Decision support systems for environmental flows: Lessons from Southern Africa

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ABSTRACT
The decision by a number of countries to re-engage with large dams creates an obligation to ensure that the attendant environmental and social consequences are dealt with adequately. In this regard, the key challenges for the future are the assessment and management of downstream environmental and social impacts. The paper examines these issues in the context of southern Africa, particularly the Lesotho Highlands Water Project. It examines the ways in which Environmental Flows can affect the environment and the livelihoods of riparians, the need to make trade-offs between different uses of the water, and the difficulties of making trade-offs if the values of stakeholders regarding water use are not supported by a legal framework. The paper highlights the need to undertake environmental flow work early in the project cycle as part of the Environmental Impact Assessment, and the need to integrate environmental flow factors into the project’s economic analysis. It explores the financial trade-offs that are implicit in environmental flow work, the need for a multi-disciplinary team to carry out the work, and the need for a transparent decision framework. Finally, the importance of establishing a decision support system for use during the operational phases of the project is highlighted.

Keywords: Environmental flows; environmental impacts; affected people; downstream riparians; water resource management; environmental impact assessment; decision support systems.

1 Introduction
Numerous countries around the world and their development partners have recognized that the rewards of engaging in high risk hydraulic infrastructure, including large dams, are sufficiently high to justify taking the substantial risks associated with such projects, especially with respect to ensuring that the dams are constructed and operated with due attention to environmental and social issues. Particularly since the failure to take account of environmental and social issues spawned opposition to large dams in the first place (WCD, 2000).

The tools and methodologies for dealing with upstream environmental and social impacts of dams are readily available; it is just a question of making the effort. However, the integration of environmental and social impacts downstream of dams into the planning and operations of dams in a structured way is both new and complex, experience is limited and commonly accepted good practice is in a state of evolution.

Natural water systems can tolerate severe floods and droughts and yet recover and return to their original environmental state. This resilience allows them to recover from some degree of human use and abuse. But there is a level of flow modification beyond which the rivers lose their ability to recover to their natural state. At this point, their capacity to meet environmental and human demands is reduced and may be lost completely.

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This means that things that were not foreseen in the earlier studies to meet environmental and social needs in the river reaches downstream. Relevant information is required to determine the amount, quality and timing of water to be released through or over dams and associated structures to ensure the maintenance of the physical and biological characteristics of the river at a specified level – through the dam outlet works that have sufficient operational flexibility to meet EF needs; and to decision making (King, 2003). Pioneering studies have helped shape and direct both the science and the management – and, importantly, the links between the two. Understandably this pioneering work was characterised by a degree of uncertainty and learning by doing (e.g., Metsi Consultants, 2000a). An atmosphere where mistakes were seen as excusable, even inevitable, and where they provided direction rather than sounding death-knells, contributed to success in these early endeavours. If further progress is to be made, however, it is imperative that lessons learnt from these early projects provide the platform for future EF work. This means that things that were not foreseen in the earlier studies must be foreseen in future efforts and that measures to ensure that this happens be put in place at an early stage.

### 3 Environmental flow science and decision support systems

It is important that the environmental scientists (to the extent possible) identify and provide for all the factors needed for a water resource to function both environmentally and as a resource for communities: the quality, quantity and reliability of water; the physical and vegetation aspects of habitat in the water and on the banks; the numbers and kinds of plant and animal populations, their distribution and diversity; and the functioning of ecosystems and the relationships amongst ecosystem components. This information is required to determine the amount, quality and timing of water to be released through or over dams and associated structures to meet environmental and social needs in the river reaches downstream.

To mitigate the potential negative impact of a project on the downstream environment and peoples, the aquatic ecosystems and physical attributes of waterways downstream of dams must be considered by specialists in terms of consequences on biodiversity and ecosystem functions. Downstream affected peoples should also be consulted about potential impacts on their livelihoods and compensated for any losses so as to at least restore equivalent livelihoods or preferably create new improved livelihoods.

Thus, the new focus introduced by EF work has two primary aspects:

- first, the environmental flows that need to be released from the structures to ensure the maintenance of the physical and biological characteristics of the river at a specified level – through the dam outlet works that have sufficient operational flexibility to meet EF needs; and
- second, the impact of the reduced flows on the availability and use of natural resources to downstream communities so that programs can be developed to mitigate resource losses and compensate the impacted communities.

