehabilitate the furrows. The leakages have

been improved by the introduction of coat lining and the installing of control gates (at the moment 150 control gates have been installed). PBWO has proposed that the traditional furrow water user committees must apply for the water rights, control the water distribution from the furrows and rehabilitate the furrows in order to reduce the water consumption.

- PBWO do also try to create awareness among the users to reduce the conflicts and to achieve an efficient use of water. Education and training of farmers and capacity building of officers in local government institutions are also one of their concerns.

- PBWO has controlled some polluters according to the standards set in the Water Utilisation Act. The water quality samples are used as evidence in the court (polluters cannot be punished before they are found guilty in the court). This procedure is rather time and cost consuming, and so far only 5 sisal estates have been fined.

- PBWO has also initiated a water quality monitoring program, and at the moment there is a proposal prepared by NEMC which they hope will be implemented within short time. This depend however on funding.

- PBWO has got the responsibility to control the release of water from NyM, and has established a simple river basin management model to undertake this.

- The office has also undertaken a social-economic study in order to predict the value of water for different uses in the basin.

- The office collects hydrological and meteorological data via the RWE from 22 stations (15 are in operation today). There are several other stations within the basin.

Co-operation and co-ordination

PBWO co-operate with central governments at Regional level such as the Regional Water Engineers, and deploy the services of their assistant mainly regarding hydrometrological data collection.

PBWO do also co-operate with the Regional Irrigation Engineers, the Zonal Irrigation Engineer, the Regional Hydrologists and the users in the basin including Tanesco.

In addition to these central government regional offices they also co-operate with districts offices, and local governments at district level, township level and village level.

Funding and Financial status

The Government was supposed to cover salaries, allowances for local personnel and operation and maintenance costs of the office. The advisory role at the office, office equipment and the transportation costs were supposed to be covered by the donors of PFRP. The donors have also financed the rehabilitation of the water control gates.

The office has as mentioned some problems to undertake the task they are suppose to due to inadequate financial support from the government. The government has not fulfilled its obligations. The studies and implementation of the river basin water resources management concept has therefore solely been based on extra funding from the donors, the inadequacy in

funding from the government has made the long term planning difficult and reduced the efficiency of a good water resources management.

5.1.6 Tanesco

Tanzania Electricity Supply Co.Ltd. (Tanesco) is one of the main user interests in Pangani, and is thereby involved in the water resources management. PBWO is responsible for the operation of NyM reservoir, but discuss with Tanesco to decide the optimum release for power generation.

5.1.7 Regional and districts units involved in WRM

Regional and District Commissioner and the Regional Development director

As mentioned in chapter 5.1.1 the central government has representatives in the regions and districts (Regional and District Commissioners). The Regional Development Director assist the Regional Commissioner, is administratively responsible for the administration (including the Regional Water Office) and is also represented in PBWB. The Regional and District Commissioner play an important role in overseeing the water resources management is properly taken into consideration in the development of the regions and districts (see figure 13).

Regional Water Engineers

The commissioner for water are represented by regional water offices in Tanga, Kilimanjaro and Arusha. The Regional Water Engineer administers the regional water office, which is under the responsibility of the Regional Development Director who in turn is under the Regional Commissioner.

The RWE has as explained earlier in some cases been delegated power (in accordance with the Water Utilisation Act) to manage water resources which is not declared as national. In these cases the RWE has been reporting to PWO directly and not through the Water Division Commissioner.

In the Pangani basin, PBWO has the overall responsibility, and in this case the RWE engineers is one of the users of water. There have not been any conflicts between PBWO and RWE regarding responsibilities and co-operation. Though it seems at the moment (PBWO is a very young institution) to be some overlapping work, and that the RWEs are the practical operators in the regions with respects to control abstractions and polluters, and also the one to collect the necessary information.

It has also been within the RWE responsibility to co-ordinate, construct, operate and maintain the domestic water supply and sewage in the region, though this was original the responsibility of the districts. More equipment and personnel at the RWE offices has made this shift in responsibility necessary.

The responsibility of RWE regarding water supply and sewerage is however about to be taken over by Rural Water Supply and Sewage organisations which are going to be administrated by the municipalities (the local government, and not the central governments districts units). This organisation might also be privatised in the future.

In Pangani river the Regional Water Engineers Office is at the moment responsible for:

- Surveys and investigations of surface and ground water hydrology and hydrogeology. They have a regional hydrologist, and are operating several gauging stations.

- Project planning, design, construction, operation and maintenance of water supply and sewerage

In some cases they do also take water quality samples to identify polluters and check if the water quality is in accordance with the Tanzania temporary water quality standards, despite the fact that this is the responsibility of PBWO.

Zonal and Regional Irrigation Engineers

The Zonal and Regional Irrigation Engineers who are organised under the Ministry of Agriculture and Livestock Development, are also involved in water resources management in the regions. They are not responsible to the Regional commissioner (only administratively connected) and are reporting directly to the Ministry. See chapter 5.1.7, and figure 13.

District Council and the District Executive Director

The local government, the District Council (see figure 12), and the administrative staff headed by the District Executive Director do also play an important role within water resources management. They are responsible for assisting the central governments controlling institutions (RWE, ZIE/RIE,PBWO). It seems like there is going to be a shift from centralism to decentralism in Tanzania and this will probably influence on the importance of the District councils in water resource management in the future.

5.1.8 Ministry of Agriculture and Livestock Development

The Irrigation Department within the Ministry of Agriculture and Livestock development with its regional units (Zonal Irrigation Departments and Regional Irrigation Departments) has become more and more involved in water resources management.

The irrigation department functions aim at:

- improving the irrigation efficiency.
- improving the Water Management for irrigation schemes, and establish criteria and guidelines for abstraction and the need for water.
- increasing the awareness of the farmers about how irrigation activities in the basin affects other users.

The irrigation department is one of the youngest department in the MALD, and was established as late as in 1981 with Zonal irrigation offices, regional irrigation offices and district offices. The main competence and resource allocation has so far been in the Zonal Irrigation Department.

There are six zonal departments in Tanzania and the Kilimanjaro Zone cover Pangani Basin.

The task of the Zonal irrigation offices are:

- Co-ordinate technical aspects regarding irrigation and assist the Regional Irrigation Engineers with technological and hydrological know how, especially in large scale irrigation projects.

- Collect and store information for future use regarding fertiliser consumption, pesticide use, water consumption, technical information etc.

It is supposed that the responsibility of the ZID will shift in the future as a result of the decentralisation process leading to more involvement from the Regional Irrigation Offices. The technical aspects regarding planning and construction of irrigation projects will probably be privatised and prepared by consultants, and ZID will just get an advisory role and control the projects during and after implementation.

5.1.9 Ministry of Tourism, Natural Resources and Environment

The Ministry of Tourism, Natural Resources and the Environment is responsible for the environmental policy concerned with water in Tanzania, despite the fact that the MWEM is given the central authority in all water issues.

The most important institutions concerning water resources management in the Ministry are the National Environmental Management Council (NEMC), and the forestry Department. The former deals with environmental issues while the latter is concerned with water sources protection.

NEMC is just an advisory body and is divided into 4 directorates:

- Directorate of Natural Resources (Terrestrial Ecology & Desert control, Freshwater and Marine Resources)
- Directorate of Research, Environmental education & Documentation
- Directorate of Pollution Control (Pollution prevention & Monitoring, National Register of Toxic chemicals and Environmental sanitation)
- Directorate of Finance & Administration

The functions of NEMC are regulated in the National Environment Management Act of 1983 and the tasks and responsibilities are, among others, to:

- formulate policy on environmental management
- co-ordinate the activities of all bodies concerned with environmental matters
- seek scientific knowledge of changes in the environment and encourage the development of technology to prevent adverse effects.
- specify standards, norms and criteria
- establish and operate a system of documentation and dissemination of information relating to the environment (They are also preparing an inventory of all existing discharges).
- formulate proposals for legislation in the area of environmental issues.
- undertake or promote general environmental educational programme for the purpose of creating an enlightened public opinion regarding the environment and the role of the public in its protection and improvement.

It is not clear how directly NEMC shall be involved in monitoring, licensing or in enforcement. There is a proposal at the moment to give more power to NEMC, and how co-ordination with other institutions (especially with PWO and the Basin Water Offices) is supposed to be in the future.

5.1.10 Ministry of Lands, Housing and Urban Development

One institution has been established to deal specifically with land use planning at regional and district level, and to integrate technical inputs from line agencies that are responsible for different aspects of this multisectoral discipline.

The National Land Use Planning Commission (NLUPC) under the Urban and Country planning Department in the Ministry of Lands, Housing and Urban Development (established by act of Parliament No 3 of 1984) is the principal organ of the Government on all matters related to land use (advisory role).

NLUPC is responsible for co-ordinating the activities of agencies that are concerned with land use planning. These include the:

-Ministry of agriculture, Livestock Development and Co-operatives, which conducts agricultural land use, land evaluation and soil conservation activities.
-Ministry of Tourism, Natural Resources and Environment.
-Ministry of Lands, Housing and Urban Development, with responsibility through its Town Planning Division for the preparation of Village Land Use Plans.

Specifically at regional level the functions of the NLUPC include co-operation between national and local government authorities and NGOs during the preparation of regional physical plans. NLUPC is also responsible for establishing and working through the Land Advisory committees (LACs) in each Region and District, to ensure that national and local interests in land use are taken into consideration (Natural Resource Institute and National Environment Management Council, 1993).

The LACs include many authorities involved in water recourses management among others RC, RDD, Regional Agricultural and Livestock Development Officer, Regional Natural Resources Officer, Regional Water Engineers and representatives of NEMC.

5.1.11 Ministry of Health

While the MWEM is responsible for promoting and developing sanitation in urban areas, it is the responsibility of The Ministry of Health in rural areas.

The Ministry of Health acting through the Regional Officers of Health has so far been concerned with water related diseases. The health implication of waste water is discusses between NEMC, the Ministry of Health and the Regional and Municipal Health Engineer (If an epidemic is discovered the analysis are passed to the Regional Health Engineer). Pangani Basin Water Office has not so far been involved.

5.2 Legal, economic and planning tools

5.2.1 Environmental action plans and policy

It has not been possible to go in detail on every policy document which might have been written regarding water. Below some of them are mentioned.

National Level

A National Environment Action plan, prepared by the MTNE, NEMC, (1994) is currently under discussion in the Government and ministries. The National Environmental Action Plan contains the state of the environment including water resources, the national environmental policy and strategies for implementation of the policy (both cross sectional strategies and sectional oriented strategies including water). The importance of this strategy is described as follow "With the greater awareness of the cross-cutting and complex nature of environmental problems and of their importance and severity, institutional structures are changing and so must the strategies. It is part of policy and strategy to involve many elements of government and society but it is also important to ensure co-ordinated multipurpose approaches to environmental problems" (NEMC, 1994)

The Government has also launched and elaborated a *water policy* (1991) in order to ensure rational use of the water resources for all purposes and its conservation. The water policy, however , gives special and more emphasis on implementation (construction), operation and maintenance of water supply. The water policy is not mentioned in NEMCs policy paper.

In 1993 the Government decided to carry out a comprehensive water supply and sanitation review incorporating some actors in the field of water resources development and management. As part of this review it was decided to carry out a comprehensive *Rapid Water Resource Assessment* (MWEM, 1995) which has been refereed to several times in this report. The Principal Water Officer who is supposed to, according to the Water Utilisation Act, to co-ordinate and have a comprehensive approach to issues concerning supervision of water use, regulation and control, and water quality was however not a member of the working group or involved in the study. This should not have been the case. The newly appointed PWO is of the opinion that statutory officers including his office should have been fully involved to ensure equitable, juridicious and sustainable uses of WR.

Pangani Basin

During the feasibility study of PFRP the development of an overall basin water resources management was as mentioned, made as an precondition. A meeting was held with representatives from MWEM, MTNE and MALD (1990), and at this meeting it was agreed to recommend to the MWEM to establish PBWO according to the WUA. Recommendations from this meeting which are based on the WUA form a basis of the function of PBWO.

In a follow up meeting " The Moshi Meeting" on January 6, 1994 chaired by the Minister of Water, Energy and Minerals, the actions to be taken by Tanzania were once again stressed and outlined. In this meeting an action plan was prepared and serve as a basis for Tanzania's efforts to improve the water management according to the requirements set by the donors for New Pangani Falls Project. PBWO was given full support from the MWEM and the regional authorities to carry the overall responsibility for the water resources management in the basin. The action plan for the basin is mainly focusing on quantitative aspects, but do also involve tasks to improve the water quality and the environmental protection. Minutes from that meeting serves as a policy declaration.

5.2.1 Legal framework and regulations

Water Utilisation Act

The legal framework is given in the Water Utilisation Act (Act No 42/1974) with amendment acts regarding water pollution (10/1981) and Miscellaneous including penalties and fines(17/1989). In the Government Notice no. 347 published on 23.09.1994 water user fees were introduced.

The Water Utilisation Act with amendments outline the functions of PWO, CWB, BWO and BWB, water quality standards (temporary) and use of fines and fees.

The standards describe both effluent and receiving waters. The standard for effluent is uniform and do not give an individual regulation of discharges. It regulates the concentration, but not the flow. The quality standards for receiving waters includes as described in chapter 3.3.2, three categories based on the suitability of water.

The law state that nobody can pollute, but there is not established any discharge permit process including control procedures.

Environmental Impact Assessment

An Environmental Impact Assessment is a method used to identify projects impacts on the environment, and one of the main objectives is to bring to focus any possible negative impacts on the environment in an early stage in the planning of the projects.
Normally there is a notification stage which requires that environmental considerations relating to the environment, natural resources and society are taken into consideration. There is a checklist which covers these areas with a number of questions, air quality, water quality, local climate, noise and vibration, radiation, waste, soil pollution, land and forest resources, water resources, marine resources, mineral and metal resources, economy and employment, demography and housing construction, services and municipal economy, development patterns and transportation, social conditions, health issues, recreation and leisure.

The Norwegian Agency for Development Co-operation (NORAD) has prepared booklets for initial environmental assessment and check lists for initial screening of the projects with regard to EIA of development aid projects. NORADs policy is to carry out an EIA for all ongoing and planned development aid projects. In cases where projects will cause major environmental impacts a full assessment is required.

The system of EIAs is not yet developed in Tanzania, and projects can at the moment be implemented without carrying out an EIA. Water resources management authorities do not necessary get involved in e.g. establishing of industry. There is however a proposed amendment to the National Environment Management Act which introduce rules for EIAs (NEMC, 1994). The proposal is under consideration in the Government. It will probably be NEMC who will act as a consultant/advisor in the EIA process.

