THE LESOTHO HIGHLANDS WATER PROJECT: ENVIRONMENTAL FLOW ALLOCATIONS IN AN INTERNATIONAL RIVER

1. BACKGROUND

Study area: location and geography

Lesotho is a mountainous, land-locked country completely surrounded by South Africa. The powerful rivers that drain the region had virtually natural flow until the 1990s, as the Eastern Highlands are remote and sparsely inhabited by rural communities, and the rivers flow through deep gorges that provide little opportunity for urban or agricultural development. Lesotho is one of the ten poorest countries in the world and river water was seen as an important potential source of revenue for this small developing country. Nearby South Africa was a potential recipient of the water.

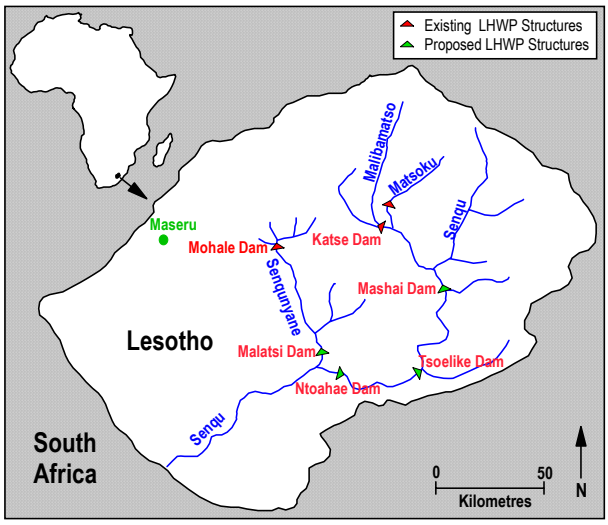


Figure 1. Senqu River System in Lesotho showing LHWP structures

The water-resource development

The Lesotho Highlands Water Project (LHWP) was established by Treaty between the Governments of Lesotho and South Africa in 1986 in an era before environmental flow assessments (EFA) were undertaken. Its prime purposes were to transfer water from the highlands of Lesotho to South Africa and to generate hydropower for use in Lesotho. The Treaty embraced five phases (Box 1 and Figure 1) but committed the countries only to Phase 1a and 1b. The institution responsible for project development and management was the Lesotho Highlands Development Authority (LHDA).

Box 1. Phases of the LHWP

Phase 1a: - Katse on the Malibamats'o River
- Muela Dam on the Nqoe River
- Delivery tunnels to South Africa
- Muela Hydropower Station

Phase 1b: - Mohale Dam on the Senqunyane River
- Matsoku Weir on the Matsoku River
- Delivery tunnels (Mohale to Katse)

Phase 2: - Mashai Dam on the Senqu River
Phase 3: - Tsoelike Dam on the Senqu River
Phase 4: - Ntoahae Dam on the Senqu River
Phase 5: - Malatsi Dam on the Senqunyane River

The 1986 Treaty set out provisions for the amount of water to be diverted and for addressing the effects of the water transfer and associated project development. The Treaty made environmental and social commitments to environmental management, maintenance of livelihoods and compensation for losses (Box 2).

Box 2. LHWP Treaty environmental and social commitments

"The parties agree to take all reasonable measures to ensure that the implementation, operation and maintenance of the Project are compatible with the protection of the existing quality of the environment and, in particular, shall pay due regard to the maintenance of the welfare of persons and communities immediately affected by the Project"

The need for an Environmental Flow Assessment (EFA)

As Phase 1a neared completion in 1997 and Phase 1b began, global awareness of the impacts of large dams was increasing. Within Lesotho and internationally, attention turned to the potential ecological and social impacts of Katse Dam. This and other LHWP structures were designed to maximize the amount of water to be transferred from Lesotho to South Africa with minimal amounts released downstream. In 1997, LHDA initiated an EFA, and delayed re-signing the 1986 Treaty, due in 1998, until its completion. The EFA was to be used to optimize flow-releases from Katse Dam (Phase 1a), Mohale Dam and Matsoku Weir (Phase 1b). It would also be used to aid decision-making about whether or not to proceed with Phases 2 to 5 and, if this was to happen, provide inputs into design, construction and operation. Metsi Consultants (a joint venture of Southern Waters Ecological Consulting of South Africa and SMEC international of Australia) undertook the EFA (Box 3).

