

# **BALANCING DEVELOPMENT AND ENVIRONMENT THE CASE OF KIHANSI HYDROPOWER PROJECT IN TANZANIA**

By: Fred Mpendazoe  
Ministry of Water and Livestock Development  
P.O. BOX 35066, Dar Es Salaam.  
TANZANIA

## **1.0 Introduction**

Hydropower, like other sources of energy is continuously being developed in order to cope with increasing power demand in the Tanzania national grid system as well as to cater for new load centres and also for power supply quality improvement. Tanzania is a developing country, with electricity per capita consumption of about 64 kWh/year. For developed countries it is over 10,000 kWh/year and in emerging economies such in China and India, it ranges from 400 to 900 kWh/year. That gives an indication of the need for increased investment in the electricity sector in Tanzania. The Tanzanian power system is energy constrained, as there is great dependency on hydropower, which is cheaper but highly dependent on hydrology. Cheaper alternative sources, have not yet been developed.

The present power system is operated through the National grid network and isolated power systems for places not connected to the National grid. The grid system generation facilities consist of hydro and thermal mix, totalling 863MW. The hydro plants have a total installed capacity of

561MW (65% of total capacity). The total installed capacity for thermal generation is 302MW of which 220MW is from gas turbines and the rest (82 MW) from diesel plants. The present maximum demand in the grid system stands at 440 MW and is growing at an average of 8% per annum. In this system, Kihansi is the latest hydro development.

The Kihansi Hydropower project designed to meet growing peak power demand in the National grid system qualified for implementation, after proving to be economically, financially, socially and environmentally feasible. However, during construction critical ecosystems that would perish upon diverting water for hydropower production were discovered. That has lead into denial of the final water right for the project until requirements for ecosystem had been determined and provided for. Since July 2000, when the power plant was officially commissioned efforts have been going on to establish conditions that would facilitate granting of the final water right.

In this paper, issues around the Kihansi water right requirements as opposed to power production and environmental conservation are discussed.

## **1.1 The Kihansi Project**

### **1.1.1 Location and Layout**

The Kihansi hydropower Plant is located in South-western Tanzania (approximately, 8° 35'S, 35° 51'E) on Kihansi river a tributary of Rufiji river in what is called Rufiji basin (**figures 1**). Implementation of the Lower Kihansi Hydropower Plant (LKHP) started in June 1994 and the power station started commercial operation in December 1999 with official inauguration in July

2000. The total cost of the project was USD 275 million financed by TANESCO/Tanzania Government, World Bank/IDA, NORAD, SIDA, KfW and the EIB.

This run-off the river plant utilises the falling water of the Kihansi river of which the total head is 853m and comprise a small dam (25m height), a reservoir of live storage of 1 MM<sup>3</sup> (inundating 26 hectares), underground waterways and powerhouse. The power plant has an installed capacity of 180MW using three turbines of 60MW each. The design discharge of the plant is 24.9 m<sup>3</sup>/s for 180MW (phase I, in operation) and 41.5 m<sup>3</sup>/s for 300MW (phase II, planned). ***Despite this hydropower facility being in operation since December 1999, it does not have the final water right up to now.***

### **1.1.2 Natural Settings of the Project Location**

The Kihansi project is located in the Kihansi river catchment (**figures 2**), which covers an area of 620 km<sup>2</sup> from the dam. The major part of the catchment is within the Eastern highlands (Udzungwa Plateau). A larger part of the Eastern side of the catchment is covered by the Udzungwa forests (forest reserve and national park) and the rest is mainly grass and bush land.

The catchment, upstream of the dam, contains 14 villages with a total human population of over 38,000 and livestock of about 4000. Agriculture is the main economic activity and is in some cases supported by irrigation. The catchment has high potential for agriculture and the future might see more development in that aspect.

The Kihansi gorge is located in the Eastern Arc, along the eastern escarpment of the southern Udzungwa Mountains. The arc forests are known to be among the world's bio-diversity hot spots

**(Figure 3).** Since the Kihansi project area lies within the arc forests, discovery of endemic species within the project area should have been expected.