Other laws and standards with influence on water resource management

The National Environment Management Act No. 19 of 1983
The National Land Use Planning Commission Act No. 3 of 1984

5.2.3 Economic instruments

Water rights application fees and water user fees

The water right application fee (provided by Act. no. 42/1974) has been revised and increased and according to Government Notice No.347, water resources management authorities has introduced water user fees to cover the cost for maintenance and control of water abstraction.

The current water user fee is rather low. Efforts are being made to review the fees to comply with the value of water.

Fines

The polluter pay principle does only to a very little degree exist in Tanzania. The authorities can use water quality samples as a proof to fine polluters. The process is however time and cost consuming, while the final decision must be taken in the court. The polluter must if found guilty pay very deterrent amount of money, and must not cover the costs for the trial. The maximum pollution fine in use is only Tshs 100,000.

5.2.4 Land Use Planning and Water master plans

Tanzania has several planning levels, including national long term plans and master plans, regional-, districts- and village land use plans.

The land use plans for the regions are prepared by NLUPC on the basis of proposals submitted by the regions LAC. The regional land use plans are broken down into district land use plans which are co-ordinated by District LACs. The plans provide information on recommended long term future land use patterns and policies for management of each land use type.

10-15 years ago Water Master plans for 17 out of the 20 regions in Tanzania were prepared, these plans are only advisory. The plans have not been revised and are outdated. These need to be updated.

The planning systems will not be discussed in detail in this report, but there has been claimed to be a lack of integration in the planning (Natural Resources Institute and National Environment Management Council, 1993)

5.2.5 Monitoring and laboratories

Hydrometerological monitoring

Registration of hydrometerological data has been carried out by the Regional Water Engineers Offices in the Pangani Basin since 1959. In Pangani basin 36 places are gauged, but due to poorly maintenance 5 stations have been temporarily out of order. Pangani Basin Water Office receive data from the Regional Water Engineer offices from 22 selected stations. The data are transmitted to PBWO at Hale from Arusha and Moshi by radio, and by direct delivery from Korogwe.

Figure 14: Mr J.Z. Riwa (PBWO) taking a reading at Buiko gauging station

Monitoring of Water quality

Only ad hoc samples have been taken, and there are no regular monitoring program. There has not been done any comparison or a comprehensive collection of water quality data for the Pangani river.

NEMC has on behalf of PBWO prepared a proposal for a long term monitoring programme in Pangani river (NEMC, 1993). NIVA has based on the study in Pangani River some additional proposals to the programme (see chapter 6.5.1)

Data collection and use

There seem to be a lack of co-ordination between the different institutions collecting data, and there are very few procedures for dissemination of the information.

Laboratories and routines

The study team did not get completely an overview of all laboratory facilities existing in the area. Only Tanga water laboratory was visited during the mission.

There exists a laboratory in Arusha as well, and one is presently under construction in Moshi (MWEM, 1995).

Tanga water laboratory

The water quality laboratory in Tanga was established in 1982, and is organised directly under the Ministry of Water Energy and Minerals. The laboratory receive water samples from the three regions Arusha, Kilimanjaro and Tanga. The results are distributed directly to Dar es Salaam to the Head, Water Quality Laboratory at Ubungo.

The laboratory has the possibility to do both physical and chemical analyses: pH, conductivity, turbidity, colour, temperature, total hardness (calcium and magnesium), alkalinity, chloride, sulphate, manganese, iron, nitrite, nitrate, total phosphorus, dissolved oxygen, biological oxygen demand, copper, chromium, fluorides, total coliform bacteria (35°C) and faecal coliforms (44°C). Some of the parameters are however analysed very seldom, or have not been analysed at all. The main reason is the lack of chemicals.

The laboratory is very insufficiently equipped and consist mainly of a spectrometer (Hatch), an autoclave, a conductivity meter, a pH meter (also portable), a refrigerator/deep freezer, an oven for drying, an incubator and a destillation apparatus. There is a weight as well, but the maximum accuracy of this is only 50 mg, and makes it unsatisfactory for analytic purpose. The lack of a balance weight with a high accuracy prevent the lab from doing analyses on filtered water samples.

The samples are not conserved, and this together with the equipment (partly out of order) influence the quality of the results.

The laboratory needs equipment and improved procedures included inter calibration, preservation procedures and a new or rehabilitated laboratory room. The staff are well trained, but there is need for upgrading.

Arusha Water Laboratory

The Arusha water laboratory is capable for analysing the same parameters as Tanga Water Laboratory.

Planned Laboratory in Moshi

The Ministry is presently constructing a water laboratory in Moshi. The building is completed at a total costs of Tshs10 million, but furintures, equipment and chemicals are still missing and it will require additional Tshs 30 million before it can start operating (MWEM, 1995).

5.3 Other factors

5.3.1 Research Institute and University

There are a number of national and parastatal institutions in Tanzania undertaking research including the universities, The Ministry of Science, Technology and Higher Education the Commission for Science and Technology, as well as various research centres. NEMC and the MWEM including the regional units are also undertaking research in this field.

5.3.2 Environmental management in enterprises

The environmental management and awareness in enterprises is very poor, and has not been addressed properly. This can be a result of very liberal environmental regulations.

5.3.3 NGO's, awareness and peoples participation

There is in general a very low awareness in the main part of the population regarding water use and pollution. This is mainly caused by a low level of education, but also as a result of poor water resources management. There has not been any good public participation in the planning processes (no public notification process) of new industries or other polluting activities in the basin.

Local environmental organisations do hardly exist, and the main involvement is from foreign organisations.

6 Conclusions and Recommendations

6.1 Major conflicts and possible remedial measures

The question of how important each of the user interests is regarding the problems and conflicts they cause, is related both to the amount of water used and their impact on the environment including the water quality. Based on the information in previously chapters, we have tried to summarise the major impacts from different user interests, and the major problems and conflicts which exist among them.

6.1.1 Water Quantity

Number of abstractions and total amount abstracted

There is a great number of abstractions(both legal and illegal) from Pangani river, and the total amount of water abstracted compared to the available water is very large. The total numbers are given by two sources and showed in table 15.

There are some discrepancy between the numbers, but the number of abstractions are about 2300 in both references. The total number of abstractions without water rights seems however to be far more than earlier expected (about 2000). The number is less than 2000 today while Pangani Basin Water office has issued water rights the last years.

The total amount of water abstracted from the river is also uncertain, while the numbers in the table are based on inspections at a given time. The total net abstraction seem to be in the order of 50-70m^3/s, but there are indications on that this might be less (PBWO, 1994).

Table 15: Number of abstractions and total net abstraction (m^3/s) in Pangani.

	WB[1]		Swedpower[2]	
	Number	Net abstraction (m^3/s)	Number	Net abstraction (m^3/s)
Water rights	171	30	1000	30.5
Abstractions without water right	2094	40	1239	19.5
Total	2265	70	2239	50

1) Source: WB, chapter 9, 1994

2) Source: Swedpower, 1993

It is assumed that due to the evaporation in Kirua Swamp, only half of the total abstractions upstream NyM is noticed as reduction in Kirua downstream the swamps. The main part of the abstractions are within the Kilimanjaro region, and are mainly located upstream NyM (see table 16). The net effect of the abstractions in Hale is therefore much less than it could have been if the abstractions were located downstream NyM.

The net effect in Hale of a total net abstraction of 50-55 m3/s is probably 30-45 m^3/s (Swedpower, 1993). The natural river flow at Hale would if there had been no abstractions, have been around 67-82 m^3/s or even more if the highest abstraction estimate in table 15 is used. Anyway, the net effect of the abstractions is considerable compared to the actual flow in Pangani river at Hale of 37 m^3/s.

Table 16: Number of illegal abstractions and abstractions with water rights in different regions

Region	Illegal	Water rights	Total
Tanga	501	36	537
Kilimanjaro	1497	28	1525
Arusha	96	107	203
Total	2094	171	2265

[Source: WB, chapter 9, (1994)]

By May 1995 a total number of water rights in the data base was 1034 with a total granted water abstraction of 30.5 m^3/sec (Kobalyenda pers.comm.). At the time of inspection, 2094 traditional furrows abstracting about 40 m^3/sec.

Dominating user interests and conflicts

It is assumed that 93% of the total number of illegal abstractions and 80% of the total water rights are for irrigation and domestic purposes (Swedpower, 1993). Using the numbers to Swedpower in table 15, this give a total number of 2000 abstractions for domestic and irrigation purposes.

It is not the only the number of abstractions which are interesting, but it is important to note that there are some very big users, and many very small. 33 of the biggest water right holders account for ca. 18m^3/s, and 10 of the biggest irrigation schemes for more than 9m^3/s (Swedpower, 1993).

The actual demand and amount abstracted by each user interest will therefore say more about the real conflicts than the total number of abstractions. The net abstraction from the different sources are far exceeding the demand due to low efficiency in the distribution system (leakages), and because the users are abstracting more water than needed. Present and future demand and present net abstraction for different user interests are shown in table 17 and based on information from previously chapters. The numbers for net abstractions are rather uncertain, while these are only assumed on the basis of calculated demand, total amount abstracted and some other information from previously studies.

Table 17: Dominant user groups (m^3/s)

User groups	Demand	Future potential/demand	Present Net abstraction [4]
Irrigation	25	46	40-56
Domestic	1.5	2.3 [2]	5-10
Hydropower[1]	30	10-15[3]	≅0
Industry	low	low	low
Miscellaneous			4-5
Total			50-70

1) Demand at Hale (≅100% return)

2) 2010 with an annual population growth rate of 3%

3)Tanesco has estimated a potential of 10 -15 MW between NYM and Hale.

4)Uncertain

One should also be aware the number for average demand and abstraction do not give an exact picture of the conflicts either, because these vary within time and space. It can, however, be concluded from table 17 that irrigation is the main user. Irrigation users are abstracting water

upstream in the catchment and causing conflicts with other user interests, especially hydropower which need a constant flow for hydro power production, but also for fisheries, other farmers and for domestic and industrial water supply. The irrigation peaks are in dry periods when the available water in the river is rather limited, and this accelerate the conflicts. The seasonal variations are however to a large extent levelled out by NyM, but upstream NyM some of the tributaries go dry in the dry periods. The potential irrigation schemes are located downstream NyM, and will if they come into operation have a great net effect in Hale. Hydropower interests do also want to look into the potential for further production, and Tanesco has estimated a hydropower potential of 10-15 MW between NyM and Hale.

One can easily see that the conflicts in the future, especially between hydropower and irrigation, might be even bigger than now.

Regulation of water use

To be able to reduce the present conflicts, the conflicts in the future, and to optimise the utilisation of water, it is necessary to control the existing abstractions and to develop tools for an efficient water resources management.

The work and studies to reduce and to optimise the use of water, which have already been undertaken very efficiently by PBWO and which have reduced the abstractions considerably, must continue like construction of control gates, rehabilitation of traditional furrows, develop programs to improve the efficiency of irrigation schemes, creating awareness among farmers etc.

A water resource management plan should be prepared (see chapter 6.3.2), and the issuing of new water rights should be based on this plan.

6.1.2 Environmental Impact

Water pollution

Water quality
The level of water quality monitoring in Pangani river is unacceptable. The few existing data do not give an overall picture of the water quality, but the scarce statistic together with impressions from the site visits in Pangani river and its tributaries give an impression of an alarming situation due to high polluted water. The water has at many sites a high content of particles, nutrients, organic matter, fluorides and a low oxygen content. The levels of micro pollutants are not known.

Sources of pollution
The bad water quality is partly caused by natural sources like the high particle content (partly man made and partly natural), high fluoride content and high salinity (saline springs). It is however the man made sources in the catchment which have the greatest impacts on the water quality.

There has not been prepared any pollution budget showing the total loads from each sector. It is therefore difficult to say something exact about the important sources for water pollution. The data on water quality are also scarce too estimate the effects from the different sources.

It seems however that municipal and industrial sources are dominant, and the total pollution load from the agriculture sector is rather low due to low consumption of fertiliser and pesticides. Intensive agriculture production and grazing of cattle has however lead to increased erosion, and

as an indirect effect of agriculture and deforestation has occurred and thereby also increased the erosion. *Effects of pollution and conflict with other user interests*

In general, the upper part of the water course, near the springs of the Mts. Kilimanjaro and Meru, are heavily polluted by untreated industrial- and human waste water from the towns of Arusha and Moshi. Pollution do also exist downstream NyM mainly as a result of sisal washing.

The loading of organic matter, nutrients, micro-organism and micro pollutants do not only affect the ecology, but also human health. Some effects of the bad water quality are obviously like the effects of fluorides and brown teeth's in the Arusha area, and the effects of nutrients and the increasing growth of water hyacinths which has been observed downstream NyM. Farmers have also reported on skin problems. The contamination by micro pollutants in fish are not known. Neither are the effects on human beings due to their consumption of polluted drinking water (micro pollutants and water borne diseases) and their consumption of irrigated crop and contaminated fish.

The pollution may not only have a local character, but can also influence on the water quality in larger parts of the catchment. The regional effects are not so obvious while some self purification of the water may take place in NyM. The regional effects from the pollution in Arusha will also be reduced as a result of self purification in Oligarwa Shambarai Swamp. The pollution from agriculture seems only to be a local problem at the moment.

Outlet of municipal waste water and waste water from industry are in conflict with other user interests and makes the water unsuitable for other purposes, especially drinking water interests, irrigation of crop and food and beverage industry.

The fast growing population and the uncontrolled establishing of industries will be a threat to the ecology in the river as well as to human health and will be a major challenge in the future. Fertiliser and pesticide consumption can also increase, and one should be cautious of the problems caused by agriculture pollution which may occur.

Other Environmental impacts

The major impact from the agriculture sector today, are the impacts caused by irrigation. Salination of the soil and increased ground water level, have already been observed for big irrigation projects in the basin. Another impact is the huge abstraction in dry period leaving little water left in the river. This influence both flora and fauna in the watershed and at the riverbank. The latter is also an impact caused by hydropower production in the basin.

Cost efficient water pollution action plan

In order to improve the situation in Pangani river a cost-efficient water pollution action plan should be prepared A water pollution action plan must include:

-Registration
-Pollution budget
-Objectives for water quality in accordance to prioritised user interests
-Prioritised pollution parameters
-Calculations of need for reduction in loading in order to reach the objectives.
-Selection of "Hot spots"/prioritised sources and measures (technical and accompanying)

The technical measures to reduce the pollution must be adapted to the local conditions, and be based on technology which can easily be operated and maintained in the area.

Hot spots causing water pollution and possible measures

It has not been within the frame of this project to propose technical measures for the pollution sources, and this type of recommendations should be based on an extensive analysis as described above in order to propose cost efficient measures. The general impression is however that the first efforts should be put on sisal production and municipal and industrial pollution sources in Moshi and Arusha. We have pointed out some of the "Hot spots" in the region and possible solutions. This is mainly based on the impression from the mission, and must be investigated further.

The regional effects are more uncertain and should be studied, especially the self purification capacity of the swamps in Arusha.

