The ecological economics of inter-basin water transfers: The Case of the Lesotho Highlands Water Project

by

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Dedication

To my beloved husband, Nkau and lovely kids, Ntšepase and Mabilikoe

Declaration

I declare that the thesis, which I hereby submit for the degree of PhD in Agricultural Economics at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at another university.

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ABSTRACT

This study developed a general framework that can be applied to integrating environmental sustainability aspects into economic development planning in the case of exploiting water resources through inter-basin water transfers (IBWT). Using the Lesotho Highlands Water Project (LHWP) between Lesotho and South Africa (SA), the study used the multi-country ecological social accounting matrix (MC-ESAM) for Lesotho and SA to integrate ecological implications of the LHWP with the economic benefits of the project. The study further used the developed MC-ESAM multipliers to analyse the impact of lost ecological services downstream the LHWP dams in Lesotho on the wellbeing of households directly affected by the project in Lesotho and the general economies of Lesotho and SA. The MC-ESAM multipliers were also used to analyse different policy scenarios aimed at compensating affected households in Lesotho for ecological losses.

The results revealed that while the LHWP has significant direct and indirect benefits in terms of social and economic development in Lesotho and SA, the project has serious unintended impacts on ecological resources and services, with resultant deleterious wellbeing implications for populations residing within the reaches of the LHWP rivers and downstream the LHWP dams in Lesotho. The results from the MC-ESAM multiplier analysis indicated that not only the income of populations directly affected by the project in Lesotho is likely to fall, but also that of other households and social groups, as well as the general economies of Lesotho. Also, because of economic dependence of Lesotho on SA in terms of imports, SA will also loose.

The policy simulation results showed that compensating the ecological losses would greatly improve the welfare of directly affected populations and the rest of Lesotho economy. The empirical analysis and policy simulations results showed relatively small impacts in general, but were significant for groups of people directly affected by the project in Lesotho. The study demonstrated the importance of integrating ecological consequences into impact assessment of IBWT before such transfers can be implemented to ensure Pareto optimality and of considering economy-wide impacts and multi-sector, multi-country linkages associated with IBWT for a holistic impact assessment of IBWT.

Keywords: *Lesotho Highlands water project (LHWP), ecological social accounting matrix (ESAM), Interbasin water transfers (IBWT), human wellbeing, Lesotho, South Africa*

TABLE OF CONTENTS

ABSTRACT .... **V**

TABLE OF CONTENTS .... **VII**

LIST OF TABLES .... **X**

LIST OF FIGURES .... **XII**

GLOSSARY OF ACRONYMS .... **XIII**

GLOSSARY OF ACRONYMS .... **XIII**

PART ONE: INTRODUCTION, BACKGROUND TO THE LHWP AND RELATED LITERATURE

CHAPTER I - INTRODUCTION

1.1 THE SETTING 2
1.2 BACKGROUND TO CASE STUDY AREA 4
1.3 STUDY RATIONALE 7
1.4 OBJECTIVES OF THE STUDY 8
1.5 APPROACH AND METHODS OF THE STUDY 9
1.6 ORGANISATION OF THE STUDY 9

CHAPTER II - THE ECONOMIC AND ECOLOGICAL SIGNIFICANCE OF THE LHWP

2.1 PROJECT AREA DESCRIPTION 11
2.2 WATER RESOURCES IN PROJECT AREAS 15
2.2.1 Water resources in South Africa *15*
2.2.2 Water Resources in Lesotho *21*
2.3 ECONOMIC SIGNIFICANCE OF THE PROJECT 23
2.3.1 Economic costs and benefits to SA. *23*
2.3.2 Economic costs and benefits to Lesotho *24*
2.4 ECOLOGICAL IMPLICATIONS OF THE PROJECT 30
2.4.1 Introduction *30*
2.4.2 Impacts in the exporting country (Lesotho) *31*
2.4.3 Impact in importing country *33*

CHAPTER III - REVIEW OF RELATED LITERATURE

3.1 INTRODUCTION 35
3.2 APPROACHES TO ASSESSING DIRECT OFFSTREAM IMPACTS OF IBWT 36
3.2.1 Positive approaches to the assessment of IBWT impacts *40*
3.2.2 The normative approach to assessment of IBWT impacts *45*
3.3 ECONOMY-WIDE MODELING APPROACHES TO IMPACT ASSESSMENT OF IBWT 48
3.3.1 I-O based models used in impact assessment of IBWT *48*
3.3.2 SAM based Models used in impact assessment of IBWT *50*
3.3.3 CGE models used in impact assessment of IBWT *52*
3.4 APPROACHES TO ASSESSING INSTREAM IMPACTS OF IBWT 55
3.5 INTEGRATED ASSESSMENT OF IBWT 58

PART TWO: APPROACH AND METHODS OF THE STUDY

CHAPTER IV - THE SOCIAL ACCOUNTING MATRIX (SAM) ANALYTICAL FRAMEWORK

4.1 GENERAL STRUCTURE OF THE SAM....64
4.1.1 Using the SAM as basis for analytical purposes 67
4.2 MULTI-COUNTRY SAM FRAMEWORK FOR THE LHWP....69

CHAPTER V- INTEGRATING ECOLOGICAL IMPACTS INTO SOCIO-ECONOMIC ACCOUNTS

5.1 INTRODUCTION....77
5.2 MOTIVATION FOR INTEGRATING ECOLOGICAL VALUES IN THE SAM FRAMEWORK....78
5.3 STREAMFLOW SERVICE VALUES ASSOCIATED WITH THE LHWP....79
5.4 ECONOMIC-ECOLOGICAL MODEL OF STREAMFLOW BENEFITS....83
5.4.1 A conceptual framework....83
5.4.2 Streamflow/natural Services to ecological production....86
5.4.3 Streamflow/natural water services to households' direct consumption 89
5.4.2 Streamflow/natural water as intermediate input in economic production....90
5.4.5 The ecological social accounting matrix (ESAM) for the LHWP....94
5.4.6 Using the ESAM to measure impacts of the LHWP....105

CHAPTER VI - VALUING INSTREAM FLOW BENEFITS AND ASSOCIATED WELFARE IMPACTS

6.1 INTRODUCTION....108
6.2 VALUATION OF ECOLOGICAL SERVICES 109
6.3 THE CONCEPT OF ECONOMIC VALUE 110
6.4 TECHNIQUES FOR VALUING STREAM FLOW SERVICES 112
6.5 MEASURING THE VALUE OF STREAM FLOW SERVICES 117
6.6 THE EMPIRICAL VALUATION MODEL FOR THE STUDY AREA....119
6.6.1 Data and sources....119
6.6.2 Streamflow services included....120
6.6.3 Valuing streamflow benefits of ecological resources 121
6.6.4 Valuing provisioning and cultural services of streamflow 126
6.6.5 Limitations of the estimated streamflow service values....130

PART THREE: EMPIRICAL MODEL, RESULTS AND CONCLUSIONS

CHAPTER VII - THE EMPIRICAL MULTI-COUNTRY-ESAM MODEL

7.1 INTRODUCTION....133
7.2 DATA NEEDS AND MULTI-COUNTRY SAM (MC-SAM) FOR THE STUDY AREA 134
7.2.1 Multi-Country MACROSAM....134
7.2.2 Multi-country MICROSAM....138
7.2.3 Disaggregation of the MICROSAM into MC-SAM....139
7.3 THE MULTI-COUNTRY ESAM 141

CHAPTER VIII - RESULTS OF THE EMPIRICAL ANALYSIS AND POLICY SIMULATIONS

8.1 INTRODUCTION....144
8.2 MC-ESAM MULTIPLIER ANALYSIS....144
8.3.2 Impact of lost ecological services on the economies of Lesotho and SA 150
8.4 POLICY SIMULATIONS....154

CHAPTER IX - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS....161

9.1 SUMMARY 161
9.2 CONCLUSION 163
9.3 POLICY IMPLICATIONS 165
9.4 STUDY LIMITATIONS 166
9.5 RECOMMENDATIONS FOR FURTHER RESEARCH 168

REFERENCES 170

APPENDIX A - SAM MULTIPLIER ANALYSES 186

APPENDIX B – GLOSSARY OF ESAM NOTATIONS 195

APPENDIX C – MULTI-COUNTRY ESAM MULTIPLIER ANALYSIS..196

APPENDIX D – LHWP STREAMFLOW VALUATION ANALYSIS..198

APPENDIX E – MACROSAM CELL DESCRIPTION..211

APPENDIX F - DERIVATION OF THE MULTI-COUNTRY MICROSAM..214

APPENDIX G – MULTI-COUNTRY ECOLOGICAL SOCIAL ACCOUNTING MATRIX (MC-ESAM)…………..225

LIST OF TABLES

TABLE 2.1: Population in Project area in Lesotho classified by District and sex......... 15
TABLE 2.2: South Africa Water Balance – 1996 estimates (million cubic meters)...... 17
TABLE 2.3: Water Balance for the Vaal Region 20
TABLE 2.4: Key details of existing Vaal Basin inter-basin transfers schemes 20
TABLE 2.5: Mean annual flow of main river systems in Lesotho 21
TABLE 2.6: Total water requirements and resources by basin in 1995 and 2025 (m^3/s) 22
TABLE 2.7: SA Provincial Gross Geographic Product (GGP) for the year 2000 23
TABLE 2.8: LHWP annual royalties for the period 1996 – 2002 26
TABLE 2.9: Projected water royalties for Phase 1A and 1B 26
TABLE 2.10: Number of tourists that visited the Mohale Construction Area 28
TABLE 2.11: Phase 1B impact on Lesotho's macro-economy 30
TABLE 4.1: The General Structure of a SAM 65
TABLE 4.2: Multi-country SAM framework for the LHWP 70
TABLE 4.3: Glossary of terms (variables) in the multi-country SAM 71
TABLE 5.1: Schematic of basic Ecological Socail Accounting Matrix (ESAM).......... 95
TABLE 6.1: Methods for estimating Environmental Values 113
TABLE 6.2: Streamflow resources and services identified as important for maintenance of riparians' livelihoods 121
TABLE 6.3: Streamflow resources and services values... 125
TABLE 6.4: Ecological resoucres' value losses due to change in streamflow condition of rivers downstream the LHWP structures (millions at 2000 prices in Maloti).... 126
TABLE 6.5: Value of lost cultural and religious services and drinking water provided by streamflows of the LHWP (millions at 2000 prices in Maloti) 129
TABLE 7.1: MACROSAM for Lesotho and South Africa for the year 2000 (in million Maloti)……………………………………………………………………………136
TABLE 7.2: Lesotho Households Classification.. 139
TABLE 7.3: MICROSAM accounts... 141

