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Benefit Sharing in International Rivers:
Findings from the Senegal River Basin, the Columbia River Basin, and the Lesotho Highlands Water Project

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Acronyms

af	Acre-feet
AOP	Assured operating plan
ASCRB	Adjusted separable cost remaining benefit
BC	British Columbia
BC Hydro	British Columbia Hydro and Power Authority
BCM	Billion cubic meters
BOAD	Banque Ouest Africaine de Développement
BPA	Bonneville Power Authority
cfs	Cubic feet per second
CBT	Columbia Basin Trust
CIDA	Canadian International Development Agency
CRB	Columbia River Basin
CRT	Columbia River Treaty
DOP	Detailed operating plan
DWAF	Department of Water Affairs and Forestry of South Africa
EIB	European Investment Bank
FCFA	Franc Communauté Financière Africaine (also XOF)
GDP	Gross domestic product
GNP	Gross national product
GWh	Gigawatt hour
ha	Hectare
ICREB	International Columbia River Engineering Board
IJC	International Joint Commission
IDB	Inter-American Development Bank
kg	Kilogram
kWh	Kilowatt hour
LFCD	Lesotho Fund for Community Development
LHDA	Lesotho Highlands Development Authority
LHRF	Lesotho Highlands Revenue Fund
LHWP	Lesotho Highlands Water Project
m^3	square meters
MCM	million cubic meters
mm	millimeter
NGO	non-government organization
O&M	Operations and maintenance
OERS	Organisation des Etats Riverains du Sénégal

OMVS	Organisation pour la Mise en Valeur du fleuve Sénégal
PASIE	Environment Impact Mitigation and Monitoring Program
PEB	Permanent Engineering Board of the Columbia River Treaty
RHDP	Regional Hydropower Development Project
RSA	Republic of South Africa
SACU	Southern African Customs Union
SAM	Social Accounting Matrix
SAR	Staff Appraisal Report
SRB	Senegal River Basin
t/ha	tons per hectare
TCTA	Trans Caledon Tunnel Authority
USACE	US Army Corps of Engineers
USAID	US Agency for International Development
XOF	Franc CFA

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Executive Summary

This paper explores two propositions regarding international river basins: 1) cooperative development of international rivers offers unique economic advantages over unilateral development and 2) benefit sharing is a necessary condition for facilitating this cooperation. Despite the intuitive appeal of benefit sharing, clear benchmarks and good practices in structuring agreeable benefit sharing arrangements are lacking. Lessons from past experience are critical for guiding emerging regional institutions and potential water-related investments in several international river basins in Africa. By examining three parallel case studies – the Senegal River Basin, the Columbia River Basin, and the Lesotho Highlands Water Project – this paper explores how the riparian countries quantified the benefits and costs of cooperative development and reached an acceptable formula for sharing these mutual gains. This paper also explores the institutional and policy arrangements needed to implement these benefit sharing schemes and common challenges to realizing growth and poverty alleviation objectives.

It is clear from these three international experiences that cooperation between riparian countries offered distinct additional economic possibilities for mutual gain that otherwise would not have been achievable through domestic means. In all cases, by focusing on the division of benefits and not on the physical allocation of water, mutual gains could be identified that were both substantive and transformative in nature. However, the process to reach a cooperative agreement can take decades, in large part because of the technical complexity of regional projects, the difficulty in establishing benefits and costs and reaching an equitable division of gains, differing policy and political environments, and unclear roles and responsibilities among project, national, and regional institutions.

Different approaches can be taken to divide mutual gains among riparians. Achieving perceived equity is critical to concluding an agreement, although it is not necessarily congruent with the ideas of economic efficiency. That is, in all three cases non-economic criteria and some degree of subjectivity played an important role in the final negotiated outcomes. What matters most, though, is that an agreed framework (or principles) for quantifying benefits be put in place to give the riparian countries both sufficient guidance and latitude in reaching a mutual agreement. The process is far more important than the actual benefits.

The success of cooperative development depends on the strength of the regional institution and degree of harmonization with national levels of government. Institutions and project agreements need to be flexible in nature, building in provisions for periodic review and assessment, to more adequately address emerging and unanticipated concerns and evolving economic and system conditions. In all cases, one key challenge is how cooperative benefits (largely national in nature) are shared with project affected and basin populations. A variety of mechanisms is possible and stakeholder involvement and consultation are critical to planning and achieving poverty reduction outcomes.

I. Introduction

Benefit sharing in international water resources is a topic of increasing attention and importance.[1] The concept that the benefits generated from transboundary cooperation in water management be shared instead of the water per se is intuitively appealing and offers a point of departure for regional dialogue. This is especially relevant in Africa, which has over 80 international river and lake basins (Figure 1). These are among the largest basins in the world and include the Congo, the Nile, the Zambezi, the Senegal, the Niger, the Volta, the Gambia, Lake Victoria, and Lake Chad. Seventeen river basins have catchment areas greater than 100,000 km^2 and 160 freshwater lakes have catchment areas greater than 25 km^2. Some of these major river and lake basins are shared by as many as ten or more countries. Eleven countries share the Congo and Niger, ten share the Nile, and eight share the Zambezi and Lake Chad. The political boundaries of 14 countries almost entirely fall within the catchment areas of one or more transboundary river systems.

Win-win opportunities in the form of generated shared benefits are essential to the effective sustainable development and management of these transboundary water resources. This is critical to providing food, energy, reliable services, and protection against water-related risks (e.g., floods and droughts) to the population, industry, and the environment. Inadequate attention, in contrast, can exacerbate livelihoods on the margin, underpin many resource-based conflicts, and undermine growth in Africa. Future climate variability and change may introduce additional pressures on already scarce and variable water resources. The management of transboundary water resources is a critical development issue for Africa now and into the future.

In the discourse on benefit sharing, two different but related threads are common. First, for large infrastructure water projects, significant economic rents and public benefits can be generated; justified on ethical and development grounds, these rents should be shared with the populations affected by the project. This is a classic resource revenue management problem and is typified by the extensive literature on how rents from natural and mineral resources (e.g., gold, oil, other extractive industries) can be shared to catalyze more inclusive growth (e.g., Fischer, 2005). Moreover, for water-related investments (primarily large multi-purpose reservoir projects), previous work has examined both policy and institutional mechanisms to ensure the direct monetary redistribution of project-related revenues or profits to project-affected populations (e.g., Egre et al., 2002). These primarily consist of arrangements on revenue sharing, development funds, equity sharing, property taxes, and preferential electricity rates.

[1] The concept has been widely discussed at several international conferences including the International Conference on Freshwater in Bonn in 2001, the Third World Water Forum in 2003, and the Stockholm Water Week in 2006.

Figure 1: International river basins in Africa (Source: Turton et al., 2006)

The second, which is the focus of this paper, is that sharing the benefits derived from the multiple uses of water rather than physical water allocation yields far greater scope for identifying mutually beneficial and sustainable arrangements among different stakeholders (e.g., nation, state, municipal, industrial, agriculture). Wolf and Hamner (2000) demonstrate that for nation-nation negotiations, out of 145 international water agreements, only 37% deal with volumetric allocations. That is, many water agreements today already address at some level economic benefits rather than water allocations. This is not surprising, as the benefits to share may include hydropower, flood regulation, irrigated agriculture, improved environmental stewardship, navigation, regional integration and increased trade – all important determinants of growth and poverty alleviation. In some cases, non-monetary benefits (e.g., political gains) may be as valuable as monetary benefits.

Moreover, such a focus can be used to promote cooperation which offers economic advantages over unilateral development and may even be a catalyst for increased security, regional stability, and peace. Sadoff and Grey (2002) provide a useful construct to categorize these possible cooperative benefits and argue that benefit sharing is a necessary condition for achieving cooperation among riparians. Specifically, the

cooperative utilization of shared waters requires a distribution of mutual benefits that is agreeable to all parties such that each is left in a superior position (in economic, social, political, and/or environmental terms) to that which could be achieved through unilateral means. The challenge, however, for reaching a distribution of mutual benefits that is agreeable to all parties (whether local, national, or regional) is in the actual implementation of such an approach. This process is never expeditious given the intricate economic nature of water, the complexity of the hydrologic system, and often difficult socio-political environments. Several challenges remain before such a concept can be useful in practice.

LITERATURE REVIEW

The literature on cooperation and conflict in international rivers is rich and covers river basins in Africa (e.g., Klaphake and Scheumann, 2006, Lindemann, 2005, derZaag and Vaz, 2003, Juizo et al., 2006), the Middle East (e.g., Scheumann and Schiffler, 1998, El-Fadel and El-Fadl, 2005), Latin America (e.g., Lee, 1995), Asia (e.g., Feng and He, 2006, Crow and Singh, 2000, Kirmani and LeMoigne, 1997), and North America (e.g., Bernal and Solis, 2000, LeMarquand, 1977). Wolf (1998) investigates the reality of historic water conflict and argues that dialogue on international water resources lends itself to cooperation and only in rare occasions actually incites violence. Phillips et al. (2006) demonstrate that transboundary cooperation is an effective tool for conflict prevention. While many agree with these ideas and the benefits to cooperation, the specific conditions (whether it be economic, political, social) required to foster cooperation and avoid conflict have been the subject of analysis by many researchers (e.g., Mostert, 2003, Crow and Singh, 2000, Lindemann, 2005, Dinar et al., 2007, Dinar, 2004, Lee, 1995, Zeitoun and Warner, 2006). Recent work examines the nature of treaties and suggests tools for resolving conflict, particularly side-payment and cost-sharing arrangements (Dinar, 2004, 2006). Game theoretic approaches have also been used as a framework for analysis (e.g., Dinar et al, 2007, Frisvold, 2006, Munro, 1979, Dombrowsky, 2007, Barrett, 1994, Carraro et al., 2005). Although this research is extensive, useful good practices are needed if benefit sharing is to be a successful component of future international agreements.

The two key challenges to benefit sharing are quantifying the cooperative benefits and determining the necessary conditions (e.g., institutional, policy) needed to manage these benefits between multiple stakeholders. As is typical of national development projects, the estimation of economic benefits often involves a series of assumptions, ranging from future demands to future prices. Uncertainty about any number of parameters can be quite large and multiplies when more riparians are involved and technical complexity added. However, these estimates must serve as the basis for discussion and negotiations among the parties. Precise quantification of benefits is highly important and riparians are unlikely to accept international agreements unless this process is transparent, coherent, and equitable. In addition, perceptions of benefits may change over time and therefore establishing flexible institutions and policies to manage the sharing of benefits is needed. Here, the experiences of others can provide some practical guidance.

METHODOLOGY AND OBJECTIVE

The objective of this paper is to investigate in detail, through three parallel case studies (the Senegal River Basin, the Columbia River Basin, and the Lesotho Highlands Water Project[2]), how the riparians in these river basins reached an agreement on a suitable methodology to quantify and share benefits and the arrangements for implementation. The scope of this analysis will be confined primarily to benefit-sharing in the context of international river basins and the sharing of benefits between nations. Benefit sharing arrangements between nations and local communities, though discussed, will not be discussed in detail. The approach taken in this paper is to present case studies to highlight in parallel the motivations, experiences, and outcomes of these benefit sharing agreements, explicitly looking at the political economy and development context, the gains to cooperation and how these were quantified, and the evolving dynamics in the basin. In many respects, the precise benefits quantified are of less importance than the process (both political and economic) that the countries adopted to reach an agreement. It is for this reason, that the variables and approach selected for analysis are largely qualitative in nature.

These case studies were selected to provide a range and complexity of issues that would be most relevant to international river basins in Africa. In all three examples, large civil works were involved necessitating cooperation to some degree. The World Bank was involved in the financing of activities in the Senegal River Basin and the Lesotho Highlands Water Project. To help the reader compare across these international experiences, the following sections are presented in each case study: 1) background and historical socio-economic development situation to describe the context for cooperation, 2) the identified project objectives and description (including legal agreements and institutional arrangements), 3) the approach taken to quantify economic benefits and costs, 4) the actual post-project observed benefits and costs, and 5) conclusions. Summary findings and future issues are presented at the end.

[2] The Lesotho Highlands Water Project does not precisely involve the development of an international river basin, but is included here given the similarity of its issues to the other two case studies presented.

II. Senegal River Basin

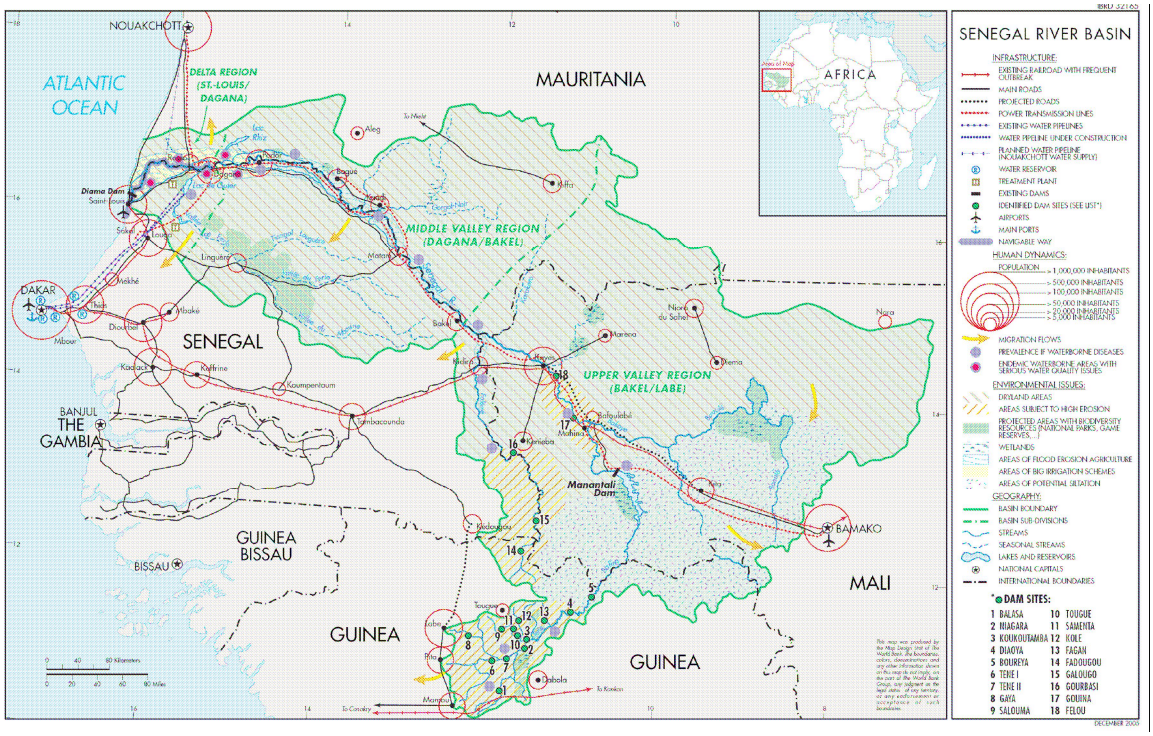

Figure 2: Senegal River Basin (Source: World Bank, 2006)

A. INTRODUCTION

With a population of approximately 12 million, the Senegal River Basin covers a total area of approximately 300,000 km^2 with 11% of the area in Guinea, 53% in Mali, 26% in Mauritania, and 10% in Senegal. The basin has three distinct geographic areas: the upper valley region (Bakel/Labe), the middle valley (Dagana/Bakel), and the delta (St. Louis/Dagana). The upper valley receives 700 – 2,000 mm of rainfall annually and provides most of the flow in the river. The middle valley and delta only receive 150 – 300 mm of rainfall annually. The Senegal River, which originates from the Bafing and Bakoye Rivers in Guinea, travels 1,800 km to the delta with a total annual discharge estimated at around 24 BCM per year (mostly between July and October).

Development context[3]

By 1972, it was clear at a national level that much could be achieved by developing the Senegal River Basin. GDP per capita[4] in 1972 was low: $197 in Mali, $377 in Mauritania, and $448 in Senegal. Senegal appeared more developed than most of Africa, with 25% of its GDP generated from the agriculture sector, 56% from the services sector, and 18%

[3] Much of this background information comes from USAID (1975).

[4] In constant 2000 US$.

from the industrial sector. Despite this, however, Senegal was faced with 90% illiteracy; low and stagnating agricultural productivity; low levels of social services, health and nutrition; and a growing rural poor. Primary crops included rice, cotton, vegetables, fruit, and cattle; production levels remained inadequate.[5] Senegal was spending 20% of its scarce foreign exchange earnings just to supply rice and bread wheat to feed its cities. Electricity consumption was only 70 kWh per capita. Mali was vulnerable to drought as agriculture accounted for 43% of its GDP. This sector provided livelihoods for 91% of the population and 76% of exports. About 90% of the cultivated land was devoted to subsistence food crops (e.g., millet, sorghum). Other crops included rice, corn, sugarcane, tobacco, tea, vegetables, fruits, and root crops. Industrialization in an area far from the coast and without access to foreign markets seemed unpromising. Mauritania was observing rapidly rising per capita incomes in part because of substantial revenues from the opening of rich iron ore deposits in the northern part of the country. Despite this, 90% of the population, of which 70% was at least partially nomadic, lived and worked in traditional sectors such as livestock, subsistence agricultural (e.g., cereals, vegetables), and fishing. Its economic development was also very much affected by drought. These traditional activities functioned as a closed economic system relying on the exchange of livestock for cereal and textiles from Mali and Senegal.

Inter-annual variability in the Senegal River hampered opportunities to fully develop guaranteed agricultural production. Prior to the construction of the two major reservoirs (Manantali and Diama), the flow in the Senegal River could vary six-fold between wet and dry years. In years of normal rainfall, the predominant local economic system consisted of as much as 400,000 hectares[6] of cultivated land along the flooded banks of the Senegal River. Local communities were primarily agro-pastoralists, relying on a combination of recessional agriculture, small animal husbandry, and fishing to support their livelihoods. At the end of the wet season (September), receding flood waters recharged groundwater and lands were enriched with nutrient-rich silt. The residual soil moisture allowed farmers to grow cereal grains with local irrigation possible from a shallow water table. Yields were reported to be modest and demands on labor and capital were low. Moreover, a production balance existed between herders and farmers, as herders moved livestock away from the river during the rainy season and then returned to the grain fields after harvest. The flood plain also provided opportunities for fisheries production, with as many as 10,000 fishers catching 30,000 metric tons annually (at about 70 kg per flooded ha).

Frequent occurrences of large floods and droughts hampered efforts to fully develop reliable agriculture production in the valley. The arable land that could be effectively farmed after the flood could range from 15,000 to 300,000 ha depending on the size and timing of the flood. Exceptionally high levels of floods in 1890, 1906, and 1950 resulted in widespread economic losses. Conversely, years of drought impacted livelihoods as agricultural yields were typically not sufficient. Furthermore, during low discharge periods, increased salt water intrusion into coastal areas was common. In fact, during

[5] Per capita food production was declining as the population was increasing by 2.2%.

[6] USAID (2003).

the severe droughts of 1972 – 1973, a saltwater wedge moved more than 200 km upstream of Saint-Louis. The continuous decline of rainfall during this period led to famine and severe degradation of the natural resource base (e.g., soil erosion, disappearance of vegetation, drying up of surface water, increasing salinity, falling groundwater levels, degradation and disappearance of pasture lands). Under these conditions, many in the basin emigrated to nearby capital cities (e.g., Abidjan, Bamako, Dakar, Libreville) seeking employment.

It was in this context that in 1972 that the Organisation pour la Mise en Valeur du fleuve Senegal (OMVS),[7] essentially a Senegal River Basin organization, was established comprising Mali, Mauritania, and Senegal. By partially or totally controlling the flows along the river by building two large reservoirs (discussed below), the three riparian countries aimed to develop large areas of land for agriculture and generate hydroelectricity to solve the problem of the low supply and high cost of electricity in the region. Moreover, these structures would maintain a sufficient flow depth in the rivers to make navigation to the Atlantic Ocean possible, opening opportunities to exploit the mineral resources in the basin. In summary, the OMVS hoped to achieve the following through cooperation:

- Promote food self-sufficiency in the basin
- Reduce economic vulnerability to climatic fluctuations and external factors
- Accelerate economic development
- Secure and improve the incomes of basin populations.

[7] In 1968, the Organisation des Etats Riverains du Senegal (OERS) comprised all four countries. In 1971, Guinea withdrew from the OERS, which was then dissolved and replaced with the OMVS. In 1972, the convention that formally established the OMVS was signed. A second convention was also signed; it established the international status of the river and its tributaries (which required notification to member states of all projects likely to modify the characteristics of the river), the principle of freedom of navigation on the river, and equal treatment for the member states.

B. PROJECT OBJECTIVES AND DESCRIPTION

In 1981, with US $620 million in financing from 12 donors,[8] construction began on two multi-purpose reservoirs. A reservoir at Diama on the river delta was completed in 1986 to prevent the intrusion of salt water into the lower valley and raise river levels to reduce the cost of pumping. A second reservoir at Manantali (11 BCM and 200 MW of installed capacity) in western Mali was built and completed in 1987 for storage, river flow regulation, and power generation. The development of power generation facilities was undertaken in a separate US $445 million investment and completed in 2002.