Sisal Industry
The effluent from the sisal industry is extremely polluted and should be treated before it is discharged into Pangani river and its tributaries. Lagoons require a lot of space, but are not based on advanced technology and seems to function well (ref. Kwamdulu sisal factory). The extent of the problem compared to other sources and the effluent characteristic should be investigated before any advanced technological solutions are implemented.

Waste Water Treatment plant - Moshi
There are some plans to rehabilitate the old waste water treatment plant in Moshi. It seems more cost efficient to build a new more modern plant, based on technology which can easily be adapted and maintained in the area. Industrial waste should be pre-treated before it is discharged to the municipal sewerage system.

Tanning Industry - Moshi
Tanning industry is normally polluting. The production process, treatment facilities, quantity and quality of the effluent should be investigated in order to see if additional measures are required.

Kibo Paper mill-Moshi
Kibo Paper mill discharge effluent with a high organic load, and contain probably also some micro pollutants. Based on the impressions from the mission the factory ought to improve their treatment facilities.

Kibo Match-Moshi
Kibo Match is probably one of the hot spots in the region. The production process, treatment facilities, amount of the effluent and the effluent characteristic must be investigated in order to propose technical solutions.

Pesticide factory-Moshi
The location of the pesticide factory, is very unfavourable in case of any accident which might affect the whole catchment. The production, treatment facilities and effluent characteristic must be fully investigated in order to evaluate the possible risk to human health and ecology. Based on the information improved treatment and emergency plans are necessary.

Textile Industry-Arusha
Textile industry is also normally polluting. The production process, treatment facilities, amount and quality of the effluent should be investigated in order to propose necessary measures.

Wall board production-Arusha
The factory producing fibre board in Arusha has already some treatment facilities. The efficiency and the effluent quality ought to be controlled in order to decide if it is necessary to optimise the treatment plant.

Brewery in Arusha
The water management authority must pay a special attention to this company The effluent need to be treated, and it is not acceptable to discharge the effluent to Themi river. The outlet and the negative impacts on the environment and downstream users will probably increase if the company have the same development in production as previous years.

The management at the factory has also planned a new treatment plant for the effluent based on activated sludge. This takes however too much space and experiments with anaerobic treatment was
carried out by some Swedish students to investigate alternatives. The anaerobic process seemed to be to vulnerable to the variations in the quality of the effluent. The company has also thought of storing and dumping the waste water containing 90% water and 10% yeast at the municipal waste dumping site. The last solution is however in our opinion not acceptable.

An effective biofilm process (submerged) can be appropriate for handling this type of waste (high concentration and variations), and will be favourable also regarding the space which is available. Based on rough calculations a reactor volume of about 200 m^3 will be necessary (15 l/s and 3000 mg COD /l). In addition one sedimentation basin of approximately 100 m^2 need to be installed. A period with process optimisation ought to be carried out.

The waste water treatment plant-Arusha
The biological WWTP built in 1970 is heavily overloaded, by industrial effluent which is not pre-treated. There are plans for upgrading the treatment plant with two more ponds, and to use two of the existing ponds for anaerobic treatment of the most concentrated waste.

The measures to improve the situation can in general include:

-Optimising of the existing process
-Pre treatment of industrial effluent
-Extension of the treatment plant

<u>Other measures</u>

Waste dumping sites
There must also be undertaken an EIA study regarding the location of the new waste dumping site in Arusha. The leakage should be collected and treated. There should also be a clear policy regarding separating of waste (industrial waste and municipal waste) both in Arusha and Moshi.

Salination
There should be paid an extra attention to drainage of existing irrigation schemes, and the environmental impacts must be evaluated in the planning of new projects. Especially if the water quality is suitable to use for irrigation (low salinity), and if the drainage is good enough or if special measures have to be implemented.

Minimum water flow
In the case of hydropower production the need and the level of a minimum flow should be evaluated, and regulation regarding minimum flow should be established.

6.1.3 Priority to user interests

As seen above there are already big conflicts between the user interests which might be accelerated in the future, and some of the sectors might even have to reduce their demands to satisfy other user interests.

It is social and political criteria which are used to make these priorities, and at the present the first priority is to get enough and safe water for drinking. The priority between the other user interests might, among other things, involve criteria based on the economical value of water used for different purposes. The economical value of 1 m^3 for irrigation purpose and for hydropower production seems to be equal (Bjørknes and Rønningen, 1994).

PBWO has also undertaken a social-economic study in order to predict the value of water for different use in the basin (1995). Some of the results from this report might help the water manager and politicians to make the necessary priorities and decisions.

6.1.4 Benefits

The benefits in Pangani river for undertaking measures to reduce the amount of water abstracted and to reduce the environmental problems are obviously.

The potential saving of water based on 233 irrigation schemes are predicted by Rønningen and Bjørknes (1994) to 170-350 million m^3/year.

If this water is used for power generation instead, this could increase the production by 70 Gwh/year. The equivalent value of this increased production may be up to NOK 55 million (equivalent to Tshs 5.44 billion) in an average year (Rønningen and Bjørknes, 1994), and it has been estimated that the constructing of intakes at traditional furrows will only represent 5% of the value which is saved.

The saving of water may also allow further agricultural development in the basin.

Reduction in pollution will improve the ecological conditions and reduce the risk to human health both via direct abstraction of water for drinking, via consumption of irrigated crop and consumption of fish. The improved water quality will also reduce the water treatment costs and make the water more suitable for food and beverage industry.

6.2 Organisation and institutional strengthening

6.2.1 Environmental action plans and policy

The Ministry of Tourism, Natural Resources, and Environment is responsible of the environmental policy including the environmental concerns for water in Tanzania. MWEM is however carrying the overall responsibility for water issues, and has also developed a water policy (utilisation and conservation).

There seem to be an overlapping in responsibility, and this is causing a lack of co-ordination between the national environmental action plan and policy (including objectives and strategies for long and short terms activities) and the sector policy and action plans to MWEM. If one want to maintain the present organisation (see chapter 6.2.2), there must be put a greater effort in co-ordinating the activities and the sectional policy with the national environmental policy.

The water policy must also be linked to other sectional policies, while the water resource management is fragmented and managed by separate departments. Regarding environmental issues this can be achieved by a better co-ordination with the national environmental policy. The national environmental policy has an integrated approach to the environmental problems and is including all sectors.

6.2.2 Division of responsibility, co-ordination and co-operation

There are many ministries, departments and administrative levels involved in the Water Resources Management in Tanzania. The most important ministries involved are the Ministry of Water Energy and mineral, Ministry of Agriculture and Livestock Development, Ministry of Natural Resources, Tourism and Environment, Ministry of Lands Housing and Urban Development and Ministry of Health. The institutions involved represents a reservoir of knowledge and experience within their sector, but due to the sectoral approach which is also explained above there is unclear roles, overlapping responsibilities and a lack of co-ordination and co-operation. These problems both exists between MWEM and the other ministries, but also within MWEM.

<u>Unclear Responsibility, co-operation and co-ordination between the departments</u>

There seem especially to be some overlapping responsibilities and unclear roles between the MWEM and MTNE (e.g. the environmental policy). There are also a lack of co-ordination and co-operation between these two departments. Lack of co-operation and co-ordination between MWEM and other departments do also exist. There should especially be a better co-ordination and co-operation with the MLHUD (land use and water use planning), but also with the Ministry of Health (rural sanitation) and MALD (improved efficiency for irrigation and creating awareness of farmers).

<u>Organisation of the Water Resources Management</u>

There is always a conflict when the main responsibility for water resource management is organised within the Ministry where some of the biggest and most conflicting user interests are organised like hydropower and water supply/sewerage. To secure an independent approach and to reduce the "disqualification", PWO and the Central water Board have been organised under the Water council, and are reporting directly to the Principal Secretary (MWEM).

The broad representation of members from different ministries of the Central Water Board, is very suitable to achieve a comprehensive approach and secure a better co-ordination with other sectors. This could however as explained above be better.

To secure an independent and comprehensive approach, focusing on the water resources instead of the users, it may be more convenient to organise the water resource management within an "Environmental and Resource Department" (like the existing MTNE excluding tourism), and which has a stronger connection to land use planning. The organisation of the water resources management is however a political issue, and the study reported here has not been extensive enough to propose this type of changes. This need to be more investigated (see below).

The authorities plays many roles like being an authority (manage, co-ordinate, advice and control), but is also an owner of industries, irrigation schemes, sewerage, water supply etc., and are therefore also involved in the construction, implementation and maintenance. This mix of the owner and authority role is causing problem. The system is however changing, and it seems like Tanzania is in a position from shifting from one party rule to a pluralist parliamentary system, from a politically guided economy to a market based one, from state ownership to both state and private ownership. This imply also a revision of the public administrative system.

The work with reorganisation of the water resources management system has already started as a part of the "Rapid Water Resource Assessment study", and the organisation is at the present under a constant evaluation and change. The Ministry of Tourism, Natural Resources, and Environment has a cross secoral approach to the management of the natural resources, and should be involved in the work of clearing the responsibilities in the water resources management. PWO and PBWO (which already have been in operation for some years) are also important members to be included in such a working group.

Unclear Responsibility, co-operation and co-ordination within MWEM, strengthen of PWO

There seem also to be some unclear responsibilities and roles, and a lack of co-operation and co-ordination within the MWEM. Another aspect is how the formal organisational set up is, another thing is how it function in practice.

There are some informal lines and short cuts in the formal responsibility lines. One example is the delegated power to the RWE.

RWE- offices which are organised under the water division commissioner and are one of the users, have been delegated power to manage water resources which are not declared as national, and are in these cases reporting directly to PWO.

This shift in power has not been ideal, but has been necessary due to the weak position of the office of PWO within the Ministry. PWO was not appointed before 1991, and has had lack of personnel (only one person, himself) and left without the necessary facilities including technical equipment (PC, telephone, copy machine, fax etc.) to undertake the tremendous work it is to administrate the water resources in Tanzania.

PWO position within the Ministry and their possibilities to undertake the work they are suppose to, certainly need to be strengthened.

In practice the Water Division Commissioner has had more power ("informal power") within the Ministry regarding the management of the water resources, and PWO has also up to recently reported to the Water Division Commissioner instead of the Principal Secretary, although the organisation chart of MWEM has it clear; PWO should report directly to the Principal Secretary (see figure 13). This is very clear and serious example is that PWO has not been involved in the World Bank Study "Rapid Water Resource Management". The World bank has co-operated with the Water Division Commissioner (one of the users) in developing water resources management in Tanzania. As the wrap up meeting with the recently appointed PWO, the mission was informed, among others, that the PWO is now reporting directly to the Principal Secretary, which is a positive development.

6.2.3 Pangani Basin Water Board and Office

Some of the water resources management problems above seem to have been solved by establishing basin boards and offices. The basin board an office co-ordinates the activities in the basin and secure an integrated water resources management.

In Pangani Basin, the office functions well in their role of undertaking the overall responsibility for the water resource management within their basin. There are however insufficient financial support from the Tanzanian Government, who has not fulfilled their obligations. This causing some problems for the office to undertake the tasks they are suppose to, and the inadequacy funding has made the long term planning difficult. The office need financial support, and need capacity building within water resources management, nature conservation, pollution and irrigation.

There seem still to be some overlapping responsibility between PBWO and the RWE, but this does not cause any conflicts in the Pangani Basin.

PBWO has a close co-operation and co-ordination with the regional water offices and their political leaders. PBWO do also co-operate very efficiently with the regional irrigation engineers, the zonal irrigation engineer, the regional hydrologists, district offices with their political leaders, local governments and users.

The co-operation with the University and NEMC should be encouraged, especially regarding water quality monitoring, pollution effects, environmental impact and state of the environment.

6.3 Legal framework, regulations, planning and economic tools

6.3.1 Legal framework and regulations

Discharge permits and control

The Water Utilisation Act state clearly that nobody is allowed to pollute, but there is not established any discharge permit process including control procedures. It is recommended that every polluter must have a discharge permit, and that new pollution activities should not be allowed to start without having this permit. Public participation is important in the discharge permit process, to ensure that all views are considered before giving (or not giving) the permit.

The effluent standards in the WUA only regulate the effluent quality. In addition there are standards for receiving water. There should be an individual regulation of discharges, and a new approach should be enacted which is based on the standards for receiving waters. The discharge permits should regulate both the quality and quantity of the effluent in accordance with the river flow and downstream users. Implementation of effluent flow, and thereby also setting a limit for the total amount of pollution which can be discharged to the recipient, prevent the polluters from diluting their effluent.

The polluters should be forced to periodically control their effluent, as well as the authorities should establish control procedures. The polluters should also be forced to establish emergency plans in case of accidents.

Municipal waste water treatment plants must also establish stricter control on what they allow industry to discharge to their sewerage system. Pre treatment of industrial waste must be enforced according to the law (section 18.8 Amendment Act No. 10 of 1981)

To date it is very difficult for the Basin Boards to fine polluters violating the standards set in the law. The WUA should be changed in order to improve this, and instead an appeal procedure can be established allowing polluters to consult the MWEM if they feel that the Basin Water Board is acting unfairly. This appeal procedure can be used in the discharge permit process.

EIA

The system of EIA is not yet developed, and there is an uncontrolled establishing of industry. The water resources management authorities do not necessary get involved or get any information when industry is about to be established. EIA must be implemented in the Environmental regulations, to have a better control with the environmental impacts of projects.

The donors have a special duty and responsibility to follow up their own projects, and minimising of the environmental impacts must be a part and a condition in their projects.

6.3.2 Economic and planning tools

Economic tools

Water right application fees, water user fees, and fines have already been established. The set Water User Fees are however rather low, and should be increased further if this is going to be an efficient tool to regulate the misuse of the water. This is also the case of pollution fines. The polluters do only pay a light fine when they are found guilty (the cost for the process for fining the polluters is many times more), and the fines should be set higher. The polluter pay principle can be even more strengthened by introducing pollution fees.

Planning tools

There are many user interests within one basin and the conflicts among them will increase in the future if the development is not controlled. A water resource management plan is a useful tool to be able to administer the water resources in a proper way. A water resource management plan shall define each user interests and their requirements, make priority to the user interests, and propose measures to achieve the desired development. The water resource plan should be linked to the

land use plan in order to achieve a comprehensive approach, and in order to make this plan not only guiding but juridically binding.

The National Land Use Planning Commission (through the LACs) which has the co-ordinating role and the responsibility of regional physical plans, can provide integration of institutions and individuals that have responsibilities within water resources management in developing juridically binding water resource plans.

There should also be a process for public participation in government decision making, including the requirement of notification and an option to comment on the plans (this must also be the case in an EIA process).

6.4 Environmental education, public awareness and research

Training and education is needed at all levels, and must be incorporated in the formal education. The general level on professionals dealing with environmental issues (both at the central and regional level), in the industry and in the public must increase.