Obviously, any water released from a dam for EF purposes will affect its yield, thus opening up the need for discussions and decision-making as to the amount and timing of flows to be released and their relative costs and benefits to different stakeholders. Achieving EF objectives, thus, involves going beyond the science of predicting impacts to ensuring that the science is considered within a decision support system that makes it easy for decision-makers to absorb, process and use information. This is particularly important when the decision context is semi-structured or unstructured. In private companies, the context for many decisions is well structured in terms of who takes decisions, what information they use and the decision criteria that are applied. When dealing with EFs, the decision context is, at best, semi-structured and, in the case of most developing countries, remains unstructured. This means that greater care has to be taken to ensure that decision-makers understand the importance of the decisions they are taking, have access to understandable data and operate within a decision framework that makes explicit both the implications of different decisions and the trade-offs involved in the decisions.

Early work on EFs under the LHWP focussed too narrowly on the science of predicting the impacts of different environmental flow regimes (Metsi Consultants, 2000a), implicitly assuming, perhaps optimistically, that the scientific data presented would be easily understandable to politicians as they sought to reach informed decisions with respect to EFs. In the event, this turned out to be an erroneous assumption and, despite expert warnings, the project authorities paid inadequate attention to establishing a decision support system at an early stage.

In this paper, we consider the key factors that should underpin an effective decision support system and use examples from southern Africa, with a particular focus on the Lesotho Highlands Water Project (LHWP), to draw lessons that identify and illustrate the characteristics of good practice in EF decision-making. For details on the LHWP experience, see Watson (2006). For additional examples of EF work in Southern Africa, see SADC (2002).
4 Context

The first lesson learned is that it is essential to plan dams in a multi-purpose context. All river systems serve multiple uses, e.g., navigation, agriculture, power generation and human water supply. What is new about EF work is that it seeks to give a voice and representation to two typically voiceless constituencies – the environment and downstream communities – and to balance their interests with other uses in project planning and decision-making. A complication arises because, while it is relatively easy to determine the needs of urban, agricultural, industrial or energy users of water, it is much more difficult to quantify the “needs” of the downstream environment or the communities that depend on downstream resources for their livelihoods. This is, in part, because of the absence of a commonly accepted methodology for determining EFs and, in part, because of the lack of a common metric for evaluating trade-offs between competing uses.

This means that the requirements of the downstream people and their environment need to be considered as early as possible in the project planning and decision-making process as part of the broader dimension of environmental assessment. Indeed, Environmental Flow Assessments (EFAs) should be carried out as part of the Environmental Impact Assessment (EIA) for each project in the context of established societal values for the environment, including a clear water allocation framework, obligations to restore already degraded wetlands and lakes and mechanisms to protect voiceless constituencies.

Clearly, evaluating trade-offs is greatly facilitated if the values of the government and its citizens are set out explicitly in a policy document that, preferably, has the force of law. Professing to be concerned about the environment only carries weight when backed up by legally enforceable policy provisions.

The elaboration of a “river classification system” (e.g., Kleyhans, 1996), which describes different river states, permits value judgments to be made regarding the degree of modification that society will tolerate and, therefore, the amount and timing of water that needs to be released as an EF to maintain the river at its targeted environmental condition. The determination of the minimum tolerable condition status of a river is a value judgment, not a technical judgment, and has to be determined for each country, based on broad consultation.

Without a supporting policy or legal framework, EF initiatives are burdened not only with determining environmental flows, but also with giving legitimacy to them (Rafik Hirji, World Bank, pers. comm.). Such a situation leads to difficulties for decision-makers, who may become confused as to whether they are designing a policy or implementing it. In the absence of a legal framework for EFs, funding organisations are increasingly likely to make EFAs pre-requisites for loans for water-resource developments. A better solution is for countries and their development partners to collaborate at a very early stage on the development of a policy/legal framework to establish ground rules and criteria for EF decision-making that makes explicit the values and expectations of society with respect to the allocation of scarce water, the degradation of rivers and the equitable treatment of project-affected people. A good example can be found in the sustainability criteria incorporated in the South African National Water Act No. 36 of 1998.

This would create the first building block for a decision support system, by establishing a value system and criteria for decision-makers to follow.