Figure 2: Manantali Reservoir

Figure 3: Diama Reservoir

Established agreements

To move forward on the construction of Manantali and Diama, several details needed to be resolved. In particular, these included the issues of the ownership of the regional infrastructure, allocation of the costs of these civil works, financing of the construction, and the management and rules governing the utilization of the river waters. It was also clear that solutions could not be found without strong cooperation among the member states. This resulted in the signing of two conventions: the Convention Concerning the Legal Status of Jointly-Owned Structures (December 1978), supplemented by the Convention Concerning the Financing of Jointly-Owned Structures (March 1982). Between them they declared that:

- All structures are the joint, indivisible property of the member states throughout their life
- Each co-owner state has an individual right to an indivisible share and a collective right to the use and administration of the joint property
- The investment costs and operating expenses are distributed between the co-owner states on the basis of benefits each co-owner draws from exploitation of the structures
- Each co-owner state guarantees the repayment of loans extended to the OMVS for the construction of the structures

[8] The donors included the governments of Saudi Arabia, Kuwait, Abu Dhabi, Germany, France, Iran, and the African Development Bank. USAID and the World Bank declined to provide capital funds, but supported environmental assessments and other research related to the projects; they also provided financial and technical assistance for the resettlement of people displaced by Manantali Dam.

③ Two entities are established to manage the jointly-owned structures for the OMVS.[9]

In particular, the adoption of the principles of equality and equity is set in the 1978 Convention. Here *equality* is to mean that each member state has legal equality to rights under the Convention and of participation in the process of arriving at decisions under the Convention. Second, and perhaps more important, in the context of benefit sharing, *equity* refers to the allocation of benefits and costs, not on the basis of a simple division into three equal parts, but on the basis of the needs of the member states of the OMVS, their capacity to put to use the benefits provided by the river, and the actual uses derived from the river (Nguyen, 1982). This was of paramount importance as it framed subsequent political discussions. ***By signing this Convention, the member states implicitly acknowledged that specific uses of the river derived economic value. And it was from this basis that benefits could be shared.*** This was unique and innovative in comparison to other contemporary river basin projects at the time.

Institutional arrangements

To manage this process and the implementation of these activities, the OMVS established four permanent institutions:

1. Conference of Heads of State and Government. This represents the apex body of OMVS, with one member from each of the three member states. The Conference sets the broad policies, with all decisions unanimous and binding on all members.

2. Council of Ministers. This group is presided over in succession by each of the member states and elaborates general policy for the development of the Senegal River and cooperation among states. Ministers typically come from relevant water-related line ministries, but others may join as needed. The Council sets the budget, defines and prioritizes projects to be undertaken, and determines the contribution of each member state for financing operations, research, and administration. The Council has the authority to obtain financing for projects.

3. The High Commission. This is the executive branch of the OMVS and is entrusted with the implementation of Council decisions. The Commission regulates and monitors water-related development in the basin on behalf of one or more riparian states. The Commission receives proposals for projects and water uses which are sent to the Permanent Water Commission for evaluation and recommendation.

4. The Permanent Water Commission. This group consists of representatives from the water-using sectors across the basin. The Water Charter principles of May 2002 (to be discussed in greater detail in Section E) extended the membership from only government agencies to include other stakeholders in the basin (e.g., farmers, fisherman associations, NGOs) and the OMVS national coordinators. Their task is to determine the

[9] The Manantali Energy Management Agency (SOGEM) and Diama Dam Management and Operation Agency (SOGED).

basis and means for water allocation among sectors. This group meets three times a year and advises and reports directly to the Council.

C. QUANTIFYING ECONOMIC BENEFITS AND COSTS

For the development of the Senegal River to proceed, a framework was needed to allocate benefits and costs that would be satisfactory to all member states. In particular, a methodology was needed to allocate the joint costs across services (hydropower, navigation, and irrigation) and member states. *Joint costs* are defined as those costs that cannot be entirely assigned to one service (e.g., cost of construction of a multi-purpose reservoir). This is in contrast to *specific costs,* which can be assigned to one service (e.g., power generation facilities). In a traditional single-country multi-purpose investment, cost allocation is typically accomplished by comparing the benefits to the costs of the various project services. Multi-country approaches are complicated because the benefits each country realizes vary. For Mali, gaining navigable access to the Atlantic Ocean and power production were of primary interest. For Mauritania and Senegal, developing irrigation and to a lesser degree power production (except for the cities) was of primary interest.

In 1977, the Council of Ministers asked that Utah State University to develop a methodology to allocate the costs and benefits of the Manantali and Diama reservoirs. Due to a lack of reliable data and the large number of assumptions needed (e.g., cost of future energy, discount rate), these studies took several years. Eventually, the Council adopted the adjusted separable cost remaining benefit (ASCRB)[10] method. The Council considered this method for allocating joint costs, described in Laughlin (1977) and Gittinger (1982), to be more equitable than the alternatives (e.g., equal division, use of facilities method). Implicit in this methodology is the estimation of benefits derived from joint operation of the two multi-purpose reservoirs. Moreover, the Council limited the analysis to three benefits only (hydropower, irrigation, and navigation) despite knowing that the project could produce a wider range of benefits and costs beyond the direct investment costs

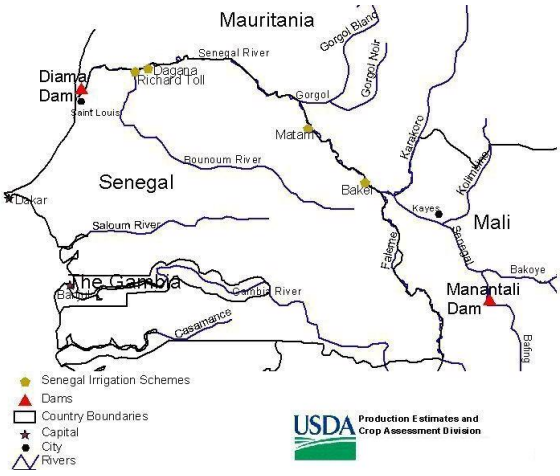

Figure 4: Major Irrigation Schemes along the Senegal River (Source: USDA, 2001)

Estimating project benefits[11]

Irrigation. To calculate irrigation benefits, data on prices, costs, and crop productivity were needed. Primary crops considered included rice, tomato, wheat, sugarcane, sorghum, maize, and cotton. Since it was

[10] See Appendix 1 for a detailed description of the ASCRB method.

[11] For greater detail on the calculations summarized here, please refer to Keith et al. (1990).

assumed that soils and climate are relatively homogenous throughout the Senegal River Basin, profitability was assumed to be similar for all member states. Two types of irrigated farms were envisioned in the basin: 30% small (1 – 2.5 ha) and 70% large (50 – 1,000 ha). The total benefit to the irrigation sector is dependent on the profitability per hectare and the assumed rate of development of irrigation. A variety of scenarios using different assumptions were tested. Discussions among the member states identified a total maximum potential of 375,000 ha of agricultural area with two crops a year (mostly rice) that could be developed with river regulation. These were divided across member states as follows: 9,000 ha in Mali, 126,000 ha in Mauritania and 240,000 ha in Senegal. Each member state retained the final responsibility for fully developing these irrigated areas. Provisions were made to account for the displacement of flood recession farming, requiring a regulated river discharge at a rate of 2,500 m^3/s during the rainy season. Total irrigation service benefits were estimated at 111 billion FCFA.[12]

Energy. The calculation of the energy benefits was based on the comparative cost of thermal power, estimated at the time to be 31.28 FCFA per kWh, and potential releases from the reservoir. The generators at Manantali (200 MW of installed capacity) could theoretically produce 1750 GWh per year. However, the actual annual energy generation would depend on the availability of water – a function of the natural rainfall availability, the minimum base flow released for navigation purposes (i.e., 200 m^3/sec), and releases for artificial floods for recessional agriculture. Using the historical average flows, it was estimated that 800 GWh per year could be generated in 9 out of 10 years while still allowing for an artificial flood of 50,000 ha. The final project energy benefits were estimated at 261 billion FCFA. For the energy benefits, it was determined *a priori* from the 1985 Council of Ministers Resolution that Mali would receive 52%, Mauritania 15%, and Senegal 33% of the energy benefits.

Navigation. The calculation of the navigation benefits was based on the comparative costs for rail and road transport. The volume of goods transported by the navigation system was based on future traffic forecasts. Estimated navigation traffic was divided among the member states by assuming that goods unloaded at a specific port would go to the state in which the port was located. Total traffic volume was estimated to increase from 40 million ton-kilometers in 1990 to about 7 billion ton-kilometers by 2030. Benefits were calculated as the cost of transporting these navigation volumes by equivalent road or rail networks. The final project navigation benefits were estimated at 530 billion FCFA.

Adoption of the *key*

Based on these estimated calculated benefits, joint costs associated with the multi-purpose reservoirs could be allocated across the services (irrigation, energy, and navigation). The final results (including the negotiated allocation across member states) became known as the *key* and are shown in Tables 1 and 2 (details are provided in Appendix 1). Of the total costs, 22.37% is allocated to the irrigation service, 30.78% to the

[12] FCFA 1000 = US $1.85.

energy service, and 46.85% to the navigation service. The final allocation of costs across the member states was based on the estimated proportions of the project services used by each state. Early on, member states informally agreed on an allocation based on the potential use by each member state of the three identified services; this included the area of land that could be developed for irrigation in each nation, the projected river transport use in terms of volume and distance, and the quantity of power consumed by potential consumers in each nation. These informal discussions became official in 1981 when the Council of Ministers approved the provisional cost allocation methodology. It is important to realize that the economic benefit of a unit of use (e.g., irrigated acres, GWh of energy, and ton-kilometers of shipping) for each member state was assumed to be the same for all three countries.[13] This *key* and was adopted by the Council of Ministers in 1985.

Table 1: Cost Allocation across Service Sectors (FCFA)

	Irrigation	**Energy**	**Navigation**	**Totals**
Project Benefits	110.90	261.24	530.08	902.22
Separable Costs	36.55	56.02	101.68	194.25
Joint Cost Proportion	37%	38%	25%	
Allocated Joint Costs	17.85	18.81	12.23	48.89
Total Sector Service Cost	54.40	74.83	113.91	243.14
Service %	**22.37%**	**30.78%**	**46.85%**	

Table 2: Cost Allocation of Reservoir across Service Sectors and Member States (FCFA)

	Irrigation		**Energy**		**Navigation**		**Totals**	
	Diama + Manantali	%	Manantali	%	Manantali	%	Total	%
Mali	6.04	***11***	18.59	***52***	12.66	***82***	37.29	***35.3***
Mauritania	16.7	***31***	5.36	***15***	1.81	***12***	23.87	***22.6***
Senegal	31.66	***58***	11.8	***33***	1.02	***6***	44.48	***42.1***
	54.40		35.75		15.49		105.64	

Final costs across countries are divided by 35.3% for Mali, 22.6% for Mauritania, and 42.1% for Senegal. In terms of benefits from these three sectors, Mauritania would receive 31% of the total irrigated potential, 15% of the energy generated, and 12% of the navigation. Mali would receive 52% of the energy generated and most of the navigation benefits. And finally, Senegal would receive about 58% of the irrigated land and 33% of the energy generated. At the time the *key* was calculated and adopted, several assumptions needed to be made. As more information became available (including potential environmental and social costs), these numbers were adjusted and re-calculated (USU, 1998) but never formally re-adopted by the Council. Differences

[13] For example, the economic benefit derived from consuming one GWh of energy is assumed to be the same in Senegal, Mali and Mauritania.

between the new and old keys were too large to be politically acceptable so in the end, no revisions were ever made.

The selection of a rigorous methodology and process by which the three riparian countries could allocate the costs and benefits of water development had important implications. First, it helped to define the financial terms and structure (e.g., debt service) of the project. Second, it cemented the view that regional cooperation was necessary to realize benefits for all riparians. This was, of course, only possible in the presence of a regional organization that was vested with the executive authority to make key decisions on behalf of its member states. Interestingly, the financial resources from the donors for the dams and other infrastructure were contingent on the adoption of the *key*.[14]

D. ACTUAL BENEFITS AND COSTS

Commonly cited positive impacts of Manantali and Diama include year-round availability of fresh water and road construction, which has increased accessibility to markets, access to healthcare for villages near the reservoirs, and rural electrification (ongoing). Indirect positive impacts have also been reported (e.g., increased cross-border trade, increased school attendance rates). However, in the context of the original *key*, the envisioned economic benefits have fallen short.

Irrigated agriculture has developed, but has been adopted at a slower pace than anticipated. Thus far, only about 130,000 ha (40,000 in Mauritania, 90,000 in Senegal, and about 100 ha in Mali) of the 375,000 ha potential has been developed. Some argue that the original 375,000 was overly optimistic to begin with. These new irrigated areas are primarily smallholder schemes of less than 100 ha, particularly in the floodplain areas with larger schemes concentrated in the delta. Actual investment costs to utilize the regularized river supply have ranged from US$ 1,500 – $6,500 per ha with rice being the main crop. A wider variety of crops is now grown in addition to rice (e.g., sugarcane, onions, tomatoes, potatoes). Average rice yields are fairly high (4-5 tons/ha), but vary among farmers (and are less than the originally anticipated 12 t/ha). For some areas cropping intensities remain low (less than 60%).

The national objective to shift farmers from low-input low-output and highly variable recessional agriculture towards market-oriented productive irrigated agriculture was indeed an important and ambitious objective. The reality, however, of undertaking this and its impacts on local stakeholders was quite different than expected. Although engaging in irrigated agriculture is more profitable on a per-hectare basis than recessional agriculture (yields of sorghum are typically low at 600 kg/ha), it is clear from several studies (e.g., Saarnak, 2003) that farmers in the region preferred recessional

[14] In the end many European governments (which had contributed about 40% of the total project costs) were forced to cancel their outstanding loans. O&M joint costs, however, remain substantial.

agriculture because it requires little labor and few inputs. It is also less risky, and the minimum output for household consumption was guaranteed. This is in contrast to high-production irrigation activities; despite their higher profitability, they have high organizational and transaction costs and marketing risks. Moreover, farmers were able to traditionally mitigate the risks of crop failure and food scarcity by pursuing a diverse portfolio of crops and domestic animals to smooth household consumption patterns. This outlook, combined with low capacity to adapt to these changes – a lift on agricultural subsidies, the shrinking of public extension services, difficulty in getting credit, easy imports of rice and the lack of a private sector – made it understandable that local farmers would not (and could not) convert so easily.[15] ***National development policies and practices were an important determinant for whether or not this transition to modern production systems would be successful or not.***

As these challenges became clearer, OMVS began to not only consider reservoir releases for irrigated agriculture but also flood releases for recessional agriculture and other uses to help preserve the ecological equilibrium in the valley. Some combination of traditional and modern agricultural methods became most amenable. Moreover, the OMVS undertook studies to determine the tradeoff between hydropower maximization and artificial floods for recessional agriculture. Model simulations showed that it would be possible to cultivate at least 45,000 ha of recessional area over a 30-year time period (52,500 ha on average) while still generating on average 96% of the hydropower target of 800 GWh per year. Releases for recessional agriculture would marginally reduce the profitability of hydropower.[16]

Thirty years after it was identified, navigation does not exist in the valley. The improvement of navigation facilities has not fully been implemented as donor agencies have so far been reluctant to provide financial resources. Interestingly, based on the *key*, more than half of the economic benefits from Manantali and Diama reservoirs were estimated to be from navigation.

With significant recent additional investments, energy production has begun to meet original expectations. Cost overruns, coupled with political and military tensions between Mauritania and Senegal, initially canceled the construction of the power

[15] Koenig and Diarra (1998) describe how villagers living near Manantali were resettled onto a smaller land base and converted to a more intensive system of cultivation that required the purchase of fertilizers. However, because of structural adjustment programs in Mali, existing agricultural extension services were stagnant and unable to provide (or subsidize) either credit or inputs.

[16] World Bank SAR for the RHDP states that the socioeconomic and environmental benefits of an artificial flood are sufficiently important to justify it, even if this reduces the energy output from Manantali. The average energy loss is valued at about US $14 million compared to recessional benefits of US $4.5 million. However, including the social and environmental benefits would swing the balance in favor of releases for the flood.

facilities. However, in 1997 a multi-donor[17] investment of US $445 million was launched, the Regional Hydropower Development Project (RHDP), to bring value to these past infrastructure investments and to mitigate problems that had emerged since the completion of the Diama and Manantali dams. The objectives of this energy project were to reduce the long-term cost of electricity supply to the three countries, contribute to meeting debt service associated with building Manantali, contribute to increasing the efficiency and reliability of power systems in the three countries, establish an effective organization to construct and operate the project facilities and to mitigate the project's environmental and health impacts, promote competitive private sector participation, and support the traditional agricultural sector downstream through the rational management of the reservoir.

In terms of energy, Mali, Mauritania, and Senegal all required reliable and low-cost power supplies to increase access to electricity for the populations in the Senegal River Basin (primarily for populations in the cities). For instance, it was anticipated that this project would represent about 50% of the total Mali power demand. Moreover, the project was expected to increase the supply of electricity to low-income rural communities and productive activities in the Senegal River Basin at a lower cost than current sources. Least-cost supplies were also expected for the three capital cities, which would benefit low-income households not currently connected. The Manantali generating facilities came on line in 2001, supplying power to the Mali grid. Senegal and Mauritania connected their power grids in 2002. Revenues from power generation will likely be used to service the debt on the loans borrowed for this construction.[18] Revenue sharing from power generation is based on the established *key* proportions (Mali 52%, Mauritania 15%, and Senegal 33%).

Unexpected environmental and social costs

The construction of Manantali and Diama has changed the river basin ecosystem, resulting in environmental and social challenges. Many of these were addressed during the RHDP project, well after the infrastructure was built. With the regularization of the Senegal River and impoundments behind Manantali and Diama, changes in the ecosystem were well documented (Brantly and Ramsey, 1999; Hamerlynck and Duvail, 2003). These include altered estuarine and freshwater system dynamics, the generation of invasive weeds and grasses, disappearance of wetland areas, degradation of fish populations,[19] reduced pasture lands, changes in forests downstream of Diama, river

[17] World Bank, African Development Bank, Caisse Francaise de developpement, Kredistanstadt fur Wiederbau, CIDA, EIB, IDB, and BOAD.

[18] According to the RHDP ICR all development objectives have been satisfactorily met. The average cost of supplies from Manantali for all three utilities in Mali, Mauritania, and Senegal is estimated at 32.05 XOF per KWh in 2030 compared to 30.9 XOF per KWh in 2003. An evaluation of the average cost of electricity in Senegal shows that the average cost of hydroelectricity is about 27 percent lower than that of thermal electricity.

[19] In a USAID-funded study, Gannett-Fleming (1979) identified and quantified some of the environmental and social impacts. For example, it was estimated that a reduction in fish

bank erosion in the upper valley, and increases in parasitic diseases in the Valley (e.g., schistosomiasis, malaria) affecting both human and livestock populations. Moreover, it is argued that this has led to social disruption and even conflict (Finger and Teodoru, 2003; Lahtela, 2003; Homer-Dixon 1998). Financed through the RHDP, in 1998 the OMVS established the Environment Impact Mitigation and Monitoring Program (PASIE) to address the adverse social, health, and environmental impacts of the Diama and Manantali dams. Moreover, as there was no assurance as to whether or not the three governments would continue to release flood waters for traditional recessional agriculture, a reservoir management plan was prepared. Other activities under this program included strengthened environmental monitoring, appropriation and right of way programs, environmental sanitation programs, a variety of studies, and the promotion of rural electrification.

Joint ownership of common infrastructure was not without its drawbacks in responding to these concerns. Joint ownership and operation made it difficult for the OMVS to quickly respond to unanticipated environmental and social problems. Member states had in some sense given up some authority to act independently and so could not quickly respond by altering flows in the system. Further complicating this was the fact that there was an inherent conflict between joint ownership and the fact that member states each assigned different levels of importance to each of the originally identified use benefits.

E. AN EVOLVING SENEGAL RIVER

In 2002, to address many of the challenges experienced over the last several decades, a new Water Charter was introduced to fully realize the potential to share the benefits of development with the broader population in the Senegal River Basin. Specifically, a new Water Charter was signed to establish the policy for water use and allocation in the Basin. The scope and purpose were broader than the previous Conventions and focused more on process than specific outcomes. The new objectives included:

- Establishing the principles and mechanisms of distributing the waters of the Senegal River between the different sectors (adding fishing, domestic use, health, and the environment as sectors)
- Defining the mechanisms for reviewing new projects affecting the river
- Determining the rules relating to the preservation and protection of the environment, particularly with regard to wildlife, flora, and ecosystems of the flooded plans and the wetlands
- Defining the methods for stakeholder participation.

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production in the lower parts of the river would result, offset partially by the increased fish production in the Manantali Reservoir and recharged depressions. This was valued at a net loss of about 15.32 billion FCFA. Early work by the Utah State team attempted to incorporate these impacts into the *key*. However, as was mentioned earlier, modifications to the agreed *key* were met with reluctance by the OMVS Council.