Box 3. Aims of the EFA

- Predict the long-term impacts of modified flow regimes on the ecosystems and communities downstream of the LHWP structures.
- Recommend mitigation and compensation for affected downstream subsistence users of the rivers.
- Design a long-term monitoring programme to assess if agreed environmental flows were being delivered, and if they were achieving the desired river condition.

2. ENVIRONMENTAL FLOW APPROACH USED

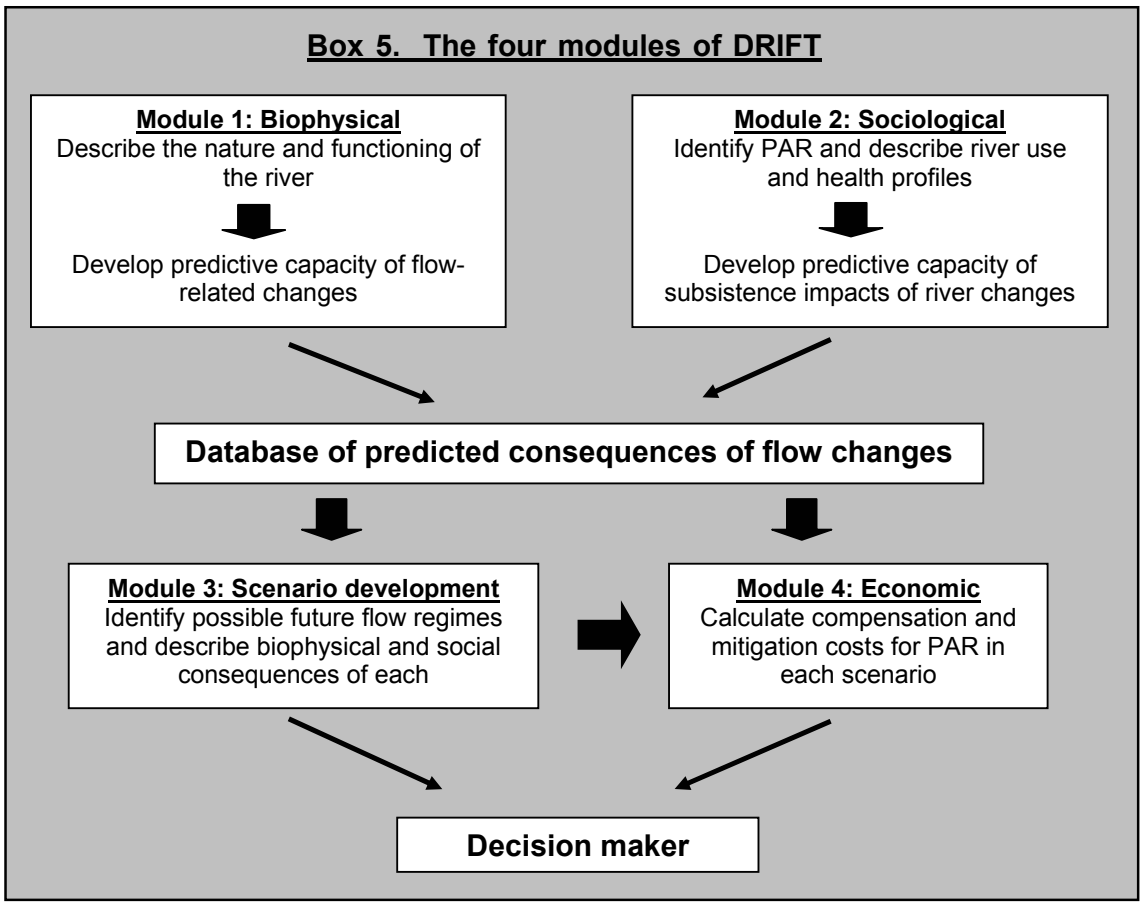
The EFA began in 1997 and was completed in 2000. It was designed to maximize understanding of the rivers and of human dependence upon them, within a one-year data-collection period. Eight sites were selected, on reaches representative of the different parts of the affected river systems from the Phase 1 structures downstream to the Lesotho-South Africa border. An international team of 25 scientists from 23 disciplines was involved in the project (Box 4).