In the longer term, the existence of a farsighted view of water resource management, protected by a legal framework, can also help avoid a number of undesirable outcomes with respect to the downstream effects of water resource utilisation. When faced with the challenges posed by water quality and water scarcity problems, i.e., catchment closure, it is not uncommon to find that the EFs are the first to be abandoned, particularly if they are not afforded legal protection. At this point, the downstream goods and services provided for by the EF can be severely compromised. Even when EFs are not abandoned, the lack of a long-term view of downstream impacts can lead to different perceptions of who or what is responsible for changes perceived by downstream riparians to be detrimental to their livelihoods (Box 1).

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**Box 1 Kafue Flats.**

The Kafue Flats are a broad alluvial plain that hosts one of the most diverse ecosystems in Zambia. As early as the 1960s, environmental maintenance flows were being made on the Kafue River. Since the construction of the Itzhi-Tezhi Dam, EFs have been made to maintain minimum and flood flows in 18 out of 22 years. Yet the perception remains, among downstream riparians and environmental observers alike, that lack of flow has created hardship for downstream people.

Part of this is due to the absence of monitoring data that would enable ecosystem changes to be determined, especially in the context of other ecosystem and socioeconomic events in the Flats. Part is due to the failure of the dam operators to warn downstream riparians of flood releases, so that lost crops and cattle were blamed on the dam even when its operators were trying to do the right thing. Part is due to a failure to understand the changing pattern of wetland and grazing that resulted from the dam.

The result is that, while some people have undoubtedly benefited from the dam (workers in industries and agriculture and urban dwellers who use electricity), many subsistence farmers, have lost grazing, fisheries and a degree of certainty over flow and flood events. Needless to say, they blame the dam and its operators. Obviously, more needs to be done to understand the impact of dams, to monitor those impacts and to involve downstream riparians in dam operating decisions, such as the timing of floods, which critically affect their lives (McCartney, 2002).

Progress has been made. Many countries in the Southern African Development Community (SADC) have adopted or are adopting water laws, which recognise the environment as a legitimate user of water and grant its allocation a higher priority compared to other consumptive and non-consumptive uses (e.g., Adams, 2000; Turpie et al., 2000; Metsi Consultants, 2000b).
South Africa, Tanzania and Kenya provide examples that constitute emerging best practice concerning water policies that explicitly recognise water needs for ecological and human/social functions. For example, South Africa’s National Water Act (South African NWA, 1998) specifies levels of river deterioration that are unacceptable and formally and legally accords EFs (the Ecological Reserve; DWAF, 1999) pride of place in deciding among alternative water uses.

5 Commitment

A legal framework, however, is insufficient to ensure proper design and implementation of EFs without broad commitment to its enforcement. If the people in charge do not signal that something is important, their personnel will ignore it – whatever the policy says. Commitment will not appear automatically; it has to be built into the system through ongoing multidisciplinary discussion and agreement on the purpose of EFs and the resolution of misperceptions. There is growing recognition that this aspect of EF work is of critical importance.

Here again, progress has been made and interventions by the UK Department for International Development (DFID), the UN Food and Agriculture Organisation (FAO), IUCN (now known as the World Conservation Union; see Box 2), the International Water Management Institute (IWMI), the UN Educational, Scientific and Cultural Organisation (UNESCO), the World Bank, WorldFish, the World Wildlife Fund (WWF) and others have gone some way towards increasing commitment to EFs. The Bank-Netherlands Water Partnership Programme has also supported important EF work under its Environmental Flow Window (see www-esd.worldbank.org/bnwpp/index).

Creating the required commitment and developing and establishing a functioning decision-support system involves bringing together different, and sometimes conflicting, disciplines into a common framework for decision-making. We deal with some of the issues that arise in the following sections.

6 Engineering

It would be inappropriate to discuss a decision support system for dam projects without talking about the need to ensure that design and operating engineers have internalised changing societal values with respect to EFs. Take the example of the LHWP. The Katse Dam won the “Project of the Century” award from the South African Institution of Civil Engineers. In addition, the Mohale Dam won 2005 Fulton awards from the Concrete Society of South Africa for best “Construction Engineering Project” and best “Construction Techniques”.

The winning of these prestigious awards testifies to the outstanding work that was done to design and build the Katse and Mohale Dams. However, a modern dam project is not judged simply on its engineering excellence. Nowadays, for an engineering project to be judged outstanding, it must also deal adequately with environmental and social issues, including EFs.