TABLE 8.1: Summary table of MC-ESAM Intra-country multipliers on selected accounts (Maloti) ... 145
TABLE 8.2: Summary table of MC-ESAM Inter-country multipliers on selected accounts (Maloti) ... 147
TABLE 8.3: Direct multipliers between households and production sectors (Maloti) 149
TABLE 8.4: Impact of lost ecological services in Lesotho due to the LHWP (2000 million Rands) ... 152
TABLE 8.5: Quantity of water supplied to different users in SA by water authorities and amount required to internalize the externality from each sector ... 156
TABLE 8.6: Effects of different policy scenarios on economies of Lesotho and SA (2000 million Rands) ... 159
TABLE A.1: Simplified schematic SAM ... 186
TABLE B1: Simplified multi-country SAM schematic ... 192
TABLE F.1: Distribution of households transfers from RSA to Lesotho ... 215
TABLE F2: Supply Shares of electricity and water industries in SA ... 217
TABLE F3: Intermediate expenditure shares for Electricity and Water Industries on different commodities in SA ... 218
TABLE F4: Factor Expenditure shares for electricity and water in SA ... 219
TABLE F.5: Intermediate income shares for water and electricity from different activities in SA ... 220
TABLE F.6 (a): Households water and electricity (aggregated) consumption in SA . 220
TABLE F.6 (b): Households water and electricity consumption (disggregated) in SA 221
TABLE F.6(c): Households water and electricity consumption shares in SA ... 221
TABLE F.7: Government electricity and water consumption in SA ... 222
TABLE F8: Micro MC-SAM for Lesotho and SA for the year 2000 (Million Maloti) ... 223

LIST OF FIGURES

FIGURE 2.1: The Lesotho Highlands Water Project 13
FIGURE 2.2: The river system in SA connecting Katse and Vaal dams 14
FIGURE 2.3: Temporal distribution of rainfall in South Africa (1922 – 1999)............... 16
FIGURE 2.4: The Vaal Basin Jurisdiction 19
FIGURE 2.5: Areas affected by modified river flow downstream LHWP dams 32
FIGURE 5.1: Streamflow Services (water as a natural resource) 80
FIGURE 5.2: Flow diagram of ecological and socio-economic flows 84
FIGURE 6.1: Schematic for Streamflow services Total Economic Valuation (TEV) .. 111
FIGURE 6.2: Change in combined consumer and producer surplus from a shift in product cost curves 117
FIGURE 6.3: Biophysical changes necessary for Valuing stream flow changes of rivers downstream the LHWP 117

GLOSSARY OF ACRONYMS

EIA	Environmental Impact Assessment
BOD	Biochemical Oxygen Demand
BOS	Bureau of Statistics
CGE	Computable General Equilibrium
COD	Chemical Oxygen Demand
CSIR	Center for Scientific and Industrial Research
CVM	Contingency Valuation Method
DBSA	Development Bank of Southern Africa
DWAF	Department of Water and Forestry
ESAM	Ecological social accounting matrix
GDP	Gross Domestic Product
GGP	Gross Geographic Product
IFR	Instream Flow Requirements
I-O	Input-Output
IBWT	Interbasin Water Transfers
LFCD	Lesotho Fund for Community Development
LHDA	Lesotho Highlands Development Authority
LHWP	Lesotho Highlands Water Project
LHWRF	Lesotho Highlands Water Revenue Fund
LMC and OSC	Lahmeyer Macdonald Consortium and Oliver Shand Consortium
MACROSAM	Macro-economic social accounting matrix
MEA	Millennium Ecosystem Assessment
MC-ESAM	Multi-country-Ecological social accounting matrix
MC-SAM	Multi-county-social accounting matrix
MICROSAM	Micro-economic social accounting matrix
MW	Mega Watts
NH_4^+	Ammonium ion
OVTS	Orange Vaal transfer scheme
PWV	Pretoria, Witwattersrand and Verreniging
PAR	Population at risk
RSA	Republic of South Africa
SA	South Africa
SACU	Southern African Customs Union
SAM	Social accounting matrix
SARS	South African Revenue Services
SEEA	System of integrated environmental and economic accounting
SNA	System of National Accounts
TCTA	Trans-Caledon Tunnel Authority
TEV	Total Economic Value
VAD	Value-Added
VAT	Value-Added-Tax
WTA	Willingness to Accept
WTP	Willingness to Pay

PART ONE: INTRODUCTION, BACKGROUND TO THE LHWP AND RELATED LITERATURE

CHAPTER I - INTRODUCTION

1.1 The Setting

Water is scarce in many regions of the world: the Middle East, Eastern and Southern Africa, and parts of Latin America. But even in countries with an overall abundance of water resources like Australia, Brazil, China, Mexico, and the United States, demand exceeds supply in many areas. To overcome water deficits, water is often imported through inter-basin transfers at international, national, regional and local levels to meet increasing demands in agriculture, industry, hydropower, and household sectors. Such transfers can have enormous impacts on the riverine ecology in the exporting area, the importing area, and the path linking the two areas.

The exporting area can experience reduced flows, changed seasonal hydrology, or reduced dilution, all of which can negatively impact on the riverine ecological resources that provide direct and indirect benefits to populations residing in the area. For example, reduced dilution can negatively impact on the quality of water and thus the health of people and animals using the water. The importing area can experience flooding of rivers; changed water temperature, chemistry and quality; and water logging, which may impact negatively on aquatic ecosystems. Imported water can also exacerbate scouring and erosion in the receiving rivers. The erosion may alter the flows necessary to inundate floodplains/wetlands and impact negatively on agricultural productivity and floodplain/wetlands ecosystems. Water transfer schemes have evident benefits in water deficient areas, but if not carefully assessed, instream ecological effects of such transfers can have serious socio-economic and environmental impacts on downstream riparians[1] in both the exporting and importing areas. For instance, too much water than optimal, could be transferred to the importing area at a high opportunity cost for lost ecological resource/biodiversity values and hence reduced social welfare. It is, therefore, important to integrate instream ecological considerations into sectoral management of water

[1] Rriparians refer to people living downstream, and directly affected by water projects.

resources in order to maximize the direct and indirect social benefits of water resource use.

In many countries policies used to manage inter-basin waters are usually based on sector-by-sector development approaches aimed at meeting economic sector's deficits (Hirji, 1998; Duda et al., 2000). These approaches do not integrate riverine ecological considerations into water management programs and hence, often lead to fragmentation rather than integration sought by socially and environmentally sustainable development[2].

Environmental Impact Assessments (EIAs) for inter-basin transfer schemes is one example where instream ecological effects of such schemes are left out. Such assessments are also often done after important projects' elements have been designed (Hirji, 1998). The Lesotho Highlands Water Transfer Scheme, popularly known as the Lesotho highlands water project (LHWP), is one good example. Recently, the Lesotho Highlands Development Authority (LHDA) commissioned a study to determine Instream Flow Requirements (IFRs) necessary to sustain riverine ecology of rivers downstream the dams of the scheme in Lesotho (LHDA, 2002a). However, this was done after important elements of the scheme had been implemented, e.g., part A of the first phase of the project had already been completed and part B had already commenced.

The main objective of the Lesotho IFR study was to assess negative impacts of modified flows of rivers downstream LHWP dams in Lesotho on riverine ecology. The study was also aimed at determining compensation required for lost values by riparians and to determine mitigation measures required. The said study assessed four IFR scenarios including the IFR in the project's treaty and design of the dams. Hydrological, biophysical and ecological impacts and dam yield of each scenario as well as resultant compensation and mitigation costs were assessed. These however, merely represented policy options available for the LHDA and the estimated costs have not been mitigated or

[2] South Africa (SA) has been one of the forward thinking countries in this regard. Its new water law shows promise for improving the integration of ecological considerations into sectoral management of water resources.

compensated yet. The present research therefore intends to contribute to improved methods of assessing benefits of inter-basin water transfer schemes by integrating ecological considerations into sectoral or economic benefits' assessments of such schemes, using the Orange River inter-basin transfer scheme between Lesotho and SA (LHWP) as a case study. Because of their magnitude, inter-basin water transfers do not only impact directly related sectors, but also the general economies of related countries. As such, this study uses an economy-wide modeling approach to assessing the economic and ecological impacts of the LHWP. Building on the results of the IFR study, this study investigates and measures the extend of direct (economic) and indirect (ecological) impacts of the LHWP as well as their induced impacts, through multiplier effects, focusing on water allocation for direct and indirect uses, in the project areas in Lesotho and SA. A multi-country ecological social accounting matrix (MC-ESAM) framework that accounts for economic and ecological uses of water and that shows direct and indirect impacts of economic sectors on sectors, sectors on ecology and countries on countries is developed and used to conduct the analysis.