Box 4. Specialists involved in the Lesotho Environmental Flow Assessment

Channel form	Hydrologist, hydraulic modeler, sedimentologist, fluvial geomorphologist, physical-habitat specialist
Water quality	Aquatic chemist, microbiologist
Biology	Botanists for riparian, fringing and aquatic plants; zoologists for fish, invertebrates, frogs, reptiles, water birds, terrestrial wildlife
Subsistence use	Sociologist, anthropologist, public health medical doctor, animal health veterinarian, water-supply specialist
Economics	Economist, resource economist

An holistic interactive approach under development, **DRIFT** (Downstream Response to Imposed Flow Transformations) was used for the flow assessment. DRIFT's basic philosophy is that all major abiotic and biotic components constitute the ecosystem to be managed; and within that, the full spectrum of flows and their temporal and spatial variability, constitute the flows to be managed. DRIFT is a data management tool comprised of four modules that allows data and

knowledge to be structured, combined and used to produce flow-related scenarios for water managers (Box 5).



Note: (PAR = population at risk, i.e. subsistence users of the rivers downstream of LHWP structures)

The population at risk (PAR) comprised approximately 155,000 people living in small villages along the rivers. These isolated rural communities were highly dependent on natural resources for their livelihood, including those from the rivers (Box 6).

Box 6. Examples of river resources used by the PAR

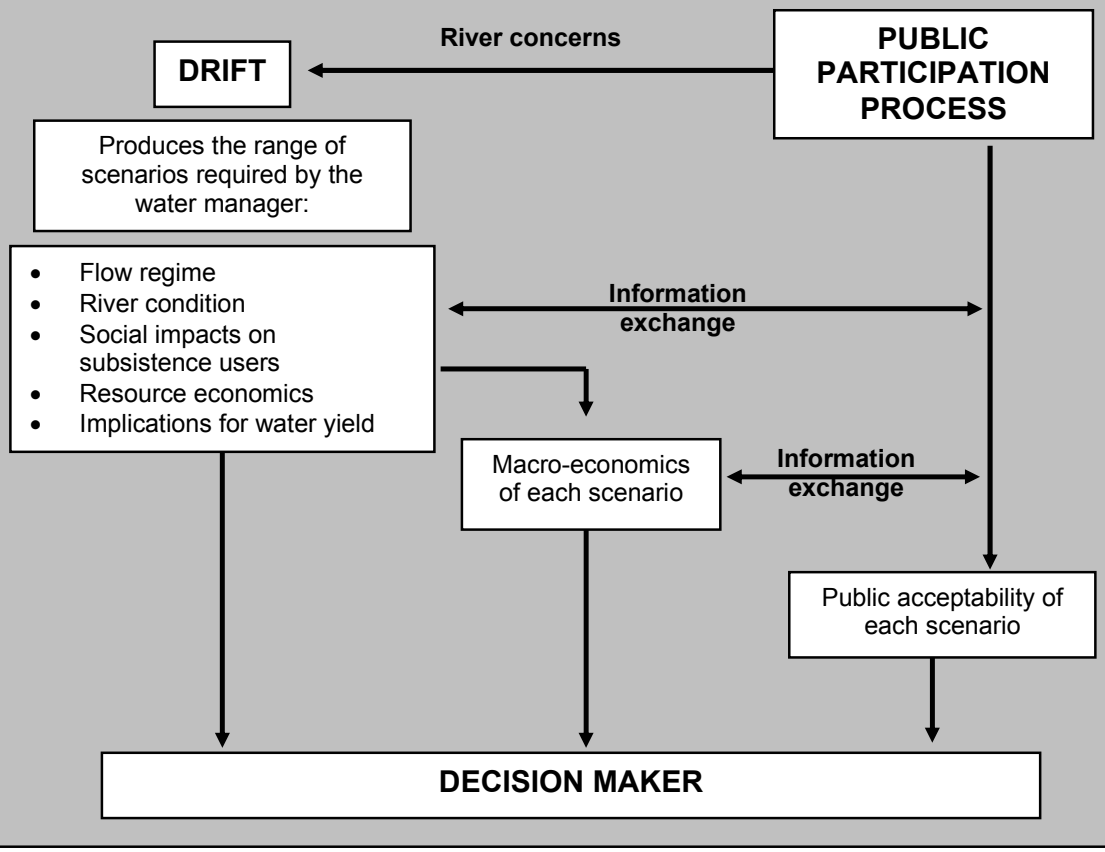
- Fish caught by 5098 households, which caught an annual average of 17.5 kg of smallmouth yellowfish, 2.2 kg of rock catfish and 3.0 of rainbow trout. The approximate market value is US$ 1.4 per kg.
- Wild vegetables harvested by 13,911 households, which gathered on average 148 plastic bags per year. The mean market value is US$ 0.3 per bag.
- Reeds, thatch grasses and the craft grass *leloli* within the riparian zone are harvested by 6713, 7972 and 5487 households respectively.
- Medicinal plants within the riparian zone are collected by 6391 households, with a mean market value of approximately US$ 6.6 annually per household.