There is no doubt that the engineers of the Lesotho Highlands Development Agency, their political masters and their peers started off judging dam projects purely on their engineering merits. It is also clear that the engineers, with their focus on construction and operations, did not feel the need to pay great attention to the EF work, accepting without question that the minimum flow provision in the Treaty was adequate.

In a sense, it is not surprising that this situation developed. The engineers wanted to get the job done quickly to meet their own professional objectives. Given that there were not yet any hard and fast rules regarding compliance with EF rules, they pushed ahead with the job at hand. None of the key stakeholders took adequate steps to ensure that the different disciplines functioned as a mutually respectful multi-disciplinary team within an effective decision support system.

The key lesson to be learned is that the management of dam sponsoring agencies has a critical responsibility to create multi-disciplinary teams that work together under a clear set of rules – a decision support system – under which all stakeholders understand and value the contributions of other stakeholders. Only then will we be able to move beyond an “us versus them” culture and truly begin to exploit multidisciplinary synergies.

Having management ensure that the engineers understand and value the contributions of the environmental and social scientists – and design and operate dams accordingly – is the second building block of an effective decision support system.

7 Science

If the policy framework is well established, the scientific challenge concerns the determination of the volume and temporal distribution of the environmental flows that are required to
achieve the target river health status, based on an understanding of how flow changes cause changes in river condition (e.g., King et al., 2003). This understanding is used to estimate the pattern of flows (including floodplain inundation and periods of low or even no flow) for the river that could be expected to:

- achieve the target river health; and
- allow the calculation of resource losses to people downstream for the purpose of determining compensation packages.

The use of resources by downstream communities include: flood-plain soils for agriculture; freshwater and coastal fisheries; other ‘fisheries’ such as frogs, insects, crabs, turtles and prawns; reeds; drinking water; sand for building materials; wild vegetables and herbs; medicinal plants; firewood; transport; and cultural and recreational activities. These uses range from the small-scale harvesting of medicinal plants by families to large-scale commercial activities.

For instance, recent studies have shown that prawn abundance off the Zambezi delta is directly related to runoff patterns in the Zambezi River (Hoguane, 1997). The presence and operation of Cahorra Bassa Dam upstream of the delta has resulted in a loss of these prawn fisheries—estimated at US$10-20 million per annum (Beilfuss, 2001a). More importantly, pioneering work being undertaken by the International Crane Foundation and the Museu de História Natural in Mozambique has revealed that EF releases from Cahorra Bassa could go someway towards alleviating these impacts without major losses of hydropower (Beilfuss, 2001b), indicating that EFs can be used not only to reduce the downstream impacts of a development, but also to rehabilitate systems impacted by past developments.

In any new sphere of endeavour, it is naïve to presume that the tools, data and knowledge required for success are available at the outset. Many African countries, in particular, do not have a good record in environmental data collection and archiving. The data and information that are typically available are limited to past consequences of flow change, correlations from elsewhere in the world, limited hydrological records and patchy distribution records for biota. In EF studies, this can be augmented with local knowledge and quickly collected information, but additional data collection is almost certain to be required for establishing the baselines that are essential for monitoring the effectiveness of EF releases.

Scientific and management confidence in EF determinations can only be enhanced by the collection of comprehensive bio-physical baseline data, followed by regular monitoring of changes. In the case of the LHWP, the collection of monitoring data was greatly delayed, with the result that long debates ensued with respect to what the impacts of the EFs had been. In a situation where there was already some reluctance to apply the EF policy rigorously, the lack of monitoring data meant that it was close to impossible to reconcile the occasional observations of environmental experts with the predicted impacts. This has since been rectified with the Lesotho Highland Development Authority recognising the need to invest in environmental data collection and the creation of a skilled monitoring team to provide much-needed informed input to adaptive management decisions.

The irony is that baseline environmental data can be collected at a very early stage, independently of any specific planned water-resource developments. It should be seen as an investment in a body of environmental and bio-diversity knowledge and data that will be intrinsically of value to a country. The compilation of such a database would contribute towards future monitoring protocols, through the identification of practical, measurable, interpretable indicators, and importantly, ensuring the equipment and trained staff to deal with them. Investments made now will yield multiple benefits later.