1.2 Background to case study area

The LHWP is one of the biggest water transfer schemes in the world. The project started in 1986 with the signing of the treaty between the governments of Lesotho and SA. The prime objective of the project is to transfer water from the highlands of Lesotho, through gravity, to the water deficient Vaal region in SA. In the process, the water will also produce hydropower electricity for Lesotho. The Vaal region is the industrial heart and an important region for the South African economy. The region produces 40% of the country's GDP, more than 50% of its industrial output, and supports more than 30% of the total population (King, 2000).

Despite it's importance, the region has few natural water resources. It has been projected that, with industrial and urban demand, the region would be facing a water deficit of $1.8m^3/s$ by 1995, growing to $106.7m^3/s$ by 2030. Clearly, SA needs more water for continued industrial development and to meet increasing urban water demand. SA could have impounded the water it gets from Lesotho from within its borders. But the LHWP was found to be a cheaper alternative for the country (See Chapter II). SA pays the full cost of the project, except for the hydropower component. The total cost of Phase 1, which is binding between the two countries according to the treaty, is R11 billion (current prices). This is split between Phases 1A and 1B as R8 billion and R3.3 billion, respectively. On completion of the project, SA will also pay an average of US$45 - 47 million per annum in royalties to Lesotho for water delivered by all parts of Phase I (World Bank, 1998).

Water transferred to SA generates hydropower in Lesotho, giving Lesotho some security in hydropower as Lesotho was a net importer of hydropower from SA before the project. The sale of water brings valued foreign earnings to Lesotho. Already the royalties comprise a large percentage of the government's non-tax total revenue (40% in the second quarter of 2000) (Central Bank of Lesotho, 2000). From this money, a revenue fund has been established through which employment opportunities were created for local communities, with the prime objective of poverty alleviation. The LHWP creates jobs as well as many other indirect employment and development opportunities. However, these apparent economic benefits conflict with ecological benefits to riparians in the project areas forgone as a result of the project.

IFRs studies have demonstrated that downstream the Orange River system in Lesotho is a host of ecological resources, which depend on instream flows of the river system. These resources have economic value to 150 000 riparians who derive livelihoods from them (LHDA, 2002a). IFR studies have shown that the current transfer of water will negatively impact on most of these resources, thus affecting the welfare of riparians. In South Africa significant ecological impacts are expected on the ecology of receiving rivers. It is expected that the water from Lesotho will alter water flow, temperature, chemistry and biology of these rivers and the Vaal dam. Ecological impacts of these biophysical disciplines were studied by Chutter et al. (1990) and Chutter (1992, 1998), but were never quantified like in the IFR studies for Lesotho. Nevertheless, the studies revealed several important ecological implications of water transfer within the reaches of these rivers. The major impact is expected to result from increased flow of the rivers, with resultant impact on the inundation of floodplains and wetlands, as well as on the biota of the rivers. Details of the LHWP, including benefits of the project, are provided in Chapter II.

Evidently, the LHWP is of paramount importance because of the significance of the water from the scheme for economic development in both Lesotho and SA, i.e., for industrial and urban development in SA, and hydropower and royalty generation in Lesotho. It is also evident that the water allocated to generate these direct economic benefits carries an additional cost to riparians in terms of loss of benefits from various ecological services due to modified flows of rivers downstream the LHWP dams. While the ecological losses emanating from the project may be small relative to the project's benefits, they may be significant for riparians. It is therefore critically important to value ecological impacts of the project and determine the extend to which related populations are affected by these impacts so that the losses can be mitigated against or compensated to ensure sustainable development.

The LHWP is a huge scheme that affects both the economies of Lesotho and SA. Because of the inter-linkages that exist between sectors directly affected by the project and the rest of the sectors in each country, and the strong economic linkages between the countries, the project is expected to have far reaching income and distributional effects within and between the two countries. In the same token, ecological effects of the project are expected to have economy-wide income and distributional implications within and between the economies of both SA and Lesotho. However, the extend of economic and ecological costs and benefits of water allocated in the scheme and their induced impacts, through multiplier effects, on the wide-economies of the project areas and the rest of the exporting and importing countries is not known. For an important and huge scheme like LHWP, which does not only impact on economic sectors, but also on the ecology of rivers and peoples' livelihoods, it is important to have a holistic management approach and to understand the full implications of allocating a cubic meter of water in the scheme to direct uses relative to indirect uses. This should provide information direly needed by the scheme's managers for informed policy making.

1.3 Study Rationale

The motivation of this study was spurred on two fronts. Firstly, it is important to know the extent of both environmental and economic impacts of the LHWP in the two countries involved. This holistic approach to impact analysis of the scheme is critically important at this point because the other phases of the scheme are yet to be negotiated. The results produced by the study should help the scheme's managers make informed decisions concerning further phases of the scheme.

The second motivation lies in the desire to bridge the gap in the literature. As mentioned, EIAs for inter-basin transfer schemes usually leave out instream ecological effects of such schemes and, as such, decisions on water developments involving diversion of water from streamflows mainly focus on direct economic water benefits, ignoring ecological benefits derived from such flows. Hence, the major objective, and contribution, of this study is to develop a general methodology that can be used to integrate environmental sustainability aspects into economic development in the case of exploiting water resources through inter-basin transfers.

Because the emphasis in this study is on income effects of the LHWP, especially welfare concerns of lost ecological services, the general equilibrium, and especially the SAM, approach is appropriate because the SAM is an important tool for analyzing social and distributional concerns. SAMs emphasise origins and distribution of income, as well as distribution of expenditure. They also emphasize disaggregation of households to study origins and distribution to different socio-economic groups of households. The SAM is particularly important in this study because one of the main objectives is to analyse the extend of ecological implications of the LHWP on the welfare of households. Because most ecological resources are non-marketed, their values are not readily available. Thus, the measurement of ecological values is critical to quantifying values that need to be integrated in the SAM model to develop an integrated environmental-economic model.

1.4 Objectives of the study

The prime objective of this study is to develop a general methodology that can be applied to integrating environmental sustainability aspects into economic development planning in the case of exploiting water resources through inter-basin transfers. Using the LHWP as the case, this study investigates and measures the economic and ecological benefits of the scheme. The study further determines the extent of direct, indirect and induced (through multipliers) effects of economic and ecological impacts of the scheme. To assess the full benefits of the scheme, the analysis covers both Lesotho and the SA.

The following specific objectives are pursued under the prime aim:

- Identify ecological resources that are likely to be affected by modified instream flows of rivers downstream the LHWP dams and their benefits to riparians.
- Using hydrological, ecological, social and economic information from IFR studies, measure the value of water allocated to the production of ecological resources (instream flow benefits) and riparian welfare changes due to modified instream flows.
- Identify the direct economic benefits of the scheme to both Lesotho and SA.
- Develop a broad social cost-benefit-analysis framework that takes into account the combination of all the said effects using a multi-country ecological social accounting matrix (MC-ESAM).
- Use the developed MC-ESAM to analyse the direct, indirect and induced benefits/costs of economic and ecological effects of the scheme on Lesotho and SA.
- Use the MC-ESAM to analyse the distribution of benefits among affected people and countries as well as welfare changes for different income groups and employment categories in both countries.
- To provide benchmark information on the total benefits and sustainability implications of the water resource involved.

- To provide better information for improved management of the LHWP and future water development plans between SA and Lesotho.

1.5 Approach and methods of the study

This study uses the multi-country ecological social accounting matrix (MC-ESAM) to measure economic and ecological effects of transferring water from the highlands of Lesotho to the Gauteng region in SA. Development of ESAM requires integration of ecological values related to water transfer in the SAM. This study adopts the utilitarian approach to valuing ecological resources. This means that only those resources whose change will affect riparian welfare are valued. Productivity/cost measures are used to value those ecological resources that riparians use directly or sell in formal or informal markets, and where instream water serves as an input in their production.

For streamflow health and cultural services, mitigation and transport costs, respectively, are used to value the services. The data for the development of the multi-country SAM comes from the country SAMs of South Africa and Lesotho for the year 2000. Valuation of ecological resources requires information pertaining to hydrological, ecological and biophysical changes resulting from modifications of streamflows. It also requires socio-economic information pertaining to the riparians who use ecological resources and prices of those resources that are sold in the market place. For health and culture related services, mitigation costs of diseases and transport costs to cultural sites are required. This study uses primary data that was collected by LHDA for IRF studies (LHDA 2002a, b, c and d).

1.6 Organisation of the study

The thesis is divided into three parts. Part One gives the general background to the case study area and forms the general motivation of the study and comprises three chapters. Chapter I introduces the study while Chapter II provides background to the LHWP. Chapter III links the study to the existing literature. It comprises review of approaches employed in assessing impacts of inter-basin water transfers: normative, positive and economy-wide approaches. Part Two covers analytical procedures followed in the thesis and consist of 3 chapters. Chapter IV provides a discussion on the general SAM analytical framework. Chapter V develops the model that integrates ecological and economic values, and the ecological social accounting matrix (MC-ESAM) is derived, and finally, in Chapter VI techniques used to value ecological services are discussed. Part Three, which provides the empirical results of the study has three chapters. Chapter VII gives the empirical model for the study area and Chapter VIII presents the empirical results of the study. Finally, conclusions, policy implications and recommendations for further research are given in Chapter IX. References and Appendices conclude the thesis content.