The new Charter introduced the concepts of sustainability and environmental protection, thus giving OMVS much more authority to respond quickly to these types of concerns. Environmental Action Plans were now required under the Charter, which mandated the monitoring and evaluation of water quality and quantity. Institutional changes were also made to make OMVS more responsive. For instance, the Charter now extended the membership of the Permanent Water Commission to include other stakeholders in the basin besides government agencies (e.g., farmers, fisherman associations, NGOs), allowing for stakeholder input and participation by the public. Last, whereas the earlier discussions were set around goals of GW produced, hectares produced, and miles navigated, the new principles were essentially based on the principles of equity and cooperation. Article 4 states:

> The guiding principles of any distribution of the River's water will guarantee to the populations of the riparian States, the full pleasure of the resource, with respect to the safety of the people and the works, as well as the basic human right to clean water, in the perspective of sustainable development.

Lessons learned

After almost 30 years of activities in the Senegal River Basin, whether these investments have achieved the goals of providing secure and improved livelihoods for the population, making the economies less vulnerable to climate variability, and accelerating economic development and integration depends in part on how success is defined and for whom. From a macroeconomic perspective, some level of success has been achieved (Figures 5 and 6).[20]

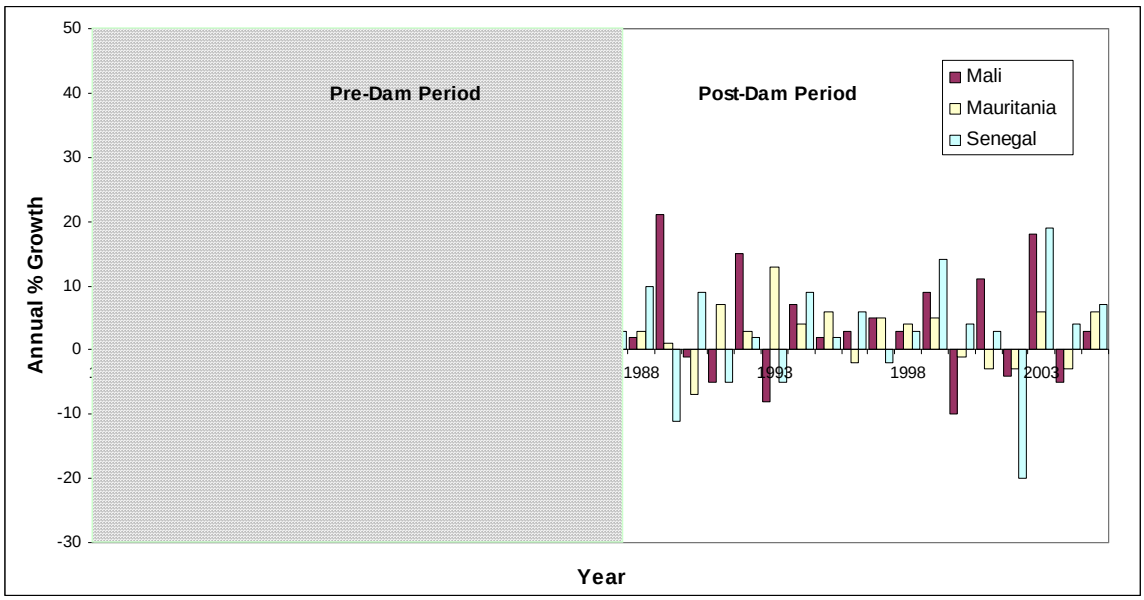


Figure 5: Agriculture, value added (annual % growth) 1968 - 2005

[20] Variability is statistically reduced in both GDP and agriculture (value added) annual growth after Manantali and Diama were completed.

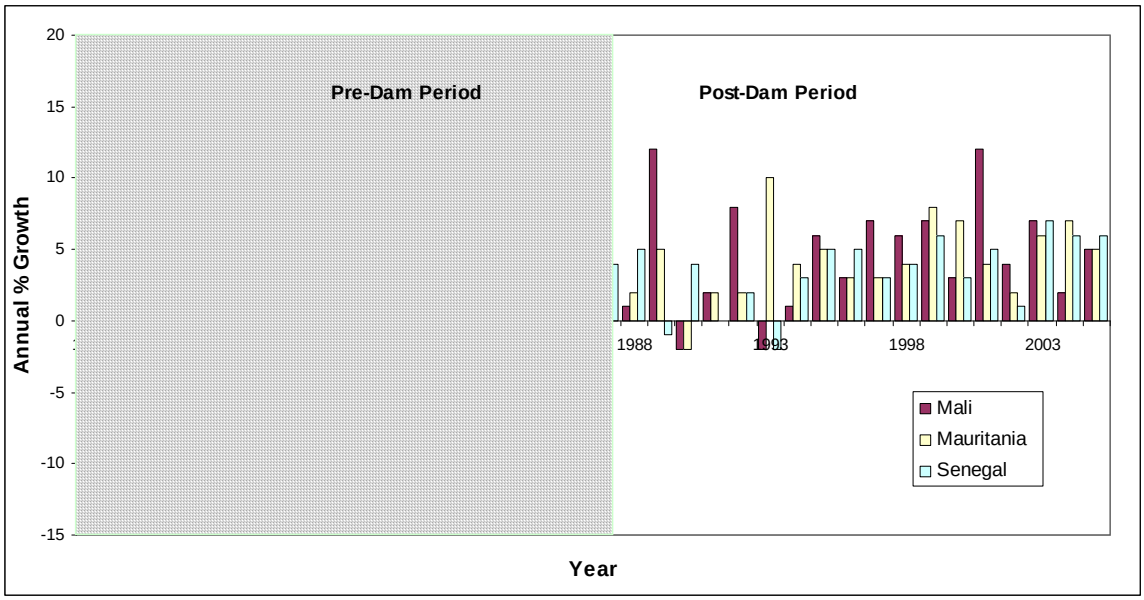


Figure 6: GDP growth (annual %) 1968 - 2005

What is promising and can serve as an example for other river basins is the clear early adoption of the principles and practice of benefit sharing. The experience here stands out compared to other river basins around the world where the international dialogue is often entrenched in discussions over water allocations, as opposed to the more productive dialogue over the benefits derived from use. This vision of benefit sharing was integral to the discussions among the nations of Mali, Mauritania, and Senegal, and helped to reaffirm that regional cooperation was an absolute necessity since all would benefit in ways that none could accomplish alone. The commitment to this principle was codified through the establishment of legal conventions and a remarkable degree of supra-national executive authority vested in the OMVS.[21] Moreover, the greatest demonstration of solidarity on benefit-sharing is espoused in the early OMVS goals themselves. That is, the benefits and aims for development would supersede political boundaries and be for all the people living in the Senegal River Basin.

If fault can be found it is this. ***Benefit sharing is not only about how nations share the benefits of a common resource, but also about how those benefits and costs of development are shared with the population at large.*** Whatever balance may eventually (or currently) be achieved between the economic benefits and the costs of development of the Senegal River Basin, it is important to consider the distribution of these costs and benefits, particularly for those estimated to be most affected (in both the positive and negative sense) and living near the infrastructure and river basin. Even if the overall balance of benefits, costs, and risks is positive and justifiable at the level of national interests, the distribution may be quite unfair. Here, some segments of the population have benefited (e.g., urban) while others have not – and in some cases, have been negatively impacted (e.g., traditional recessional farmers).

[21] The term "solidarity" is often mentioned amongst OMVS and member state officials.

The Senegal experience highlights an important dilemma: the frequent disconnect between national and local development. It was understood that this development would be shared with the broad public and raise many out of poverty. In the absence of formal direct mechanisms to transfer wealth created, the reality can be tenuous. For instance, the objective of achieving food security in hindsight was dependent on not only infrastructure but also on national policies (e.g., stagnant agricultural extension, decrease in the provision of rural services, country-wide structural adjustment). Thus, to ensure that these benefits would be shared broadly required that regional institutions be well coordinated with the activities and, perhaps more important, policies of member states. A more multi-dimensional and nuanced view of development with the requisite investments (both of a hardware and policy nature) are needed to maximize benefit sharing between national goals and local populations. How this works in practice is a foremost challenge for nations and in the context of benefit sharing, requires far greater attention. Formal direct mechanisms (e.g., social funds) could be one way to address this.

Last, this case study demonstrates that the values and ideas of development can change over time. In 1972, preparing a comprehensive environmental and social assessment for a major project was not common practice. This is said not to relieve OMVS of its obligations, but rather to suggest that what was needed was an institution flexible enough to meet emerging standards. Finding this flexibility can be a challenge, especially when member states abdicate some sovereignty to a regional body and structures are jointly owned and managed. OMVS, however, has taken important steps through its new Water Charter to be much more responsive. ***For the concept of benefit sharing to be fully realized, institutions need to be adaptable and have legal frameworks to allow for flexibility.***

III. Columbia River Basin

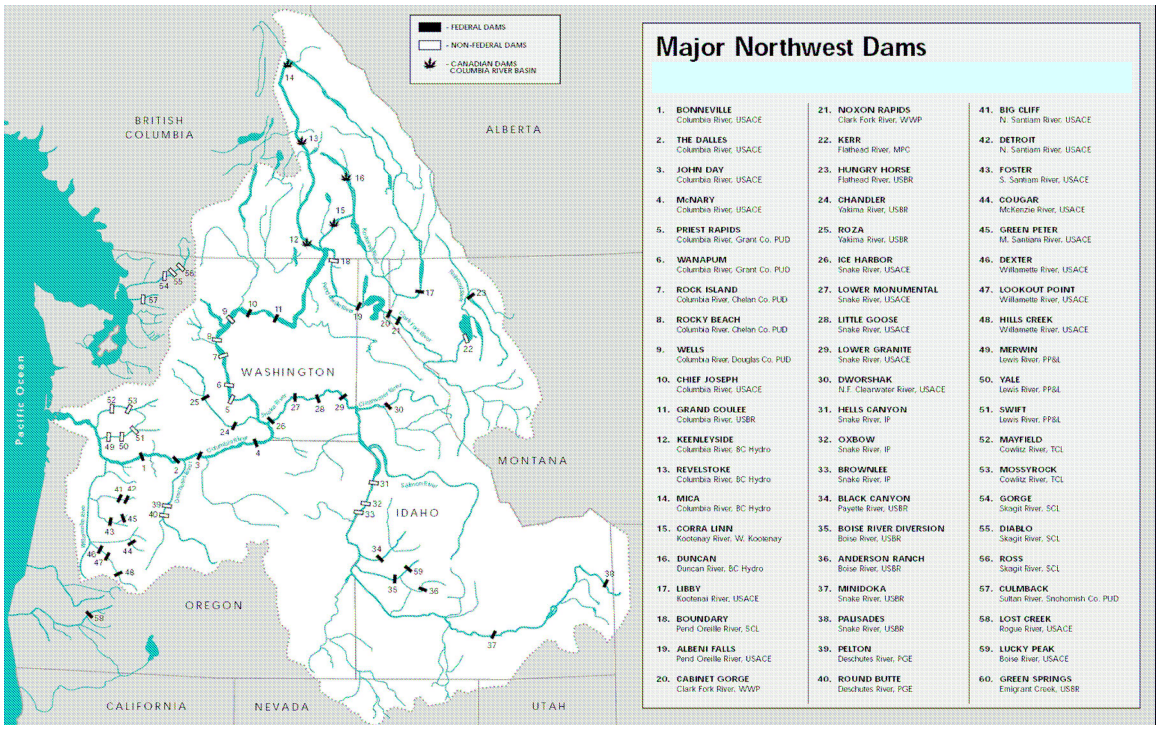


Figure 7: Columbia River Basin (source: Federal Columbia River Power System, 2001)

A. INTRODUCTION

The Columbia River Basin drains a watershed of about 670,000 km² with 15% of the area in Canada and 84% in the United States. The watershed's total population is about 6 million (2005). The Columbia and its major tributaries (Snake, Kootenay and Clark Fork-Pend Oreille Rivers) travel some 2,000 km to the Pacific with a mean annual discharge of about 250 BCM (about half that of the Mississippi River). Along the Kootenay River, the United States and Canada are both upstream and downstream of each other. The Basin is bounded to the north and east by the Rocky Mountains, to the west by the Cascade Range, and to the south by the Great Basin. Moreover, this system is characterized by substantive elevation differences (e.g., the source of the Kootenay

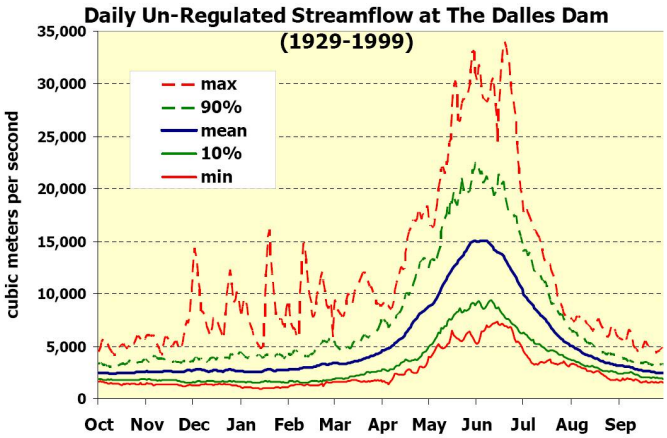


Figure 8: Monthly Un-regulated flows at The Dalles Dam

River is 1,200 m above sea level) and is ideal for the generation of hydropower. Precipitation also varies greatly across the basin. Along the coastal summits and upper reaches of the Columbia (in British Columbia) annual precipitation can be over 2,500 mm. More typically, annual precipitation ranges from 250 – 400 mm around the Snake River sub-basin and 400 – 600 mm in the Columbia Plateau areas.

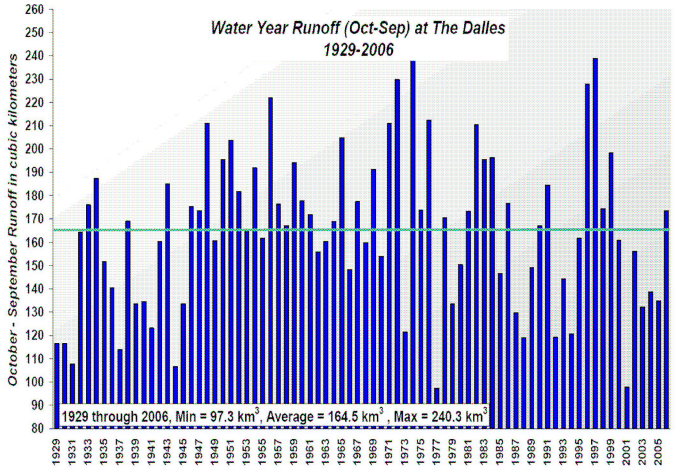


Figure 9: Annual flows at The Dalles Dam

Along the west side of the Cascade Range, atmospheric moisture precipitates as rain predominantly during the winter months. In contrast, on the eastern side of the Cascade Range towards the Rocky Mountains, most precipitation falls in the form of snow during the winter months. Peak runoff occurs during May – July at the height of the snowmelt season. Since most of the runoff originates here, the hydrologic variability is driven by this seasonal pattern. Variability is significant in this system. At the international border, the maximum recorded flow exceeds the minimum by 52 times. In normal years, at The Dalles Dam (Oregon), the average maximum recorded annual flow exceeds the minimum by 30-35 times (Figures 9 and 10).

Of importance from an international management perspective is the significant contribution from Canada to the flows east of the Cascades, where most of the US hydroelectric plants are located. Thirty eight percent of the total runoff originates from Canada. From a power perspective, the US dependence on flows from Canada is clear; the Canadian contribution to runoff at Bonneville Dam, the lowest power plant on the Columbia main stem, is over 40% and increases upstream to the Grand Coulee Dam, where it approaches 70%. Currently, on the 725 km stretch between Bonneville and Grand Coulee, 192 generating units at 11 dams have an installed capacity of over 19,565 MW and generate a yearly average of 91,918 GWh. Total hydroelectric capacity in the system is 35,000 MW. It is estimated that up to 80% of the electricity supplied to the US Northwest is generated from hydropower (Bisanti et al., 2003).

Development context (pre-Treaty)

After World War II, two major development challenges for Canada and the United States in the Columbia River Basin were periodic and sometimes devastating flooding and meeting growing energy demands. In 1948, melting snows and heavy rainfall caused extreme flooding and much damage to communities in both countries. In particular, in Vanport, Oregon (Figures 11 and 12), a dike was breached resulting in excessive property damage and the deaths of several people. Damages were estimated at over $100 million (LeMarquand, 1977). The city was never rebuilt. Other areas that were

impacted by the floods included Bonners Ferry, Idaho, Portland, Oregon (Figure 13), the City of Trail on the Columbia, and Creston Flats in British Columbia on the Kootenay River. Although several storage dams had already been built on the Columbia system by this point – notably Grand Coulee Dam (built in 1938-1942) – and served to reduce the flood damages from this event, it was apparent that additional storage regulation was needed.

Figure 11: Flooding in Vanport, OR (Source: USACE, Portland District, photo archive)

Figure 10: Railroad Dike Break in Vanport, OR (Source: USACE, Portland District, photo archive)

Figure 12: Flooding in Portland, OR (Source: USACE, Portland District, photo archive)

Moreover, because of its relatively dense human settlements, high-valued agriculture, and growing urban-industrial developments, the lower Columbia floodplain (downstream from Bonneville Dam) was highly vulnerable (from an economic perspective) to flood risks. This area represented 90% of the total potential of damages in the entire Columbia River Basin.

Despite the significant social and environmental implications of flooding in the Columbia River Basin, the perceived economic benefits of flood control relative to other uses (power production in particular) were less. According to the US Army Corps of Engineers (1950), the percentage of the total benefits that federal dams in the Columbia River Basin would realize for power generation was 84%. This was in comparison to 12.7% for flood control, 2.7% for navigation, 0.1% for irrigation, and 0.3% for recreational uses. In the 1950s, half of the demand for electricity for the Pacific Northwest was devoted to supplying energy for various defense agency needs (e.g., aluminum plants, light metals, aircraft production) which would grow steadily over this period. As these regions would grow economically

and in population,[22] it was clear that given the current level of control, meeting future demands (both in terms of flood control and energy demands) would be a challenge.

Existing infrastructure

During the 1930s, an extensive system of levees and related civil works were built along the lower Columbia for flood protection, but more was possible. At the time the United States and Canada were considering joint development of the Columbia River Basin, about 60% of the 220 km stretch below the Bonneville Dam was protected to some degree with infrastructure that could contain flows up to about 800,000 cfs (22,600 m^3/s). According to USACE (1958) estimates, this protection was sufficient to reduce annual damage by about 35%. By 1959, after several additional multi-purpose projects were developed (primarily Grand Coulee Dam; see Figure 14), a total of about 10 BCM of storage could be used. Measured at Dalles, this complement of additional storage could reduce a peak discharge of 35,000 m^3/s and reduce the annual potential damage by a further 44% (leaving the lower Columbia floodplain still exposed to about a 21% risk. It was assessed that an additional 22-26 BCM were needed to control the river to not exceed the levee capacity at Dalles.

Figure 13: Grand Coulee Dam (Source: US Bureau of Reclamation, photo archive)

Moreover, by 1960 about 340 m of the 400 m drop between the international boundary and the Columbia delta on the main stem had been developed for hydropower (9,800 MW of installed capacity and 7 BCM of storage for power production). On the Clark Fork-Pend Oreille and Snake Rivers, 3,000 MW and about 10 BCM of storage existed. On the Canadian side, although large hydroelectric potential existed, development was limited, with none on the Columbia River main stem (only 271,000 kW below Kootenay Lake). Demand for electricity was rising in the region and it became increasingly apparent that greater upstream regulation through storage could be used to improve production at hydroelectric plants in both countries.

[22] Population in the Pacific Northwest grew at 15.9% from 1960-1970, at 22.9% from 1970-1980, and at 12% from 1980-1990. The area's population of about 6 million in 1960 reached almost 9.5 million by 1990.

Existing policies

Existing policies in both the United States and British Columbia played an important role in setting the conditions for agreement and negotiating positions between the parties. US policy on the provision of power during this period was in favor of reducing the role of the federal government. A "Partnership Policy" had been adopted that in effect discouraged the construction of federal hydropower projects as long as non-federal alternatives existed. Moreover, Federal Power Act provisions required that non-federal developers of storage provide regulation for federally-built head plants (i.e., run-of-the-river plants) downstream without compensation. Thus, the incentives were clearly against building storage and as a result head plants were built in mass.

With most investment in run-of-the-river plants and a deficiency in storage and consequent regulation, the full economic potential of the system was being underutilized. In 1959, the system could produce 2,972 MW of prime power in the absence of stream regulation. However, by regulating the stream using the existing storage, prime power production could be increased to 5,310 MW. Furthermore, without further development of head, an additional 7 BCM of storage upstream of Grand Coulee could increase power by 1,000 MW. ***Thus from the United States' perspective, given the substantive hydrologic variability and both the potential to reduce flood losses and improve power production, the construction of upstream storage was a prime objective of the Columbia River Treaty negotiations.***

In Canada, a combination of large distances from the Columbia Basin to the major load center in Vancouver and slow growth in power demands prior to 1945 resulted in little development in the Canadian portions of the Columbia River Basin. However, by the 1950s with growing urban demands, it became important for British Columbia (BC) to begin to look more carefully at the potential to develop hydropower. Moreover, a national policy that prohibited the export of surplus power (prior to 1963) was interpreted at the time to require that any power benefits generated downstream from Canadian storage would need to be repatriated. In addition, at the time general federal policy was aimed towards reducing reliance on American capital and commerce, thus restricting US propositions to advance capital to build upstream storage.