Applying the 80/20 rule: Zambezi Delta Shortage of data or time is not an excuse to do nothing. If it were, then no EFs determinations would have been done in Africa; in fact, almost two hundred have been completed. Many methodologies are designed to operate in data poor situations and can provide a respectable indication of EFs for maintaining different river functions, with little or no data, provided there is some hydrological information available.

In 2005, the Gabinete do Plano de Desenvolvimento da Região do Zambeze (GPZ) and partners undertook an initial EF investigation using DRIFT (King et al., 2003) for the Zambezi Delta based entirely on existing information (in particular, hydrological and hydropower modelling) and very limited hydraulic data, combined with expert opinion (Bielfuss et al., in prep.). The main aims of the project were to identify potential conflicts/tradeoffs among users in the Zambezi delta area with respect to flow requirements and to explore the potential for improving the condition of the Zambezi delta through environmental flow releases from Cahora Bassa Dam, chiefly reducing dry season low flows, providing a regular annual flood and possibly regulating large floods (1:5 year return period or larger).

The project provided guidance on EF options in the delta with very little data and in a short space of time (2 months). This illustrates the classic 80/20 rule or Pareto Principle: one can achieve 80% of a goal with 20% of the effort, while the remaining 80% of effort is required for the last 20% of progress. The Zambezi study was used to illustrate the potential mitigating effects of EFs in the delta and the low hydropower losses associated with them, as well as identifying key knowledge gaps and data requirements for a comprehensive EF determination for the Zambezi River and delta (i.e., that last 20%).

This kind of work illustrates the potential for EF work to overcome the tendency of shared water resources to be sources of conflict and to make them opportunities for cooperation.

Establishing an adequate knowledge base at an early stage in project development, even if it is based on limited data, constitutes the third building block for an effective decision support system, by underpinning decisions with a sound body of data.

8 Economics

Notwithstanding the growing evidence in support of EFs, there remain many misperceptions around EFs, which can be damaging to their successful design and implementation. It is sometimes claimed that taking care of EFs will fatally compromise the
economic viability of water resource development. Yet, despite initial resistance, EF costs are increasingly being viewed just like other kinds of project costs that have been introduced into economic analysis over the years. The pharaohs paid little attention to labour safety issues in building the pyramids, but no one would undertake a project today without considering that providing adequately for worker safety was a legitimate project cost. The same is true of environmental impact assessments, resettlement provisions and HIV/AIDS protocols that were once regarded as a nuisance have become “business as usual”. The World Bank only introduced its environmental safeguard policy in the 1980s, but it is today regarded as a sine qua non of water resource management.

To put the economic costs of EFs into perspective, it may be noted that, under the LHWP Phase 1, the EF-related costs, including studies and compensation, were \( \approx 0.5\% \) of project costs; downstream compensation costs were about one fifth of upstream compensation costs (Table 1).

<table>
<thead>
<tr>
<th>Phase</th>
<th>EF Study Costs</th>
<th>Downstream Compensation</th>
<th>Upstream Compensation</th>
<th>Total Project Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A + 1B</td>
<td>2</td>
<td>14</td>
<td>68</td>
<td>2900</td>
</tr>
</tbody>
</table>

While the water transfer benefits of the project are reduced in progressively more eco-friendly EF scenarios, the Economic Rate of Return (ERR) of the project would only be moderately reduced if EF releases were increased. Furthermore, the project’s economic benefits to Lesotho and South Africa would remain substantial. Thus, although it would not maximize the economic benefits of the project and both parties would have to contend with reduced benefits of the project, it would be economically defensible to increase the EFs for ecological or social reasons. In the event, the compromise EF scenario finally adopted did not seriously affect the project ERR, reducing it from 7.60% to 7.35% (Klasen, 2002).

EF issues are simply the latest on the list of things that have to be dealt with. In future, dam costs will be underestimated if they fail to account for ALL the economic costs of the project, including those pertaining to EFs, for example:

- EF determination studies;
- design features to permit EF releases;
- additional operational and monitoring costs, e.g., staff, consultants, equipment and EF audits;
- the effect on yield of mitigating environmental and social impacts through EF releases;
- compensation payments; and
- consultations and communications, e.g., website, public relations and meetings.

It is important to be absolutely clear that the costs of dealing with EF issues are legitimate project costs that must be taken into account. Failing to deal with them does not make them go away, it simply distorts the ERR calculations to the extent that the true costs of the project to the community are not taken into account. This is not good economics; nor is it good public decision-making.