CHAPTER II - THE ECONOMIC AND ECOLOGICAL SIGNIFICANCE OF THE LHWP

2.1 Project area Description

The LHWP is one of the biggest water transfer schemes in the world. The project started in 1986 with the signing of the treaty between the governments of Lesotho and SA. The prime objective of the scheme is to transfer water from the highlands of Lesotho through gravity, to the water deficient Vaal region in SA.

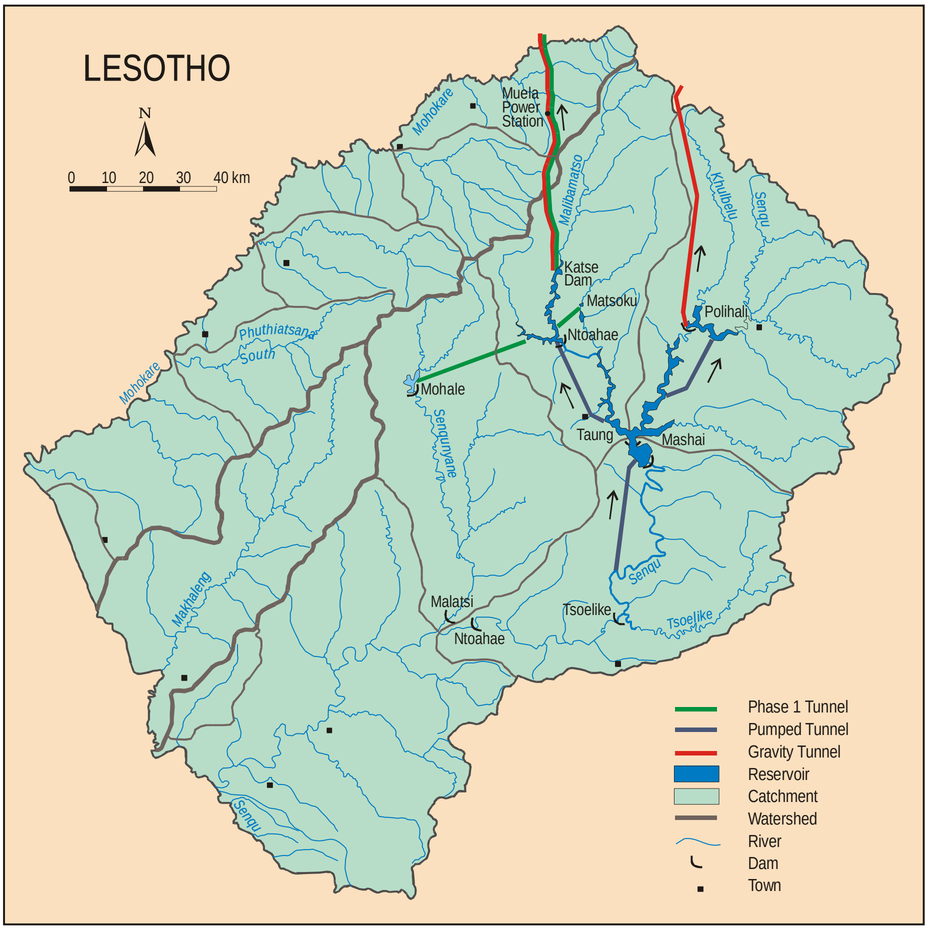
The project consists of an interlinked system of dams and tunnels designed to regulate the flows of the upper Senqu (Orange) River basin in Lesotho, to store water in Lesotho and deliver it to the Vaal River Basin in SA. The river system of the basin, namely, Makhaleng and Mohokare Rivers and their respective tributaries, flow into SA, becoming the Orange River. South Africa could have impounded water from the Orange River within its boarders through the scheme known as the Orange Vaal Transfer Scheme (OVTS). But this water is already too far south by the time it passes from Lesotho to be easily accessible to the Vaal Region. South Africa then found transporting water from the highlands of Lesotho through gravity as a cheap alternative.

Implementation of the LHWP was planned in four phases: phase IA and B, phases II, III and IV. Phase IA comprised of 180m storage dam at Katse site, construction of hydropower scheme within Lesotho, the Muela hydropower plant, with a capacity of 72 megawatts (MW), 45 km gravity transfer tunnel from Katse reservoir to Muela hydropower plant; 37 km gravity delivery tunnel - Trans Caledon Tunnel - from the Muela tailpond to the upper reaches of the As River in SA. This stage of development allowed the transfer of 18 m^3/sec. Phase IA is complete and water is already being transferred to SA, since 1998. Phase IB comprises 140m high storage dam at Mohale site and 30 km long gravity transfer tunnel from Mohale reservoir to Katse reservoir. It also includes construction of a diversion weir on the Matsoku River and a 6 km gravity tunnel connecting the weir and Katse reservoir. Construction of phase 1B has already started and has a completion date of 2004. On completion, this phase is expected to yield 11 m^3/sec of water and about 38 MW of hydropower. In total, the 'Muela hydropower will yield 110 MW of hydropower in Phase 1.

Phase II comprises a 170m high storage dam, a pumping station, a 19 km long conveyance between Mashai and Katse reservoirs and a conveyance system from Katse reservoir northwards to the Vaal River System. The phase is expected to yield 25 m^3/s. Phase III involves construction of a 160m high storage dam at Tsoelike site, a pump station and a 4 km conveyance system connecting Tsoelike and Mashai reservoirs. Incremental yield from this phase is expected to be 10m^3/s. Lastly, phase IV includes 125 m high storage dam at Ntoahae site, a pumping station and a tunnel connecting Ntoahae and Tsoelike reservoirs, with incremental yield of 5 m^3/s. The whole project is expected to provide 70 m^3/sec by 2021, which is the expected date of the project completion. The present Treaty however, commits the two countries to Phase 1 only. Figure 1.1 below shows the layout of the whole project.

The water of Phase I is supplied by the following river system: Malibamatso, Senqu, Matsoku and Senqunyane. From Katse reservoir the water passes through the 'Muela hydropower plant to generate power. Afterwards, the water is transferred by the Trans-Caledon Tunnel into the upper reaches of the As River in SA. From the tunnel outlet, the water flows northwards via Saulspoort Dam, the Liebenbergsvlei River and the Wilge River to Vaal Dam (see Figure 2.2), where the water is impounded for industrial and municipal use in the Vaal region.

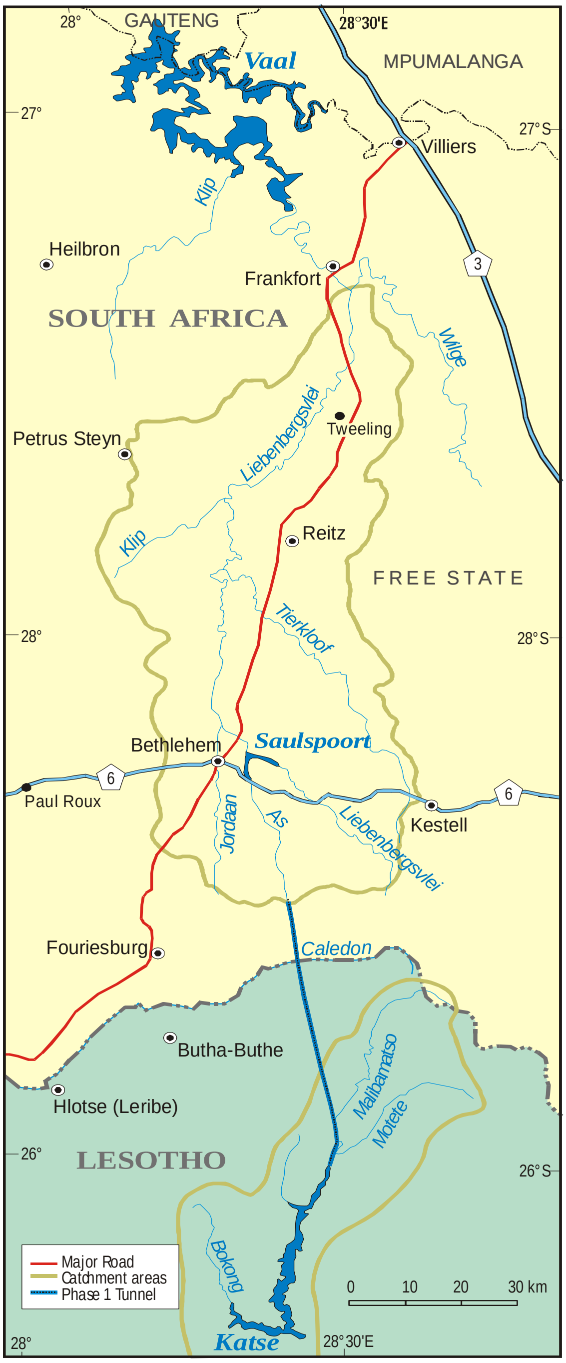
FIGURE 2.1: The Lesotho Highlands Water Project



Source: TAMS Consultants (1996)

The project area includes the main catchments of Malibamatso, Senqunyane and upper Senqu rivers in Lesotho and other areas to the north of those catchments, that are affected by project works in Lesotho and South Africa (see Figures 2.1 and 2.2). The project area in Lesotho falls into two ecological zones, the mountains, and the foothills/lowlands. The main reservoir sites are in the mountain zone. The project area in Lesotho is located in the districts of Butha-Buthe, Leribe, Mokhotlong, Thanbatseka and Qacha's Nek. The population of these districts is reported in Table 2.1 below.