It is also noteworthy to consider that Canada, like the United States, is a federal country. ***However, in Canada, the authority of the provinces in resource issues including water resources is much stronger than in the American states.*** For international rivers, authority between the federal government and the provincial government overlaps. While the federal government has authority to negotiate, sign, and ratify international agreements, the provinces have the ownership of the water resources and the authority to implement development schemes. This was among several reasons why the Treaty of 1961 was not actually ratified by the Canadians until 1964.

B. PROJECT OBJECTIVES AND DESCRIPTION

History of the Columbia River Treaty

Given the development and policy contexts, additional storage could be developed to more efficiently generate power for the region and to meet flood hazard objectives that would be mutually beneficial to both countries. And unlike many international river basins in the developing world, both technical expertise and capital were readily available and circumstances for the joint development of the Columbia River were largely favorable from the political perspective given the stable and peaceful relations between these two countries. The primary challenge, however, would be to structure an agreement on the joint development of the Columbia River that would be satisfactory (economically and politically) to both parties in the context of their existing policy environments.

In 1944, the governments of the United States and Canada delegated the task of assessing the possibility (in engineering terms) of joint development to the International Joint Commission (IJC).[23] Fifteen years later the International Columbia River Engineering Board (ICREB), which had undertaken the necessary engineering investigations, submitted their detailed technical findings.[24] IJC also submitted the principles by which the benefits of cooperative development would be determined and allocated (discussed in detail later). These two documents formed the basis for the negotiations on the Treaty between the two governments, which began in 1960.

Box 1: History of the Libby Dam (see Figure 15)

Prior to the signing of the Columbia River Treaty, the United States had unsuccessfully applied to the IJC to permit the building of the Libby Dam in Montana, US. The Libby project would provide storage to protect against flooding and increase firm power output at large existing and planned hydroelectric plants downstream. However, the reservoir would back almost 70 km across the border into BC, disrupting communities and existing transport infrastructure. The US offered to compensate the Canadians for the cost of resettlement and relocation, and would not charge for the economic benefits that Canada would receive from better flow regulation. The Canadians, however, argued that additional power benefits ought to be repatriated back to Canada since the higher heads (about 45 m) in Canada would increase the hydropower output at Libby. This application was ultimately withdrawn (and resubmitted in 1954 but rejected again over the terms of sharing downstream of benefits). Pressure from the USACE and US public utilities would ultimately result in the inclusion of Libby in the Columbia River Treaty despite the poor economics of the project.

Several critical issues delayed the signing of the treaty. First, with the unsuccessful application by the United States to build the Libby Dam (see Box 1) due to unresolved issues regarding compensation, it became clear to British Columbia that any cooperative development must be based on

[23] Set up pursuant to the Boundary Waters Treaty of 1909, the IJC is an independent bi-national organization to help prevent and resolve disputes relating to the use and quality of boundary waters and advise both Parties on related questions. The IJC consists of three members from the United States and three from Canada. This is an example of a "boundary" commission (Fischhendler, 2003).

[24] International Columbia River Engineering Board (1959)

the principle that a portion of downstream benefits from upstream development be returned to the upstream nation. This would be essentially resolved with the IJC principles, although strict adherence to this concept would not actually be achieved. Second, several diversion schemes within Canada from the Kootenay River into the Columbia (and even all the way to the Fraser Basin) were being discussed, which was a subject of tension between the negotiating Parties. Third, there was reluctance on the part of BC to receive outside financing for such projects. However, it did not have sufficient resources to finance the proposed ICREB dams. Fourth, general concerns were raised regarding the populations that would be displaced by storages in the East Kootenay. Fifth, given the fact that Canada would need to develop power to meet growing demands, it was becoming more apparent that the United States stood to gain with or without an agreement. Last, although the US would accept the concept of sharing downstream benefits to pay for upstream storage, specific criteria that could be utilized to calculate and share benefits were far from clear.

After these issues had been resolved, the Columbia River Treaty (CRT) was eventually signed on January 17, 1961. Within months it was ratified in the US Senate. However, the Treaty was delayed by three years as responsibilities between the Federal Government of Canada and the Province of British Columbia were being determined. In particular, BC wanted to maintain control and sovereignty over all projects in its boundaries, but needed outside financial help. Since the Canadian federal government signed the Treaty but had not reached an agreement on its implementation with the Province, BC felt it could veto implementation until one further demand was met: the sale of downstream power entitlement. Such an arrangement would reduce the costs to BC, which would still receive its entitlement 30 years later when the market in BC was anticipated to be large enough. By January 1964, a Protocol Note and related documents were prepared and the CRT was finally ratified.

Treaty infrastructure

The objectives of the cooperative development of the Columbia River Basin were to build storage in Canada for direct use (e.g., hydropower generation) and to provide downstream benefits to the United States by way of 1) increased flows during the natural low flow seasons to increase hydropower production at plants in the United States and 2) modification of the peak discharge to reduce flood hazards along the lower floodplain reaches.

Figure 14: Dams built under the Columbia River Treaty (A - Libby; B - Mica; C – Keenleyside/Arrow; D - Duncan) (Source: public)

Under the CRT, Canada agreed to build three storage dams totaling about 20 BCM in Canada: Mica Dam, Keenleyside/Arrow Dam, and Duncan Dam. These dams under the CRT would be operated in coordination with downstream projects for maximum flood control and power generation. The US also received the right, which it exercised immediately, to build the Libby Dam. The CRT also gave Canada the right to divert water from the Kootenay in the vicinity of Canal Flats, British Columbia, to the headwaters of the Columbia River (to date, this right has yet to be exercised). These projects added 25.3 BCM on top of the existing 16.4 BCM available at the time the Treaty was signed in 1961. Finally, since the prospects for large-scale additional consumptive uses were limited (e.g., irrigation potential was limited except for parts of the US), the negotiations over the CRT would offer no problems of the kind typically found between riparian nations where consumptive use by one riparian would affect the other. Table 3 gives the details of these storages.

Table 3: Summary of CRT Storages and Details

	Mica	Keenleyside	Duncan	Libby	Total
Storage (BCM)	8.6*	8.8**	1.7	6.2	25.3
Capacity (MW)	1805	185	-	600	2590
Height (m)	198	52	40	112	
Completion year	1973	1968	1967	1973	

* additional 6.2 BCM added later ** additional 0.3 BCM added later

Operational implications

Unlike other treaties for the joint development of a river basin, the CRT also made provisions for system design and operations. The CRT obliges the two countries to develop joint operating plans. Under the Treaty, two main operating plans guide system operations: the assured operating plan (AOP) which is developed for a six-year period to guide flood control and power generation operations, and the detailed operating plan (DOP) which is prepared one year in advance. The DOP is prepared annually and updates the AOP using updated reservoir-level information gathered from weather stations in the basin (the CRT provides for a hydro-meteorological system). Moreover, the DOP goes beyond flood and power objectives to include other benefits such as fisheries and recreation. The CRT outlines the priorities for water use as follows: 1) consumptive uses (to include water for domestic, municipal, irrigation, mining, or industrial purposes), 2) flood control (which poses upper limits on reservoir levels), 3) firm energy (reservoirs must be drafted as far as necessary to meet the specified requirements), 4) reservoir refill (requirements for refill by 31 July to maximize firm energy capability the following year), and 5) secondary energy production (energy production that cannot be guaranteed in all hydrological sequences).

As detailed in the CRT, 10.4 BCM of storage at the Keenleyside, Duncan and Mica dams are to be allocated for flood control benefits. An additional 8.7 BCM of Treaty storage and 6.2 BCM of non-Treaty storage are available on call at a cost of almost $2 million for each of the first four requests. Flood control operating plans draft a portion of Canadian flood control storage by March each year based on a forecast of the April through August unregulated flow at Dalles. In addition, 19.1 BCM of Canadian storage are operated for optimum power generation and dependable peak capacity in Canada and the US, limited only by flood control objectives, which take precedence. Canada is required under the CRT to operate Treaty projects according to the specified monthly plans, but has the flexibility to operate individual projects for maximum Canadian benefit as long as the overall Canadian storage obligations and targets are met.

Downstream benefits

The calculation of downstream benefits is explicitly given in the CRT. In exchange for this upstream storage, Canada received one half of the extra power produced by US generating plants ("Canadian Entitlement") and also one-half the value of the flood damage reduction the reservoirs in Canada would help to protect in the US floodplains over the minimum 60-year life of the Treaty. For the flood protection benefits, Canada received a one-time payment of $64.4 million (1961 dollars), which was dependent on the successful completion of the agreed storage and commencement of operation. In addition, British Columbia sold the first 30 years of its "Entitlement" to a group of US utilities[25] for $254.4 million. This money was then used to finance the three Treaty dams

[25] Because the BPA was not permitted to purchase power for resale, it served as the broker between British Columbia and a consortium of utilities in the Pacific Northwest known as the Columbia Storage Power Exchange, which would be the recipient of the Canadian entitlement.

in Canada. Canada's half of the downstream power benefits is approximately 1,200-1,500 MW of capacity and 520-560 average MW of energy. These sales agreements expired in 1998, 1999, and 2003, corresponding to 30 years after the scheduled in-service dates for each of the three CRT dams. It is estimated that BC will receive approximately $5 – 9 billion for the remaining years of downstream benefits (e.g., for the 2005-06 operating year, Canada's share of the downstream power benefits is valued at around $250 million). Last, in return for paying for all the flowage costs in Canada, Canada does not pay the US for the power and flood control benefits in Canada from the operation of Libby dam.

Institutional arrangements

Under Article XIV, the CRT requires that both Parties designate entities empowered to carry out the provisions of the Treaty (Figure 16). The US designated the US Army Corp of Engineers (USACE) and the Bonneville Power Administration (BPA). The USACE is the most senior of federal agencies (established in 1802) involved with the management of water resources in the United States and operates under the civilian branch of the US Army. General responsibilities include navigational improvements, hydroelectric generation, nationwide flood control operations, and the creation of river basin plans. The BPA directs much of the reservoir management and river flow system for hydropower generation and flood control. Unlike the USACE, the US Bureau of Reclamation, and the public utilities, BPA does not own the dams and generation equipment.

Created in 1937 to market electricity from Bonneville and Grand Coulee, BPA sits under the US Department of Energy. BPA wholesales much of its energy to public and private utilities. BPA also controls access to the federal transmission system in the Pacific Northwest region and intertie[26]. Canada designated the British Columbia Hydro and Power Authority (BC Hydro). BC Hydro is a provincial crown corporation and the primary electric utility for the region. These entities established the Operating Committee and the Hydro-meteorological Committee to implement the operating requirements.

Finally, the CRT established a bi-national institution, the Permanent Engineering Board (PEB), which consists of two appointed members from each country. The PEB has the responsibility to monitor the flows of the Columbia and Kootenay Rivers at the US-Canada border, monitor the hydroelectric and flood control operation plans, reconcile differences concerning technical and operational matters, and make periodic inspections to ensure that the objectives of the Treaty are being met. The IJC can serve as a dispute resolution mechanism if needed.

26 Pacific Intertie is an electric power transmission line that transmits electricity from the Pacific Northwest south to Los Angeles using a high voltage direct current (HVDC).

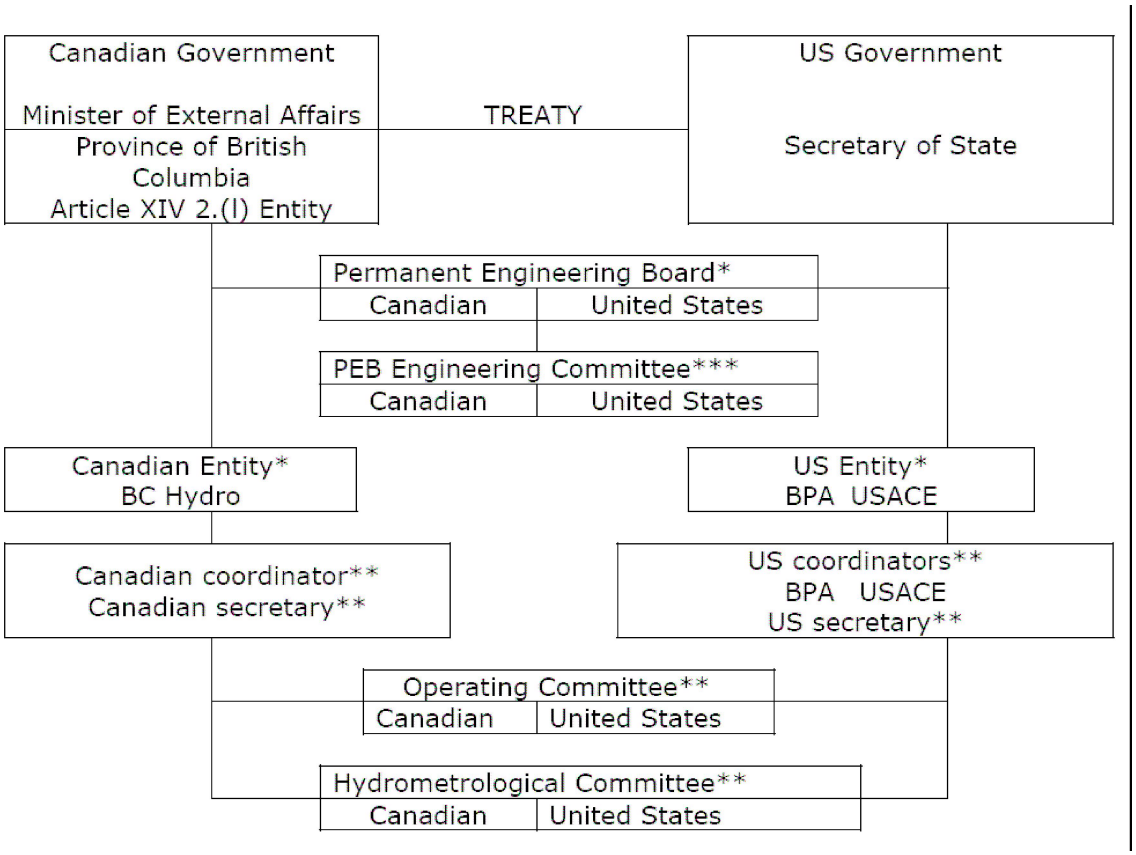


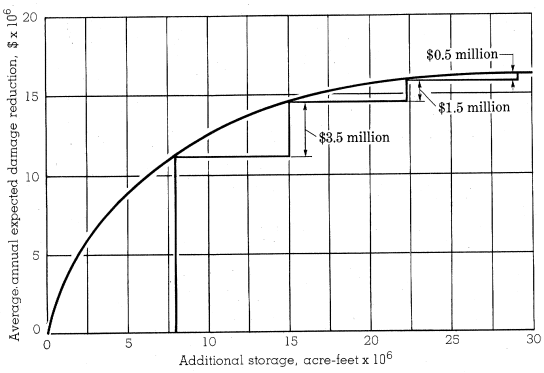
Figure 15: Columbia River Treaty Organization

* Established by Treaty ** Established by Entity *** Established by PEB

C. QUANTIFYING ECONOMIC BENEFITS AND COSTS

Identifying the most economic storage projects (given the existing stock of infrastructure) for the cooperative use of a river system is a complex analytical undertaking. It requires an understanding of the impacts of new additional storage, both in terms of the system hydrology and the economics of storage (see Box 2). In the context of the CRT, this was complicated further by how the regional power system (both demands and other alternative supplies) might change. General agreement was reached early on that the economic benefits from the joint development of the Columbia River Basin would be the difference between the amount of electricity and flood damages avoided with and without the use of CRT storages. How these identified benefits would then be equitably divided was a matter of great debate and took some five years to resolve from the time that the technical possibilities had been identified. It is instructive, first, from a benefit-sharing perspective, to review the underlying principles that were established to guide this process.

Box 2: Economics of reservoir storage



Evaluating the economics of storage for power production and flood protection is complicated by the fact that added storage has both complementary (additive) and substitutive (displacement) effects. Added storage can be complementary to existing run-of-the-river plants from a power generation perspective. However, for flood protection, the siting of additional storage requires a tradeoff between protecting the locales immediately upstream of the floodplain and maximizing power production in the upper reaches of the system. Added storage may also have substitutive effects as there are diminishing marginal returns to storage (see the figure inset). The productivity of storage is a function of the current amount of storage in the system and expected growth in regional loads exceeding the hydropower potential. Thus, this diminishing marginal return to storage has important implications for the sequencing of reservoirs. To maximize the net benefit for mutual sharing, projects must be added in their most economical sequence, as it is possible that some projects may be added whose benefits exceed costs on a first-added basis only because they pre-empt some of the surplus benefits of additional storage. This can have implications for the calculation of gross and net benefits. (Source: Krutilla, 1967).

IJC Principles

In January 1959 the United States and Canada asked the IJC to make recommendations on the principles to be used to determine the 1) benefits that would result from the cooperative use of storage waters and inter-connections with the Columbia River system, and the 2) apportionment between the two countries of power generation and flood control benefits. ***In the end three general principles, seven power principles, and six flood control principles were developed to guide the negotiations on the cooperative development of the Columbia River.*** Highlights are given below.

General Principle No. 1

Cooperative development of the water resources of Columbia River Basin, designed to provide optimum benefits to each country, requires that storage facilities and downstream power production facilities proposed by the respective countries will, to the extent it is practicable and feasible to do so, be added in the order of the most favorable benefit-cost ratio, with due consideration of factors not reflected in the ratio.

This principle aims to ensure that storage projects are added in sequence according to their economic merits. Moreover, the phrase "… to the extent that it is practicable and feasible to do so" recognizes the fact that other non-monetary criteria besides economic ones may be considered in the adoption of projects. The reader must be reminded that at the time these principles were being formulated, two particular storage sites were of concern: 1) Libby Dam was being promoted by the Army Corps of Engineers in the United States, even though it was economically inferior to mutually exclusive Canadian sites and 2) High Arrow Lakes in BC was good on economic merits but opposed by

some political interests in BC. Krutilla (1967) argued that while Principle No. 1 would come close to maximizing the cooperative mutual benefits, it is not clear that it would produce the best sequence of reservoirs or maximize the net benefits for each riparian. Moreover, the use of a benefit-cost ratio as the economic criterion of choice (as opposed to net present value, for instance) can be problematic.

General Principle No. 2

Cooperative development of the water resources of the Columbia River Basin should result in advantages in power supply, flood control, or other benefits, or savings in costs to each country as compared with alternatives available to that country.

Specifically in regards to power and flood benefits, the division of benefits is described in the following:

Power Principle No. 6

The power benefit determined to result in the downstream country from regulation of flow by storage in the upstream country should be shared on a basis such that the benefit, in power, to each country will be substantially equal, provided that such sharing would result in an advantage to each country as compared with alternatives available to that country, as contemplated in General Principle No. 2. Each country should assume responsibility for providing that part of the facilities needed for the cooperative development that is located within its own territory.

Flood Control Principle Nos. 3 / 4

The monetary value of flood control benefit to be assigned to the upstream storage should be the estimated average annual value of the flood damage prevented by such storage

The upstream country should be paid one-half of the benefits as measured in Flood Control Principle No. 3 i.e., one-half of the value of the damages prevented.

Box 3: Calculating payments for flood control

The monetary value of flood control benefits is based on the average annual value of flood damage prevented determined by the USACE. To control to 800,000 cfs, a unit value for effective storage of $1.38 per acre-foot (af) per year was used. Additional flood control benefits to control beyond to 600,000 cfs were valued at $0.114 per acre-foot per year. Thus, the annual benefits for of the CRT storages are:

Arrow Lakes: 3,820,000 af x effectiveness factor of 0.875 x $1.38 per af = $4.61 million
Duncan Lake: 1,270,000 af x effectiveness factor of 0.560 x $1.38 per af = $0.98 million
Mica: 80,000 af x effectiveness factor of 1 x $1.38 per af = $0.11 million

These amounts are then annualized over a 55-year period (except for Mica, which uses 51 years) and discounted at 3 7/8 % and divided by 2 results in a total Treaty sum of $64.4 million.

Krutilla (1967) argues that because of the diminishing returns to additional storage and the subsequent displacement effects (see Box 2), a simple half division of gross flood and power benefits would make General Principles Nos. 1 and 2 incompatible with each other. That is, although a selection of projects could be agreed to, and while they produce equal amounts of power and flood protection for each riparian, they may do so only at the sacrifice of the economies inherent in cooperative development. However, this principle is carefully qualified and left to the negotiating teams as is noted at the end

of Power Principle No. 6 with the statement "… where such sharing would not result in an advantage to each country as contemplated in General Principle No. 2, there should be negotiated and agreed upon such other division of benefits or adjustments as would make the cooperative development feasible."