The EFA focused on the river ecosystem, as the resource base, and on the PAR, as the most directly affected people. Other recognised stakeholders (Box 7) were included outside the DRIFT application, via a Public Participation Process (Box 8).

Box 7. Population at Risk (PAR) and other stakeholders

- **PAR**: 155,000 people (8,300 households in 338 villages) living along the rivers downstream of the LHWP structures and using the rivers for subsistence.
- **National authorities**: Lesotho – Government of Lesotho, Ministries of Natural Resources (Water Affairs, Environment, Science & Technology, Conservation), National Environmental Secretariat, Ministry of Finance, Department of Rural Water Supply, Department of Tourism, Sport & Culture, Prime Minister's Office; South Africa – Government of South Africa, Department of Water Affairs & Forestry.
- **Traditional authorities**: Principal Chiefs of Lesotho (24) and their community development representatives.
- **Lenders/donors**: World Bank, European Investment Bank, Development Bank of South Africa.
- **Other interested parties**: International NGOs, Lesotho Council of NGOs, NGOs/civic organisations/individuals in Lesotho and South Africa.

Box 8. The relationship between DRIFT, a Public Participation Process and a regional macro-economic assessment.



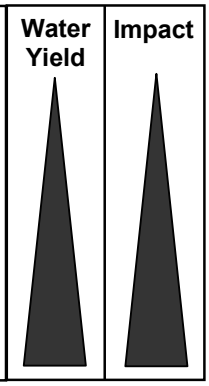
Outputs of the Environmental Flow Assessment

DRIFT was used to produce four main scenarios (Box 9) and several subsequent scenarios as input to negotiations between Lesotho, South Africa and the World Bank. Each scenario described the volume and pattern of water flow released from the dams, and the predicted

environmental and PAR impacts (Box 10). The general trend was that the greater the reduction of downstream flows, the greater the environmental and PAR impacts. The greater the downstream impact, however, the more water in the dams for others uses including sale to South Africa.

Box 9. Four Environmental Flow Scenarios developed for the LHWP

- **Minimum degradation:** The condition (hypothetical for reaches impacted by Katse Dam) that would maintain the rivers in a state of minimum degradation from their present conditions, accepting that dams would be in place.
- **Design Limitation:** Based on the practical limitations of flow releases imposed by the designs of Phase 1 structures and by the requirement for moderate water yield.
- **Fourth:** Between the Treaty and Design Limitation Scenarios.
- **Treaty:** Legally defined by the release conditions in the 1986 Treaty. It would have the highest water yield stored in the dams but the most severe environmental and socio-economic impacts.



Box 10. Examples of predicted ecosystem changes and implications for the PAR in the Treaty Scenario for reaches close to Katse Dam.

- Cobble beds used for fish spawning and feeding largely lost, and a severe increase in muddy areas with increase in the protozoan gut parasite *Giardia lamblia*.
- 80-100% decrease in the number and depth of pools used by fish as refugia.
- Increase in aquatic algae, sometimes to pest proportions, with increased gastro-intestinal illnesses in people and livestock.
- 20-30% loss of the important food plant *Chenopodium album.*
- 60-80% loss of the grass *Merxmuellera macowanii*, used for medicine and making rope.
- 50-75% increase in the blackfly *Simulium chutteri,* a bloodsucking pest of sheep, cattle and horses.
- Very severe decrease, perhaps to local extinction, of the food resource smallmouth yellowfish.
- Widespread loss of waterbirds, including those used for meat or medicine, such as African black duck, giant kingfisher and hammerkop.
- Critically severe impacts on PAR in terms of diarrhoeal disease and nutrition and severe increases in skin and eye diseases.