FIGURE 2.2: The river system in SA connecting Katse and Vaal dams



Source: Adapted from Chutter and Ashton (1990)

TABLE 2.1: Population in Project area in Lesotho classified by District and sex

District	Males	Females	Total
Butha-Buthe	38 552	39 6333	78 185
Leribe	89 858	92 614	182 472
Mokhotlong	27 359	28 186	55 545
Thaba-Tseka	32 132	32 915	65 047
Qacha's Nek	50 518	54 085	104 603

Source: BOS (1996)

Land use patterns mainly comprise grazing/grasslands and cropping land, which is characterised by subsistance farming. Traditional form of land tenure prevails under the authority of chiefs. There is communal access to grazing and open water, with arable land traditionally allocated to farmers by chiefs and headmen. Many households are dependent on wage remittances from one or more workers, mainly in South African mines. However, this source of income has been declining over the years with depreciation in gold prices and resultant retrenchments in South African mines. The land in South African portion of the project is primarily used for mixed agriculture. Cultivation takes place in the flatter valley bottoms, while the steeper slopes offer grazing for livestock. The main crops in the area are maize and wheat. All land is privately owned, The largest urban center in the area is Bethlehem which has a total population of aproximately 59 800 (2004 estimates).

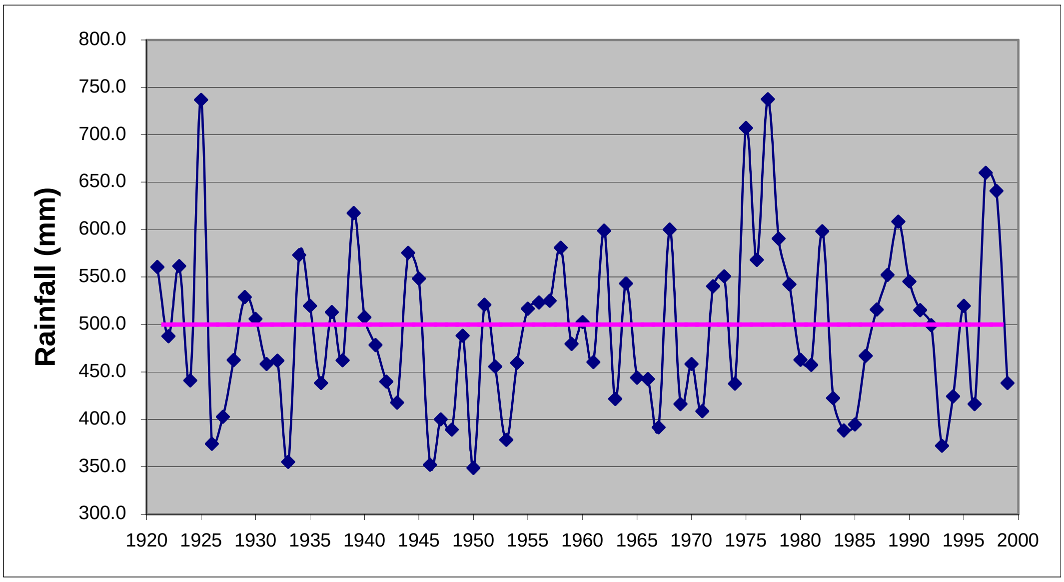
2.2 Water Resources in Project areas

2.2.1 Water resources in South Africa

South Africa is located in the semi-arid part of the world. In global terms, its water resources are scarce and extremely limited in extent. The average annual rainfall is 500mm compared to the global average of 800 mm and it has high temporal (Figure 2.3) and spatial variability. On the contrary, the mean potential evaporation varies between 1100mm to 3000mm, exceeding the annual rainfall substantially (Crafford et al., 2001).

Figure 2.3 shows that South Africa's rainfall is highly variable and unpredictable. In addition to the temporal variation in rainfall, the country has a wide spatial rainfall with the Eastern part of the country receiving the lowest amount (less than 200 mm/year on average), and the Southern part receiving the highest amount (grater than 800 mm/year on average).

FIGURE 2.3: Temporal distribution of rainfall in South Africa (1922 – 1999)



Source: SA weather Bureau (2000) (in Crafford et al., 2001)

This clearly shows an uneven distribution of rainfall, and thus natural water resource availability across the country. Additional to the unpredictable and uneven nature of rainfall in SA is the poor groundwater resources. The country is mainly underlain by hard rock formations which, although rich in minerals, do not contain any major groundwater aquifers which could be utilized on a national scale (DWAF, 1986). As a result of all these water deficient problems, South Africa is classified as a water scarce country. In many parts of the country, available water supply does not meet water requirements[3] (Basson et al., 1997). Table 1.2 shows the water balance picture of South Africa according to geographic regions.

TABLE 2.2: South Africa Water Balance – 1996 estimates (million cubic meters)

Region	River basin	Maximum yield	Water requirements	Balance available
North region	Crocodile/Limpopo	1117	1732	-615
	Olifants	1449	1641	-192
Eastern inland region	Komati Maputu	2252 2582	1401 919	851 1663
Eastern coastal region	Umfolozi Tugela Umgeni/Umzimkulu Umzimvubu Mbashe/Kei	1531 2900 4122 2635 2191	933 813 1941 934 983	418 2087 2181 1701 1208
Southern coastal region	Great Fish Sundays Gamtoos Gouritz	263 164 801 565	580 407 347 434	-317 -243 454 131
South Western region	Breed/Berg Olofants/Doring Buffels	2508 585 2	1891 491 14	617 94 -12
Karoo region	Senqu Orange to Vaal confluence Orange below Vaal confluence	4481 1533 0	21 700 1834	4460 833 -1834
Central Region	Vaal	1789	2029	-240
South Africa		33290	35320	-2030

Source: Adapted from Basson et al. (1997).

From the table it is notable that in many regions water supply falls short of water requirements. On average, South Africa has an annual short fall of 2030 million cubic

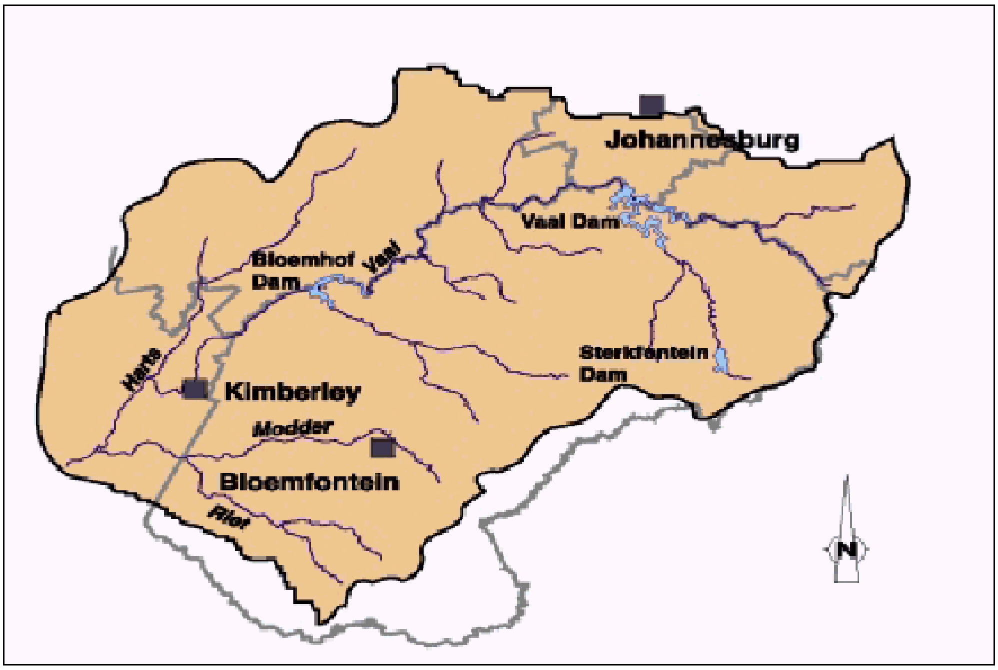
[3] Though it is not clear from the original source what the term 'requirements' mean in the context of water needs in SA.

meters of it's water requirement, and it is estimated that by the year 2030 this figure will have increased to 106.7m^3/s due to population growth and industrial expansion (King, 2000). Because of water deficits, SA has embarked on major dam constructions and inter-basin water transfer projects to augment water supplies in water deficient regions. The inter-basin water transfers and dam constructions have created the storage capacity of about 27 000 x $10^6 m^3$ for the country of which 40% is contributed by the LHWP (CSIR, 1999; King, 2002).

The LHWP is specifically aimed at augmenting water supply in the Vaal basin to specifically supply Gauteng/Vaal region and its vicinity. The Vaal Basin comprises the total Vaal River catchment with its tributaries. It drains part of Mpumalanga, Free State, Gauteng, North West and Nortrhern Cape (See Figure 2.4). The Vaal River is the most developed and regualted river in South Africa and the River System supports about half of the economic activity in South Africa (Basson et al., 1997). The river system is regulated by major dams constructed to provide water resources to different groups of users. These comprise:

(i) Vaal Dam, for serving Gauteng and Vicinity;
(ii) Vaal Barrage, for water quality management;
(iii) Grootdraai Dam, for serving the industrial and mining areas of Mpumalanga;
(iv) Bloemhof Dam, for irrigation purposes;
(v) Sterkfontein Dam, a major reserve storage reservoir fed by pumping from the Thukela River;
(vi) Several other dams on tributaries of the Vaal, for water supply to municipalities and irrigation. These include Saulspoort, Kopies, Boskop, Allemanskraal, Erfenis, Groothoek, Krugersdrift, Kalkfontein, Taung and Spitskop.