Finally, to establish the idea of the sharing of downstream benefits the IJC state the following:

> ***General Principle No. 3***
>
> *With respect to trans-boundary projects in the Columbia Basin, which are subject to the provisions of Article IV of the Boundary Waters Treaty of 1909, the entitlement of each country to participate in the development and to share in the downstream benefits resulting from storage, and in power generated at site, should be determined by crediting to each country such portion of the storage capacity and head potential of the project as may be mutually agreed*

In summary, the IJC Principles reflect two elements critical in determining the benefits and defining the equitable division of gains in the international development of a river basin system. First, General Principle No. 1 recognizes that the value of cooperative gains is dependent on 1) restricting mutually exclusive elements in the system to those that are most economical and 2) constructing these in a sequence that permits the more economical projects to be built before the less economic projects are added. Second, related to General Principle No. 2, each Party aims to achieve a position superior to that which can be attained independently (via the cost savings of an alternative domestic means). Although Krutilla (1967) argues that this is inconsistent with the recommendation that each party receive half of the power gains and flood damage, a purposeful level of imprecision is provided in these Principles to give the negotiating parties ample latitude to reach a mutual agreement. These concepts represented a sophisticated level of benefit-sharing applicable to cooperative undertakings.

Sharing of benefits

The Principles were not explicit in how the net gains would be shared, but rather sought to obtain an equal division of the gross benefits subject only to the restriction that there would be a net advantage to each of the Parties. After a sequence of projects was selected, how the mutual gains would be divided was a matter of great debate. The principle that the IJC penned used the idea of sharing the net gains in such a way that each country would be in a position superior to what it would have attained independently. However, although sharing the net gains from cooperation would be most satisfying from an economic perspective, ultimately this approach was rejected in favor of sharing the gross gains to cooperation. Although the US and Canadian federal governments supported using net gains as a basis for division, British Columbia was strongly opposed to this. In some respects, the preference towards using gross gains is understandable. First, it is easier to reach an agreement with this approach as joint evaluation is not required. That is, as Krutilla (1967) demonstrates, undertaking a system-wide economic analysis is not trivial. Furthermore, a certain degree of

uncertainty is reduced for each Party as decision makers only need to be responsible for the evaluation of their own benefits and costs. Finally, by using a net benefit approach, each Party will want to assume costs incurred in their own country to be charged to the total benefits before distribution (e.g., the US wanted its historic costs to be included; Canada only wanted to include the most economic sites according to the ICREB, which were situated in Canada). This highlights the practical problem when there is no mutual agreement on what costs (current and sunk) should be included. So although using gross benefits may not necessarily result in an equal sharing of net benefits (as alternative costs may be different), the rationale for strong British Columbian opposition (especially given the financial situation in the Province) was understandable. This was only partially corrected through the General Principle No. 2, which required, however, that the total net benefits one country expects to get ought to be greater than the benefits it would expect to receive from developing a domestic alternative.

Moreover, as is well illustrated here with the CRT, economic objectives may not be the only objectives for consideration. For instance, a US State Department official before the Senate ratification is quoted as saying:

> We are anxious that this agreement operate to progressively reduce power costs in British Columbia; firstly and obviously because if there was going to be agreement it had to operate in that direction for the Canadians; secondly we regard Canada as a partner in the free world, and its growth, its economic growth, as being important to the United States. (US Senate, 1964)

D. ACTUAL BENEFITS AND COSTS

Although the Principles were instrumental in guiding the decision-making process, the most economical approach to joint development of the Columbia River Basin system was not achieved. The details of the economic analysis are not presented here. For an in-depth analysis of the economics of the CRT, the reader is referred to a significant work by John Krutilla (1967). A summary of this economic critique follows.

By 1967, Canada had clearly advanced to a position superior to what (in economic terms) it could have achieved independently, while the US emerged with a position inferior to one that was attainable had it chosen to rely exclusively on its domestic financial resources. First, from a system point of view, Libby Dam itself was uneconomic compared to Canadian alternatives. For instance, analysis shows that the inclusion of the Libby storage in lieu of an alternative on the upstream Dorr-Bull River results in a relative loss of net benefits of about $135 – 140 million. This represents less mutual gain to be shared between Canada and the US. Moreover, with construction of the Libby Dam, the Duncan Dam was perhaps unnecessary. Second, construction of the Peace River Dam may have made the need to re-regulate the discharges from the Mica Dam unnecessary. As a consequence, the construction of the Arrow Lakes Dam, which created much social disruption, may not have been necessary. Third, an intertie between the US northwest and southwest may have reduced the need for upstream Canadian

storage (from the US perspective). Fourth, Canadian planning did not consider the full range of domestic alternatives to power (e.g., coal deposits for thermal power). In the end, the final analysis revealed that the Treaty of 1961 was quite favorable to Canada, resulting in cost savings of approximately $250-500 million. A substantial share of these savings to Canada did not result from increased economy due to cooperation, but from the heavy costs to the US of its portion of the Columbia system, given the division of the downstream benefits.[27] Finally, the analysis reveals that many decisions were made for political rather than economic reasons, and in many cases these political decisions were actually predictive of feasibility.

Nonetheless, there can be little question that the CRT storages have made substantial improvements in meeting the flood management objectives in the US. High discharge rates in 1972 and 1974 would have been almost 1 million cfs at Dalles in the absence of these upstream storages. These major storage projects were credited with preventing losses of $474 and $538 million. It is equally true that it relies on a more expensive set of projects than would have emerged had the US independently managed this using economic criterion alone. Estimated flood damages prevented for the entire Columbia River Basin due to all storage (including Treaty storage) is shown in Figure 17.

[27] These economic gains, however, were eroded from the inflation in construction costs reducing the expected cash surplus (anticipated at the time of the lump-sum sale of downstream benefits) after building the treaty storage dams.

Water Year	Maximum Annual Mean Daily Peak[1] @The Dalles (kcfs)		Damages Prevented ($1 million)		Water Year	Maximum Annual Mean Daily Peak[1] @The Dalles (kcfs)		Damages Prevented ($1 million)	
	Unreg	Observed	Lower Columbia[2]	Columbia Basin[3]		Unreg	Observed	Lower Columbia[2]	Columbia Basin[3]
1948	1010	1010	*	*	1976	637	419	15.65	43.08
1949	660	624	0.67	*	1977[5]	276	183	0.00	0.00
1950	823	744	9.80	*	1978	565	313	6.00	30.61[4]
					1979	482	306	1.50	4.65
1951	672	602	0.80	*	1980	544	341	5.16	15.26[R]
1952	579	561	0.34	*					
1953	672	612	1.18	*	1981	579	436	10.91	45.26[R]
1954	590	560	0.26	*	1982	759	422	15.22	78.62
1955	614	551	0.62	*	1983	732	400	18.48	131.00[R]
					1984	628	376	10.71	107.29
1956	940	823	25.00	37.67	1985	550	274	10.45	23.46
1957	820	705	6.60	11.11					
1958	735	593	3.55	7.83	1986	719	388[R]	0.24[R]	72.06[R]
1959	642	555	0.88	2.6	1987[5]	439	284	0.00	9.09
1960	493	470	0.08	0.58	1988[5]	342	236	0.00	2.74
					1989	512	312	6.30	37.10
1961	789	699	6.50	7.7	1990	511	372	1.66	15.75
1962	503	460	0.09	1.79					
1963	481	437	0.03	0.65	1991	568	348	2.64	101.16
1964	764	662	7.60	22.91	1992[5]	328	232	0.00	0.71
1965	669	520	1.44	7.18	1993	602	382[R]	0.00[R]	81.37
					1994[5]	381	224	0.00	11.74
1966	455	396	0.00	0.43	1995	552	296	0.03	61.54
1967	781	622	14.21	20.80					
1968	533	404	0.26	1.07	1996	719	456	4.32[R]	227.03[R]
1969	628	449	2.61	5.51	1997	898	571	48.33	378.64
1970	634	429	1.16	6.34	1998	617	442	1.44	88.09
					1999	715	379	0.17	95.97
1971	740	557	8.49	25.76	2000[5]	450	375	0.00	35.33
1972	1053	618	213.10	260.49					
1973[5]	402	221	0.00	0.52	2001[5]	327	174	0.00	21.56
1974	1010	590	239.73	306.36	2002	607	374	0.00	124.39
1975	669	423	9.41	40.97					

[1] Observed discharges are preliminary values calculated from project data.
[2] Damages are for the Columbia River below McNary Dam. [Dollar values are for the year of the flood. Willamette excluded.]
[3] Totals are damages prevented by major projects above The Dalles during the spring and summer runoff. Damages prevented in Canada and/or by levees and channel improvements are not included.
[4] Damages are based on the flood of December 1977.
[5] No flood control operations [i.e., unregulated flow does not exceed 450 kcfs at The Dalles].
[R] Revised

Figure 16: Effect of Reservoir Regulation on Flood Peaks and Damages (Source: Columbia River Management Group, 2003)

Columbia Basin Trust

Reflecting the times in which it was negotiated, the Treaty does not consider uses other than power and flood protection. However, in recent decades a variety of environmental and social concerns have arisen. When the reservoirs behind Keenleyside, Duncan, Mica, and Libby dams began to fill, some 2,300 people were displaced and 60,000 ha of high-value land were flooded. Furthermore, numerous First Nations' cultural and archaeological sites were submerged. As most of the principal benefits from upstream storage were conferred upon major regional population centers, many of these local communities received little in the way of economic benefits. To redress some of these issues, in 1995, the Columbia River Trust was established under the Columbia Basin Trust (CBT) Act to "… support efforts by the people of the Columbia Basin to create a legacy of social, economic, and environmental well-being and to achieve greater self-

sufficiency for present and future generations." The Columbia Basin Trust received a $295 million endowment from British Columbia. $250 million was committed over a ten-year period to finance power projects and a lump-sum payment of $45 million was reinvested for the benefit of basin residents through short-term cash investments, business loans, real estate ownership, and venture capital projects. In addition, the CBT receives $32 million over a 16-year period for operations. BC further committed to transfer $250 million to the Columbia Power Corporation, the Columbia Basin Trust's joint venture partner in power projects in the basin. Fifty percent of the net profits go back to the CBT to be spent on social, economic, and environmental benefits.

Supplemental operating agreements

Moreover, to adjust to changing values and demands in the basin, the entities can agree to additional agreements to vary operations when benefits to both parties are anticipated. For instance, under the Non-Power Uses Agreement, modifications to flow out of the CRT storages can be made to realize fisheries and recreation objectives, originally not considered in the CRT. Other agreements include the Libby Coordination Agreement and the Whitefish Agreement. BC has also undertaken a stakeholder consultation process (Water Use Planning) to more closely involve stakeholders in reservoir operations.

E. LESSONS LEARNED IN THE COLUMBIA

The joint development of the Columbia River Basin demonstrates that significant mutual advantages are possible. Regardless of whether or not the most could have been achieved from the CRT, it is clear that the Treaty storage built has had a positive impact for both the United States and British Columbia.

The Treaty plus, perhaps more importantly from the benefit-sharing perspective, the preceding IJC Principles, are unique in that downstream benefits are explicitly shared with the upstream riparian. This is a major benefit-sharing mechanism. Moreover, the Treaty prescribes in detail how the downstream benefits would be calculated and also shared. Although the Treaty requirement of a 50/50 sharing of all gross power and flood control benefits may be perceived to be the most "equitable," it is not clear that the final arrangements resulted in the maximum mutual cooperative gain possible (compared to the alternative domestic options available to each). Krutilla (1967) points out that despite the fact that the CRT produced equal amounts of power for each riparian and that this was done at the sacrifice of the economies inherent in cooperative development, the Treaty and IJC Principles do provide the guiding concepts towards an efficient and equitable cooperative development of the Columbia River.

To the extent a Treaty can build flexibility into the implementation of activities, there will be advantages given the general inflexibility associated with large infrastructure projects. The CRT is an important planning and operations agreement guiding the realization of power generation and flood protection for both the United States and

Canada. Flexibility is critical as the final selection of schemes will have a high level of uncertainty because not all information will always be available and conditions (political, technical, and economic) will change. A certain degree of flexibility through the CRT is apparent, as evidenced by more recent supplemental operating agreements. LeMarquand (1977), though, questions why it was necessary to have the details of system design and implementation in the Treaty itself. He argues that a treaty of such nature should only set out the principles on which development should proceed (more informal agreements have the advantage of giving the negotiators more flexibility in selecting projects to reflect changing conditions without having to go back to national legislators for approval). Although perhaps true, the lesson here is that an agreement must provide for maintaining an equitable share of benefits between the countries that will be sufficiently robust over time.

Finally, the experience with the CRT highlights the importance of non-economic criteria and how the history of development and priorities can affect a negotiated outcome. Krutilla (1967) summarizes this best:

> This leads one to speculate that at the highest levels in the United States there may have been greater interest in concluding an amicable settlement with Canada regarding future development of the Columbia – an objective with which few would quarrel – than in realizing positive economic advantage from the cooperative undertaking…One can only assume that creating an incentive for Canada to provide storage for the system in the United States may have been consistent with internal US power policy as well as with the furtherance of good neighborly relations during the 1960 negotiation, and that after 1961 the latter objective alone provided reason for supporting the Treaty negotiated under the previous administration.

IV. Lesotho Highlands Water Project

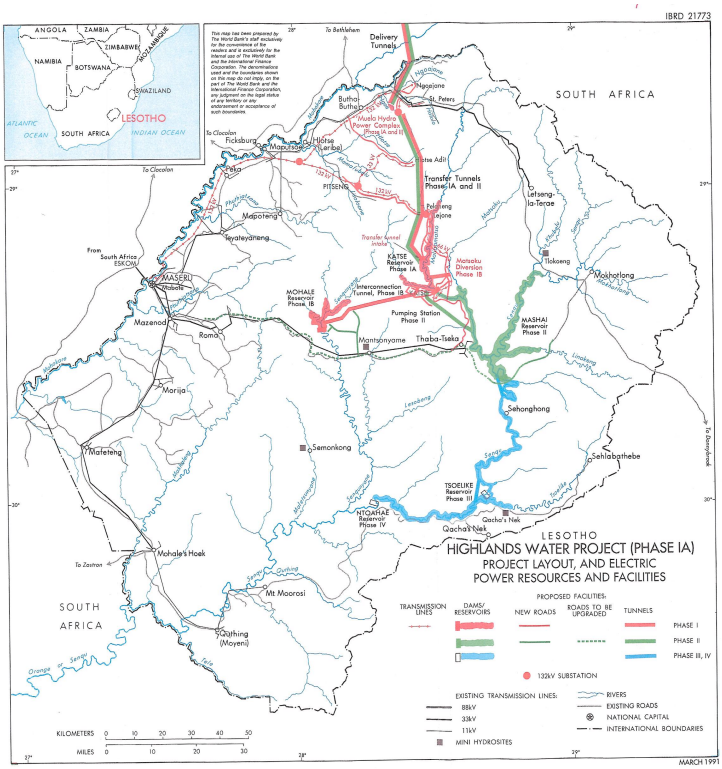


Figure 17: Lesotho Highlands Water Project (Source: World Bank, 1991)

A. INTRODUCTION

The Orange-Senqu River Basin covers an area of about 900,000 km^2 and is the largest and longest river in South Africa. The Senqu River (4.73 km^3/yr annual flow), which becomes the Orange River when it enters South Africa, has its origins in Lesotho. The main tributaries of the Orange-Senqu River in Lesotho are the Malibamatso, the Makhaleng, and the Senqunyane Rivers. With a current population of 2.2 million, Lesotho is a small, landlocked country covering about 30,300 km^2. Lesotho lies almost entirely above 1,000 m, with 80% of the country over 1,800 m. As a result, Lesotho remains cooler throughout the year than countries at the same latitude. Two-thirds of its land area comprises mountains and small valleys, with less than 10% suitable for permanent crop cultivation. Water is the only natural resource in relative abundance in Lesotho.

Lesotho receives about 800 mm a year of rainfall in the western part of the country; it falls primarily during the summer months. In the Highlands in the east, mean annual rainfall is higher at about 1,200 mm and contributes about half of the Senqu River's flow (around 150 m^3/s). Inter-annual variations in rainfall are considerable, resulting in periods of droughts and flooding. Average total available water in Lesotho is estimated at 5 BCM annually.

Development context

Lesotho has achieved a substantial macro-economic performance since independence in 1966, despite political and social upheaval. With a current (2005) gross domestic product of US $550 per capita (near the average for sub-Saharan Africa), Lesotho is a landlocked economy, completely surrounded by the Republic of South Africa (RSA), which has a GDP of $3,535 per capita. Growth rates from 1960 to present have, on average, been around 5% per annum (a high of about 25% and a low of -15%).

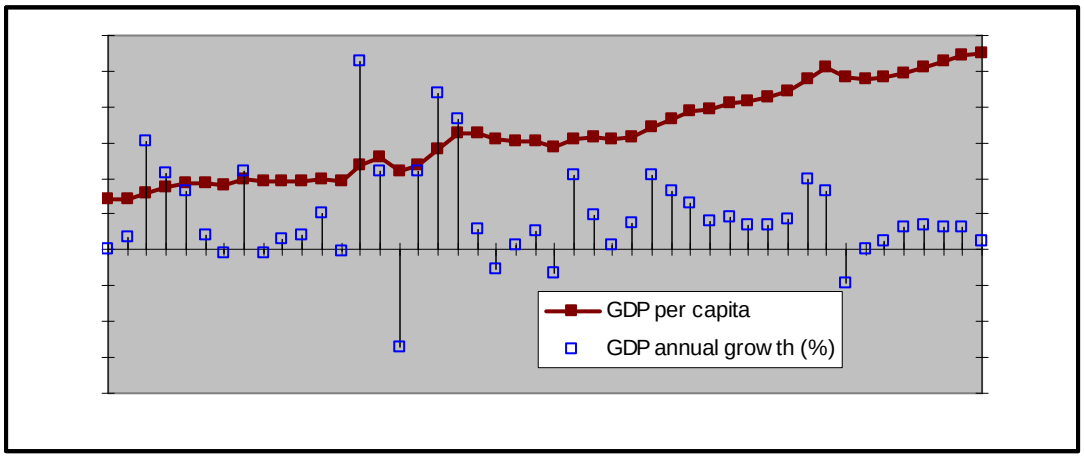


Figure 18: GDP annual growth (%) and GDP per capita (Source: World Bank data)

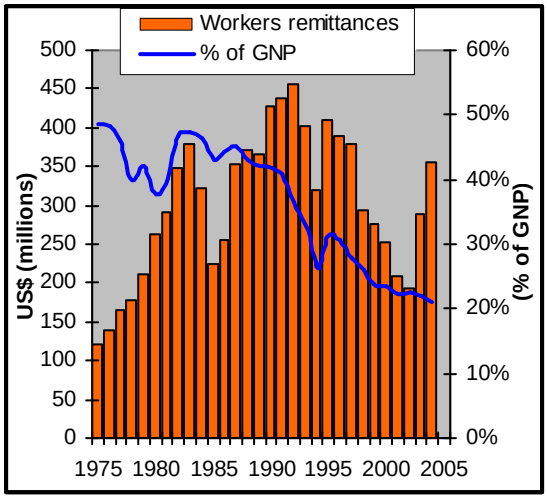


Figure 19: Value of worker remittances in Lesotho (and as % of GDP) (Source: World Bank data)

Lesotho has been economically dependent on the RSA: 90% of its imports come from the RSA while 65% of Lesotho's exports go to the RSA. Moreover, the gold mines in South Africa had been a major source of employment and income for the Lesotho labor force (miner remittances accounted for 62% of GDP in 1989). In recent years, remittances have declined significantly and now represent only about 20% of GNP (Figure 20). In addition to remittances from the migrant Basotho people, the economy was dependent on tourism, subsistence agriculture, and light manufacturing (e.g., textile, clothing, leather). The structure of the economy since 1960 has dramatically changed from a near 100% reliance on the agriculture sector to the industry and service sectors contributing the bulk share of GDP (about 40% each).

Nevertheless, agriculture is still the leading sector for the rural economy and provides employment and income for about 40% of the workforce (this has remained fairly constant since 1980). Total arable and permanent cropland is 325,000 ha (about 10.7% of Lesotho's total area). Irrigated agriculture is limited by the topography of the country (the estimated irrigable area is about 16,000 ha, or less than 1% of the total land area). Moreover, with per capita agricultural production falling since 1970, households must rely on external sources and imports to meet food requirements. According to the World Food Programme, the 1980 cereal production contributed to about 80% of the national requirements; by 2004, cereal production was contributing only 30%.

Moreover, prior to 2001, the energy resources of Lesotho were extremely limited despite growing demands (Figure 21) and the country was almost completely reliant on RSA for commercial energy supply (90% was imported). Primary fuel needs were met by local vegetation and agricultural residues, and supplemented by imported wood, coal, petroleum, and electricity. The development of hydropower was the only promising possibility in terms of commercial energy resources (2,000 GWh estimated). This, however, has changed dramatically and is discussed in this paper.