Creating of public awareness and training of farmers to motivate them for efficient use of water has already been within PBWO work, and must continue. This motivation should also include environmental aspects.

More research is also needed to analyse the state of the environment, and to understand how different activities in the catchment influence the water quality and hydrology in the basin(see chapter 6.5).

6.5 Water quality monitoring and laboratories

6.5.1 Water quality monitoring program

Need for a regular water quality monitoring programme

There has, as mentioned earlier, been paid little to no attention to pollution sources and water quality problems, and the present level of monitoring is unacceptable.

Due to the severe pollution in the catchment and the consequences for future use of the water, it is important that a regular monitoring program is established in order to quantify the size of the problems and to take actions before the situation comes completely out of control.

Comments to NEMC's existing draft

NEMC has, as mentioned earlier, already on behalf of PBWO prepared a proposal for a long term monitoring programme in Pangani river and in the tributaries (NEMC, 1993). The programme form an acceptable base for a monitoring of River Pangani, and it should be implemented as soon as possible. However, NIVA has based on the study in Pangani river including site visits, some additional proposals to the programme both regarding the selection of localities, the water quality parameters and some few other comments.

NIVA's comments to the existing draft are listed below, and the monitoring program is given a detailed description:

- Selection of stations
  Each monitoring station should be given a detailed description and an exact location. This must include arguments for establishing the stations and the benefits of each of the stations.

- The number of monitoring stations.
  The number of stations should be increased and include reference stations in upper parts of the river system (non-polluted/pristine areas), sampling stations downstream areas where big pollution sources are located, sampling station(s) within and downstream the NYM reservoir and sampling station near the river mouth to the sea. NIVA has also proposed to move some of the existing monitoring stations.

- Analyses of sediment and biological material and registration of water flow.
  In addition to (or in stead of) water analyses, analyses of sediment and biological material should be included at some of the stations. The fish, together with bottom sediments from NyM provide an excellent possibility for monitoring of heavy metals, fluoride and pesticides in the Pangani River. Old specimens of raw fishes could be examined for mercury (fish fillet), copper, zinc, cadmium, chromium and pesticides (fish liver). Fish bones could also be examined for fluoride. Measuring of water flow must be included at all stations for mass balance calculations of pollution.

- Procedures for sampling, analyses, processing, storing and reporting of data must be established.

- Need for personnel and training
  It should be evaluated if there is need for one person to undertake all steps in the monitoring program, sampling, analysing and compiling of data, or if this can be undertaken by the existing personnel at PBWO and at the laboratories in the area. The persons involved must be trained in order to undertake proper sampling and field preservation of the samples. It is also necessary to train personnel at the laboratory to undertake analyses (including use of new equipment) and to be able to maintenance the equipment. A program for constant updating of all personnel should be established.

- Revision of the monitoring program
  The monitoring should be revised after one to two years, where sampling stations and parameters might be excluded or added.

<u>Sampling stations, selection of parameters and sampling frequency</u>

Sampling stations;
NIVA's proposal for a water quality program in the region is as mentioned based on the programme introduced by NEMC. Additional sampling stations, parameters, and arguments for establishing the monitoring stations are listed below in table 18 (the stations are marked on figure 15):

Parameters;
Abbreviations used are:
Temp. = temperature (°C), pH = acidity, Cond.= electrical conductivity, Turb.= turbidity, TSS = total suspended solids, SIR = suspended ignition rest, P = total phosphorus and phosphate, N = total nitrogen

and nitrate, F = fluoride, BOD = biological oxygen demand, COD = chemical oxygen demand, Heavy metals = copper, zinc, cadmium, chromium, lead, iron, and manganese. Main ion.= calcium, magnesium, sodium, potassium, chloride, sulphate, and alkalinity, Chl-a.= chlorophyll a, E.coli44 = faecal, thermostable (44°C) bacteria.

Sampling frequency;
NEMC (1994) has proposed a sampling frequency of four times a year; 1)two weeks after the rainy session has started, 2) one month before the rainy season ends, 3) two months after the end of the rainy season and 4) in the middle of the dry season. This seems to be a very good approach in order to follow the variations during the year.

Table 18: Sampling stations for water quality

No	Location	Parameters	Arguments	Remarks
0	Outlet to the Indian Ocean (Pangani)	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, SIR Main ion.Chl-a, E.coli44	Contribution to the marine environment.	New loc.
1	Hale (Pangani)	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Main ion.Chl-a, E.coli44, Heavy met.and pesticides in fish.	Environmental problems (Hyacinth) in the intake pond to Pangani power station, influence from Luengera river (east), tributaries from west, sisal pollution and domestic waste Korogwe-Hale.	NEMC loc. Water st. ID17
2	Korogwe (Pangani)	Temp. pH, Cond. Turb.TSS, SIR, P, N, BOD,COD, Main ion.Chl-a, E.coli 44.	Water quality after config. with main tributary Gomba (east), tributaries from west and influence from sisal industry.	NEMC loc. Water st. ID14
3B	Gomba, Mkomazi river	Temp. pH, Cond. Turb.TSS, SIR, P, N, BOD,COD, Main ion.Chl-a, E.coli44	Water quality in main tributary. Might be polluted by domestic waste water and run off from agric.	Former NEMC loc.3 moved from Luengera to Goma river Waterst. IDB17
4	Mkomazi river	Temp. pH, Cond. Turb.TSS, SIR, P, N, BOD,COD, Main ion.Chl-a, E.coli(44°C)	Water quality in main tributary to Gomba river. Referance loc.	NEMC loc.
5	Buiko (Pangani)	Temp. pH, Cond., Turb,TSS, SIR, P, N, BOD,COD, Main ion.Chl-a, E.coli(44°C)	Water quality in Pangani upstream main sisal pollution.	NEMC loc. Water st. ID10

Table 18. Continues

No	Location	Parameters	Arguments	Remarks
6	Downstream NYM. (Pangani)	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met. pectisides Main ion.Chl-a, E.coli (44°C)	Water quality in the beginning of main Pangani river. Self purification in NYM.	NEMC loc. Water st. ID 8C
6 B	Middle of NYM.	Water column (all depths): Temp, pH, Cond.,Oxygen. Sediments and fish: Heavy metals, pesticides, E-coli.	Water quality in NYM, including analyses on sediments and fish.	New loc.
6 C	Ruvu River upstream NYM.	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met., pecticides, Main ion.Chl-a E.coli44	Water quality in the eastern main inlet to NYM. All main pollution included	New loc.
7	Kikuletwa River up-stream NYM.	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met., pecticides Main ion.Chl-a ,E.coli44	Water quality in the western main inlet to NYM. All main pollution included	NEMC loc.
8	Rau River (tributary to Ruvu) after confl. with Njoro spring	Temp.,pH, Cond, Turb, TSS SIR, P, N, F, BOD, COD, Heavy Met, Pecticides, Main Ion, Chl-a, E-coli 44 °C	Pollution from Moshi after the water is used for irrigation, and poll. from the eastern tributaries in Kilimanjaro Region.	NEMC Loc.
9 A	Njoro Spring (Tributary)	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met. Main ion.Chl-a, E.coli44	Water quality in main tributary. Referance loc.	Former NEMC loc. moved few meter upstream (pumphouse) Waterst.IDC-35
9 B	Njoro River (Tributary to Ruvu river)	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met. Main ion.Chl-a, Pesticides E.coli44	Mun. and Ind. poll.from Moshi.Irrigation of rice field Heavy polluted	New loc.
10	Himo River (Tributary to Ruvu river)	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met. Main ion.Chl-a, Pesticides E.coli44	Runoff from coffee fields	NEMC loc. Wat.st.IDC11A
11 B	Weru-Weru (Tributary to Kikuletwa)	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met. Main ion.Chl-a, Pesticides, E.coli44	Pollution from Moshi and runoff from. agriculture fields	Former NEMC loc.11moved to a tributary upstream

Table 18 continues

No	Location	Parameters	Arguments	Remarks
12	Kikuletwa River (upper	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, heavy met. Main ion.Chl-a, Pesticides E.coli44	Runoff from Arumeru district	NEMC loc. Wat.s.ID55
12B.	Maji ya Chai (Tributary to Kikuletwa)	Temp. pH, Cond. Turb. F, Main ion.	Heavily polluted by Fluorides	New location Wat.st. IDD29
13	Arusha, Msangazi?		The exact location and the purpose is not known	NEMC. loc
14	Near Remiti?		The exact location and the purpose is not known	NEMC loc.
15	Kikuletwa River (near airport)	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met. Main ion.Chl-a, Pesticides E.coli44	Runoff from Arumeru district and influence from saline springs	NEMC loc.
16	Themi River (before Olgaiwa Sham-barai Swamp)	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met. Main ion.Chl-a, Pesticides E.coli44	Pollution from Arusha and runoff agriculture fields. Heavy polluted	New loc.
17	Themi River (Spring area) Olesha/ Oligilai	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met. Main ion.Chl-a, E.coli44	Referance loc. (in water tanks before distr.)	New loc.
18	Nduruma River at Mbuguni	Temp. pH, Cond. Turb.TSS, SIR, P, N, F, BOD,COD, Heavy met. Main ion.Chl-a, Pesticides E.coli44	Runoff from Arusha and agriculture fields. Heavy polluted? Used for irrigation	New loc

6.5.2 Laboratory- strategy, facilities and procedures

There are some existing laboratories in the region to undertake water quality analysis, but these are insufficiently equipped and proper laboratory procedures are missing. In addition there is a Central water quality laboratory in Dar es Salaam. It is necessary to evaluate all laboratories in the area and establish a laboratory strategy. It should also be considered whether it is appropriate for PBWO to have and administer their own laboratory or if this should be independent from the office.

The laboratory facilities must be improved, including housing, equipment and access to chemicals. Improved laboratory facilities can be achieved by rehabilitation of existing lab(s) or building a new lab which can analyse all parameters. Intercallibration with other laboratories should be established. The new laboratory in Moshi might fulfil the requirements when it is completed.

Figure 15: Location of monitoring stations (for detailed information upstream NyM see figure 3)

6.6 Registration and information

6.6.1 Need for registration

To undertake a proper water resources management there is need for a lot of information regarding the water resources (status and long term series), but also information regarding the activities in the area (both present and planned).

Some of the data needed are listed below:

- Geographical Information; Population, climate, geology,
- Water resources (quantity, quality and variations)
- Location and size of different activities in the catchment
  -Drinking water abstractions (ground water and surface water) Location, quality and size
  -Agriculture; abstractions for irrigation, crop production, fertiliser consumption and pesticide use, husbandry's etc.
  -Pollution sources (discharges, effluent quality and treatment facilities)
  -Fisheries and catch potential
  -Hydropower production
  -Forestry etc.

There is already a lot of existing data, but some information is rather limited. There is therefor need for further registrations, and there should be established a program for collecting and routines for updating this information.

6.6.2 Access to information and co-ordination

The already existing information is collected by many sectors, and mainly stored on a ministerial basis. The information is therefore not floating back to regions and districts. There is also a lack of co-ordination between the different sectors regarding collection and exchanging of information.

There is need for a centre which has access to the sectoral basis and which gather this information and distributing it to the regions and districts, or there must be established better procedures for the distribution of information from the ministries.

There is also a need for co-ordinating the data collection and avoid double work.

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Annexes

Annex 1: Program for the visit to Tanzania

Wednesday 03.05.1995

- Departure from Oslo

Thursday : 04.05.1995

- Meeting with NORAD-Alf Adler
- Visit Norplan

Friday 05.05.1995 Meeting with institutions in Dar Es Salaam

- Ministry of Water energy and Minerals-Acting Principal Water Officer,PWO, G.K.M, Shirima
- Ministry of Tourism, Natural Resources and Environment- National Environmental Management Council
- Ministry of Lands, Housing and Urban Development-Land use Planning Commission

Monday 08.05.1995 Meetings in Dar es Salaam

- Ministry of Agriculture-Agriculture and Livestock Division-Irrigation Department
- Tanesco

Tuesday 09.05.1995.

- Drive to Hale
- Meeting with Pangani Basin Water Officer (PBWO)

Wednesday 10.05.1995-

- Meeting with PBWO
- Meeting with the Regional Water Engineer (RWE) in Tanga.

Thursday 11.05.1995

- Meeting with PBWO
- Surveying of Pangani in the surroundings around Hale
  -Hydro electric power station,
  -the Dam
  -Pangani River from the Dam and down to the outlet from the tailrace tunnel.
- Reporting

Friday 12.05.1995

- Meeting and site visit to Kwamdulu sisal factory
- Meetings with PBWO
- Reporting

Sunday 14.05.1995

- Drive from Hale to Moshi including surveying of Pangani River, tributaries and NyM reservoir

Monday 15.05.1995

- Meeting with the Regional Water Engineer in Kilimanjaro region
- Surveying of pollution sources in Moshi District
- Meeting with T.P.C Limited sugar cane factory in Moshi
- Reporting

Tuesday16.05.1995

- Meeting with Zonal irrigation department in Moshi
- Meeting with a Tanning Industry in Moshi
- Transport to Arusha

Wednesday 17.05.1995

- Meeting with RWE in Arusha region
- Meeting with a Textile Industry, Sunflag LTD
- Meeting with Fiber board Ltd

Thursday 18.05.1995

- Meeting with Tanzania Breweries Limited and surveying of the waste water outlet
- Site visit to the municipal waste water treatment plant in Arusha
- Meeting with General Tyre
- Reporting

Monday 22.05.1995

- Transport from Arusha to Dar es Salaam
- Reporting

Tuesday 23.05.1995

- Reporting

Wednesday 24.05. 1995

- Wrap up meeting with PWO (J.M.Kobalyenda), Ministry of Water, Energy and Minerals
- Wrap up meeting with NORAD
- Reporting

Thursday 25.05.1995

- Departure from Dar es Salaam to Norway
- Reading and reporting

Annex 2: Documentation of visits and interviews

2.1 Norplan-Dar es Salaam

Time and place:

Thursday 04.05.1995, 0900-11.00 at Norplan's main office in Dar Es Salaam.

Represented:

Norplan, Are Bjørn Ovanger
NIVA, Leif Lien and Kjersti Dagestad

Summary:

After landing in Dar Es Salaam we were picked up by Norplan and driven to the main office in Dar es Salaam. Norplan has been the consulting company for the Pangani Falls Redevelopment project and is also responsible in following up the project both with regards to the Water Management (advisory function) and in the testing period of the Hydro power station.

The main purpose of the meeting was to get some brief information and practical help for arrangement of the field trip to Pangani River. Norplan has shown great willingness from the start in helping the project team to carry out this study.

The project team did also get a brief information about the status of PFRP:

The new power station in Pangani Falls was handed over to TANESCO in February 1995 after two months of testing. Norplan think it is very important to follow up the project further and assist TANESCO in operating the power plant, but also assisting Pangani Basin Water Office further to ensure that the donors (The governments of Norway, Sweden and Finland) requirements for the project are fulfilled. They have applied to NORAD for further engagement.