9 Finance

The LHWP provides an interesting example of what can happen when financial aspects are an important element of project design. Since the LHWP was designed and built to earn royalties by transferring water to South Africa, financial considerations were paramount. It is not surprising, therefore, that the theme that underlay virtually all of the debate on EF flow levels concerned the potential loss of revenue that would result from increasing EFs above the minimum value stipulated in the Treaty.

Table 2 shows the present value of the net benefits to Lesotho under each of the EF scenarios. The Minimum Degradation Scenario largely maintained the health of the river, the Design Limitation Scenario was driven by the technical design of the EF outlets at the dams, and the Fourth Scenario was mid-way between the Treaty and the Design Limitation Scenario and paved the way for negotiating a solution in between the more extreme scenarios.

While no-one would seriously expect a project sponsor to give up 19% of total project revenues, as would have happened under the theoretical Minimum Degradation Scenario, being willing to consider trading off a loss of revenue of between 3.3% and 9.0%, as would happen under a compromise between the Treaty Minimum and the Design Limitation Scenarios, for environmental gains and reduced resource losses might not seem to be too unreasonable, especially since doing so would not substantially affect the economic rate of return.

However, what was seen as a modest trade-off by the World Bank team was seen by the Lesotho authorities as a significant loss of revenue that could be used for development purposes in Lesotho, especially given the budget constraints faced by the Minister of Finance. The fact that bringing the parties together on a compromise proved difficult illustrates the importance of

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Table 2 Financial Losses Under Four EF Scenarios (from Klasen 2002).

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Treaty minimum</th>
<th>Minimum degradation</th>
<th>Design limitation</th>
<th>Fourth scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Benefit (Maloti Millions (1999))</td>
<td>3328</td>
<td>2698</td>
<td>3031</td>
<td>3218</td>
</tr>
<tr>
<td>Financial Losses by Scenarios vs. Treaty Minimum</td>
<td>0</td>
<td>-630 (-19%)</td>
<td>-297 (-9%)</td>
<td>-110 (-3.3%)</td>
</tr>
</tbody>
</table>
articulating values and establishing a negotiating and decision framework at the earliest possible stage.

From the above discussion, it can be seen that good – and complete – economic analysis, including financial aspects where appropriate, is the fourth building block for an EF decision support system.

10 Bringing it all together for decision-makers

EF work is about decision-making in a complex environment and requires that political and technical authorities and their development partners understand and deal with the trade-offs involved in designing an EF policy. These trade-offs form the basis of both technical and political decisions so it is vital that they be analyzed and presented in a manner that makes it as easy as possible for decision-makers to understand the implications of their decisions. To reach informed decisions, it is necessary to move beyond identifying and measuring impacts to quantifying trade-offs.

Data has to be assembled on all the elements discussed above. However, it does not matter how good the data are if they cannot be presented in such a way as to make the trade-offs transparent. Under the LHWP, a mass of data was available from EF studies, but not in a form that was easy for the non-specialist to understand (e.g., Figure 2). It is essential to establish a structured decision support system so that multidisciplinary data can be used to quantify and elucidate trade-offs without polarizing decision making around single discipline concerns. The objective is to assemble specialist data from different disciplines to help decision-makers work through the implications and consequences of the choices available to them. The objective of a decision support system is to inform decisions, not to automate them.

In the absence of a transparent decision support system, the issues were most often posed by protagonists in terms of an environment versus development trade-off: “We built the dam so that we could transfer the water and use the royalties for development in Lesotho” or more extremely “The World Bank is putting the environment over development” or even more explicitly “We transferred the water and used the royalties to sustain downstream development above the development in Lesotho” or more extremely “The World Bank is putting the needs of the whole country above the concerns of a few people downstream above the development in Lesotho” or more extremely “The World Bank is putting the environment over development in the development partners’ area”.

But there is a complication that goes beyond the calculations. The fact that different people attach different weights to different factors means that discussions and negotiations on environmental flows are intrinsically very difficult and can become contentious. This is only to be expected and the best way to deal with it is to make things as explicit as possible. Otherwise, the different stakeholders may tend to take advantage of their greater sectoral knowledge to exaggerate the weight to be accorded to their arguments.