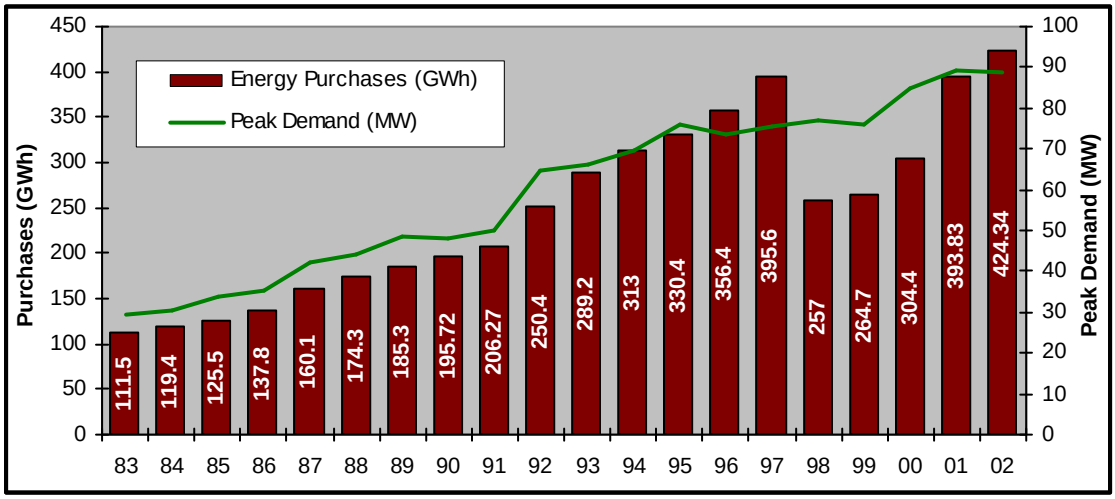


Figure 20: Energy Purchases and Peak Demands in Lesotho

Despite modest and consistent growth, poverty indicators have been stagnant. A major development challenge is that half the population lives below the poverty line and income inequality in Lesotho is among the highest in the world. Over time, Lesotho has experienced a decline in the Human Development Index and life expectancy, reflecting the high HIV/AIDS prevalence rate. This has estimated to have affected GDP annually by 2.4% between 1992 and 2002. Poverty is also overwhelmingly rural in nature. About 70% of the population lives in the rural and mountainous areas where income is generated from traditional, largely subsistence, low value-added agriculture and herding. However, overstocking and inadequate herd management have led to overgrazing, widespread soil erosion, and limited production. Finally, unemployment remains generally high (from 23% in 1986 to 45% in 2002).

A major development objective for Lesotho prior to the Lesotho Highlands Water Project (LHWP) was to broaden the economic base and reduce vulnerabilities to external factors (i.e., reduce economic reliance on RSA). The country possesses few exportable natural resources. Until only recently, the development of a modern industrial sector has been limited by the small size of the domestic market, the necessity to import nearly all raw materials and intermediate goods, proximity to the highly industrialized South Africa, and a shortage of skilled manpower. However, the average total available water in Lesotho was about 5 BCM and current national consumption is not more than 60 MCM. Allowing for increased water consumption resulting from normal population growth and additional usage for industry and agriculture, available

water resources far exceeded future requirements. ***Thus, given the slim natural resource base, the relative abundance of water provided a unique opportunity for Lesotho.***

Water issues in South Africa

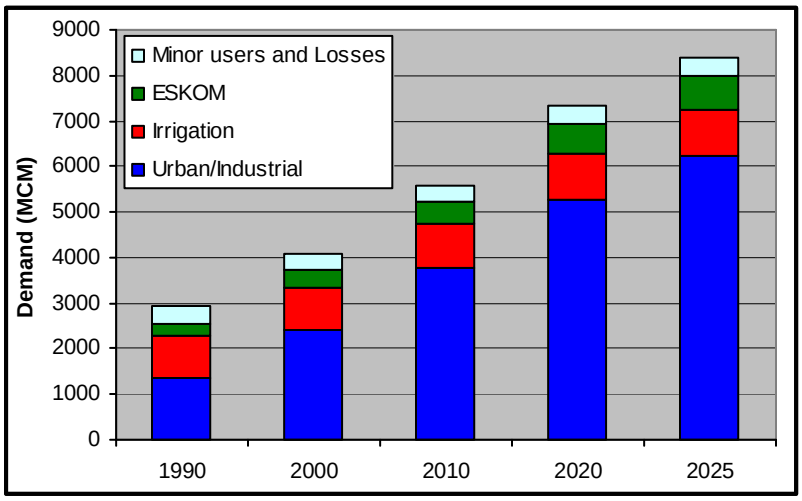


Figure 21: Vaal River Supply Area Existing and Projected Water Demand

South Africa was chronically short of water. The mean annual rainfall in South Africa is 500 mm, and generally decreases from east (about 1,250 mm) to west (about 50 mm on the Atlantic Ocean coast). Only 20% of the total land surface area receives more than 800 mm per year.

Evaporation rates tend to be high, ranging from about 1,200 mm in the east to about 2,750 mm in the west. Thus, only about 9% of the mean annual rainfall reaches the rivers as runoff and is equal to about 54 BCM. Only about 60% of this amount, however, can be utilized. Available water is estimated at 1,300 m^3/capita (e.g., compared to Israel at 450 m^3/c and the United States at 9,913 m^3/c).

The situation in the industrial heartland of Gauteng, however, was even worse: supply was not sufficient to meet the large and growing demands. By the mid-1980s water demand in Gauteng had outstripped the mean annual utilizable runoff of the Vaal River. With the region comprising almost 60% of the national GDP and 42% of the urban population, water needed to be imported to meet the growing supply-demand gap (only 8% of the total water runoff is available to this region). Moreover, the Department of Water Affairs and Forestry (DWAF) estimated in 1989 that the total water demand in the Vaal River supply area would increase by 3% per annum (from 2,843 MCM in 1989 to 8,370 MCM by 2025). Projections by sector are given in Figure 22. Most of this increase was projected for the industrial and urban sectors (mostly in the Gauteng region).

B. PROJECT OBJECTIVES AND DESCRIPTION

It was in this context – the relative abundance of water in Lesotho and the enormous projected water demands in South Africa – that the LHWP was envisioned. The feasibility of diverting large quantities of water from the Senqu and Orange Rivers to the north was studied in the 1950s and 1960s. Through a series of dams and tunnels, LHWP was to divert a portion of the water currently leaving Lesotho in the Senqu and Orange

Rivers northward to the Vaal River Basin in the Gauteng Province of RSA. The LHWP takes advantage of the head differential between the highlands and lowlands to generate hydropower for Lesotho. The LHWP is implemented in five phases (the first phase has been completed), which would together transfer 70 m^3/s of water to South Africa. Phase 1A, which transfers 16.8 m^3/s, delivered the first water in January 1998 and began delivering electricity in late 1998. Phase 1A cost about US $2.5 billion (of which the World Bank financed less than 5%); 15% of the total cost was for the hydropower plant. Phase 1B transfers an additional 11.8 m^3/s and costs US $880 million (of which the World Bank financed $22 million). Table 4 gives a summary of the phases.

Table 4: Summary of the LHWP Project

	Phase 1A	**Phase 1B**	**Phase 2**	**Phase 3**
Primary infrastructure	Katse Dam	Mohale Dam	Mashai Dam	Tsoelike Dam
Dam height (m)	185	145	182	155
Active storage (000 m^3)	1519	850	2430	1250
Power generation (MW)	72	N/A	166	N/A
Water transfer capacity (m^3/s)	16.8	11.8	28	8.6
Transfer tunnels	Yes	Yes	Yes	No

Note: Phase 4 and 5 include the construction of Ntoahae and Malatsi reservoirs, respectively.

Box 4: Details of LHWP Phase 1A and 1B

Phase 1A was completed in 1998 and consisted of the Katse Dam, a concrete arch dam built across the Malibamatso River. This phase also included: 1a) a 55 m arch dam at Muela, 2) a 45 km long transfer tunnel between the Katse reservoir and Muela, 3) a 72 MW hydropower plant at Muela, 4) a 125 km 132 kV transmission line from Muela to Maseru, 5) a 15 km delivery tunnel which carries water to the Ash River and eventually into the Vaal River, and 6) 200 km of new access roads, including several bridges.

Phase 1B was completed in 2002 and consisted mainly of the construction of the Mohale Dam. This phase also included: 1) a 32 km tunnel from Mohale to Katse, 2) a 15 m concrete weir at Matsoku and associated 6 km tunnel to Katse, and 3) upgrading of about 60 km of existing roads and construction of 21 km new roads.

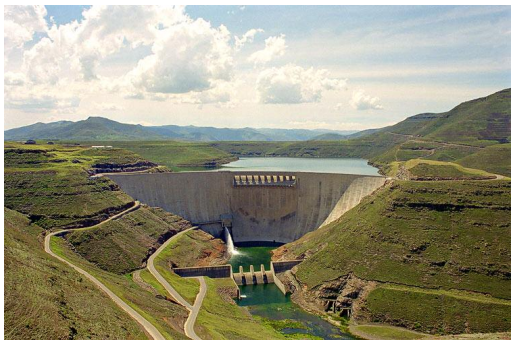


Figure 22: Katse Dam

Figure 23: Mohale Dam

The objectives of the LHWP, as described on the project website,[28] are:

- To provide revenue to Lesotho by transferring water from the catchments of the Senqu and Orange Rivers to meet the growing demand for water in the major industrial and population centers in RSA
- To generate hydropower for Lesotho
- To provide the opportunity to undertake ancillary developments such as the provision of water for irrigation and potable water supply
- To promote the general development of the remote and underdeveloped mountain regions of Lesotho, while ensuring that comprehensive measures are taken to counteract any adverse effects the project might have on the local population and their environment.

Established agreement

The Treaty on the Lesotho Highlands Water Project between the Government of the Kingdom of Lesotho and the Government of the Republic of South Africa is the basic agreement between the two Parties to implement the LHWP. The Treaty, which was signed in 1986, covers the rights and obligations of each Party and lays down the quantities of water to be delivered, the cost sharing provisions, and the scope and calculation of payments for the water. It also sets out the principles for financing, constructing, and operating and maintaining the system. ***Most importantly, the Treaty recognizes that there are real benefits to cooperating[29] and explicitly defines the mechanisms for which the two countries will share the cooperative gains from joint development.***

Key provisions of the Treaty include:

- RSA is responsible for all costs of the LHWP related to the transfer of water (including construction, operation and maintenance, and social and environmental mitigation measures), whether incurred directly by RSA or initially financed by loans to the Government of Lesotho or Lesotho Highlands Development Authority (LHDA). These debt service- and cost-related payments will be met by RSA, regardless of the project's performance. Lesotho is responsible for any hydropower costs or any ancillary development.
- The Treaty commits the parties to the first two phases of the project (1A and 1B), with provision for future phases. That is, the Treaty commits to 38 m^3/s and not the full 70 m^3/s development.
- RSA will pay Lesotho royalties for water transferred and Lesotho will receive all hydroelectric power generated by the project. Article 12 provides that South Africa

[28] http://www.lhwp.org.ls

[29] The Treaty states: "Recognizing the advantages of regional development and that co-operation between the Parties with regard to the development of mutual water resources can significantly contribute towards the peace and prosperity of the Southern African region and the welfare of its peoples."

share the net benefit with Lesotho on the basis of 56% on the part of Lesotho and 44% on the part of South Africa, with the net benefit computed as the difference between the present value of the LHWP and similar alternative projects.

③ 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.

On this last provision, it is important to note while the Treaty is explicit in requiring that no person is made worse off by the project, this is in contrast to the LHWP's objectives, which sought to actively promote development in communities affected by the project. Article 4 of the Treaty also states that each country will be allowed the opportunity to undertake ancillary developments (i.e., investments that would fully take advantage of the existing infrastructure) in its territory including 1) the provision of water for irrigation, potable water supply and other uses, 2) the development of other projects to generate hydroelectric power, and 3) the development of tourism, fisheries, and other projects for economic and social development. Thus, the Treaty does provide for this possibility and does not preclude the development of other projects that may or may not impact the LHWP, provided that obligations under the Treaty are met.

Institutional arrangements

The Treaty establishes national and bi-national institutions to support the project's development (discussed below). At the national level in Lesotho, the Ministry of Natural Resources, and in the RSA, the Department of Water Affairs and Forestry (DWAF) are designated to implement specific provisions of the Treaty. The primary autonomous institutions established are:

The **Lesotho Highlands Water Commission** (prior to 1999, the Joint Permanent Technical Commission) comprises representatives of both governments (RSA and Lesotho) and has overall monitoring and advisory responsibilities. The LHWC is responsible for ensuring that 1) the overall project is efficiently implemented and operated, 2) funds expended by LHDA for the implementation of the water transfer component qualify as costs for reimbursement under the Treaty, and 3) agreed quantities of water will be delivered to RSA according to the established time schedule. The LHWC also serves as a conflict resolution mechanism between the two Parties. The LHWC must also be consulted in matters related to budgets, operation and implementation plans, maintenance plans, tender procedures and documents, appointment of consultants and contractors, allocation of costs, and financing arrangements and loan agreements.

The **Lesotho Highlands Development Authority** is charged with the engineering, construction, and operation and maintenance of the LHWP in Lesotho. LHDA is overseen by a Board, appointed by the Lesotho Minister of Natural Resources and the LHWC. LHDA is mandated to, *inter alia*, 1) capture and transfer water from Lesotho to

RSA, 2) generate hydroelectric power for Lesotho, 3) maintain agreed rates of flow, 4) effect all necessary catchment conservation measures to prevent pollution, and 5) ensure that members of local communities will be able to maintain a standard of living not inferior to current conditions.

The **Trans Caledon Tunnel Authority (TCTA)** is mandated with the engineering, construction, and operation and maintenance of the project works in South Africa, and is designated by the RSA as the authority responsible for ultimately bearing all project costs and project debt. TCTA then sells water to DWAF in RSA with the aim of full cost recovery.

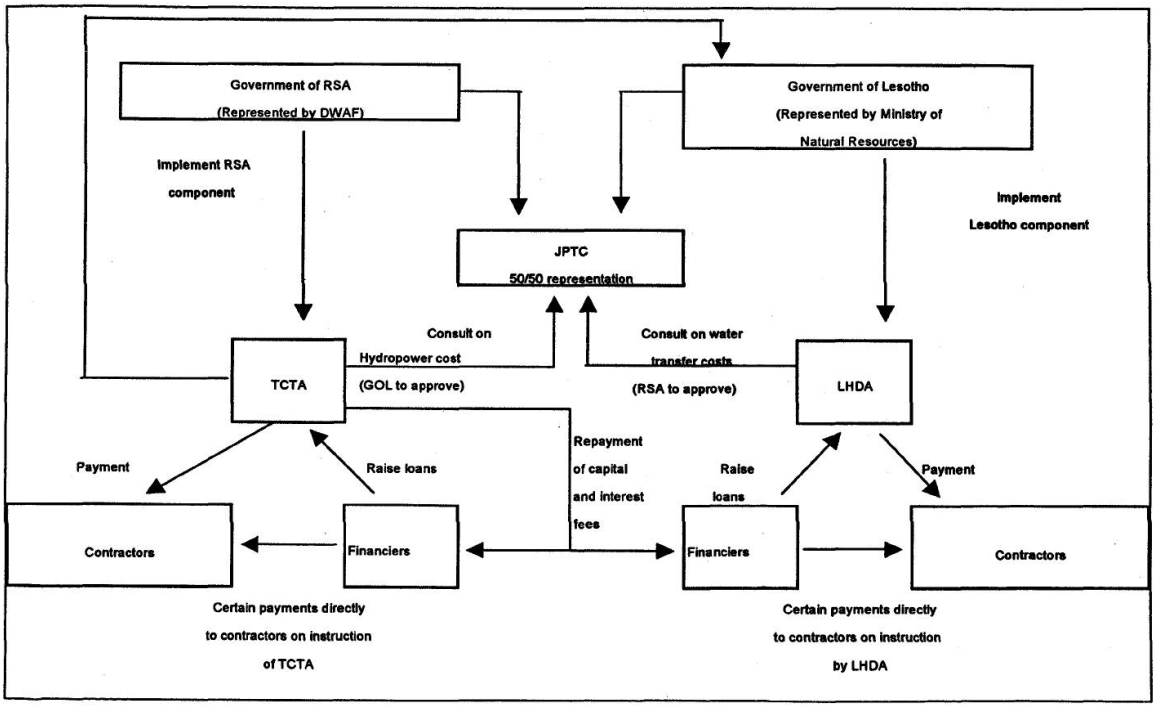


Figure 24: Institutions to manage and implement LHWP

C. QUANTIFYING ECONOMIC BENEFITS AND COSTS

The LHWP Treaty is unique in that it explicitly stated how benefits from cooperative development would be shared, instead of the water itself. South Africa had its highest-value use for the water in the Vaal River system, which provided domestic and industrial water to the Johannesburg and Pretoria areas in Gauteng. South Africa could, therefore, simply transfer the water from within its own boundaries to the Vaal system. However, if the water were captured in the Senqu system in the Lesotho Highlands, much of the flow to the Vaal system could be gravity driven and through a much shorter and less complex series of civil works than would be required to transfer the same amounts from the Orange River in South Africa. Therefore, a potential win-win benefit for both Parties was clear.

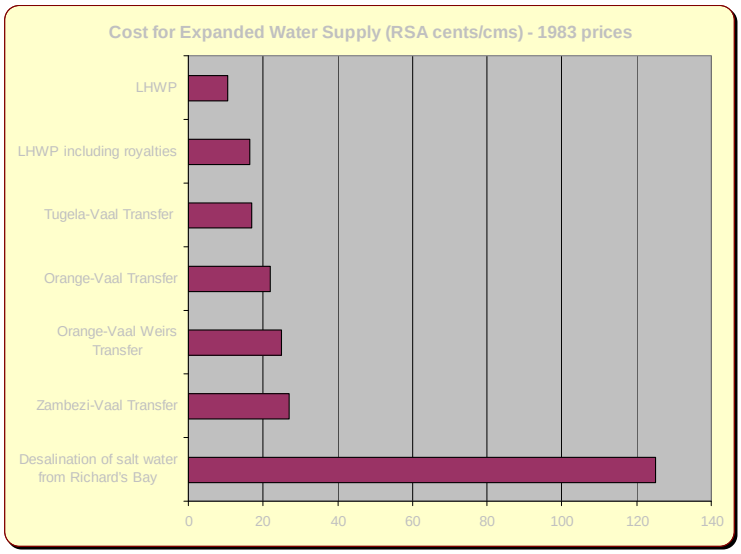


Figure 25: Results of the 1983 analysis of alternatives (Source: World Bank, 1991)

An appropriate approach to estimating the benefits of a transfer from the Lesotho Highlands was to consider the difference in cost to RSA between two projects for a fixed amount of delivered water. One of these two projects was entirely within the RSA and the other required cooperation between Lesotho and RSA. This cost savings calculation (or economic rent) was used as the basis to determine the royalty paid directly to Lesotho.[30] In summary, the royalties were not for the water explicitly, as the water would flow into RSA regardless, but rather the cost savings for undertaking LHWP.[31] A comparative analysis of different water supply options revealed that LHWP was indeed the least-cost option (at least by 200% according to World Bank, 1991; Figure 26).

How this net benefit would be shared between each riparian was stated in the Treaty and was largely a matter of negotiation.[32] Specifically, Article 12 provided that South Africa undertake to share with Lesotho, by way of royalty payments, the net benefit (56% for Lesotho and 44% for South Africa) computed as the difference between the present value of the LHWP and similar alternative projects. Thus, RSA would pay royalties to Lesotho equivalent to 56% of the cost savings identified by going forward with the LHWP. At the time of the signing of the agreement and using 1) the available reservoir and flow data and 2) a 6% discount rate and a January 1995 base-year, it was estimated that the net benefits to Lesotho and RSA would be approximately $360 million and $280 million, respectively.[33] These amounts would be recomputed as provided by the Treaty, but served as an early estimate of the benefits of cooperation. Moreover, it was anticipated early on that Lesotho could, as a result of the LHWP, receive additional

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[30] So, unlike the practice for resource-extractive industries (e.g., oil and gas, mining, forestry) where royalties are calculated on either the market value of the good or the volume of the resource extracted without reference to the overall profitability of the project, the method used in the Treaty and in calculating the royalty explicitly values the economic rents of LHWP (Rothman, 2000).

[31] This is an important distinction as many South African officials were careful in clarifying the "royalty" on the water transfer to avoid confusion over the actual "rights" and status of water (Baillat, 2005).

[32] The project was identified (including feasibility studies) early on, but failed to materialize because governments could not agree on the payment terms.

[33] Using a ~3.6 million = $1 exchange rate.

revenues from the Southern African Customs Union (SACU) for LHWP imports, increased tax revenues as a result of the project activities, and additional revenues from the spread in concessionary financing and debt service payments from RSA.