## **2.0 Project Development**

### **2.1 Permits and Clearances**

Any development intervention requires some kind of permit from an Authority with mandate to control and direct such type of intervention. In connection with electricity generation, the Ministry of Energy and Minerals is mandated to issue licences for such projects. The Electricity Ordinance (Cap.131) of 1957 and its amendments of 1957 and 1961, provides the legislation for the licenses. However, these laws do not clearly spell out sectoral linkages to take into account other necessary clearances before issuing of electricity business licenses.

### **2.2 Important Clearances**

The following are the most important Clearances required or that might be demanded before a license to generate hydropower is issued:

- Clearance for Health, Safety and Welfare under the Factories Ordinance (Cap. 297) of 1952.
- Environmental clearance according to the Tanzanian Constitution (1977) and environmental policy (1997).
- Water Right, in accordance with the Water Utilisation (control and regulation) Act no. 42 of 1974, amended by Acts No. 10 of 1981, 17 of 1989 and 8 of 1997 (Ministry of Water and Livestock Development)

One clearance may not be granted until one or more others have been obtained, e.g. water right may be granted after receiving environmental clearance and attached conditions (if any) transferred to the water right (if applicable). Existing legal provisions do not make such linkage obligatory.

## **2.3 Water Right Administration**

### **2.3.1 Legal and institutional framework**

The water right is governed by the Water Utilisation (control and regulation) Act no. 42 of 1974, subsequently amended by Act No. 10 of 1981, Act no. 17 of 1989 and Act No. 8 of 1997. Overall administration of the water right issues fall under the Ministry of Water and Livestock Development. Act No. 10 of 1981 introduced the concept of allocating water basing on hydrological boundaries thus establishing Basin Water Boards and Basin Water Officers. It also introduced the aspects of pollution control.

### **2.3.2 Water right granting procedures**

The present regulation provides the following steps in processing the water right application:

- 1) Submitting application to Water Officer before construction starts
- 2) The Water Officer publishes notice of application in the gazette.
- 3) Water Officer (shall) serve the notice upon stakeholders and interested parties to react within 40 days.
- 4) Then, the Water Officer presents the application with relevant reports and opinions to the Basin Board, for discussion and advice.
- 5) Water Officer may issue the water right after the board recommendations.

- A provisional grant of water right with conditions is issued before the construction of any works and date specified by which the works to be completed to the satisfaction of the Water Officer.
  - The Final grant of water right is issued after the completion of the works subject to the provisions of the Water Utilization (control and regulation) Act and special terms and conditions are specified if any.
- 6) The applicant can appeal to the Minister responsible for water if not satisfied with the decision of the Water Officer.

### **3.0 Kihansi water right**

After the project definition phase, TANESCO (the developer) made a water right application in October 1993 for 41.5 m<sup>3</sup>/s, initially to generate 180 MW and ultimately 300MW. The Rufiji Basin Water Board (RBWB) granted provisional water right in November 1996 with a condition that provision be made for a by-pass flow of 7 m<sup>3</sup>/s for the ecosystem, the lowest flow in the records in the area. What were the bases for this condition? ***Precautionary principle*** had to apply, in the absence of information that could lead to determination of the minimum desired flow for the ecosystem.

#### **3.1 Information required for Kihansi final water right consideration**

In order for the Rufiji Basin Water Board to deliberate on the application for the water right for Kihansi project the following information is required:

- Hydrographic reports indicating the available quantity of water, other users in the same basin and future demand.
- Water quality aspects in the area, present and future indication

- Ecosystem needs before and after development, from environmental authorities.
- Project study indicating demand and mode of and provision for operation of the hydropower facility from the developer.
- Administrative reports from mainly the District Authorities within the project area.
- Opinion of other stakeholders who might be affected by the development.

The information that was missing and could not be easily obtained was that on water requirements for the Kihansi gorge ecosystem. When such requirements become known, it is also possible to design the power plant operation policy that suits such requirements.

### **Final Water Right Grant**

Under normal circumstances, after the completion of the works to the satisfaction of the Water Officer, the developer gets the final water right. TANESCO requested for the final grant after completion of the works (February 2000). However, the Water Officer is still holding it due to the reason that some basic issues on the mode of operation and the amount of water required for ecosystem maintenance are still not resolved among the relevant authorities.

### **4.0 Kihansi Water Right Constraints**

There are a number of issues that have hindered the granting of the final water right and these are:

- "Unexpected" situation surfaced in 1996, when project implementation had reached a very advanced stage. There was discovery of endemic and threatened species in the Kihansi gorge.