Finally, the problem is complicated by the fact that the elements in the trade-offs do not have a common numeraire. Everyone knows what a dollar foregone is worth; few people understand the value of moving from one river classification category to a higher one.

It is also fair to note that decision-makers are more used to dealing with engineering and economic data than environmental data. While hydrological data and economic calculations are no less complicated and uncertain than environmental data, decision-makers are used to them and take the findings of engineers and economists at face value. It is important, therefore, to take extra care in the presentation of environmental data, especially concerning difficult concepts like “river condition”, so that decision-makers can better understand the parameters of the decisions that they are making, can treat all sources of information with the same degree of confidence and can reach fully-informed decisions.

Under the LHWP, the trade-offs only really became clear when a presentation to decision-makers made explicit, for each EF Scenario, the trade-offs between River Condition, Royalty Revenue and the Economic Rate of Return. Then the Lesotho Highlands Water Commission, which represented the political authorities, was able to see exactly how much revenue they would have to give up to achieve each of the different river condition outcomes, i.e., how many Maloti (the currency in Lesotho) a given environmental gain would cost. Even if they were unsure of the precise nature and size of the environmental gain, placing a price tag on it seemed to facilitate the evaluation of the trade-off and the eventual reaching of a decision.

The decision support framework used under the LHWP is shown in Table 3.

To indicate the magnitude of the problem under LHWP, each EF scenario was rated as no, low, moderate, severe or critically severe impact on each of six environmental variables for each of the four river reaches – twenty-four pieces of information, which increased to fifty-four when pluses and minuses were introduced for two categories. An attempt was made to simplify the data by introducing weights ranging from 9 for critically severe to 1 for no impact. This allowed each reach to have a single indicator for each scenario, as presented in Table 3. No attempt was made to weight the environmental variables. It is evident that decision-makers are not likely to be able to understand the import of a single numerical indicator for environment. A way has to be found to present the data more effectively. Nonetheless, the simplified decision framework did focus the minds of the decision-makers.

Although the characterization is crude, it served to focus the minds of the decision-makers on the trade-offs before them. They
Cate Brown and Peter Watson

Table 3 The LHWP Decision Framework.

<table>
<thead>
<tr>
<th></th>
<th>Treaty</th>
<th>Fourth</th>
<th>Design limitation</th>
<th>Minimum degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Economic Value of Losses</td>
<td>8.0</td>
<td>6.4</td>
<td>5.7</td>
<td>2.9</td>
</tr>
<tr>
<td>(Maloti million; 1 US$ = Maloti 6.46)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lost Variable Royalty</td>
<td>0</td>
<td>41</td>
<td>218</td>
<td>463</td>
</tr>
<tr>
<td>(Maloti million)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of Total Royalties</td>
<td>0</td>
<td>1.5</td>
<td>8.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Rate of Return</td>
<td>7.6%</td>
<td>7.4%</td>
<td>7.3%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Reach 2 Environmental Indicators</td>
<td>58</td>
<td>40</td>
<td>35</td>
<td>17</td>
</tr>
<tr>
<td>Reach 3 Environmental Indicators</td>
<td>52</td>
<td>35</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>“Reasonableness” Flag</td>
<td>–</td>
<td>MEAN</td>
<td>REASONABLE</td>
<td>GENEROUS</td>
</tr>
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</table>

The facilitator added the row called “Reasonableness Flag” to inspire a spirit of compromise, noting that, while no-one expected the Lesotho Government to give up 17% of royalties, it seemed miserly to refuse to give up 1.5%. This characterization prompted the decision-makers to explore how they each interpreted “reasonable”. The facilitator also encouraged the decision-makers not to become fixated on the four scenarios that had been studied. Instead, he invited them to consider intermediate points, such as one halfway between the Fourth and the Design Limitation scenarios.

The result of the meeting was that the decision-makers agreed that it would be reasonable to increase releases somewhat in excess of the Treaty Minimum, although it took more discussion to reach a resolution on the precise number.

The important lesson is that, once the decision-makers were presented with all the data within a decision framework, they were better able to see the trade-offs, to test them against their value systems and to contemplate compromise solutions. It also allowed them to explore options in a “safe” environment without compromising their decision-making prerogatives.

This indicates that it is desirable to provide regular feedback to decision-makers as the EF process evolves. This would help to educate decision-makers about the building blocks, demystify the final analytical results and facilitate the final decision step.