2.2 NORAD

Time and place:

Thursday 04.05.1995 at the Norwegian Embassy in Dar Es Salaam.
Monday 08.05.1995 at the Norwegian Embassy.

Represented:

Alf Adler (project co-ordinator for the Pangani Falls Redevelopment project) and Osvald Haugebotn (responsible for environmental aspects in NORADs projects in Tanzania)
NIVA, Leif Lien and Kjersti Dagestad

Summary:

The main purpose of the meetings was to get practical information to be able to carry out the study, and to get NORAD's opinion about the progress of the Pangani Falls Redevelopment Project and Pangani Basin Water Management.

We also wanted to get information about the function of the water management system according to the donors requirements, the main problems and conflicts in the catchment area to Pangani River, main user interests, pollution sources, water quality problems in the basin and NORAD's environmental engagement in Pangani in particular and in Tanzania in general.

The progress of the Pangani Falls Redevelopment Project and the function of the water management in Pangani Basin:

In the opinion of NORAD the project has fulfilled the requirements to the donors, especially regarding the abstraction of water for hydro power production related to other user interests in the catchment area.

PBWO has reduced the abstraction by installing water gates. The water gates are installed at the largest users (approximately 200) and are operating according to the need of water. The biggest users have been identified due to extensive field visits and registration also executed by PBWO. The majority of these sources are located upstream NyM, and the reductions in water abstraction have not only been positive for the hydro power production, but also for other users downstream who have been secured permanent water supply throughout the whole year.

The hydro power station is being operated very efficiently (release of water from NyM is adjusted to the hydrological regime).

Water right application fees and water user fees have respectively been updated and introduced since mid of 1994, and the fees are used to cover some of the operating expenses for PBWO and will thereby indirectly be transferred back to the users. The fees set are however rather low.

NORAD is positive to extent the Norplan advisor function for a period in the area to secure that the project is properly implemented.

Pollution sources

Some major pollution sources were mentioned:

Sisal Washing: Sisal production has increased the last year after a low conjecture in the late eighties. The increased production is due to multiple use of the raw material (paper production, concrete ceiling cover and traditional ropes), but also because the increased oil prices sisal can compete with plastic ropes. The main sisal production area is located between NyM and Pangani Falls. The waste water from Sisal production is very concentrated concerning organic content, and can be seen visually at the outlets.

Tanning Industry, Tanning industry was mentioned as another potential pollution source.

Pesticide production, A factory producing pesticides has also been noticed by NORAD.

Wallboard production located between NyM and Pangani Falls.

Domestic Waste Water from villages and towns has not yet been noticed as a problem by NORAD. VIP latrines sponsored by NORAD have been introduced in the area. VIP latrines are transportable, built above holes dug in the ground and are moved a few meters when it is filled up. NORAD has initiated a program for building these latrines by providing the builders with building material and equipment.

Sugar cane farms and sugar cane refinery plants: These were mentioned and are mainly located in the Moshi Area.

There was also mentioned to be an industrial area south of Arusha.

Mercury pollution due to gold production is not regarded as a problem in Pangani, but was mentioned to be a big pollution source in the Tanzanian catchments of lake Victoria and Lake Tanganyika. A new invent has been introduced with support from NORAD, the equipment recycle the mercury with 99% in small scale productions. The mechanism was simple, cheap and easy to handle and operate. In NIVAs opinion the equipment can be very useful in the abatement of severe mercury pollution from gold production (legal and illegal) also in other countries.

The pollution from agriculture is not known, but the use of commercial fertiliser is relatively small due to the high prices on the product. NORAD will probably give some support for the introduction of commercial fertiliser.

Identified problems

Growing of Hyacinths (a floating water plant with a large surface area)has been an increasing problem downstream NyM and in the intake dam to Pangani power station. The Hyacinths cause problems both due to larger evaporation (three times higher than from an open water surface), and because of operation problems for the Hydro power station.

User interests and activities in the area

Agriculture is mainly located upstream NyM, and is based on traditionally multi agriculture. The soil and climate in the Kilimanjaro/Arusha area is favourable for agriculture. Downstream NyM the main production is sisal.

Fisheries; The activity in the region is rather limited. There has been observed some activities lately in the intake dam to Pangani Falls. There are also some fishing in NyM.

Aqua culture, do not take place.

Drinking Water Supply, In the upper parts of the catchment area, people are served with domestic drinking water from springs and surface water. Further down in the catchment ground water wells are dominating, and supply from Pangani river is in general not suitable.

Irrigation, is the main water abstraction in the Kilimanjaro and Arusha areas.

2.3 Ministry of Water, Energy and Minerals-PWO

Time and place:

Friday 05.05.1995, 0900-11.00

Represented:

Acting. Principal Water Officer; G.K.M Shirima
Head of Hydrology section in MWEM; Hydrologist, M.O. Msuya
NIVA, Leif Lien and Kjersti Dagestad

Summary:

The main purpose of the visit was to get an overview of the water management system in Tanzania and the ongoing activities in Pangani.

The department has initiated a project together with The World Bank focusing on the efficiency and organisation of the water resource management system, pollution sources, conflicting user interests and water quality problems. Phase I of the study "Rapid Water Resources Assessment" (an approach of the whole country) and phase II (analysis of each basin) has just been finished and will be printed within a few weeks. The project will continue with more detailed studies and measures in each of the 9 basins. Two of them Pangani and Rufiji are already in operation.

NIVAs report will in a certain degree be overlapping, but also complimentary to the World Bank report.

The organisation of the water resource management system will as a result of the World bank study be revised, and is also under constantly revision today.

As for the case of Pangani Basin, PWOs responsibility has been delegated to the BWO. These issues were before delegated to the regional water engineers in cases where the river was not characterised as a national resource. The opinion of acting PWO is that the basins must be in dependent bodies as today, and not under the commissioner for water affairs who is in charge of water supply/sewerage and therefore one of the big users. These have to report to the PWO, whose office is responsible for Water Resources Management in Tanzania mainland.

Special problems in the Pangani Basin were mentioned to be high water demand compared with the available amount, high pollution due to fertiliser consumption and sisal washing. It is not necessary to irrigate the Sisal.

The main issues regarding Pangani Basin have been;

- Rehabilitation of water control gates to decrease the water demand. This has been a success not only regarding other user interests, but also for the farmers who have reduced their problems regarding erosion and who have obtained a better flood control (decreased the problem with destroyed harvest). About 200 gates have been installed, and replaced old furrow intakes.

- Making the PBWO responsible for the management and decision on the release of water from NYM (for Hydro electric production at Pangani Falls).

- The Introduction of water user fees. The fees used are rather low, but are expected to be revised and substantially increased in the future to deter polluters.

- PBWO and PWO have also tried to raise the awareness of the people, not only with respect to the amount of water used, but also regarding pollution. 5 sisal washers have already been fined for polluting the Pangani river. Up to now PBWO has taken grab samples periodically for pollution control. The samples are analysed at the Central Water Laboratory of MWEM situated at Maji Ubungo. Depending on the result the polluters in many cases just get a warning, and few have been fined. Due to high costs and comprehensive bureaucracy, the cost/benefit of a trial is less than the effort of the process. The rules and the incentives have to be strengthen in order to reduce the pollution.. The law must be revised especially regarding industrial sources. PWO does also encourage self control at the polluters, rather than a comprehensive control by the authorities.

2.4 Ministry of MTNE and Ministry of LHUD

Time and place

Friday 05.05.1995, 11.00-13.00, Office of National Land Use Planning Commission in Dar Es Salaam

Represented

Ministry of Tourism, Natural Resources and Environment-National Environmental Management Council (NEMC), I.A.J Michallo
Ministry of Lands, Housing and Urban Development, Office of National Land Use Planning Commission, J.M.S Shilungushela.
NIVA, Leif Lien and Kjersti Dagestad

Summary

The purpose of the visit was to get an overview of how these to institutions are involved in Water Resource Management and the co-ordination with other ministries and departments.

Several reports dealing with water resource management, pollution and water quality were presented. Of special interest was the water pollution monitoring plan which has been prepared by NEMC. This plan has not been implemented, but is expected to come into operation after the Environmental policy (under consideration) is approved by the government.

Special problems mentioned; Hyacinths, sisal washing and area runoff in the rainy seasons.

NEMC has for the time being just an advisory role in the Environmental Department in the Ministry of Tourism, Natural Resources and Environment. The ministry deals with environment and ecology; fishery, wildlife, forestry and the total environment also including monitoring and water quality. NEMC is carrying out studies and preparing action plans. The present co-ordination with other departments is at the moment weak, but co-operation and co-ordination between the different departments dealing with environment is also one of the main issue in the above mentioned environmental policy. One of the proposal is to give NEMC an authority function and not just an advisory role. NEMC expect at least to have an environmental co-ordinating role concerning the 9 basins in the country and work closely with them. NEMC will probably also co-ordinate and take part in EIA studies. An amendment to the National Environment Act no. 19 of 1983 is proposed describing the process and guidelines for how Tanzanian EIAs should be carried out. The economical responsibilities for carrying out the studies are not yet decided (the Government, the contractors or both).

The Office of National Land Use Planning Commission has also an advisory function under the Urban and Country Planning Department. As part of the land use planning process in an area, each sector and their interaction are evaluated including what kind of activities which can be established in one area with respect to the amount and quality of water. There is a proposal to strengthen the Water Boards in the Basins to also include land use planning.

2.5 Ministry of ALD-Irrigation Department

Time and place

Monday 08.05.1995, 09.00-11.00, Ministry of Agriculture, Agriculture and Livestock Division, Irrigation Department.

Represented

Assistant Commissioner Irrigation, E.H. Masija
Environmental Engineer, Irrigation Department, Mr. A.L. Simukanga.
NIVA, Leif Lien and Kjersti Dagestad

Summary

The purpose of the meeting was to get an overview of the institutional set up, co-operation with other departments and ministries, tasks and responsibilities of the department, irrigation and agriculture activities, crop production, fertiliser consumption and main environmental problems.

The organisational set up for the Ministry of Agriculture with focus on the Agriculture and Livestock Division-The Irrigation Department was explained. In every region (20 on the mainland) there is a regional Irrigation Engineer, and between the regions and the state administration it has been established Zonal Engineer Offices (6 zones) which are responsible for the co-ordination of the Regional Engineers within each zone. The administrative area of The Zonal Engineer offices, do not follow the basins, but the northern zone includes both Kilimanjaro, Arusha and Tanga regions.

The Ministry of Water, Energy and Minerals is responsible for water and the water policy. The Ministry has formed a Central Board and basin boards where the Irrigation Department is represented. The water management are however split up on many institutions and departments, and there has up to now been little to no co-operation or a comprehensive approach in the water management.

The Irrigation Department is responsible to get a water right, according to the water utilisation act, from the Central Board or the Basin Boards (if established) in the planning of a new irrigation project. There are however conflicts with the water utilisation act and customary laws saying that everybody has the right to abstract water. This has especially been a problem in the Kilimanjaro and Arusha regions, where there are conflicts with other users (especially hydro power production), and where traditional irrigation has been in operation for 300-400 years. The farmers do not accept to pay for the water. Usually the traditional furrows were administrated by committees (a village or a clan) which where responsible for the utilisation, distribution and maintenance of the furrows. The Irrigation Department has built this old system into the new organisation and structure and established water associations consisting of the farmers in the area. The Irrigation Department is responsible for making this structure function and to train the farmers being involved.

The World Bank has as a part of the study "Rapid Water Resources Assessment" formed study teams with each of the sectors involved in water management. The main objectives for the irrigation sector are:

- Improve the irrigation efficiency from approximately 25%-50%
  The Government has prioritised to assist small farmers.

- Improve the water management regarding irrigation and establish criteria and guidelines for water abstraction and the actual need of water.

- Increase the awareness of the farmers of how irrigation effects other users.

The crop production is extremely depended on irrigation and increase the production from about 1 to 4.5 tonnes/hectare on average (depending on crop).The irrigation technology is based on low cost technology (mostly on open channels). In larger irrigation projects more modern technology like sprinkling equipment with small holes is introduced.

The Ministry of Agriculture is also concerned with water pollution and erosion, and are investigating how much an area can bear of livestock with respect to water use and runoff. The Arusha area has a big number of cattle, and in the dry seasons these cattle's are drinking water directly from the river. This has caused problems with siltation, erosion and health problems for the population who abstract water for drinking.

The Zonal or Regional Irrigation Engineers have numbers about fertiliser consumption. Fertilisers are not highly subsidised yet, these are very expensive but are used to some extent. Sisal do not need to be irrigated or fertilised. Pesticides was said to be used only in a small scale.

The main identified problems in the Pangani Basin concerning irrigation were mentioned to be:

- Saline water; especially in the area around Kikuletwa caused by saline springs

- Siltation

- Water borne diseases like Bilharzia, but also malaria

- Industrial pollution from Moshi effecting both human health and the crop production.
  The irrigated water is taken from Karanga river which passes Moshi. Farmers in this area have complained about oil films on the crop. Downstream, Kibo paper mill, the farmers are also exposed to skin problems. The environmental engineer did not know if and what kind of fungicides were used at the factory. Outlets from tanning industry (Njoro river) and faecal pollution from rural population without pit latrines were also mentioned. The factory which are going to produce pesticides has not yet come into operation. The factory is going to establish a treatment plant, but there are of course a lot of concern among the population both regarding human health and environmental problems.

2.6 Tanzania Electricity Supply CO.LTD - Tanesco

Time and place

Monday 08.05.1995, 11.00-13.00 Taneso's main office in Dar Es Salaam

Represented

Research & Development Division, Manager; D.E.P Ngula
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to get an overview of hydropower production in the Pangani River, and how environmental problems and research are dealt by Tanesco.

Research & Development Division
Tanesco is 100% owned by the state. The Research & Development Division is organised under the Corporate Planning and Research Department and is responsible for executing applied research in co-operation with other institutions. They co-operate especially with the University of Dar es Salaam, but also with foreign institutions. Some examples of the projects and tasks are:

- alternative energy, e.g. solar energy
- increase efficiency and saving programs
- EIA's

The division is relatively young in the organisation, and have not been completely settled. Their main objectives concerning environment are to participate, follow up and increase the competence regarding EIA studies. Up to now EIA's have been carried out as a part of the donors requirements.

Hydropower production:
There are four hydropower plants located in Pangani river, table 19 shows the location and the planned and existing installed capacity. Tanesco want to make a comprehensive study of the total potential for hydro electric power production in the catchment.

Environmental aspects:
Water Hyacinths was mentioned as a problem at Hale. The growth of the hyacinths are moving up in the river, but has not yet reach NyM. There seem however to be some immigrated plants in NYM from the eastern tributaries.