Investigations that followed after that, established that the changed flow conditions could not support the gorge ecosystem which due to its importance should be conserved.

- Until the project reached the commissioning stage in July 2000, no study had identified the minimum amount of water that could sustain the Kihansi gorge ecosystem.
- The provisional water right for Kihansi required a minimum of 7 m<sup>3</sup>/s to be continuously released for the environment. The basis for the design of the Kihansi power plant was to utilise as much of the flow of the Kihansi river as was available and, its economics hinged on that. As the long term average flow of Kihansi river is about 16.3 m<sup>3</sup>/s, allowing a by-pass of 7 m<sup>3</sup>/s (>40%) all the time would be tantamount to closing down the project
- The project was designed primarily for peaking to run at full capacity during the peak 4-6 hours per day and the rest of the time to accumulate water in the reservoir. Furthermore, it was to take as much of base load as possible during the wet season, thereby, increasing storage in larger power reservoirs in the system. Therefore, the primary objective would not be achieved if a continuous flow of 7 m<sup>3</sup>/s would be left for the environment.

#### **4.1 Position on hydropower production (economic aspects)**

Due to the above constraints, the project has no final water right up to now. The developer, TANESCO, is not satisfied with the condition on the provisional water right requiring a continuous release of 7 m<sup>3</sup>/s for the ecosystem. That option would send the Kihansi project outside the limits of its economic justification. This is clearly seen from an analysis provided by the developer and presented in the table below and in **figure 4**, showing the impact of various by-pass releases on the Kihansi plant energy production and the total system energy availability.

By-pass (m <sup>3</sup> /s )	Kihansi production		Total System production	
	Firm (GWh)	Avg. (GWh)	Firm (GWh)	Avg. (GWh)
0	387	935	698	2825
1	327	883	636	2773
2	266	831	611	2721
3	206	778	517	2667
4	146	723	456	2613
5	85	668	396	2558
6	24	613	335	2503
7	0	557	273	2446

## 4.2 Position on Environmental Impact

Information as regards to what extent the environment would be affected under the above by-pass releases is still not provided.

- The Water Officer for Rufiji basin requested the advice of the Directorate of Environment in the Vice President's Office on what should be regarded as a minimum desired flow for the

ecosystem in the area after diversion and specifically in the gorge. A satisfactory answer could not simply be given. Scientific studies had to be undertaken to assist this determination. But studies may take too long! How long could that wait?

Any trade-off has to balance both the investment's economic goals and the environmental conservation requirements. In the meantime, the project provides continuous release of 1.5-2.0 m<sup>3</sup>/s for the environment, equivalent to about 14MW. This amount of power is sufficient to cater for the demand of a major town in Tanzania.

### **4.3 Previous Environmental Studies and outcome thereof**

#### **4.3.2 Environmental studies (*Pre-construction*)**

Parallel with the technical and economic studies, environmental studies were conducted, notably the following:-

- Environmental study conducted by JICA/EPDC 1989-90 as part of the feasibility study for the Kihansi Hydropower Project.
- Environmental Assessment of the Kihansi hydro-electric Project conducted during early 1991 by M/S EKONO ENERGY, financed by the World Bank (WB).

Both studies identified impacts for which appropriate mitigation measures were recommended. In general terms their findings concluded that the Project was sound from the environmental view point and recommended its development. The WB, in addition sent its own experts to visit the site and made a critical review of the above two studies. The WB assessment (1992) was also in favour of developing the Kihansi Project.

### **4.3.3 Environmental Studies During Project Implementation**

NORPLAN AS were commissioned to undertake a detailed EIA of the project following recommendations by the various participating donors to augment the findings of the pre-construction environmental studies. The field studies started in March 1993 and a final report delivered in December 1995. The EIA identified some impacts related to the project and based on these the Lower Kihansi Hydroproject Environmental Programme was formulated in the beginning of 1996 to mitigate the impacts. The environmental programme which was multi-donor funded had by end of 1997 received funds amounting to about US\$ 10 million. The components of that programme were as follows:

- a) Public health programme (MUAJAKI), concerned with health and safety aspects in and around the project area
- b) Catchment Management Project (CMP), concerned with instituting conservation approaches in development undertakings in the catchment that would ensure water availability for the Kihansi project in the long term
- c) Long-term Environmental Monitoring Programme (LEMP) concerned with investigations on the Kihansi Gorge ecosystem.
- d) Social-economic Mitigation and monitoring Project (SEMA-ki), that attempted to identify socio-economic impacts associated with the project and providing mitigation measures

### **4.3.4 Discovery of Valued Ecosystem**

The above components were very successfully done and its due to one of them, the LEMP that discovery of the rare toad (December 1996) that raised awareness on the uniqueness of the Kihansi Gorge ecosystem came about. That created immense pressure on all parties involved in the project and attracted amazing global attention.