Specifically, in regards to the formula used to calculate the delivery payment, the net benefit comprised of an investment element representing the capital investment costs difference, an operation element representing the electricity costs difference attributable to pumping operations, and an operation and maintenance element representing the remaining O&M costs difference. Details of this calculation were agreed upon in the Royalty Manual.

This net benefit reflects an approximation of the economic benefits to cooperation. This is only an approximation, as additional benefits (e.g., rural infrastructure in Lesotho, tourism) and costs (e.g., social disruption, resettlement) that were enabled from the larger LHWP project were not necessarily equally distributed between the Parties. South Africa, which incurred the project costs (including a majority of the environmental and social mitigation expenditures) and made royalty payments to Lesotho, gained the consumer surplus and bulk sale benefits of the additional water and other indirect multiplier benefits. Lesotho, on the other hand, incurred the environmental and social losses and a small portion of the cost to mitigate these losses, received none of the benefits from water use, but received the royalties and hydropower benefits and multiplier effects from the economic activity and infrastructure as well. According to World Bank project documents, whether from the RSA, Lesotho, or entire project perspectives, the cost-benefit analysis revealed positive net present values.

Table 5: Summary of Incremental Benefits and Costs of LHWP Phase 1

	LHWP Project	**RSA**	**Lesotho**
Costs	③ Project Costs ③ Environment and Social Mitigation ③ Environment and Social Losses ③ Downstream Losses	③ Project Costs ③ Water Royalties ③ Environment and Social Mitigation (RSA share) ③ Downstream Losses	③ Environment and Social Losses ③ Environment and Social Mitigation (GoL share)
Benefits	③ Consumer Benefits ③ Revenue from Bulk Water Sales ③ Hydropower Benefits ③ Environment and Social Mitigation ③ Indirect Economic Benefits ③ Infrastructure	③ Consumer Benefits ③ Revenue from Bulk Water Sales ③ Indirect Economic Benefits	③ Water Royalties ③ Hydropower Benefits ③ Environment and Social Mitigation ③ Indirect Economic Benefits ③ Infrastructure

D. ACTUAL BENEFITS AND COSTS

Water deliveries and revenues to Lesotho

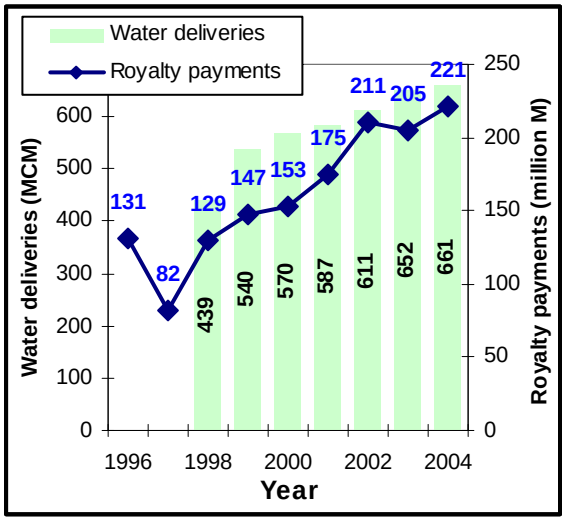

Figure 26: LHDA Water deliveries and royalty payments

To date, significant royalty revenues for water deliveries have accrued to Lesotho (Figure 27). The total water delivered through December 2003 to RSA is 3,315 MCM. Royalty payments received from RSA up through the end of 2006 were M1,918 million. This is 167% more than what was originally expected. Although larger than expected, the net present value and economic rate of return of the project in an ex-post analysis (World Bank, 2007) were lower than originally appraised, despite lower project costs (about 30% less). This was primarily due to changes in water demand in RSA (see Box 5) and the implementation of an in-stream environmental flow requirement. Nonetheless, the net benefit to Lesotho is approximately $0.12 per m^3 delivered. Finally, cumulative SACU revenues by 2007 were M1,060 million and additional tax revenues due to LHWP were M1,124 million by 2005. The impact of these royalties and associated revenues are shown in Table 6.

Box 5: The South Africa Demand Assumption

The planning for Phase 1 was based on projections of water demand in RSA made in the mid-1980s, which served as the basis for the treaty demand curve and water delivery obligations. However, since then the RSA not only considered supply augmentation options but also recognized the importance of addressing demand-side issues. Four developments took place to influence the pattern of demand: 1) water restrictions imposed from 1983 – 1987 and twice in the 1990s, 2) increase in water tariffs (a 25% increase for consumers) to move towards economic pricing of water, 3) use of incentive measures to encourage greater efficiency and conservation of water use, and 4) the population of RSA was about 4 million less than previously estimated. Therefore, during the preparation of Phase 1B, it was unclear whether delaying this phase would be prudent. An analysis by the World Bank (1998) showed that Phase 1B could be delayed by up to 7 years. However, the cost implications (e.g., contractor remobilization, SACU compensation, foregone hydropower benefits) were determined to outweigh the potential cost savings of delay.

Table 6: Fiscal Accounts as a % of GDP

	1981-1987	1987-1998	1998-2004
All Revenues	19.7	40.5	40.8
SACU customs revenue	8.2	21.0	19.2
Non-customs tax revenues	6.4	12.6	14.2
Water royalties	0.0	0.4	2.4

Source: World Bank Lesotho Country Economic Memorandum (2005).

Hydropower generation and sales for Lesotho

To date, annual energy production has been about 400 GWh, which has been adequate to meet domestic needs and generate export revenues (Table 7). According to the Lesotho Country Economic Memorandum (World Bank, 2005), the power generation costs are, however, higher (due to delays in securing financing and a 30% drop in the real price of electricity from Eskom) than the costs to buy power from South Africa. The costs of electricity generation can be reduced to reasonable levels if the power plant is operated at full capacity and excess power is exported (in 2005 representing less than a percent of total production). The prospects for future power sales will depend on growth in the demand for power in the coming years and a preference for hydropower, which is cleaner (South Africa generates using low-grade coal) and more suited to meeting peak demand.

Table 7: Electricity Generation and Sales Revenue

Year	Planned Generation (GWh)	Actual Production (GWh)	Peak Output (MW)	Electricity Sales to LEC (million M)	Export Energy (GWh)	Export Revenue (million M)
2001	387	371.57	78.1	44.13	-	-
2002	391	372.95	77.7	44.76	23.22	0.734
2003	389	377.93	78.5	43.25	35.32	1.305
2004	436	428.79	77.9	48.69	40.28	1.664
2005	424	419.83	74.6	56.35	2.39	0.428

Source: World Bank.

Macro-economic impact of LHWP

For a project of its size relative to the economy of Lesotho, it is no surprise that the LHWP has had an enormous and transformational impact. According to the most recent Lesotho Country Assistance Strategy (World Bank, 2006), the economy has undergone a fundamental transformation and structural change over the last 15 years. This has in part been due to an exceptional increase in foreign direct investment, mainly from RSA for the LHWP, which stimulated economic growth and generated sustained export revenues for the country (Table 8).

Table 8: Economic Growth Rates for Lesotho

	Pre LHWP (1980-1987)	**High LHWP** (1987-1998)	**Post LHWP** (1999-2004)
GDP (incl. LHWP) growth rate (%)	2.8	6.0	2.5
GDP (not incl. LHWP) growth rate (%)	2.8	5.4	3.3
GNP growth rate (%)	4.2	3.0	1.6
GNP p.c. growth rate (%)	1.9	1.0	0.2
Consumption growth rate (%)	n/a	2.8	1.3
Consumption p.c. growth rate (%)	n/a	0.7	-0.1

Source: Lesotho Country Economic Memorandum (World Bank, 2005).

Beginning in 1986, foreign direct investment associated with the LHWP changed the structure of the economy. During the high-LHWP period, the contribution of the primary sectors to GDP contracted. This period also coincided with the arrival of the textile and garments industry (supported by the African Growth and Opportunity Act) and the subsequent strong export performance of this sector. Both were associated with large-scale investments financed by foreign capital inflows and accelerated growth in GDP (about 6% per annum). Within the secondary sectors, the LHWP construction sub-sector grew at 116% per year and contributed 6% of GDP. Although its inter-sector linkages were few, the LHWP had positive spillovers into utilities and local construction. Growth in the electricity and water sectors escalated to 23% and local construction grew at 5% per year. The LHWP also spurred growth in services such as business, information technology, hotels, and tourism. This strong macro performance was partially offset by declining miner remittances as employment opportunities for Basotho in RSA mines declined (Figure 20).

Currently (post-LHWP period), more than 80% of GNP is produced domestically and GDP growth has slowed to about 3% in part due to significantly smaller flows of LHWP-related loans and grants. The Lesotho economy is now primarily export-driven with remittance income at about 20% of GNP. Private investment, mostly in the manufactured exports sector, has emerged as an important indicator of growth and contributes about 18% to GNP. Lesotho is now less dependent on the RSA.

To decompose the marginal impacts of LHWP investments, expansion of the textile and garment industry, and declining remittances on growth, a social accounting matrix was developed. This model (described in the Box 6) estimates that for a 6.2% growth rate during the high LHWP period that this growth can be decomposed as follows: 1) 4.8% growth associated with LHWP investments, 2) 2.3 % growth from the increase in garment exports, and 3) 1.0 % reduction in growth due to declining migrant remittances. Summary results are given in Table 9. Some additional results from the model include:

- The primary sector (agriculture, livestock and forestry) gained about 4 % in response to the LHWP and garment sector shocks, but half of this growth was offset by dampened demand due to shrinking remittance incomes.
- LHWP-related activity raised demand for manufactured products by an additional 2%, but half of this was trimmed away by declining remittances.
- Construction sector growth, a combination of local and LHWP-specific construction activity, was almost entirely propelled by LHWP investments and measured 17% per annum.
- The service sectors recorded growth rates ranging between 2 – 6%. The fastest growing sectors were transport, communications, business and financial services.
- Although the increase in LHWP investments dominated the hike in GDP growth rates, in each case, the positive impact of LHWP and garment sector expansion was eroded by declining remittances.

Box 6: Lesotho Social Accounting Matrix (SAM) 2000

The Lesotho national accounts-based SAM includes data from the 1994-95 household expenditure survey, 1999 labor force survey, 2000 agricultural census and information from the Central Bank for the year 2000. It comprises 53 activities and 57 commodities, 10 occupational groups for labor, 6 types of capital owners, 6 types of enterprises, 10 types of households covering urban, rural mountains, lowlands and Senqu River Valley with distinctions between rural and urban households, and various breakdowns of government revenues and expenditures. There are two accounts for parastatals, one for LHDA and the other for the remainder of the private sector.

Table 9: Summary Results from Lesotho SAM

Contribution to:	**Decline in remittances**	**Increase in LHWP investment**	**Rise in garment exports**	**Combined effect of all 3 shocks combined**
GDP growth	-1.0%	4.8%	2.3%	6.2%
Number of jobs created	-7,600	14,000	10,000	17,000
Employment growth	-1.6%	3.1%	2.3%	3.7%
Household income effect				
Change in income distribution	-2.1%	2.5%	1.2%	1.7%
- High income households	-1.9%	2.5%	1.2%	1.7%
- Low income households	-3.3%	2.2%	1.3%	2.1%
- Urban income households	-1.0%	1.6%	0.9%	1.5%
- Rural income households	-4.1%	4.3%	2.0%	2.2%

Source: Lesotho Country Economic Memorandum (World Bank, 2005).

SAM analysis of poverty

Despite the project's favorable contribution to economic development, the impact on poverty reduction has been limited. Although economic growth driven by LHWP and textile exports has increased per capita income significantly (a 4.7% increase per year during 1987–1997, compared with 1% during 1997–2004), poverty (in terms of incidence, depth and severity) remained virtually unchanged (as was shown earlier and in Table 10).

Table 10: Incidence, Severity, and Depth of Poverty

	Poverty Line (PL)		Ultra Poverty Line (1/2 PL)	
	1986/7	1994/5	1986/7	1994/5
Incidence	58.8	58.3	34.7	38.6
Depth	32.8	35.4	17.7	21.4
Severity	22.8	25.9	11.8	14.9

Source: Bureau of Statistics – estimates based on the 1987/8 and 1994/5 Household Budget Surveys.

The key insight of the SAM is that while GDP growth was sustained at 6.2% per annum for a decade, it was neither accompanied by sufficient job creation nor a significant increase in household income. There are a number of reasons for this, as detailed in the Lesotho Country Economic Memorandum (World Bank, 2005).

First, the primary sector, which supports the bulk of the rural poor, grew slowly concomitant with declining agricultural production. A substantial contraction in the share of primary sector GDP (a 24.3% contribution GDP during the pre-LHWP time period to a 18.9% contribution during the high-LHWP period) triggered large-scale losses in rural job opportunities. This was exacerbated by an increase in the proportion of poor returning to the rural areas (e.g., employment opportunities for the Basotho in RSA mines declined). Second, growth was excessively capital-intensive and although overall employment did increase, it did not reduce unemployment rates of over 25%. Third, rural areas, where most poverty is concentrated, benefited little from the LHWP and the garment sector growth. Approximately 40% (or 6,800 of the new jobs) were in the primary sector, where average earnings were not high enough to pull households out of poverty. This was offset fully, however, since about 90% (or 6,800 of the job losses) occurred in the primary sector due to falling remittances. Finally, most of the jobs created were in the manufacturing and/or urban areas. Construction jobs that were created by the LHWP required high-skill workers who initially came from RSA. By later years in the LHWP (primarily Phase 1B) more local opportunities were made available to the Basotho.[34]

[34] During Phase 1B, the Basotho benefited from nearly 12,500 person years of work. The Basotho earned M540 million in 2002 prices or nearly 7% of GDP. Both skilled and unskilled labor benefited from this employment. Additionally, through contracting, Basotho received nearly M98 million for about 1,700 person years of work. Under major civil works, the Basotho were paid

In summary, wage-paying employment opportunities in the LHWP and garment industry were insufficient to lower unemployment rates, while most workers in rural households remained unemployed or were underemployed in subsistence agriculture. Difficulty in translating this economic growth into poverty alleviation results was highlighted in the 1996 and 1998 Country Assistance Strategies (World Bank, 1996, 1998). In the absence of the LHWP though, poverty rates could have increased substantially (given the declining trend with remittances).

Revenue funds for project affected communities

Lesotho sought to use the revenue boom due to LHWP to reduce rural poverty. From the outset it was well understood that the LHWP would contribute to economic growth, but not much to employment and the rural poor (World Bank, 2005). Thus, the Government of Lesotho aimed to channel a portion of the revenues from the project into a dedicated fund (with the remainder going directly into the Government budget). The original aim was to channel 75% of the SACU revenue windfall, including water royalties, towards rural development (mostly rural access roads, footbridges, water supply systems, and soil conservation). Water royalties from the LHWP began to flow in 1996 and a significant portion of these revenues was initially placed into the Lesotho Highlands Revenue Fund (LHRF). While there had been some initial success in starting a poverty-focused public works program, the Fund suffered from a number of weaknesses. The selection of some of the investments was not transparent, technical designs were weak (some of the dams and roads have been washed away) and weaknesses were detected in financial control and monitoring. Fund operations were suspended in 1997. Linked to Phase 1B (and prerequisite for World Bank support) a new restructured fund (the Lesotho Fund for Community Development, LFCD) was established aimed at ensuring community-driven development, employment generation, and poverty reduction.

By 2006, 101 projects were identified. Of these, 58 projects had been completed, 26 had been suspended, and 17 were ongoing. The annual average amount disbursed was only about M22 million (compared to the original M75 million target). Cumulative expenditures between 1991 (LHRF) and 2002 (LFCD) were about M200 million and are estimated to have provided average monthly employment of 3,702 workers on a full-time equivalent basis. It is reported that the funds had gone into building 1,100 km of rural roads, 210 earth-fill dams, 60 footbridges and forestry conservation works by 2002.

In summary, the use of a revenue fund to redistribute the wealth generated from the LHWP is a challenge. These funds have not been entirely successful due to numerous factors, including weak and politicized implementation, low capacity of communities to manage large construction projects, lack of local government structures, projects that are not demand driven, lack of technical support, and lack of a monitoring strategy. The World Bank (2007) concludes that given the Government of Lesotho's existing sound

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M110 million in consultancies. Unlike Phase 1A, nearly 50% of the supervisory consultants were Basotho.

allocation framework, off-budget support in this context may not be the most appropriate mechanism for redistributing project revenues towards rural development.

Environmental and social issues

Much has been written about the environmental and social impacts of the LHWP, more than can be adequately covered here.[35] ***It is important to note that in the context of benefit-sharing, the Treaty does not explicitly set out how the benefits of cooperation would be shared with the communities immediately affected***. Article 15, states that:

> 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 maintenance of existing welfare conditions is also referenced in Article 7:

> The LHDA shall effect all measures to ensure that members of local communities in the Kingdom of Lesotho, who will be affected by flooding, construction works, or similar project related causes, will be enabled to maintain a standard of living not inferior to that obtaining at the time of first disturbance.

The environment and social components under Phase 1A and 1B represented approximately 3% ($70 million) and 12% ($120 million) of total project costs, respectively. In general, the key environmental and social impacts associated with the civil works of LHWP were assessed to be successfully mitigated under Phase 1B; all affected sites were successfully rehabilitated, household standards of living maintained, comprehensive compensation paid,[36] and downstream impacts mitigated (World Bank, 2007). The more challenging activities were those associated with broader development issues (i.e. revenue fund), which were a key objective for the LHDA.

A phased approach to the development of the LHWP has allowed the project planners to adapt and to eventually become more responsive to the needs of the community. Some significant environmental achievements include: nature reserves, fisheries development, biological monitoring, introduction of a breeding program for the Maloti Minnow, and environmental education programs. Some significant social achievements beyond maintaining the pre-LHWP welfare of the community include: 2,545 VIP toilets to 126 Highland villages, rural infrastructure, secondary and tertiary education for qualifying children, a small business credit scheme, and rural income enhancement

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[35] Readers are referred to Ambrose (2006) and Matli (2005).

[36] The compensation package was designed to include individual compensation for fixed assets, including dwellings, gardens, trees, *kraals*, and graveyards. Compensation for the loss of communal grazing lands, access to common property, brushwood fuel, useful grasses, medicinal plants, and wild vegetables was made through community-based compensation and development programs in agriculture, tourism, and small business support.

programs. The extent of the community's involvement in the planning and selection of these activities has been a constant challenge, but has improved over time.

E. CHALLENGE OF GROWTH VERSUS POVERTY ALLEVIATION

At the heart of the LHWP is the 1986 Treaty that explicitly lays out the terms for sharing the benefits of cooperation. This Treaty is unique in that the Parties recognize the advantages to cooperating on the development of mutual water resources and the opportunity for mutual gain. For South Africa, to augment supplies to meet the growing demands in the Gauteng by transferring water from the Orange River would have been a costly proposition. By cooperating, a least-cost option of transferring water directly from Lesotho could be negotiated and a win-win opportunity realized. The Treaty explicitly sets how the cost savings to RSA for undertaking the LHWP would be shared (56/44%) with Lesotho by way of annual royalties.

The Treaty only requires that affected communities be made no worse off. The LHDA, however, undertook as one of its objectives to promote the development of these Highland communities. Although new cooperative benefits were realized and shared with local populations in Lesotho, the experience has been a challenge. It is clear that the revenues from the LHWP (e.g., water royalties, SACU receipts) have had a substantial impact on the economy of Lesotho, both in magnitude and in changing the underlying structure of the economy. Moreover, these revenues have been important in ensuring economic stability in the context of a changing national and regional economy. This is clear from both the macroeconomic indicators (e.g., contributing almost 5% to GDP growth 1987-1998) and also from the SAM modeling exercise that was described earlier. Unfortunately, during the decade of the high-LHWP era, it was apparent that the record high growth in GDP did not translate into sufficient job creation or an increase in household income for the rural poor. This, however, must be interpreted with caution as presumably in the absence of the LHWP (with declining trends in remittances and the developments in the domestic market) poverty could have worsened.

A direct financial mechanism was devised to channel these revenues into local development. Concerted efforts were made at the beginning to consider this as a development project and to redistribute the windfall in revenues. However, the revenue fund has been marred with difficulties in terms of technical support, transparency, and accountability since its inception. Some accomplishments have been made in terms of rural infrastructure, but on balance, this fund has done little for poverty reduction.

In summary, what the LHWP demonstrates is that there can be benefits to cooperation and that these can be explicitly determined and shared between Parties. How the benefits are shared between nations will often be a matter of negotiation. The 56/44 split adopted in the Treaty (as opposed to a straight 50/50 split) probably reflects the poorer economic state of Lesotho compared to RSA. ***The greater challenge is determining and finding mechanisms that can effectively and in a timely manner translate these new cooperative benefits into development and poverty reduction outcomes.***

V. Summary Findings

What follows are key summary findings from the previous case examples (Table 11):

1. ***In all three case studies, cooperation between riparian countries offered possibilities for mutual gain***. These gains represent additional benefits that could not otherwise be achieved if each riparian acted unilaterally. For the LHWP, the Republic of South Africa required additional water to meet growing industrial needs in Gauteng Province. Lesotho could transfer water to this region at least-cost compared to the alternatives available to the RSA and in return receive substantial royalties. The cost savings with LHWP represent an explicit economic gain to cooperation. For both the United States and Canada, additional upstream storage in the Columbia River Basin (CRB) was needed to provide downstream flood protection and power generation. Joint coordination in operations was required to maximize these opportunities. The jointly-owned infrastructure built in the Senegal River Basin (SRB) provided the necessary platform to reach (to date) largely power and irrigation objectives that none of the riparians could achieve individually given the substantial financial requirements. For all three case studies, from the historical and development perspectives, these potential mutual gains (both monetary and non-monetary) were the primary carrots for reaching resolution on these agreements.