Saline springs; Substantial amounts of saline water originating from ground water springs enter the river Kikuletwa. The high salinity of river Kikuletwa make the water unsuitable for irrigation.

Short time effects of fish production in NyM: The filling up of water in NyM begun in 1967. Shortly after the catch of fish raised to a considerable level. This high catches sustained for many years (it was assumed about 10 years). Thereafter it was reduced to a level where very small amounts of fish were exported out of the area. One theory for the unexpected long period of "short time effect" (high production of fish), was that smoking of fish leading to deforestation along NyM had increased the erosion and the washing out of nutrients from the soil to NyM and thereby prolonged the short time effects.

Tanesco will follow up the environmental studies in Pangani Falls with monitoring according to the recommendations, and also study the long terms effects on ecology.

Table 19: Hydro power plants in Pangani

Location	**Established**	**Existing -(planned production) MW**	**Remarks**
Kikuletwa		0 (1.5)	Not operating at the moment
Kilimanjaro Region, downstream Kikuletwa		0 (11)	Prefeasibility study, bigger fall head
Outlet of NyM	1967	8	Bypass possibilities of water to Pangani
Mandera, Downstream NyM		0 (15-20)	
Hale	1964	21	
Old Pangani Falls	1930	17.5	Temporarily operating in periods with exceeding of full capacity at Pangani
New Pangani Falls	1995	66	In operation
Total		95	

2.7 Pangani Basin Water Board and Pangani Basin Water Office

Time and place

The interviews were made in the period Tuesday 09.05.1995-Sunday 14.05.1995 at Hale camp.

Represented

The main person interviewed were:

Pangani Basin Water officer: L.B.A Luhumbika
Senior Hydrologist at Pangani Basin Water Office: Kamugisha
Senior Advisor from Norplan at Pangani Basin Water Office: J.E. Værnes
NIVA, Leif Lien and Kjersti Dagestad

Summary

The study team wanted information about organisation and responsibilities, co-operation with other institutions, tasks and activities at the office, environmental and water quality problems, pollution sources and general information.

Organisation and responsibilities:

The Water Council under the Principal Secretary in the Ministry of Water Energy and Minerals is responsible for the water resource management in accordance with the water utilisation act. The Central Board and Principal Water Officer are administrative bodies within the water council.

The establishing of Basin Boards and Basin Water Offices is stipulated in Amendment No.10, 1981 in the Water Utilisation Act. These offices had not come into operation at the time when the Pangani Redevelopment Project was initiated in 1991, and the donors (Norway, Sweden and Finland) put up as a requirement that this office had to be established in the Pangani River Basin in order to achieve a better regulation of water use, environmental protection and pollution control.

The responsibilities of Pangani Basin Water Office are stipulated in the law. The task so far has been concerned with the use of water, but they have also in some extent controlled and fined polluters:

- All abstractions of water (about 2000) in the Pangani River Basin ha been registered, mapped and stored in a data base. Some of the users had water rights, but some were illegal. The inspections have resulted in issuing of 1000 water rights.

- The furrows have so far been very inefficient (20%), and one main task has been to rehabilitate the furrows. The leakages have been improved by the introduction of coat lining and the installing of control gates (at the moment 200 control gates have been installed). PBWO has proposed that the traditional furrow committees must apply for the water rights, control the water distribution from the furrows and rehabilitate the furrows in order to reduce the water consumption. PBWO do also try to create awareness among the users to reduce the conflicts and to achieve an efficient use of water. Education and training of farmers and capacity building of officers in local governmental institutions are also one of their concerns.

- PBWO has controlled some polluters according to the standards set in the Water Utilisation Act. The water quality samples are used as evidence in the court (polluters can not be punished before they are found guilty in the court). This procedure is rather time and cost consuming, and so far only 5 sisal estates have been fined.

- They has also initiated a water quality monitoring program. At the moment there is a proposal which they hope will be implemented within short time. This depend on funding.

- PBWO has got the responsibility to control the release of water from NyM, and has established a simple river basin model to undertake this.

- The office has also undertaken a social-economic study in order to predict the value of water for different use in the basin.

- The office collects hydrological and meteorological data from 22 stations (15 are in operation today). There are several other stations within the basin.

- The office try to co-ordinate the planning in the basin, avoid sector planning and encourage comprehensive planning. The office has got support from the MWEM (Moshi meeting, 1994) to undertake this role, but little has been done because of lack of funds from the Government.

Co-operation and co-ordination

PBWO co-operate with central governments at Regional level such as the Regional Water Engineers, and "buy" their assistant mainly regarding hydrometrological data. The regional Water Engineers are administratively connected to the Regional Development Directors which in turn are under the Regional Commissioners. In water issues the Regional Engineer reports to the Water Division Commissioner in the Ministry of Water Energy and Minerals. The RWE is one of the users of water and there are no conflicts between PBWO and RWE regarding responsibilities and co-operation .

PBWO do also co-operate with the regional irrigation engineers, the zonal irrigation engineer, the regional hydrologists and the users in the basin.

In addition to these central governmental regional offices they also co-operate with districts offices, and local governments at district level, township level and village level.

Funding and Financial status

The Government was supposed to cover salaries, allowances for local personnel and operation and maintenance costs of the office. The advisory role at the office, office equipment and the transportation costs were supposed to be covered by the donors. The donors have also financed the rehabilitation of the gates. The office has some problems to undertake the task they are suppose to due to meagre financial support from the government. The government has not fulfilled their obligations. The studies and implementation of the river basin water management concept has therefore solely been based on extra funding from the donors, the lack of funding from the government makes the long term planning difficult and reduce the efficiency of a good water management.

Staff

The staff of PBWO in addition to the water officer was supposed to consist of persons who could cover the fields; hydrology, pollution, water resource management, nature conservation, law and technical aspects. Today the office has a water officer, one senior hydrologist and four technicians. The office need more people, and PBWO has as a first step been thinking of a person with knowledge within water quality and pollution. There is also need for more competence within water resource management, nature conservation and irrigation.

2.8 The Regional Water Engineer-Tanga

Time and place

Wednesday 10.05.1995, 11.00-13.00 at the Regional Water Engineers office in Tanga.

Represented

Regional Water Engineer Mr. J.A. Mukumwa
Chief of the Water quality Laboratory in Tanga: Ms. E. Materu
Water officer: Mr. L.B.A Luhumbika
Senior Hydrologist, PBWO: Mr. Kamugisha
Civil Sanitary Engineer (RWEOS): J.P. Maluga
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to get an impression and information about the water quality laboratory in Tanga, the environmental problems in the region, user interests and activities, organisation and tasks of the regional water engineer's office and co-operation with other institutions.

The water quality laboratory in Tanga was established in 1982, and are organised directly under the Ministry of Water Energy and Minerals. The laboratory receive water samples from the three regions Arusha, Kilimanjaro and Tanga. The results are distributed directly to Dar es Salaam to the Head, Water Quality Laboratory at Ubungo. It has been established a monitoring program, but because of lack of money, this is only followed to some extent. NIVAs impression was that the sampling was done sporadically, and it has not been taken any samples in Pangani River the last to years. The most frequently taken sampling was done for drinking water supply to Tanga Town. The laboratory has the possibility to do both physical and chemical analyses: pH, conductivity, turbidity, colour, temperature, total hardness (calcium and magnesium), alkalinity, chloride, sulphate, manganese, iron, nitrite, nitrate, total phosphorus, dissolved oxygen, biological oxygen demand, copper, chromium, fluorides, total coliform bacteria (35°C) and faecal coliforms (44°C). Some of the parameters are however, analysed very seldom or has not been analysed at all. The main reason is the lack of chemicals. Samples were not conserved and this together with the equipment (partly out of order) influence on the quality of the results. The laboratory was very insufficiently equipped and consisted mainly of a spectrometer (Hasch), an autoclave, a conduct meter, a pH meter (also portable), a refrigerator/deep freezer, an oven for drying, an incubator and a destillation aperture. There was a weight as well, but the accuracy of this was 50 mg and is unsatisfactory for analytical purpose. The lack of a balance weight with a high accuracy prevent the laboratory from doing analyses on filtered water samples.

The laboratory needs equipment and improved procedures included inter calibration, preservation procedures and a new or rehabilitated laboratory room. The staff was originally well trained, but there is need for constant upgrading.

The main responsibilities of the WRE at the moment is to implement the policy from the Ministry of Water Energy and Minerals, co-ordinate and undertake the technical aspects regarding domestic water supply and sewage in the region (piped supply and sewage) and to undertake hydrological monitoring.

There is one main intake (Mandera) in Pangani for domestic water supply. A water treatment plant (Tambora plant) has been in operation since 1967 and consists of sedimentation, slow sand filtration, coagulation (aluminium sulphate) and chlorinating. 50 l/s is abstracted, but the treatment plant is designed for 80 l/s. With a specific consumption of 45 l/person and day this give a calculated number of 95,000 people. The number is smaller while leakage has not been taken into consideration. The total population of Tanga is approximately 200,000. It is only Tanga town which has installed sewage, but the effluent is not discharged to Pangani River but to the Indian Ocean. The main pollution source to Pangani in the region is sisal production, but the regional water engineer has not got any comprehensive overview of pollution sources. It was also mentioned that air pollution from a cement factory may affect Pangani River. The regional representatives of the Ministry of Land Use and Urban planning has got a better overview of the activities in the region, but there is little to now co-ordination between the two offices. The old water master plan is not updated, and are only followed to some extent

2.9 The RWE in Kilimanjaro and inspection of pollution sources

Time and place

Monday 15.05.1995 and Tuesday 16.05.1995 at the RWE office in Kilimanjaro, and in the surroundings of Moshi.

Represented

Regional Water Engineer in Kilimanjaro region, A.K. Kigingi (introduction)
Hydrologist at RWE, Kilimanjaro region, Sarmett
Hydrotech. at RWE, Kilimanjaro Region, M.S. Temu (partly)
Pangani Basin Water Office, J.Z. Riwa
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to get an overview about, organisation of water resource management including co-operation with PBWO, water supply, water quality problems and pollution sources in the region. This summary is based on the interviews at RWE, but also on the site visits. NIVA has also added some own comments based on the site visit.

Organisation and tasks;

The RWE office is at the moment divided into six sections; administration, account, water Research (surface and ground water, hydrology and hydrogeology), Project planning and design (water supply and sanitary engineering), Construction and Regional Maintenance unit. The gauging stations are operated by WRE, and the data are collected and send to PBWO and the Ministry of Water Energy and Minerals in Dar Es Salaam. The WRE does also from time to time take water quality samples to identify polluters and check if the water quality is in accordance with the water quality standards. Some of these samples are taken due to the complaining from users of water in the region. The samples are mainly send to Maji Ubongo in Dar Es Salaam for analyses. PBWO has also taken some water quality samples in the region, but none has been fined so far.

Water Supply;

The total population in Kilimanjaro region is approximately 1.3 mill, 700,000 are living within Moshi district and ca 120,000 of these are living in Moshi Town.

The project team did not get any full overview of the water supply in the region, but 40,000 are served with piped water from Njoro springs (southern part of the town). The water is not treated except from chlorinating. The water intake at Njoro spring was visited. Njoro Dhobi which is located 3 km upstream Njoro Spring flows together with Njoro spring and forms Njoro River. The water collected from the spring in the pump house is affected by both domestic waste water from Njoro Dhobi and from several pit latrines located around the spring. While visiting the place people did also wash clothes, and took their baths immediately downstream the pump house. This means that the clean water coming form Njoro spring already gets affected at the spring. The centre of Moshi town is also served by piped and chlorinated water from two other springs; Mseri and Shiri. The water quality was said to be good. The rest of the population abstract water from ground wells, but some do also abstract water directly or via furrows from the tributaries to Pangani.

Pollution sources and possible conflicts, impression from the site visits;

The point pollution sources in the region do either drain to Njoro river which flow into Rau river and then to NyM, or they drain to Karanga river which flows into Kikuletwa. The pollution from Njoro river do only partly reach Rau river, while most of the water in Njoro river is abstracted for irrigation.

We did not get any comprehensive overview of the pollution sources, but the main point pollution sources to Njoro river were assumed to be Kibo paper mill, tanning industry (see chapter 9.2.15), leakage from the municipal waste dumping site (both industrial and municipal waste are mixed together), domestic sewage mixed with industrial effluent and an outlet from a brewery. There were also other possible pollution sources in this area draining to Njoro river like oil tanks, beverage industry and a number of smaller industries (some were closed down at the moment).

The main pollution sources to Karanga river were said to be Kibo Match, Bonito Bottlers and a pesticide factory which has not yet come into operation. Some impression from the site visits in the region, and some of the main pollution sources are described below:

Domestic waste water:
The total population in Moshi town is about 120,000. There is one main outlet of sewage, located 2-3 km downstream Njoro spring, which receive waste water from ca 100,000 people (85%) together with industrial effluent. 30,000 people (25% of the population) discharge sewage directly to this outlet while 70,000 (60% of the population) use septic tanks. The waste water from these are collected and transported to the same outlet. The sewage was supposed to be treated biological in a waste water treatment plant, but this has not been in operation for 15 years. The remaining population in Moshi town ca 20,000 (15%) use pit latrines. The population in the surroundings and in rural areas in Moshi district and Kilimanjaro region do also use pit latrines.

The main outlet of sewage and the former WWTP were visited. The treatment plant, based on activated sludge, was built in the early sixties, but was closed down because of the lack of power. The 4 aeration ponds were now overgrown. There are some plans to rehabilitate this old treatment plant, but in our view it seems more cost efficient to build a new more modern plant, based on technology which easily can be adapted and maintained in the area. When the treatment plant was in operation the sludge, which not only consisted of domestic waste but also waste from industry, was used as soil improvement.

The sewage which today is bypassed the old treatment plant severely affects the water quality, and makes Njoro river extremely polluted and not suitable for any use. The situation during the dry season is approximately the same while this river has more or less a constant flow during the year. The outlet was during the visit estimated to 50-60 l/s and the water flow in the river 1.5 m^3/s. The influence of industrial waste water could also be seen visually and the outlet seemed to be anaerobic. Toilet paper, parts of clothes and other items were floating in the river and hanging in the trees along the river bank. Despite the extremely bad water quality in the river the water is abstracted 2-3 km downstream, and used for drinking water as well as for irrigation of crop The outlet is in our opinion completely unacceptable and actions must be taken and followed up immediately.

Municipal waste dumping;
In the same area as the sewage outlet there is located a municipal dumping site containing both municipal and industrial waste. Leakage from this dumping site probably contain a lot of harmful waste including heavy metals and organic micro pollutants

Kibo paper mill
The waste water from Kibo paper mill is collected in 4 lagoons (the way they are constructed they function more or less as storage tanks, and it is only the last pond which might have any treatment effect). The treatment efficiency is therefor supposed to be rather limited. The outlet from the last pond is discharged into a channel for irrigation purpose. The rice pads which use the water drain to Njoro river. The farmers in this area have complained about skin problems. It was said that the water used for irrigation will only drain to Njoro river in the raining seasons.