The Kihansi gorge is located in the Eastern Arc (**figure 3**), along eastern escarpment of the Southern Udzungwa Mountains. The gorge, created by the Kihansi river is approximately 4 km in length. The Kihansi river, as it flows through the gorge, plunges over a series of scenic water falls and rapids creating a fine spray which spreads over the Gorge. The Gorge is termed to be home of numerous endemic flora & Fauna species believed to be dependent on the fine spray for survival. These species include the Kihansi spray Toad (*Nectophrynoides asperginis*) and three endangered plant species, the wild coffee (*coffea esp.*), a specie in the Acanthaceae family and a specie in the Triuridaceae family.

As a result of the reduction of water flow through the gorge, creating isolation and area effects, habitats, plants and animal species of the Kihansi gorge face increasing destruction & extension threats. ***That has created great concern both locally and internationally, such that steps had to be taken to address those concerns; firstly, due to the Tanzania's international obligation as a signatory to a number of environmental conventions, and secondly, to establish bases upon which consideration of a final water right for the Kihansi project could be done.***

#### **4.4 Concerns Shown on Kihansi Gorge Ecosystem and Measures Instituted**

With the above named concerns and constraints, measures to rescue the situation have been devised to address pertinent issues and to lead to a transparent mechanism for arriving at the Kihansi water right. Such measures are briefly described in the subsequent sections.

#### **4.4.1 International Pressure and Support**

When construction of Kihansi was nearing completion in late 1999, both the donor community and environmental organizations expressed vehement concern for ensuring that diversion of water for power production should not lead to extermination of the already identified greatly valued Kihansi gorge ecosystem. Whereas Friends of the Earth appealed to the World Bank to take steps to save the Kihansi gorge ecosystem, the participating donors (including the WB) provided funding for trial and emergency, as well as long-term mitigation measures.

#### **4.4.2 Captive Breeding**

In order to guard against potential loss of the Kihansi Spray Toad which, is the only identified fragile indicator species in the Kihansi gorge, the Wildlife Conservation Society (WCS) entered an agreement with Government of Tanzania in which it offered to take 500 toads for captive breeding in the US. In case those at Kihansi were wiped out, and those in captive breeding continue to survive and multiply, re-introduction to Kihansi or other place in Tanzania would be done at a convenient future time. Toads in captive breeding at Zoos in the US are doing fine and studies of their biology and ecology continues, to-date (references 7 & 9).

#### **4.4.3 Immediate Rescue and Emergency Measures (IREM)**

Before impoundment of the Kihansi reservoir, some measures were instituted in the gorge wetlands where, the spray toads are found, so as to ensure survival of the toads at reduced water flow. Flow reduction went to the tune of 1.5 to 2.0 m<sup>3</sup>/s, as compared to the 7 m<sup>3</sup>/s assumed to be the minimum required. However, sprinklers have been installed in the respective wetlands and these use a portion of the flow to produce sprays that create a micro-climate assumed to be conducive for the survival of the toads.

Since no determination of environmental flow requirements had been done at the end of the project, funding for measures to continue sustaining the ecosystem while the plant was in operation had to be urgently mobilised.

Funds amounting to US\$ 1.86 million in form of grant were made available jointly by NORAD (Norway) and Sida (Sweden) to finance these measures in a one year project (January 2001-December, 2001) called, "**Immediate Rescue and Emergency Measures (IREMP)**". This short-term project was initiated among other things to attempt to protect the valued spray dependent ecosystem in the Kihansi Gorge after the spray generating discharge had been reduced. Furthermore, it included work for initial water right preparation which were to come up with recommendations on the optimum operating conditions/criteria for the Kihansi project.

The short-term project is about to end and it is hoped its recommendations will be incorporated into the Long-term (5 years) Lower Kihansi Environmental Management Project (LKEMP) under funding by the WB.