The preferred compensation for most PARs was via programmes of assistance aimed at replacing the lost resources.

3. MANAGEMENT ACTIONS: DECISIONS TAKEN AND IMPLICATIONS

Policy development entailed consideration of the benefits gained from the sale of water from Phase 1 on the one hand, and the ecological and social impacts of this on the other hand. If Phases 2 to 5 do not proceed (not decided), Phase 1 will provide the only water for sale. Based on the DRIFT assessment, the regional macro-economic assessment and the Public Participation Process, scenarios were selected for the rivers that were considered to be the best overall trade-off (Box 11).

It was intended in the 1986 Treaty that the Matsoku River would continue to receive more of its flow than other Phase 1 rivers, and a low weir was planned rather than a dam to divert water to Katse reservoir. With the environmental flow (EF) policy in place, this was confirmed. Prospects for survival of the endangered Maluti minnow *Pseudobarbus quathlambae* will be enhanced by the commitment to 40% of total flow remaining in the river. High and low flows will continue, because abstractions to Katse will halt during very low flows and floods will continue to flow over the weir. In the 1986 Treaty, Mohale Dam was committed to release approximately

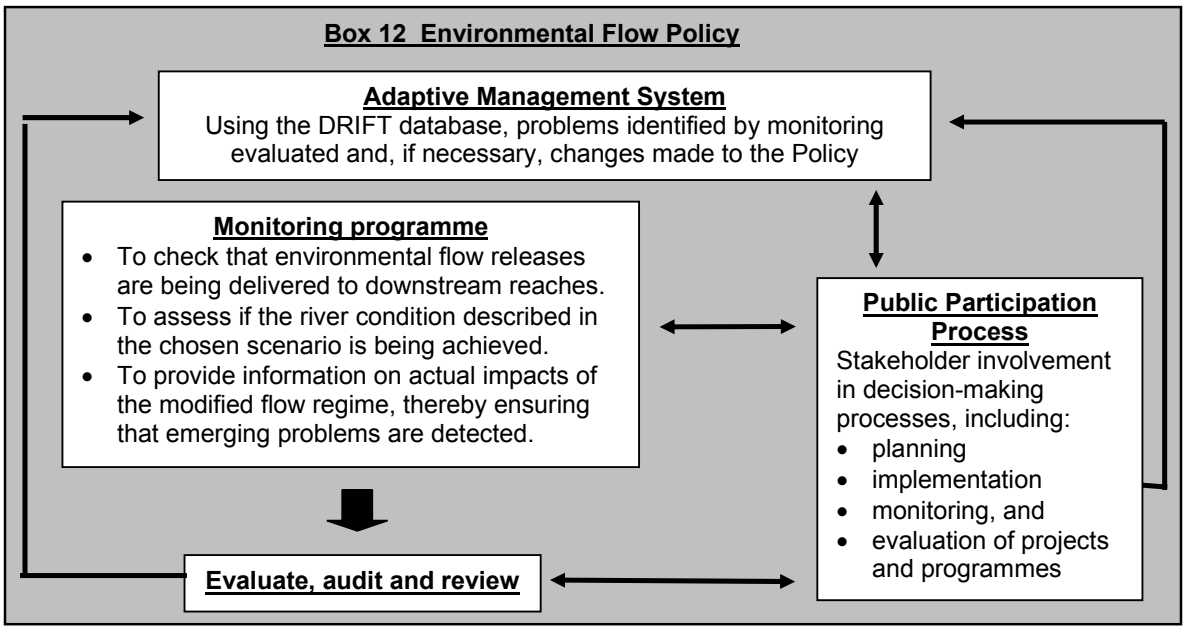
3% of the total flow of the Senqunyane River at that point, in a continual unvarying release. Under the EF policy this will increase to about 10.4% released, in a flow pattern of low flows and floods as defined using DRIFT. Changes to the design of Mohale during the EF project enhanced the capability to release floods. Total flow will rise to 22% of natural some 30 km downstream of Mohale due to runoff from the mountains. Katse Dam was committed to release approximately 4% of total flow of the Malibamats'o River at that point in a constant release. With the EF policy in place this will increase to about 10.7%, but releases will be much less variable than for Mohale as Katse was already constructed, with small release structures, when the EF project started. All the rivers will show improved condition with distance downstream from the structures, due to high levels of catchment runoff.