FIGURE 2.4: The Vaal Basin Jurisdiction



Source: Basson et al. (1997).

Water use in the basin is currently dominated by irrigation (66 %). By far the dominant growth in water requirements is foreseen in the domestic, urban and industrial sectors and is largely driven by population growth together with the concomitant urbanisation, increased standard of living and services as well as the supporting economic growth and industrialization (Basson et al., 1997). In this respect it is estimated that, should current growth trends and usage patterns prevail, the total requirements for water in these sectors will approximately double over the next 30 years, or will grow at roughly 3 % per annum (Basson et al., 1997). The water balance for the basin without inter-basin transfers is as follows:

TABLE 2.3: Water Balance for the Vaal Region

		1996		2030	
River Basin	Maximum yield (106m3/yr)	Water requirements (106m3/yr)	Balance available (106m3/yr)	Water requirements (106m3/yr)	Balance available (106m3/yr)
Vaal Basin	1789	2029	-240	3830	-2041

Source: adapted from Basson et al. (1997)

Evidently, the Vaal region already has the water deficit of 240 million cubic meters and it is projected that it will have the deficit of 2041 million cubic meters by the year 2030 (Basson et al., 1997). To augment water supply in the Vaal Basin, inter-basin water transfer schemes have been built and these include:

- Thukela-Vaal
- Buffalo-Vaal
- Assegaai-Vaal
- The Lesotho Water Highlands Transfer Scheme (LHWP)

Table 2.4 below shows the amount of water transferred by each scheme. From the Table the LHWP contributes more than 40% of total inter-basin imports and is aimed at supplying Gauteng and its vicinity with fresh water.

TABLE 2.4: Key details of existing Vaal Basin inter-basin transfers schemes

Source basin	Recipient basin	Average current transfer (10^6 m^3/yr)	% of total transfers	Use
Assegaai	Vaal	81	6%	Industrial, domestic
Buffalo	Vaal	50	4%	Industrial, domestic
Tugela	Vaal	630	47%	Industrial, domestic
LHWP 1A*	Vaal	574	43%	Industrial, domestic
Total		1335	100	

*Water from Phase 1B is not yet transferred to SA.

Source: adapted from Basson et al. (1997).

2.2.2 Water Resources in Lesotho

Unlike SA which is water scarce, Lesotho has bountiful water supply. Mean annual rainfall ranges from less than 600 mm in the lowlands to over 1 000 mm along the main mountain ridges. Inter-annual variations in rainfall are significant and are characterized by persistence levels which results in cyclical droughts. The whole country of Lesotho falls within the Orange River basin/catchment and the mountains/highlands of Lesotho provide the source of the basin. Although the mountains/highland region of Lesotho constitutes only about 5% of the total catchment of the Orange River (excluding the Vaal system), it provides about 50% of the total catchment run off. The water originating from the highlands of Lesotho is characterized by relatively good chemical quality and lower sediment content than water originating from other parts of the Orange River catchment (LMC and OSC, 1986).

The distinct geological feature of Lesotho is that all rivers flow in the same South-westerly direction, due to lower strata of sand stone being uniformly laid in a North-easterly to South-westerly plan (TAMS Consultants, 1996). All the rivers flow into South Africa. The thee river basins making up the surface water course system of Lesotho are the Senqu (Orange), Mohokare (Caledon) and the Makhaleng. These rivers leave Lesotho at an elevation of approximately 1 400 meters above sea level. The watershed between the Drakensberg and the Maluti constitutes the headwater of the Orange River, which is the largest catchment in South Africa. The mean annual flows of the river systems are shown in Table 2.5 below. Like the country's rainfall, the river flows are highly seasonal.

TABLE 2.5: Mean annual flow of main river systems in Lesotho

Basin	Mean Annual Flow
Senqu (Orange)	105.5m^3/s
Mohokare (Caledon)	26.5m^3/s
Makhaleng	16.7m^3/s

Source: TAMS Consultants (1996)

Lesotho is also endowed with ground water resources, both dynamic (renewable) and static though this comprises only seven percent of total available water. Despite the fact that Lesotho abounds in water, it only uses a very small percentage of total available water. Table 2.6 below shows water availability and requirements in Lesotho between 1995 and 2025. Domestic consumption in the table (i.e. Rural and Urban) also includes commercial, industrial, schools and government consumption of water. For 1995 data, agricultural consumption figures are also included.

TABLE 2.6: Total water requirements and resources by basin in 1995 and 2025 (m^3/s)

Basin	**1995**		**2025**			**Resource Availability**	
	Rural	Urban	Rural	Urban	Agricul ture	Surface water	Ground water
Upper Mohokare and Hololo	0.02	0.07	0.03	0.21	0.00	4.59	0.37
Hlotse	0.02	0.04	0.03	0.15	0.16	8.59	0.38
Middle Mohokare	0.02	0.20	0.03	0.69	0.09	1.39	0.50
Puthiatsana North	0.02	0.04	0.04	0.12	0.11	6.12	0.43
Phuthiatsana South	0.03	0.15	0.04	0.90	0.04	4.79	0.47
Lower Mohokare	0.04	0.05	0.06	0.19	0.01	1.00	0.93
Upper and lower Makhaleng	0.05	0.02	0.08	0.09	0.32	16.71	1.24
Upper Senqu	0.02	0.00	0.06	0.00	0.00	52.00	2.49
Senqunyane	0.02	0.00	0.03	0.00	0.00	24.42	1.11
Middle Senqu	0.02	0.00	0.05	0.02	0.00	18.90	1.09
Maletsunyane, Qhoali, Ketane and Senqu	0.04	0.03	0.08	0.07	0.36	10.18	1.83
Total	**0.29**	**0.61**	**0.54**	**2.44**	**1.10**	**148.70**	**10.83**

Source: TAMS Consultants (1996).

From the table it can be noted that even with future possible water demand, total water demand in 2025 will only be 4.08 m3/s out of the total available water of 159.52 m^3/s. This means Lesotho will only require about three percent of its total water in 2025.

2.3 Economic significance of the Project

2.3.1 Economic costs and benefits to SA

The LHWP water is aimed at supplying the Gauteng region, which is the industrial heart of SA. Gauteng is the economic heartland of South Africa. It is formed by the Pretoria, Witwatersrand and Vereeniging (PWV) complex of the former Transvaal. It borders the Northern Province, Mpumalanga, the North West and the Free State to the south. It is spatially the smallest province, covering 21 025 km^2 or 1,7% of the total surface area of South Africa. It's population is 7,8 million (1994 estimates), and it is the second highly populated province after Kwazulu Natal with 8,9 million. It comprises 18% of total South African population. The population grows at 2, 18 percent (1994 statistics) (DBSA, 1998). Despite the fact that Gauteng is the smallest province in South Africa, it contributes the highest to the countries GDP compared to other provinces. In 2000, the province's geographic gross product (GGP) was R303 242 million at current prices compared to the country's GDP of 888 059 million Rands (DBSA 1998). Gauteng therefore contributed approximately 34% to the GDP, which was by the far the largest contribution, with Kwazulu-Natal a distant second at 15,5% (See Table 2.7 below.

Deleted:)

TABLE 2.7: SA Provincial Gross Geographic Product (GGP) for the year 2000

Provinces	GGP	% Contribution
Western Cape	125 957	14,2
Northern cape	72 471	8,2
Free State	17 558	2,0
Eastern Cape	49 225	5,5
Kwazulu-Natal	137 758	15,5
Mpumalanga	64 916	7,3
Northern Province	62 853	7,3
Gauteng	303 242	34,1
North West	54 079	6,1
South Africa	**888 059**	**100**

Source: Statistics South Africa (2002).

Gauteng is the most industrialised and urbanised province in SA. It produces more than 50% of the country's industrial output, and employs more than 30% of the total population (King, 2000). Despite it's importance, the region has few natural water resources (see Table 3). It has been projected that, with industrial and urban demand, the region would be facing a water deficit of 1.8m^3/s by 1995, growing to 106.7m^3/s by 2030 (King, 2000).

Clearly, SA needs more water for continued industrial development and to meet increasing urban water demand. The direct benefits of the scheme to SA are, therefore, water for industrial development and municipal/urban use. SA pays the full cost of the project (R11 billion for Phase 1, current prices), except for the hydropower component. It will also pay an average of US$45 - 47 million per annum in royalties to Lesotho for water delivered by all parts of Phase I (World Bank, 1998). This is equivalent to R0.19/m^3 (1995 prices) (Conningarth Economists, 2004). To pay for the Lesotho Highlands Water Project costs, the Trans-Caledon Tunnel Authority (TCTA), responsible for managing the SA part of the project, sells the project water to DWAF at 69c/m^3 (1995 prices) (conningarth, 2004). SA also benefits in terms of OVTS opportunity cost.

Indirectly, SA benefits from employment opportunities generated by the scheme. Already many South Africans are working in the project as engineers, consultants and in other establishments. The economy of SA is benefiting from increased economic activity spurred by increased project related exports to Lesotho, e.g., more than 80% of the project related exports came from SA (LHDA Annual Reports 1988/89 – 1997/98)

2.3.2 Economic costs and benefits to Lesotho

Economic costs and benefits of the LHWP to Lesotho can be divided into two groups: permanent and transitory/transitional benefits. Permanent benefits are defined as benefits accruing as a result of the water transfer. These include benefits from water sale and hydropower generation, permanent infrastucture and benefits arising from compensation and mitigation programmes for environmental and social losses associated with the project. Transitory benefits relate to benefits which dissipate with the completion of construction activities, e.g., employment creation.