The effluent and treatment facilities at Kibo Paper mill has been studied (Mugulu and Mbaga, 1993), and organic pollution and insufficient treatment has been observed (high organic loads). The waste water was not analysed with respect to micro pollutants, but in the same report it is mentioned that chemicals like caustic soda, aluminium sulphate and calcium hypo chlorite are used in the production process. The Kibo Paper mill management was based on the result from the report recommended to improve their waste water treatment facilities, and to avoid outlet to Karanga river during rainy seasons. The outlet from the factory was also visited during our mission, and the effluent seemed to be very polluted with organic substances.

The other industry mentioned above which discharge to Njoro river, including the brewery and the tannery, will probably also affect the water quality in the area.

Karanga River;
The hot spots located in Karanga river are assumed to be Kibo Match, Bonito Bottlers and the new pesticide factory . The effluent from *Kibo match* flows into three ponds before it is discharge into the river. The project team had only a short stop at one of the ponds, and do hardly no anything about the production process or the quality of the outlet. Samples taken by Pangani Basin Water Office (1994) indicated a high organic load. Micro pollutants including heavy metal were not analysed due to lack of chemicals. Phosphorus may also be high in this type of effluent.

The *pesticide fabric* which has been established lately, but has not yet come into operation is 100% owned by the state. There is little to no information about the production and the effluent. WRE has not succeeded, despite several attempts, to get any information. They assume that the factory will produce copper sulphate, and the waste water will probably be discharge via storage tanks and a tunnel to Karanga river. They are concerned both for the water and possible air pollution form the factory.

General comments by NIVA:
Outlets from pollution sources and the water quality seems to be completely out of control in Moshi municipality. The water management authorities both (WRE and PBWO) have not got any completely overview of the pollution sources, treatment facilities, quantity and the quality of the outlets. The industries are mainly owned by the state. The area is also densely populated, and the water is used both for drinking water and for irrigation of crop. This makes the situation even worse and the bad water quality is not only a treat to the ecology, but also to human health. The few studies which have been undertaken indicate also these potential risks e.g. farmers who are exposed to skin problems. Another serious factor is that Moshi is located in the upper part of catchment area, and the pollution will thereby not only have a local effect, but also a regional and might even have an effect in the whole basin downstream the outlets. Water quality problems, discharge permits, control of polluters and EIA's seems to have been prioritised low for a long time. The most serious example of this is the location and the studies which has (or not has) been undertaken regarding the establishing of the pesticide factory in the area. Actions regarding pollution sources in this area must be taken immediately

2.10 Zonal Irrigation Department, Kilimanjaro Zone

Time and place

Tuesday 16.05.1995 at the Zonal Irrigation Department, Kilimanjaro Zone in Moshi.

Represented

National project co-ordinator (former zonal irrigation engineer), C.K. Chiza
Hydrologist at RWE, Kilimanjaro Region, Sarmett
Pangani Basin Water Office, J.Z. Riwa
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to get detailed information about agricultural activities and crop production, including water requirements, fertiliser consumption and pesticide use for different crops in the three regions of Tanga, Kilimanjaro and Arusha. We wanted also to get an overview of environmental studies which have been undertaken by the department, conflicts with other user interests and tasks which are handled by the department.

Organisation and tasks;
The irrigation department in MALD is a young department, and was established in 1981. The administrative borders of the zones follow the basin borders, except for smaller catchments where one zone consists of two basins. This is resulting in six zonal irrigation departments instead of nine. The Kilimanjaro Zone covers Pangani Basin.

There was originally supposed to be Irrigation Engineers in every region and district, but so far the main competence and resource allocation has been in the Zonal irrigation offices. They have started the process of decentralisation. The Zonal irrigation office co-ordinate technical aspects regarding irrigation and collect and store information for future use (they have established a database for information regarding fertiliser consumption, pesticide use, water consumption, technical information etc.). The office does also assist the Regional Water Engineers with technological and hydrological know-how, especially in large scale irrigation projects like Lower Moshi Irrigation scheme. As mentioned above there will be more decentralisation in the future, and the technical aspects regarding planning and implementation of irrigation projects will probably be privatised and undertaken by consultants. The ZID will probably get a regulatory and advisory role and control the projects during and after implementation.

Environmental studies, conflicts with other user interests, crop production, water consumption, fertiliser and pesticide use;

Environmental issues have not been addressed properly in the planning of new irrigation projects. The office has undertaken some soil surveying, and there have also been some studies regarding irrigation and water borne diseases like Bilharzia, Malaria and Cholera. The studies have identified some problems with saline soil. The soil samples are send to a large scale laboratory in Tanga "National soil service laboratory". The main problem with soil surveying is that the analysis can take more than one year, which is much too late when a irrigation project is going to be implemented. Increased ground water levels have also been observed in three schemes due to poorly drainage.

They have implemented FAO's water quality standards for irrigation purposes, and in this respect it is especially Kibo Paper mill which cause conflict with irrigation.

The water demand for irrigation is very high from June-October, and there is a shortage of water for irrigation in this period. The office will try to implement standards and train the farmers to use only the necessary amounts of water for different crops and seasons. Today the efficiency is low because of lack of knowledge about irrigation, but also because of leakage's in the furrows leading to waste.

The project team got a lot of information in form of reports.

2.11 The Regional Water Engineer in Arusha

Time and place

Wednesday 17.05.1995 and Thursday 18.05.1995, The regional water Engineer office in Arusha and site visits in the district.

Represented

Regional Hydrologist at the Regional Water Engineer office in Arusha Region, J. Nasari
Pangani Basin Water Office, Technician, J.Z. Riwa
Sanitary Engineer at Urban Water and Sewerage in Arusha, J. Mgeyekwa (partly)
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the meetings and the surveying in the district of Arusha was to get an overview of activities in the region with focus on water supply, pollution sources and water quality.

Population, rivers and districts in the catchment area to Pangani Basin

Parts of Arusha district (only Arusha town) and the whole of Arumeru district are within the catchment area to Pangani Basin. The total population residing to Pangani Basin from Arumeru district including Arusha town is approximately 280,000. The total population in Arusha town is approximately 135,000.

Arusha town and parts of Arumeru district drain to Pangani River via several tributaries (Burke, Ngarenaro, Themi and Kijenge) before all confluence with Themi river which is the main river from this part. Themi river ends up in a swamp area (Olgarwa Shambarai Swamp) which was said to only have (if it has at all) connection with Kikuletwa river during the rainy season. The rest of Arumeru district drain partly via Nduruma river which also ends up in some swamps. Nduruma river was said to be dry before entering the swamps. The water in Nduruma river is abstracted for irrigation. Arumeru district do also drain via several other tributaries (Malala, Tengeru, Makumira, Magarisho, Ngarendro, Usa river and Maji ya Chai) which all ends up in Kikuletwa river.

Water supply

The drinking water in Arusha town and Arumeru district is abstracted and distributed from the springs originating at the foot of Mt. Meru. The water quality is in general considered as good (chlorinated), but they have some severe problems with high fluoride content. The water supply is also based on deep ground water wells, and a few take their water from shallow ground wells. These shallow ground wells are sometimes polluted by waste water from pit latrines. Some downstream users abstracts water directly via furrows from the tributaries.

Main pollution sources and conflicts

Domestic Waste water: It is only 12.5% (about 17,000) of the total population in Arusha town which are connected to the municipal waste water treatment plant (the waste water treatment plant and a site visit to the plant is described in detail in appendix 2.21). The effluent from the waste

water treatment plant is discharged to Themi river. The rest of the population in Arusha town use mainly pit latrines (approximately, 90% of the remaining population in Arusha town, about 110, 000), but some have private sewage systems based on septic tanks (about 8,000). The partly treated waste water from these septic tanks are infiltrated in the ground. There was no information regarding sludge handling from these septic tanks. The rest of the population in Armeru district (about 145,000) use mainly pit latrines. This give the following figures for the population in Arusha Town and Arumeru district draining to Pangani Basin:

Municipal Waste Water treatment plant	17,000
Septic tanks	8,000
Pit latrines	255,000

Other main pollution sources discharging directly or via the municipal waste water treatment plant to Themi river were mentioned to be ATZ Textile industry which pump the waste water to the municipal waste water treatment plant, Sunflag textile (see appendix 2.17), Tanzania Brewery (see appendix 2.20), General Tyre (see appendix 2.19) and Fibre board African Ltd (see appendix 2.18). A number of smaller industry is also located in the catchment area.

The municipal waste dumping site is located in a residential area in the centre of the town, and cause conflicts with the neighbours. Leakage from the dumping site is draining to Themi river. The dumping site was not visited. There are some plans for a new location, but there was no information about these plans or if there existed plans for treatment of leakage.

There are conflicts between the pollution sources in Themi river and other user interests. Especially in areas where the water is abstracted for drinking water and irrigation purposes.

Nduruma river is mainly polluted by pesticides and fertilisers used for coffee production.

NIVAs impression based on interviews and site visits in Arusha district

The pollution sources in Arusha district cause conflicts with other user interests. The treatment facilities are pore, and the effluent effects the local water quality severely, especially in Themi river which is used both for drinking water and irrigation of crop. It is uncertain how the bad water quality in Themi river effects Kikuletwa river, and this has not been investigated so far. There will be a significant self purification in the swamps, but there is also a risk for accumulation especially of heavy metals and organic micro pollutants. A monitoring program including ground water should be established to study the effects on Kikuletwa river. There is also need for a comprehensive registration of pollution sources, effluents, water quality and user interests for surface and sub surface sources (especially irrigation, process water for industry and drinking water) in order to prepare an action program.

There must also be undertaken an EIA study regarding the location of the new waste dumping site, The dumping site should be established with collection and treatment of leakage. There should also be established a clear policy regarding separating of waste (industrial waste and municipal waste).

2.12 Site visit to Pangani River from Hale to Moshi

Time and Place

Sunday 14.05.1995

Represented

PBWO, J.Z. Riwa
NIVA, Leif Lien and Kjersti Dagestad

Summary

On our way from Hale to Moshi several sites on Pangani River were visited; monitoring station 2, 4, 5 and 6 (included NyM).

The trip gave us an overview about agriculture production in this part of the river, which were mainly based on sisal production the area between Hale and NyM. Some rice and maize were also grown especially upstream NyM.

The monitoring stations seem to be suitably located according to the objectives of the monitoring program, but it is important to take the water quality samples in the central part of the main stream and not near the shore.

2.13 Site visit to Pangani Falls redevelopment

Time and place

Thursday 11.5.1995. The visit included the intake pond, washing facilities which had been established for the local population, the intake dam, the upper section of the former falls, the old English power station, a major part of the dry stretch of the riverine gorge, the tailrace channel, a few hundred meters downstream the conjunction of the tailrace tunnel and the river and finally the new power station.

Represented

Resident Manager, Norplan, Sten Hernes
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose with the site visit was to get an overview of the project and the environmental impacts caused by the reconstruction.

Hernes described the various steps during the construction periods, he also (patiently) answered all our questions and guided us through all interesting spots in the area according to our request.

General impressions;
The new intake pond covers the former river bed and a former swamp area. This swamp has now a stable annual water level compared to the situation before the regulation, though the possible daily variation can be about 2 meters. This daily variation is not regularly used. The new water level of the pond favour rice production throughout the whole year in a significant part of the plain.

The surface water of the intake dam showed an extensive growth of water hyacinth. The hyacinths have so far been mechanically removed and stored on the "banks". A further utilisation of this waste can be favourable (animal food, fertiliser, soil improvement etc.).

Washing facilities which have been established and situated at the intake dam, ensure a constant outflow of 50 l/sec from the dam to the former falls throughout the whole year (day and night). This is, so far, the only minimum release of water to the dried river gorge.

The old English power station in the former falls is now used only during high flood periods (this rainy season, 1995, with high precipitation, the station had only been used for a short period). A short safari downstream the old power station to the moist forest in the river gorge showed that the black and white colobus still are present in the area (they were also observed in the area downstream the conjunction of the tailrace channel and the river). The African Violet, Saint paulia tong Wensis, which has been claimed to be endemic to Pangani Falls, was observed in the steep slope of the gorge (a similar or an identical violet was also later during our trip observed in the lime caves of Amboni near Tanga). The forest did not show any signs of drying, but our safari took place at the end of the rainy season and only some months after the new power station came in operation. The long term effects or the situation in the dry season may be worse. The river bed, in the vicinity of the old power station had several rock pools. This part of the former river had also several small falls and rapids. A constant flow of 20 l/sec (which supposed to be permanent throughout the year) through this pools prevented a visual impression of stagnating water. Invertebrates and tadpoles were observed in most of the pools.

Further downstream from the old power station, rapids had existed but the water was now running smoother. In this part of the river bed, thresholds had been constructed. These thresholds gave especially a good impression of the river bed, and the water quality seemed to be acceptable for permanent fish populations.

Downstream the tailrace tunnel a foot path had been constructed. Due to topography, the western river bank was set by concrete cover. The visual impression of this area will probably be improved by natural re vegetation within a few years.

General remarks about the EIA

The redevelopment of Pangani Falls has included extensive construction work in the whole area. In general the way the rehabilitation have been done gave a very good aesthetic impression. The thresholds in the river bed have increased the surface of the water substantially, and the ravine forest looked healthy at present (rainy season). However regular visits to the forest by a skill person will reveal changes of the biota. A minimum release or short flushes of water from the intake dam might be considered as necessary if decisions are made to protect this forest.

2.14 Sisal washing factory, Kwamdulu

Time and place

Friday 12.05.1995 at Kwamdulu Sisal Factory situated near Korogwe.

Represented

Pangani Basin Water Office: Mr. Y.M.K Ngoma
Manager at the Kwamdulu Sisal factory: G. Kivuyo
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to get an overview of the production process, type and outlet of waste water, monitoring and control and treatment facilities.

The factory is private and has 440 employees. The sisal is transported for spinning in Tanga.

The manager described the growth and production of sisal. on the estate. The young seeds (baby plants) are taken directly from the old mature stem and planted on a nursery ground for 2-2.5 years. Thereafter they are transferred and planted in rows at their permanent production area, and can be harvested 1-2 times a year for up to 12 years. The first harvest takes place after 18-36 months.

There is no need to irrigate the sisal, even not when the sisal is replanted. Some fertiliser was however used when the plant was replanted. A "handful" of phosphate fertiliser was used for each plant. Later on some potassium was added to plants showing deficiency. Pesticides were also used when deficiency was observed ("Hyvarex", Sisal Weeval", Aldrin and carbicromum).