Box 11 The chosen environmental flow allocations for the three rivers involved in Phase 1

LHWP Structure and River	Pre-LHWP river condition	Scenario chosen	Pos-LHWP target river condition	% Total flow released at structure	Distance downstream to next study site and % total flow at that point
Katse Dam – Malibamats'o River	Class 2 near natural	Treaty/ Fourth	Class 4 significantly modified	10.7%	2 km 11%
Matsoku Weir – Matsoku River	Class 2 near natural	Treaty	Class 3 moderately modified	15.4%	2 km 40% (floods continue over weir)
Mohale Dam – Senqunyane River	Class 2 near natural	Fourth	Class 4 significantly modified	10.4%	30 km 22%

A draft Environmental Flow Policy for Phase 1 was formulated (Box 12). Adaptive management will be pursued, using the DRIFT database and subsequent monitoring as the primary management tool. In early 2003, with all Phase 1 structures operational, the project entered the monitoring phase.

Box 12 Environmental Flow Policy



4. KEY CHALLENGES AND LESSONS LEARNT

Timing of the EFA was not ideal since it was only commissioned after construction of Phase 1a and during the course of the final design and initial construction of Phase 1b. This meant that the very small outlets in Katse Dam could not be increased in size to release bigger flows, and only limited design changes, notably modifications to the design and size of the Mohale Dam outlets, could be made for Phase 1b. The EFA should begin at the earliest scoping stage of a water-resource development. It should inform structure location, design and desirability, and not be constrained by these stages already having been completed.

Three assumptions were made during the planning of the LHWP in the 1970s, which proved to be wrong.

- Assumption: Removal of 95% of the flow would have little impact on the downstream rivers other than close to the dams. *The EFA showed there would be significant hydrological, biophysical and socio-economic impacts all the way to the Lesotho border.*
- Assumption: People downstream of proposed LHWP structures made very little use of riverine and riparian resources. *The EFA showed that there was extensive and sometimes complex relationship between the PAR and the rivers.*
- Assumption: The major impacts of the dams would be on upstream communities who lost land through inundation by the reservoirs. *The EFA showed extensive existing and potential future economic and social impacts downstream of the structures.*

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Websites

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www.lesotho.gov.ls - Official Lesotho Government website
www.sametsi.com - Website for the Metsi consultancy group

SUMMARY

The Lesotho Highlands Water Project was established by Treaty in 1986 between the governments of Lesotho and South Africa, to transfer water from Lesotho to South Africa and generate hydropower for Lesotho. The Project embraced five Phases of which the Treaty committed the countries to Phase 1. This consisted of Katse Dam, Mohale Dam, Matsoku Weir and supporting structures. National and international concern over large dams led to an environmental flow (EF) assessment as Katse was nearing completion. Twenty-five specialists from 23 disciplines took part in the three-year EF study, using an holistic approach called DRIFT. Scenarios of likely

consequences of dam-induced flow and sediment changes were produced, predicting in detail how the downstream river ecosystems could change and how this could affect subsistence users of the river's natural resources. Compensation and mitigation costs for these losses were provided. Guided by the DRIFT outputs, the two governments negotiated releases from Phase 1 structures that were higher, more varied and closer to natural than the 1986 Treaty required. Lessons learnt were that the EF assessment should have been completed in the early scoping phase of the development, to inform structure location, design and desirability. Several major assumptions made in the 1970s and 1980s that guided the content of the 1986 Treaty were shown by the EF study to be erroneous.

KEYWORDS

Instream flow assessment. Environmental flow assessment. Lesotho Highlands Water Project. Katse Dam. DRIFT.