2.3.2.1 Permanent benefits

The primary permanent benefit of the project to Lesotho is water royalties paid by SA. These are Lesotho's share in the 'benefit' of the LHWP. The project's treaty defines the 'benefit' as the opportunity cost of the Orange Vaal Transfer Scheme (OVTS) which would transfer water from Lesotho to SA, but be entirely located within the borders of SA. This opportunity cost is defined as the cost difference between the LHWP and OVTS. According to the treaty, this benefit should be shared between SA and Lesotho on a 0.46:0.56 ratio, and the Lesotho's share is to be paid by South Africa as royalties over a fifty-year water delivery period.

The treaty provides for two monthly royalty components, namely:

- Fixed monthly payments representing the saving in capital costs of the LHWP compared to OVTS. This payment is calculated over the whole project and does not vary with project phases.
- Variable monthly payments in two parts, both being expressed as a rate per cubic meter of water delivered: (i) representing the saving in pumping costs of the LHWP compared to the OVTS and (ii) representing the saving in normal operation and maintenance costs (LHDA, 2003).

The treaty makes the provision that the royalty payments should be indexed to the RSA production price and electricity prices. This ensures that true economic value of the royalty payments is preserved and is not eroded by inflation or devaluation of the Rand. Therefore, SA pays Lesotho a fixed index-linked annuity per month and a variable royalty for each cubic meter of water delivered to SA. The first fixed royalties began in January 1996 and will continue until all project costs have been redeemed and Lesotho' share of the benefit has been paid in full. The variable royalties continue for the lifetime of the treaty, which is indefinite (LHDA, 2003). Table 1.8 below reports royalty payments for Phase IA from the year 1996, when fixed royalties commenced, to the year 2002.

TABLE 2.8: LHWP annual royalties for the period 1996 – 2002 (current million Maloti)

Year	Water Royalties for Phase 1A	GDP	% of GDP
1996	130.5	4 053.7	3.2
1997	81.8	4 719.5	1.7
1998	129.2	4 920.7	2.6
1999	146.9	5 564.9	2.6
2000	153.2	6 238.5	2.5
2001	174.8	6 478.3	2.7
2002	210.5	7 610.7	2.8

Source: LHDA (2003).

Table 2.9 below reports projected royalties for Phase 1A and 1B between 2003 and 2020 in 1995 prices. The Phase 1B royalties were scheduled to commence in 2003 when the transfer of water from the Mohale Dam to SA begins (LHDA, 1997). However, the Mohale Dam was only impounded on the first of November, 2002 and this process is expected to end by the end of 2003. If this happens the water from Phase 1B (and thus royalties from SA to Lesotho) will start flowing on the first of January 2004.

TABLE 2.9: Projected water royalties for Phase 1A and 1B (1995 million Maloti)

Year	Water Royalties for Phase 1A	Water Royalties for Phase 1B	Total Water Royalties for Phase 1
2003	98.5		98.5
2004	98.5	4.6	103.1
2005	98.5	20.8	119.3
2006	98.5	23.4	121.9
2007	98.5	26.7	125.2
2008 – 2020	98.5 annually	29.2 annually	127.7 annually

Source: LHDA (1997)

The water transfer royalties make a direct contribution to total government revenues which will then indirectly have a positive influence (through government expenditures and capital transfer) on domestic income. The royalties bring valued foreign earnings to Lesotho. Already the royalties comprise a large percentage of the government's non-tax total revenue (40% in the second quarter of 2001) (Central Bank of Lesotho, 2001). From this money, a revenue fund (first, the Lesotho Highlands Water Revenue Fund (LHWRF), and second and current, the Lesotho Fund for Community Development (LFCD)) has been established through which employment opportunities are created for local communities, with the prime objective of poverty alleviation. The LHWRF was established in 1991 to channel LHWP proceeds to various social projects in the communities. By 1998 M189 million (current prices) had been committed for community-based public works programs countrywide. This saw 138, 000 people getting employment. However, the fund collapsed due to mismanagement (LHDA, 2003). In 2001 the LFCD was launched with the mandate of implementing the following community-based projects: roads, footbridges, small earth-fill dams, forestry and soil conservation works. To date the total cost of projects approved by the fund exceeds M251 million (current prices).

The other permanent benefit is the hydropower. Water transferred to SA generates hydropower in Lesotho, giving Lesotho some security in electricity. Lesotho used to be a net importer of hydropower from SA before the completion of Phase 1A of the LHWP. The water flowing from Phase 1 will flow through the Muela hydropower station, which for Phase 1 has a rated capacity of 72 MW. On completion, Phase 1B will add about 38 MW of hydropower. Already, Lesotho is enjoying the benefits of locally produced electricity from Phase 1A. On the 11th November 1993, LHDA and the Lesotho Electricity Corporation (LEC) signed a Power Sales Agreement. The agreement allowed the two parties to collaborate in the national interest in installing, operating and maintainig facilities forming part of the hydropower component of the LHWP, and the sale of electricity from LHDA through the 'Muela Hydropower (LHDA, 2003). Since September 1998, when 'Muela hydropower was commissioned, LHDA started selling electricity to LEC. To date LEC has purchased 1, 072, 775 MW of energy from LHDA and this has saved Lesotho about 152 million Maloti in electricity imports (LHDA, 2003). Hydropower sales will have a lasting positive effect on Lesotho's economy, through contributions to domestic factor income and reductions in electricity imports. Other permanent benefits of the project include infrastructure created in support of the project. These include access roads to the central highlands of the country. Key features of permanent infrastructure include roads, housing and services at Katse, Mohale and 'Muela new towns, electricity power substations and transmission lines, and telecommunications. For Phase 1B alone these amount to approximately M1527 million in current prices (LHDA, 2003). This will be particularly important in the development of regional tourism and commerce.

Tourism has been singled out as one of possible job creation activities in the highland areas of Lesotho by many studies. The road network that has been built because of the project will enhance this activity. Already there is evidence of increased tourism in the project areas. About 3000 visitors visited the Katse Information Center every month during the Katse Dam and site construction phase (LHDA, 1997). Phase 1B construction site has also been receiving number of tourists over the years. Table 2.10 below shows the number of tourists visiting the Mohale construction area from 1998 to 2001.

TABLE 2.10: Number of tourists that visited the Mohale Construction Area

Year	1998	1999	2000	2001	Total
Number of tourists	2324	7191	7626	10393	27534

Source: LHDA (2003).

Projects of this magnitude often result in enormous environmental and socio-economic losses to people residing in project areas. The final category of permanent benefits emanate from expenditures on compensation and mitigation programs aimed at environmental and social impacts of the project. The main socio-economic losses associated with the project were land, houses and other economic resources. To mitigate against these losses, both short- and long-term measures were taken. Short-term measures included direct compensation of households and communities for lost productive assets. On the other hand, long-term measures were aimed at facilitating the development of alternative sustainable livelihoods for affected communities and households. Three programs were used to achieve this:

- Production program – including livestock and range management, mountain horticulture, fisheries, forestry and land-use-planning

- Education program – including skills and income generation training and the establishment of necessary facilities.
- Infrastructure program – including feeder roads and reservoir crossings, water supply and rural sanitation, construction communities, and visitor information and tourism. Already, M241 million (current prices) has been spent on resettlement, compensation, development, and public health programs related to Phase 1B only (LHDA, 2003).

Additionally, the people of Lesotho have also benefited in terms of training and capacity building. Skills developed by workforce during construction period will permanently improve employment prospects and earning potential of the workforce. Rural Skills Development Program has been established to enhance skills and employment potential of people directly affected by the project in the project areas. Beneficiaries of this program will acquire skills that are expected to sustainably raise their income earning potential. Benefits arising from environment and socio-economic changes will also accrue to people directly affected by the project in project areas.

2.3.2.2 Transitory benefits

Transitory benefits are short-term and occur during the construction phase, which then dissipate following completion of the project. The most important transitory (transitional) benefits are labour earnings and government revenue through project related SACU receipts, both of which contribute to Lesotho's economic growth. A study that was commissioned in 1996 to analyse the economic impact of Phase 1A, and to make projections for Phase 1B, came up with the following important findings:

- Phase 1A accounted for about 14% of Lesotho's GDP and 400 % of value-added in the building and construction sector in 1994.
- Government revenue increased. In 1994 alone the government experienced a surplus of 156.3 milliot Maloti (1995 prices) compared to 136.6 million Maloti (1995 prices) deficit that the government would have realised without the project. The study estimated that this would have balloned to nearly 800 million Maloti (10.9 % as large as GDP) by the year 2002.

- In 1998 when Phase 1A rounded up, the project accounted for 13,6 % of Lesotho's GDP, 13% GNP, 35.3% value-added in building and construction and 27.8 % in government revenues (Dogget, 1996).

The microeconomic impact study of Phase 1B by the LHDA, Economics section, showed that the phase has created 8 000 jobs, amounting to 22 000 person years, while M250 million (current prices) worth of contracts and sub-contracts have been awarded to Basotho companies according to preliminary figures up to December, 2000 (LHDA, 2003). In 1998 Phase 1B accounted for 6.5 % of the county's GDP, 5.6 % of GNP and 21.4% of value added in the building and construction sector. Additionally, the Phase accounted for 7.4 % in total government revenue. Table 2.11 below summarises these benefits for the years 1998 and 2002.