The production of sisal fibres was demonstrated by the manager, and include crushing, washing, drying, brushing and packing of the sisal. The drying is performed in the sun and the Sisal need only 1-2 days depending on the weather. It is the leaves of the sisal plant which are used for fibre production. The total monthly production of fibre on the estate was 140 tonnes, and it was running the whole year.

Of special interest was the effluent from the washing process. The washing procedure required about 20 l/s (estimated). The sisal juice, which was very concentrated, was lead to a dumping area where the liquid portion drained to a pond. The outlet from the first pond lead to a second pond and then to the last and third pond. A visit to the third pond demonstrated a water body with 5 species of fish (3 tilapia and 2 "cat fish"). Herons and fishermen. Earlier observed crocodiles do also indicate a functioning (eco-) system. The outlet of water from the third pond visually gave an impression of clear water. However blue green algae were floating on the pond and the outlet bed had some aufwucks.

The method used at Kwamdule for cleaning waste water from sisal seems to function satisfactory with the present level and possibilities for technical equipment, and also with respect to operation and maintenance. If the water quality in Pangani river is considerable improved in the future, further steps for cleaning should be considered also on this estate. This must however be based on a cost effective analyse and the water quality in the effluent must be determined and based on comprehensive and exact analyses.

2.15 Tanning Industry-Moshi

Time and place

Tuesday, 16.05.1995, Tanning Industry in Moshi.

Represented

Regional Water Engineer in Kilimanjaro region, A.K. Kigingi (introduction)
Hydrologist at RWE, Kilimanjaro region, J. Sarmett
Pangani Basin Water Office, J.Z. Riwa
Tanning factory, System co-ordinator, R.Kahn
Tanning factory, Rehabilitation technologist, V.R. Nagarajan
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to receive some information about the production process, use of chemicals, the quality of the effluent and treatment facilities.

The factory had been in operation, but was taken over by a private international Indian firm a few months before the visit and was still under rehabilitation. The factory was originally owned by the state. The factory will produce leather, and there are also some plans to include the finishing process for the final products. The extent of the finishing process and the final products which were going to be produce were not yet decided upon. By the planned full run of the factory, 120 to 200 persons will be employed, and the daily use of municipal water and private owned ground water will be 450,000 litre /day. There is given a description below of the planned process.

The raw material will mainly be sun dried cattle skin, and the process starts with softening (with water), thereafter a lime bath for removing hair and remnants of meat and fat. This process also includes $MgSO_4$ which will be recycled during the process of preparation of leather. The conservation of the skin will include two different methods, chromium tanning or vegetable tanning. The chromium process includes several chromium baths, and the vegetable tanning is based on extracts from various plants (among Memosa species). The chromium solutions can be reused a couple of times, but the excess water has to be treated (chromium is removed by liming baths). The colouring of leather will mainly be done by pressure an heat (finished covers are stuck to the surface of the leather), and little to no dyes will be used. Cyanide will not be used in the dying process. The effluent is going to contain among others organic waste (fat and remnants from hair and meat), $MgSO_4$ and chromium.

The effluent treatment unit was also under rehabilitation, and the management at the factory stated several times during the interview that the effluent after treatment will obtain the same quality as the drinking water. They had the possibility to analyse the water in their own laboratory, but could not see that it would be necessary to establish a monitoring program as long as they could guarantee drinking water quality. WRE in Kilimanjaro or PBWO did not have any information about the outlet, and there was not given any permit. An application or information will be sent after the factory has come into full operation.

2.16 Sugar cane factory Moshi

Time and place

Monday, 15.05.1995, T.P.C Limited.

Represented

Hydrotech. at RWE, Kilimanjaro Region, M.S. Temu
Pangani Basin Water Office, J.Z. Riwa
T.P.C. Limited, Chief Agricultural engineer, V.M. Sekao.
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to get information about the production, irrigation, fertiliser consumption, pesticide use and the handling of waste.

TPC (Tanganyika Planting Company), is 100% owned by the state and is one of the biggest sugar factories in Tanzania with 4000 employees. The factory was up to 1980 owned by E.P. Møller (Dk).

The total annual amount of sugar produced in the factory is currently 35.000 tonnes (10 months of production and 2 months of maintenance during the rainy season)

The chief agriculture engineer, Sekao, described the growth of the canes and processing of sugar on the farm. A sugar cane can be harvested for the first time 12-13 months after planting. Thereafter it can be harvested every 11 months, up to 17 times.

Urea is used as fertiliser after 2-3 months then after 5 months from the first planting. Ferrobromid is used as pesticide 165 ml/ha on a area of 1500 ha annually. Seed were formerly treated by heating, but "Aritan" is now used.

After harvesting, the sugar canes are transported to a central factory on the estate for crushing, Three main waste product were mentioned: Melissa, Bagass (fibre) and filtered mud. Melissa is used as animal food and to some extent consumed by the local population. Baggas (remnants of stem and leaves) is dried and used as fire material in the processing of sugar. The filtered mud is utilised as fertiliser.

The sugar cane factory use water for irrigation and cooling. The water is abstracted from their own boreholes and from Weru Weru river. The company complained about the bad water quality from Weru Weru especially caused by Kibo Paper mill.

The temperature of the cooling water is raised from 20-100°C during the process, and are stored in lagoons before the water goes back to the river again. The irrigation water (about 30%) is drained back to the river via furrows entering Kikuletwa. There is also some surface runoff directly to NyM.

2.17 Textile Industry-Arusha

Time and place

Wednesday, 17.05.1995, Sunflag LTD.

Represented

Regional Hydrologist at the Regional Water Engineer office in Arusha Region, J. Nasari
Pangani Water Office, Technician, J.Z. Riwa
Sunflag LTD, D.C. Mhanbo
Sunflag LTD, E. Mgoma
NIVA, Leif Lien and Kjersti Dagestad

Summary

Two main textile factories are operating in Arusha, Sunflag and ATZ-textiles. Sunflag was visited and the main purpose of the visit was to get information about the production process, the quality of the effluent and treatment facilities.

The factory has 40000 employees and produce 100-120 tonnes of fabrics per month, and 35000 T-shirts (mainly for export). For comparison ATZ has a production of 15.000 T-shirts per day.

The production process includes washing of fibres, bleaching and dying. The washing is mainly processed with caustic soda and sodium carbonate. The bleaching is undertaken by hydroperchloride, sodium carbonate, sodium hydrosulphate, detergents and organic stabilisators. Two main dying methods are used; polyester dying and cotton dying. Polyester dying is performed with about 10 dispersed colours. Cotton dying included black colouring with Na_2S (sulphur dying) or a "reactive dying" using chromophorus, Chloroforms, acetic acid, sodium carbonate, agoral naphtalein and other chemicals. The waste water effluent from Sunflag is pumped to ATZ and transferred together with this effluent without pre treatment to the municipal waste water treatment plant in Arusha. There are no effluent data available.

2.18 Wall board production-Arusha

Time and place

Wednesday, 17.05.1995, Fibre board African Lmtd

Represented

Regional Hydrologist at the Regional Water Engineer office in Arusha Region, J. Nasari
Pangani Water Office, Technician, J.Z. Riwa
Fibre Board African Lmtd, Management
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to get an overview of products, the production process, quality of the effluent and treatment facilities.

The fibre board factory in Arusha has four main products; Fibreboard, polls, planks and furniture's. The sawmill produces "planks" of many different tree species. Little to no waste results from the process. The furniture production has no waste products. Poles from (Eucalyptus and Gravelled) for electrical- and telephone transmission are produced annually in a number of 10,000. Tanalith, consisting of copper, chromium, and arsen, is used for conservation. The tamalith bath is not renewed only refilled when necessary.

The main waste effluent is from the fibreboard production. 6,000 tonnes of fibreboard's are produced annually, using cypress, eucalyptus and pine. The process includes cutting, heating (using excess wood and oil) and binding of fibre together with pressing. In the heating process parafinwax, emulgate and ammonium are added. No conseptic or gluing components are used. The total water consumption at the factory is 85,500 m3/day, which are distributed over 300 days of operation per year. The waste water from the process is treated in two successive ponds. Both ponds are aerobic with mechanical aeration. The volume of the ponds is 8,000 m^3, with a surface area of 25x25m and 25x75 m respectively for the first and the second pond.

The effluent from the wallboard process has a pH of 4.5-5.5. The pH after the treatment ponds is approximately 7. During the mission we did not obtain any data on organic content in the effluent, but there was a high colour on the water and the organic content (hardly degradable) is supposed to be high.

Portions of the effluent from the factory is utilised for fertilising and irrigation of a small area (2-3 da) of maize and beans. The exceeding effluent is transported to Themi river.

2.19 Tyre production-Arusha

Time and place

Thursday 18.05.1995, General Tyre

Represented

Regional Hydrologist at the Regional Water Engineer office in Arusha Region, J. Nasari
Pangani Water Office, Technician, J.Z. Riwa
General Tyre, Manufacturing Manager, M.H. Wilhelm
General Tyre, Assistant plant engineer, J.J. Mngava
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to get some information about the production process, type and quality of the effluent and waste water treatment facilities.

General Tyre has been operating for 25 years, and has 450 employees. The company produce 1000 tyres per working day and 300-400 per day in the weekends. Inner tubes are also produced. All raw material and pre-fabricated products are imported. The raw material consists mainly of (carbon black) natural rubber in addition to synthetic rubber and nylon products. Waltzing of rubber cause friction heath and the machine need to be cooled. Water , which is recycled, is used for cooling. Steam pressure (also recycled) is used to form the tyres. The rest of the process for making the final tyre is performed without use of water.

The management said there was no outlet from the factory, and spill with oil was absorbed by powder. The management followed EPAs standards both regarding water and air pollution.

During our one hour visit in the production hall, everything seems to function well and no spill with water could be seen. There was only some minor spill with oil.

A sewage treatment plant was installed at the factory to treat the domestic waste from the employees.

2.20 Brewery-Arusha

Time and place

Thursday 18.05.1995, Tanzanian Breweries Limited

Represented

Regional Hydrologist at the Regional Water Engineer office in Arusha Region, J. Nasari
Pangani Water Office, Technician, J.Z. Riwa
Tanzanian Breweries Limited, M. Muller
NIVA, Leif Lien and Kjersti Dagestad

Summary

The main purpose of the visit was to get information about the production, the quality of the effluent and treatment facilities.

The brewery which is a joint venture company between The Tanzanian Government and a private South African company, produces 30 000 m^3 lager beer annually. The last years the production has increased with 30-50% annually, and the company can still not satisfy the local market. The company has 430 employees.

The brewery produces 30 000 m^3 lager beer annually.. The beer production require 300 000 m^3 of water per year (beer/water=1/10), with a certain inlet water quality (soft with a low content of organic matter, dissolved solids, sulphate and chlorine). The process is especially vulnerable to a high content of organic and chlorine while these forms chlor-organic compounds which give a raise to smell and taste. The company is served with municipal water, but they also plan to establish their own groundwells. The production of beer at the brewery is traditionally; malting of barley, adding of sugar, yeast and water. The excess malted grain is sold as animal food. The main effluent is the remaining yeast in the water after production and waste from the washing process. The latter consist of CaCl, N_2OH and H_2O in addition to "Oxania" which includes some phosphate. The pH of the effluent varies between 4 and 8. The mean concentration of PO_4 is 25 mg/l and varies between 2-110 mg/l. The content of organic matter is very high and 3000 mg/l.

For the time being the hot effluent (holding approximately 40-50 ^0C) is discharged directly to Themi River without treatment. Estimated (from a field visit) and calculated from the amount of produced beer this gives and outlet of ca 15 l/sec. During the visits the discharged water was very hot and turbid, and visually the colour and transparency of Themi river changed considerably between upstream and downstream the discharge. Themi river had at the time of the visit a water flow of approximately 1 m^3/s (rainy season). The water flow during the dry season is approximately half.

The management at the factory has also planned a new treatment plant for the effluent based on activated sludge. This takes however too much space and experiments with anaerobic treatment was
carried out by some Swedish students to look at alternatives. The anaerobic process seemed to be too vulnerable to the variations in the quality of the effluent. The company has also thought of storing and dumping the waste water containing 90% water and 10% yeast at the municipal waste dumping site.

Impressions:

The waste water from the brewery need treatment and it is not acceptable to discharge the waste water directly to Themi River. An effective biofilm process (submerged) can be appropriate for handling this type of waste (high concentration and variations), and will be favourable also regarding the space which are available. A reactor volume of about 200 m^3 will be necessary (15 l/s and 3000 mg COD /l). In addition about 100 m^2 sedimentation basin need to be installed. Process optimisation ought to be carry out before the detailed construction of the waste water treatment plant.

2.21 Waste water treatment plant-Arusha

Time and place

Wednesday, 17.05.1995, The regional water engineer office in Arusha
Thursday 18.05.1995, Site visit to the municipal waste water treatment plant in Arusha.

Represented

Regional Hydrologist at the Regional Water Engineer office, J. Nasari
Pangani Water Office, Technician, J.Z. Riwa
Sanitary Engineer at Urban Water and Sewerage in Arusha, J. Mgeyekwa (partly)
NIVA, Leif Lien and Kjersti Dagestad

Summary

The purpose of the meeting and the site visit was to get an overview of the treatment process and the efficiency of the waste water treatment plant in Arusha.

12.5% (about 17.000) of the total population in Arusha town are connected to the municipal waste water treatment plant The municipality in Arusha is responsible for the maintenance and the operation of the waste water treatment plant. Arusha Urban Water and Sewage (AUWS) will however in the future be organised as an independent unit.

The biological WWTP built in 1970 is designed for 4000 m3/day, and consist of a grit and 5 ponds in series (without mechanical aeration). The waste water is heavily overloaded, with a present flow of 5500 m3/d. This is mainly caused by industrial effluent which is not pre treated. The municipal waste water at the treatment plant represents only about 20% of the total load (45 l/pd). The industrial effluent do not only cause problems with the capacity of the treatment plant, but do also inhibit the bacteria's in the biological process. The BOD outlet from the waste water treatment plant is normally 220 mg/l. while the standard is set to 20 mg BOD/l.

When the treatment plant was visited, only three of 5 pond were in operation, the other one were tapped down in order to remove sludge. The sludge was transported to the municipal land fill. The effluent from the plant seemed to be anaerobic, and not properly treated. The outlet has an effect on villages downstream (about 15 km), which use the water for irrigation and drinking water.

There are some existing plans for upgrading the treatment plant with two more ponds, and use two of the existing ponds for anaerobic treatment of the most concentrated waste.

2.22 Coffee production

No coffee plantations were visited during our mission. These were only observed, but information was gathered from various sources. A coffee tree starts to produce coffee beans five years after planting. Thereafter for a period of 20 years the tree will give one harvest each year.

In the processing of coffee beans the 4 covers of the beans are removed, this is done by two methods. The two outer covers are removed mechanically with use of water. The waste water is used as fertiliser for the coffee plants. The other two covers are removed by drying.

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