#### **4.4.4 Lower Kihansi Environmental Management Project (LKEMP)**

This is a long term project (5 years) which among other things will define the permitting criteria for the water right for the Kihansi project and also establish an environmental management plan for Kihansi. Another important item to be covered will be the institutional capacity building for environment and water resources management. Formulation of the project has already been done and its funding by the World Bank already approved since July 2001. The project is estimated to

cost about US\$ 6.3 million, and is funded under credit arrangement by IDA to the Government of Tanzania (GOT).

Under this project it is intended by the end of 2003 the final water right for TANESCO will have been granted. The process will be a transparent one that intends to include various stakeholders to come to an objective decision on water allocation for the hydropower generation and for maintenance of the ecology of the gorge and its wetlands ecosystem. It will also take into account what is taking place up stream, in the upper catchment.

In the process of establishment of the final water right, the project will continue to implement the work plan for the modified flow regimes as recommended under IREMP and further reviewed under LKEMP. The activities that will be undertaken in the period of five years, are summarised as follows:

- Interim bypass flow monitoring which will guarantee water availability for the environment during the process of establishment of the water right.
- Flow manipulation and ecological studies for the purpose of testing the efficacy of measures for partially restoring the degraded Kihansi Gorge ecosystem.
- Financial and economic evaluation on various scenarios of modified flows on the power loss will be studied. This will contribute to the recommendations on environmental flow as input for decision making by the responsible Authority (Rufiji Basin Water Board).

## **7.0 Concluding Remarks**

### **Environmental Flow Requirements Assessment**

In conclusion, register is made of the demand for water right determination involving environmental flows, as follows:

- The process of determining water for the environment is difficult, as in some cases it may require substantial amount of resources in terms of time, finance and manpower, and also an enabling environment. Scientific studies are required to establish both ecological needs and socio-economic needs. Furthermore, operating within existing legal and institutional framework is limiting in certain aspects. In addition, awareness raising is also a critical requirement, as the measure of success in upholding a water right, may greatly be influenced by the degree of awareness on the part of relevant stakeholders.
- Determination of environmental flows requires special expertise and capacity on the part of handling institutions and developers. It is important to make an inventory of the available capacity and look into ways of building it to required levels.
- Natural resources mapping and identifying areas of conservation importance and respective significance for conservation needs is of paramount importance. Nations should plan for such work, in order to provide basis for guiding development plans that involve the natural resources.

## **8.0 List of References**

1. BEAT Luhanga, September, 2001: Tanesco and the Environment - Case Study: Lower Kihansi Hydropower Project, Paper presented at a workshop on environmentam decision making for issuing water rights at Morogoro 24-27 September, 2001.

2. JM King, RE Tharme & MS de Villiers, July 2000: Environmental Flow Assessments of Rivers: Manual for the Building Block Methodology; WRC Report No: TT 131/00, Freshwater Research Unit, University of Cape Town
3. Ministry of Water and Livestock Development, (2000): Draft National Water Policy (August 2000).
4. Multi-sectoral Technical Advisory Committee, GOT, May, 2001: Tanzania: Lower Kihansi Environmental Management, Technical Assistance Project - Project Implementation Manual.
5. NORAD/NVE, October 1999: Proceedings of the Conference on Licensing Procedure for Electric Power Development and Environmental Management, held at Iringa 4-7 October, 1999.
6. NORPLAN A.S. May 1999: Lower Kihansi Hydropower Project, Preparation of Catchment Management Plan, Main Report.
7. Sam Lee, 15 January 2002: KIHANSI SPRAY TOAD REPORT NO. 2; Wildlife Conservation Society, Department of Herpetology, 2300 Southern Boulevard, Bronx, NY 10460-1099
8. TANESCO/NORPLAN A.S. March, 2001: Lower Kihansi Hydropower Project - Project for Immediate Rescue and Emergency Measures (IREMP)
9. Tanzania Electric Supply Company Limited, January 2002: LOWER KIHANSI HYDROPOWER PROJECT, IMMEDIATE RESCUE AND EMERGENCY MEASURES: Volume 1 - Draft Final Report, By NORPLAN A.S
10. United Republic of Tanzania, 1974: Water Utilisation (control and regulation) Act No. 42 of 1974.