Establishing a decision framework that allows decision-makers to explore trade-offs in a non-threatening environment at an early stage in the decision process is the fifth building block of an effective EF decision support system.

11 Institutional context

The likelihood of establishing an effective decision support system and reaching sound decisions on environmental flows can be greatly influenced by the existence or absence of institutions, formal and informal, with mandates to ensure that environmental flow work is carried out in a satisfactory manner. Ortolano et al. (1987) used, in an article written nearly two decades ago, the concept of “control” from organization theory to explain differences in the effectiveness of EIA work. Although their focus is on EIA, their findings apply equally to EF policies. The institutional influences that they posit are shown in Table 4.

With all of these “controls” in place, there is a high probability that EF work will be carried out to a high standard. Ortolano et al. (1987) argue that a combination of “controls” is required for effective oversight. In the case of the LHWP, only Instrumental Control from a development partner and limited Outside Agency Control from NGOs were in place, resulting in substantial difficulties in assuring effective EF work.

Assessing the institutional context and the presence of effective “control” agents could well be considered as a sixth building block to determining whether or not EF work is likely to be effective. In cases where “controls” are absent, it would be worthwhile to create them before embarking upon EF work.

12 Implementation

It is tempting to believe that all problems are solved once an EF Policy has been approved. This would be a mistake. Just as many problems can emerge in the implementation phase as in the design phase.

Left to their own devices, dam operating agencies may not pay adequate attention to implementing EF Procedures. This is borne out by experience under the LHWP as the dam operators initially
overreacted to unexpected rainfall patterns by being too eager to reduce EFs. From this, it may be concluded that it is desirable for EF Procedures to err on the prescriptive side during the early stages of their implementation until the operating agency has developed experience in applying them. The LHWP EF policy states “LHDA shall implement an adaptive management system for EF management and related matters…” However, ‘Adaptive Management’ was not defined. This left LHDA to grapple with the issue of how to respond to changes in rainfall patterns. It was successful because all parties believed that it provided an appropriate balance between prescriptiveness and flexibility. This principle is being applied to other aspects of EF implementation in an effort to build more flexibility into the procedures – albeit in an explicitly controlled manner.

The creation of a decision support system for implementation and operation is the final building block of a comprehensive and effective EF decision support system.

13 Conclusions

The key theme is the need for adaptive water resource management in the face of uncertainty.

This is particularly important since downstream ecosystems and communities are voiceless constituencies that are typically marginalized in decision-making. It is necessary to ensure that their voice is heard. Thus, it is important to consider not only the biophysical impacts downstream of dams, but also the socioeconomic impacts so that both can be included in any tradeoffs that are made. This means that EF analysis must provide adequate detail on the range and combinations of expected environmental impacts and social resource losses. It must also be able to describe how these outcomes relate to the values of the stakeholders concerned. Environmental and social impacts have traditionally been treated separately. Recent experience in Lesotho demonstrates that they are best dealt with as an interrelated system.

Successful implementation of EFs requires commitment, foresight, planning, management and, above all, communication. A key ingredient is achieving a genuine commitment to EFs by all stakeholders and providing a legal policy framework to support sustainable and equitable allocation of water resources.

Scientific and management confidence in EF determinations, and in subsequent planning, is enhanced by the availability of comprehensive bio-physical baseline data, much of which can be collected at a very early stage and independently of any planned water-resource developments. At the stage of determining EFs, the provision of options (scenarios) linking EFs with future downstream benefits and losses within an agreed decision framework is essential. This permits a process, which consults rather than simply informs, which facilitates an objective and transparent assessment of the tradeoffs between off-stream and on-stream uses of water and which provides an understanding of and agreement on a compensation package for downstream riparians.

Early consideration of operating procedures, plus training and culture change for operators, will facilitate implementation of EF releases. In this context, it is also important to ensure that dam outlet works are designed to provide adequate flexibility to meet the range of flow releases that might be required by an EF policy.

Procedures should include adaptive management which can respond to unavoidable uncertainty in a way that balances prescriptiveness and flexibility and which is supported by clear monitoring protocols and communication feedback loops between everyone involved in water-resource management.

All of these can, and should, be built into a decision support system that all stakeholders can have faith in. It is no exaggeration to say that this should be one of the very first EF tasks to be undertaken.

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References