2. ***These three case studies demonstrate that the process to reach a cooperative agreement is never expeditious***. The initial investigations into the LHWP began in the 1950s with feasibility studies undertaken in 1978 and the completion of Phases 1 and 2 (of 5) in 1998 and 2002, respectively. The identification for the potential to develop upstream storage in Canada began in 1944 with feasibility studies undertaken in 1959 and the completion of the Treaty storages between 1967 and 1973. The OMVS announced its work program in 1973 and Manantali and Diama dams were completed in 1988 and 1986, respectively. The reasons for protracted negotiations include difficulties in establishing benefits and costs, debates on an equitable division of benefits, unresolved roles and responsibilities between project and regional entities, existing national and sub-national institutions, and the political and policy environments.

3. ***Reaching resolution was complicated in part because of the difficulty in establishing the benefits and costs with certainty.*** System-wide hydro-economic analysis is a problematic exercise in the international context, as the coordination of inputs across borders introduces a greater degree of uncertainty than wholly domestic projects. For the SRB, the benefits of hydropower and navigation were calculated based on the comparative cost of equivalent alternatives (thermal power and rail and road transport, respectively). In practical terms this required, *inter alia*, future estimates of traffic volume, thermal power costs, and energy demands for each riparian. For the CRB, flood benefits were based on estimated flood damages avoided and power benefits were based on incremental power generated from additional upstream storage. Even the exercise of determining which storages to

adopt, however, was complicated by the fact that introducing additional storage into a system with an existing endowment of infrastructure would have uncertain complementary and substitutive economic effects. From the RSA's perspective, the costs savings of undertaking the LHWP were compared to the consumer benefits, which depended on future estimates of water demand and population growth. In fact, as became clear in later phases of the LHWP, both of these quantities had been over-estimated. For all three, differences between ex-ante and ex-post benefits may be quite large and understandable since riparian values and objectives are likely to evolve as more information becomes available.

4. ***For all three case studies, riparians focused on the division of benefits (and costs) of water use and not on the physical allocation of water***. By focusing on the allocation of benefits, the riparians in these case studies had far greater scope for identifying mutually beneficial arrangements. For instance, in the CRB, the discussions between the US and Canada revolved around determining the combination of storages that would generate the most economic power and flood protection. Many different options could be evaluated and discussed. Negotiations on specific border flows would have been intractable. For the LHWP, although the project itself is an inter-basin transfer, the benefit arises because of the location of the water and not the quantity per se, as flows in the Senqu would reach RSA regardless. The distribution of benefits from hydropower, irrigation, and navigation development in the SRB were explicitly negotiated. By focusing on these benefits a richer set of development possibilities could be discussed with a greater potential to meet disparate riparian objectives. Note that for the CRB and LHWP, the primary benefits discussed were not consumptive in nature, thus avoiding what is typically a contentious issue.

5. ***For these three case studies, different approaches were used to divide mutual gains among the riparians. Achieving equity is critical, although not necessarily congruent with economic efficiency.*** In the SRB, the equal division of benefits would not be the most equitable because each member state had different development goals and varying abilities to utilize these generated benefits. For instance, navigation was a primary objective for land-locked Mali, thus, 86% of those benefits was negotiated at the expense of more irrigation and energy. For the CRT, an equal division (50/50) of gross benefits was advanced by the Canadian negotiators and ultimately accepted. A division of the net benefits would have been more appropriate from an economic perspective. Moreover, the final negotiated storages did not maximize the mutual net gains possible, suggesting the importance of non-economic considerations during negotiations (e.g., US political relations with Canada). For the LHWP, a negotiated division of the cost savings of 56/44 presumably reflects the relative economic and development positions of Lesotho and RSA.

6. ***Harmonizing regional institutions with national (and sub-national) levels of government is critical and requires clearly defined roles and responsibilities***. From these three case studies, institutions span the range of responsibilities from river basin planning to management and operations to both. The OMVS in the SRB is essentially a river basin organization with a clear planning and development mandate. This institution has developed into a strong regional body. Coordination

with national programs and policies is crucial to success, as evidenced by the results of OMVS's promotion of irrigated agriculture in the Basin. These early efforts in Senegal developed at a slower pace than anticipated due to conflicting national policies (e.g., lift on agriculture subsidies, shrinking public extension services). In contrast, the Permanent Engineering Board and the Lesotho Highlands Water Commission were specifically established to implement activities under their treaties. The LHDA, the LHWP Lesotho entity, however, has taken a larger role in planning and managing the overall development of the Highlands. This has resulted in some conflict with the Lesotho federal government. Thus, coordination between domestic Treaty institutions and existing government agencies must be carefully considered. Last, even prior to signing of the CRT, great effort was taken to clarify the roles and responsibilities between the Canadian federal and provincial governments. In particular, BC has ownership over the water resources in its boundaries and the authority to implement development schemes, while the federal government has the authority to negotiate, sign, and ratify international agreements. An additional three years was taken to come to an internal agreement (largely regarding the sale of downstream benefits to help finance the CRT storages) before the CRT could be ratified by the Canadians.

7. ***The degree to which ancillary developments are provided for can be an important determinant of long-run success***. These additional investments (beyond the infrastructure and resettlement and compensation amounts) can take advantage of the primary infrastructure to leverage additional positive development impacts. For instance, under the LHWP Treaty, specific provisions were made that would allow Lesotho to undertake extra developments in its territory (e.g., hydropower, irrigation, potable water supply, tourism, fisheries) so long as delivery obligations are met. Lesotho took advantage of the built infrastructure to develop hydropower and consequently is no longer a net importer of energy. Moreover, several activities were undertaken to promote the general development of communities in the Highlands to more widely and equitably distribute the benefits of the LHWP. However, largely in response to criticism over negative impacts, actions in the CRB were taken to give greater consideration to objectives beyond the original CRT objectives (e.g., fisheries, recreation development). Finally, in comparison to the more developed CRB, the infrastructure in the SRB has provided an important platform for future investments (e.g., most recently, energy production and in the future, navigation).

8. ***A major challenge is sharing (re-distributing) these cooperative benefits with local populations***. Here, two communities are of interest: direct project-affected populations and the broader basin population. In both the CRT and LHWP Treaty, direct inferences are made in treaty documents to maintaining (not improving) the welfare of those immediately affected by the project. The LHWP Treaty also requires maintaining the existing quality of the environment. Resettlement and appropriate compensation measures that will be satisfactory to all will always be a challenge. Beyond the project-affected populations, the three case studies reveal concentrated efforts to share benefits more broadly. For instance, Lesotho aimed to channel a portion of the revenues from the LHWP into a dedicated fund towards rural

development (mostly rural access roads, footbridges, water supply systems, and soil/catchment conservation). Although significant resources were made available from the LHWP royalties and some community infrastructure were built, the use of this fund to redistribute the wealth has not been entirely successful in improving the poverty situation in the Highlands. In the CRB, where most primary beneficiaries were located in the major urban centers, the Columbia Basin Trust was established to broaden the benefit base and restore the negative impacts on project-affected communities. Financed partially from the BC budget and partially from the Canadian portion of the downstream benefits, the Trust gives the community a partnership role in new power projects in the Basin and also supports social, economic, and environmental development of the Basin community. Similarly, in response to growing concerns over the impacts on several groups in the SRB, the OMVS passed in 2002 a new Water Charter to refocus its objectives to achieve a more equitable distribution of benefits to the population in the Basin.

9. ***Greater involvement of local stakeholders is an opportunity for broader benefit sharing.*** In all three case studies, little stakeholder involvement occurred early in these programs. However, project entities are increasingly recognizing the importance of consultation in planning and achieving poverty reduction outcomes. With the Water Charter in the SRB, membership to the Permanent Water Commission is extended to not only government agencies but to other stakeholders (e.g., farmer and fisher associations, civil society). Under the Lesotho development funds, an effort was made to involve the communities in the planning and managing of these local projects (with mixed successes). Last, extensive stakeholder participation has occurred through the Columbia Basin Trust. Moreover, BC has begun a stakeholder consultation process (Water Use Planning) to more closely involve these groups in reservoir operations to reflect other local objectives (e.g., fisheries, recreation).

10. ***Building flexibility into project agreements and institutions is crucial for addressing future changes***. The environments within which these projects and treaties reside are complex and ever evolving. By building provisions for periodic review and assessment, institutions can more adequately address emerging concerns and changing economic and system conditions. Soon after the construction of Manantali and Diama dams, several environmental concerns emerged that the OMVS was unable to resolve quickly. This was in part due to the lack of a clear mandate and authority. Moreover, for infrastructure that is jointly owned and managed, flexibility is an enormous challenge. The Water Charter now gives the OMVS a broader scope to respond. The CRT is a fairly rigid operating and planning document. The near-exclusive concern for power production and flood protection within the terms of a fixed 60-year agreement has caused some dissatisfaction. However, the entities have managed to find creative ways to address these shifting values (e.g., supplemental operating agreements to address fishing and recreation demands). Finally, the LHWP Treaty is similar to the CRT. However, the LHDA has managed to evolve beyond the engineering, and operation and maintenance of the LHWP to be more responsive to the needs of the communities in the Highlands.

VI. Moving Forward

The findings from these case examples illustrate that benefit sharing can be put into practice. This is of direct relevance to emerging transboundary river basin institutions in Africa where increasing scarcity and pressures on water resources will require cooperation. Policymakers recognize that this is needed to unlock the full benefits of sustainable water management for poverty reduction and economic growth. Some key lessons for future benefit sharing arrangements in river basins in Africa include:

Cooperation can offer distinct economic gains. By focusing on the division of benefits and not on the physical allocation of water, mutual gains can be identified that are both substantive and transformative in nature. The cooperation that was achieved here in these examples did not come easily. The development context and prevailing socio-economic conditions at the time, rational and perceived economic gains by all parties, and eventual strong political support were all important to reaching an agreement. These specific conditions may not always exist in other river basins and so timing can be critical. However, other forms of cooperation (e.g. information and data sharing) may be worthwhile for building the foundation for regional dialogue and future benefit sharing in water resources.

Patience and perseverance are needed. The process to reach a cooperative agreement can take decades, in large part because of the technical complexity of regional projects, the difficulty in establishing benefits and reaching an equitable division of gains, differing policy and political environments, and the time needed to define roles and responsibilities among project, national, and regional institutions. Patience is needed. The transaction costs for engaging in such a long process may be large, but the benefits to share may outweigh.

Quantifying benefits is always a challenge, but the process is more critical. Deals frequently stall or collapse under the weight of uncertainty around the benefits to be derived and shared. Though, quantifying benefits and costs with precision by its very nature will always be a challenge and perhaps an unrealistic goal. In fact, in some cases the differences between ex-ante and ex-post benefits may be quite large as riparian values and objectives evolve. What matters most is that an agreed framework (or principles of engagement) for quantifying benefits is put in place to give the riparian countries both sufficient guidance and latitude in reaching a mutual agreement. This process must be transparent at all times.

The division of benefits will be negotiated and a matter of equity. Different approaches can be taken to divide mutual gains among riparians. Achieving perceived equity is most important to concluding an agreement and may not necessarily be congruent with the ideas of economic efficiency. That is, discussions should provide for enough latitude such that non-economic criteria and some degree of subjectivity can shape the final negotiated outcomes.

Institutions and stakeholder involvement matter for long-term success. The long-term success of cooperative development depends on the strength of the regional institution and degree of harmonization with national levels of government. Institutions and project agreements need to be flexible in nature, building in provisions for periodic review and assessment, to more adequately address emerging and unanticipated concerns and evolving economic and system conditions. LeMarquand (1977) states eloquently that the "… goal would be to achieve an agreement in which the fortunes of the basin countries will rise and fall together, without there being a relative shift in the distribution of costs and benefits that can cause dissatisfaction and irritation". Extensive stakeholder involvement is critical to ensuring this long-term satisfaction with an agreement.

FUTURE CHALLENGES AND AREAS FOR CONTINUED INVESTIGATION

These three case studies offer reference points for emerging institutions and negotiations on new agreements. However, several outstanding challenges remain and should be carefully considered when crafting future benefit sharing arrangements. These include, among others:

- With predicted water resource changes in some basins making it more difficult to predict, quantify, and capture economic benefits, how can agreements be made more robust to future climate change?
- To ensure popular support for an agreement, which rent sharing (e.g. revenue sharing, development funds) approaches are most likely to succeed and achieve local level development objectives?
- Are some economic valuation methodologies more robust than others?
- Are some economic valuation methodologies more easily accepted and understood by negotiating parties?
- Can benefit-sharing arrangements take into account water quality benefits?
- What additional challenges do transboundary groundwater aquifers bring to these discussions?
- In establishing a river basin organization (or regional treaty institution), what committees or structures are needed to ensure harmonization with national level policies?
- Under what conditions should agreements and treaties embed operational system guidance?
- Under what conditions should agreements and treaties only provide for general principles of engagement?

Finally, although only three case examples were reviewed in this paper and several questions remain, these experiences and others demonstrate that benefit-sharing is more than an abstract ideal.

Summary Table 11: Findings from Three Case Studies on Benefit Sharing in International Rivers

	Senegal River Basin	Lesotho Highlands Water Project	Columbia River Basin
Countries (% of Basin)	Senegal (10) , Mali (53), Mauritania (26), Guinea (11)	Lesotho, South Africa (no Basin)	United States (85), Canada (15)
Basin pop. (million)	12	2.2 (Lesotho)	6
Area (km^2)	300,000	30,000 (Lesotho)	670,000
Annual flow (BCM)	25	10 (Orange-Senqu River)	250
Annual precip. (mm)	150–2000	800-1200	200-2500
Key treaty/project agreements	Convention (1972a,b); Convention (1978); Convention (1982); Water Charter (2002)	Lesotho Highlands Water Project Treaty (1986)	IJC Principles (1959); Columbia River Treaty (1961); Exchange of Notes and Protocol (1964)
Identification	1970s	1950s (feasibility studies in 1978)	1944 (feasibility studies in 1959)
Primary infrastructure	Manatali (1988), Diama (1986)	Katse (1998), Mohale (2002), Mashai, Tsoelike, Noahae, Malatsi (not completed)	Mica (1973), Keenleyside/Arrow (1968), Duncan (1967), Libby (1973)
Highlights of treaty	Conventions established to resolve details regarding establishment of river basin organization, ownership of regional infrastructure, legal status of Senegal River, allocation of costs of works, financing of construction, and management and rules governing utilization of the river waters.	Project agreement with specifics regarding implementation and schedule of transfer of water and calculation of royalty payments.	Project agreement with specifics on storage to be built and division and calculation of benefits; planning and operating details also provided in treaty.
Principal benefits discussed	Irrigation, hydropower, navigation	Water transfer, hydropower	Hydropower, flood protection
Approach to valuation of benefits	Difference in net primary returns (for irrigation) and comparative cost (next best method of producing the same service; e.g. power and navigation) with and without main-stem infrastructure	Difference in cost to RSA between two projects for a fixed amount of delivered water	Difference between benefit of electricity generated and flood damages avoided with and without the CRT storage reservoirs.
Benefit sharing mechanism (bilateral)	Benefits were negotiated outcomes based on ability to use; benefits served as basis for cost allocation using the adjusted separable cost remaining benefit methodology.	Cost savings to RSA for undertaking the LHWP in comparison to alternative domestic options is shared: 56% to Lesotho (in royalties) and 44% to RSA.	The additional downstream gross benefits of flood protection and energy generation due to built upstream storage are shared 50/50.

	Senegal River Basin	Lesotho Highlands Water Project	Columbia River Basin
Broader benefit sharing (local)	Water Charter established and included local stakeholders on the Permanent Water Commission	Community development fund established to re-distribute a portion of revenues back into local communities	Columbia Basin Trust established to make communities partners in power development; supplementary operating agreements to incorporate other objectives (e.g, fisheries); dialogue with First Nations
Regional Institutions	Organisation pour la Mise en Valeur du Fleuve Senegal (OMVS)	Lesotho Highlands Water Commission	Permanent Engineering Board
National Institutions		Lesotho Highlands Development Authority; Trans Caledon Tunnel Authority	US Army Corp of Engineers, Bonneville Power Authority
Remedies to differences between ex-ante and ex-post benefits	Variety of environmental and social programs taken up under the regional hydropower project; Water Charter established; Flood recessional releases	Revenue funds were re-configured to be more targeted in approach; More resources utilized to minimize environmental and social impacts in subsequent phases.	Establishment of Columbia Basin Trust to remedy environmental and social impacts; Supplemental operating agreements utilized to account for new values in the system.
Stakeholder involvement	Initially little; later a broader range of stakeholders was represented on the Permanent Water Commission	Engagement through the allocation of resources from the development fund	Initially little; later BC established the Columbia Basin Trust to make local communities partners in future power development and also began a water use planning process to include stakeholders in reservoir operations.

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VIII. Appendix

Adjusted Separable Cost Remaining Benefits Methodology

A methodological difficulty arises when costs cannot be attributed to a single service (because the project generates multi-purpose benefits), which is important for determining user fees for cost recovery. In the adjusted separable cost remaining benefits methodology (ASCRB), cost allocation across a variety of services (e.g., irrigation, hydropower, navigation, and flood control) is achieved by comparing the benefits derived from these services to the services' costs.

Total costs can be divided into two types of costs: separable costs and joint costs. Separable costs (SC) are costs that can be associated with a certain project service. The separable cost of a specific service is the difference in project costs with and without the service in question. For instance, power turbines would be a specific cost for hydropower for a multi-purpose reservoir. Thus, since the cost of the power turbines would increase the cost of the multi-purpose reservoir, that incremental increase is separable to the hydropower service. Joint costs, on the other hand, are costs that are incurred to provide more than one service and cannot directly be identified with a particular service (e.g., concrete for reservoir). The difference between the sum of the separable costs and the total costs are the joint costs.

With the ASCRB, the joint costs are allocated proportional to the ratio of remaining benefits for each service where the remaining benefit is the lesser of benefits or alternative costs minus the separable cost for the given service. Mathematically this can be represented as follows:

$$RB_i = (\text{lesser of } B_i \text{ or } AC_i) - SC_i$$

$$JC_i = JC \times \frac{RB_i}{\sum_i RB_i}$$ where i is indexed to the particular service.

$$TC_i = SC_i + JC_i$$

Using details from Keith et al. (1990), the calculation of the key for OMVS is shown below in Table A1. An explanation of each step is given in Table A2.

Table A1: Cost Allocation (in 1984 FCFA)*

		Irrigation	Energy	Navigation	Totals
(1)	Project Benefits (B)	110.90	261.24	530.08	902.22
(2)	Alternative Costs (AC)	82.6	109.61	147.74	
(3)	Justifiable Costs	82.60	109.61	147.74	339.95
(4)	Separable Costs (SC)	36.55	56.02	101.68	194.25
(5)	Costs for Other Purposes	206.59	187.12	141.46	535.17
(6)	Adjustment Factor	1.19	1.22	1.19	
(7)	Adjusted Separable	43.47	68.37	120.94	232.78
(8)	Remaining Benefits (RB)	39.13	41.24	26.80	107.17
(9)	Joint Cost (JC) Proportion	37%	38%	25%	
(10)	Allocated Joint Costs	17.85	18.81	12.23	48.89
(11)	Total Sector Service Cost	54.40	74.83	113.91	243.14
	Service %	***22.37%***	***30.78%***	***46.85%***	

* numbers are revised from Keith et al. (1990) based on personal communication with the author

Table A2: ASCRB Instructions

	Service i	Explanation
(1)	Project Benefits (B)	For service i, this is the discounted annual stream of benefits.
(2)	Alternative Costs (AC)	The alternative cost is the cost of providing service I using a single-purpose infrastructure.
(3)	Justifiable Costs	This is the lesser of the project benefits or the alternative costs. It represents the maximum cost of the service to meet aggregate economic efficiency
(4)	Separable Costs (SC)	Separable costs are the sum of the specific costs associated with service I and the separable common works costs.
(5)	Costs for Other purposes	This is the total cost of the project minus the separable cost. This must be less than the total justifiable costs minus the justifiable cost for that service.
(6)	Adjustment factor	(Row 3 + row 5)/total project cost. This factor relates to the cost savings resulting from the inclusion of the specific service.
(7)	Adjusted separable costs	Row 4 * row 6.
(8)	Remaining benefits (RB)	Row 3 – row 7.
(9)	Joint cost (JC) proportion	As described in the equations above, row 8 / (sum of row 8).
(10)	Allocated joint costs	(Total cost – sum of row 4) * row 9.
(11)	Total service sector costs	Row 10 +row 4.