TABLE 2.11: Phase 1B impact on Lesotho's macro-economy

Item	**Amount accounted for by Phase 1B (millions of 1995 Maloti)**		**Economic share due to Phase 1B (%)**	
	1998	**2002**	**1998**	**2002**
GDP	260.2	183.0	6.5	3.9
GNP	290.4	178.1	5.6	3.6
Building and construction	178.1	111.7	21.4	12.3
Government revenue	144.4	196.5	7.4	9.3

Source: Adapted from LHDA (2003).

2.4 Ecological Implications of the project

2.4.1 Introduction

Section 2.3 has demonstrated important economic benefits of the LHWP. However, as explained in the introductory chapter, the natural water in stream/rivers has important ecological benefits and if inter-basin water transfer developments compromise the ecological reserve for water, the result may be deleterious effects on the ecological resources and services. This may be true for both the exporting and importing rivers of the development. This section discusses ecological implications of the LHWP in both the exporting and importing countries (i.e., Lesotho and SA, respectively).

2.4.2 Impacts in the exporting country (Lesotho)

IFR studies conducted by LHDA have demonstrated that downstream the Orange River system in Lesotho is a host of ecological resources, which depend on instream flows of the river system (LHDA 2002a and b). The studies demonstrated that grasslands and shrublands, with occasional wetlands, dominate the vegetation. Vegetation zones along the rivers typically have a higher proportion of woody vegetation consisting of both indigenous and exotic species. In general, the following non-cultivated resources are found:

(i) Thatch grass provides an important thatch material for highlands riparians.

(ii) Crafts grass is used by riparians either to make a variety of crafts or sold unprocessed to crafts' makers.

(iii) Wild vegetables are eaten or sold in urban areas by riparians.

(iv) Shrubs and debris comprise an important source of fuel for riparians.

(v) Trees are used by riparians for construction and fuel purposes.

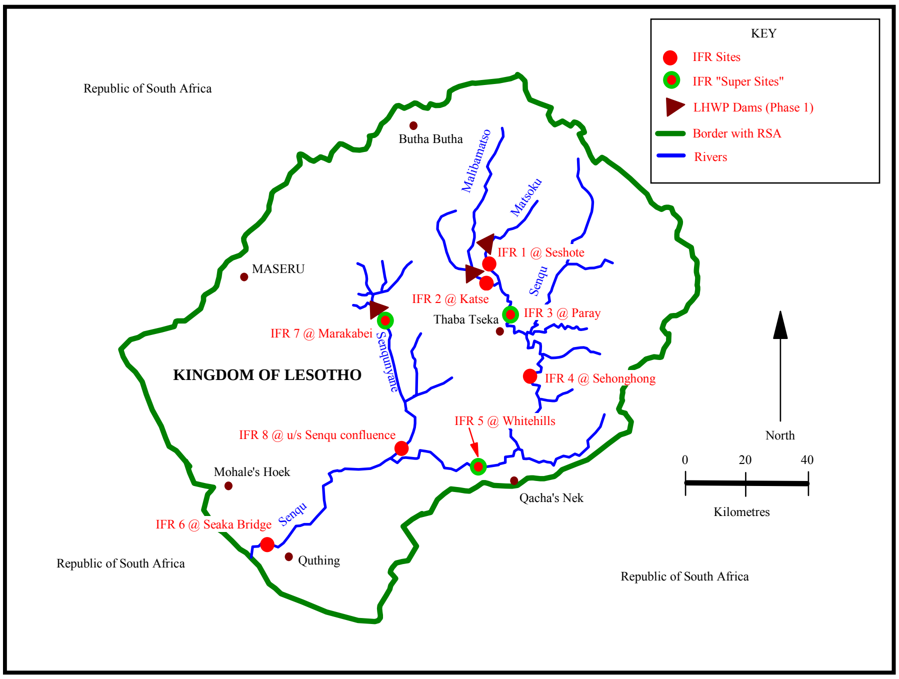
(vi) Medicinal plants are used locally by riparians, or traded regionally (i.e., in Lesotho, or in SA) (LHDA 2002c).

Other than vegetation, wildlife communities are found and are highly distinctive with several endemic species, though densities are low due to heavy exploitation (LHDA 2002a). Instream the river system, different varieties of fish (Smallmouth Yellowfish, Rock Cat Fish and Rainbow Trout) are found. These provide an important source of protein to riparians.

The human population downstream of the LHWP structures (i.e. dams and weirs) within Lesotho is about 155, 000. Most of these people live in small villages, with a small proportion living in larger settlements such as Marakabei. Lack of formal education and high unemployment are characteristic of most communities. Rural people are heavily dependent on ecological resources for their livelihood, while foreign employment (South African mines) represents an important but declining source of income. The value of ecological resources and services used by the human population downstream the dams was estimated to be R46.3 million annually (2000 prices) (LHDA, 2002d).

Cultivated agriculture is another important source of livelihood though agricultural lands are constrained in size by topography and soil depths. Figure 2.5 below shows areas in the villages likely to be affected by modified river flows downstream the LHWP dams in Lesotho. These are areas labeled IFR sites in the map.

FIGURE 2.5: Areas affected by modified river flow downstream LHWP dams



Source: LHDA (2002a).

The IFRs study (LHDA, 2002a) identified several biophysical impacts of the modified flows of the Upper Orange River system as well as the Population At Risk (PAR) as a result of the project. IFRs study covered impacts on the vegetation, fishery, geomorphology, hydrology, hydraulics, and water quality. The IFRs biophisical component of the study revealed that the biophysical changes identified will lead to reduction in a significant number of the ecological resources identified above, thus leading to a welfare loss to riparians. It is therefore critically important to value ecological losses of the LHWP to determine the extend to which the project will erode the riparians welfare.

2.4.3 Impact in importing country

Significant ecological impacts are expected on the As, Liebenbergsvlei and Wilge Rivers and Saulspoort Dam. The additional water from Katse Reservoir is expected to alter the flow, temperature, chemistry and biology of these rivers and dams. The ecological impacts of these biophysical disciplines were studied by Chutter and Ashton (1990) and Chutter (1992, 1997), but were never quantified as in the IFR studies for Lesotho. Nevertheless, the studies revealed several important ecological implications of water transfer within the reaches of these rivers. The major impact is expected to result from the increased flow of the rivers, with resultant impact on the inundation of floodplains and wetlands, as well as on the biota of the rivers.

The As and the upper Liebenbergsvlei River valleys have narrow floodplains which are often inundated during floods. These floodplains and wetlands contribute significantly to agricultural productivity in the valley, and also serve as an important habitat for wild vegetation and animals (birds). There are also several wetlands located in the Liebenbergsvlei valley, which are important in the ecology of the Highveld geese and duck. Jackson (1987) estimated that about 50% of the spurwing goose and 40% of the yellow bill duck and Egyptian goose populations of the whole Highveld mould are in the Eastern Orange Free State, which is where these wetlands are located. It is expected that increased flows of the As and Liebenbergsvlei Rivers will lead to high erosion of the river beds and this will alter the flows necessary to inundate riparian floodplains and will probably destroy existing wetlands (Chater et al., 1990). The increased flows are also expected to increase the size of the rivers, which is expected to impact positively on the diversity of riverine biota. Rainbow trout, and other riverine plant and animal species present in both the Malibamatso and Nqoe Rivers in Lesotho are expected to be transferred through the Trans Caledon tunnel to the As River. This is expected to displace the present fauna further downstream, but no major negative impacts on the indigenous fish are expected from this change. While it is equally important to estimate ecological values in this case, the estimation is not performed since the corresponding biophysical changes have not been quantified. The next chapter reviews literature related to this study.

CHAPTER III - REVIEW OF RELATED LITERATURE

3.1 Introduction

Interbasin water transfer (IBWT) projects have been used to transfer water from water abundant to water deficient areas/regions since about 50 years ago. The transfers are mainly aimed at augmenting supply to meet offstream demands for water in agriculture, industry, hydropower and household sectors with ultimate objective of boosting economic growth and society's welfare in water deficient regions. Accordingly, the economic and social desirability of such transfers have been traditionally based on the direct net benefits realized in offstream uses that the transfers are planned for. One problem with this approach to evaluating IBWT projects is the fact that it does not consider the economy-wide (indirect) effects of these changes. Moreover, such transfers can leave insufficient water to support the many instream ecological services of water in the exporting area. Instream water services include sustenance of ecosystems by regulating floods, water chemistry, temperature, quality and logging as well as sand deposists within rivers; and by supporting survival and growth of aquatic resources like fish and wild vegetation among others.

The external ecological costs associated with altering the volume and quality of water within a basin due to the transfers are often ignored. Even when included, they are usually done as adhoc assessments once the transfers have been implemented (e.g. LHDA, 2002a). This situation is perhaps due to the challenge involved in evaluating instream benefits of water. While it is relatively easy to evaluate offstream benefits of water typically used for producing marketed commodities, it is difficult to evaluate instream benefits because many of the involved ecological services of water are usually not traded in markets (Hassan and Lange, 2004; Freeman, 1991; Acharya and Barbier, 2000). Accordingly, the literature on assessment of IBWT can be grouped into the following four approaches:

(i) Studies evaluating net benefits of IBWT based on direct offstream uses of water in the importing region

(ii) Studies that consider indirect economy-wide impacts of changes in offstream supply and use of water as a result of IBWT

(iii) Studies evaluating external net benefits of ecological uses of water in the exporting region, and

(iv) A more recent thread of the literature representing studies that integrate instream with offstream net benefits of water in the importing and exporting regions

This chapter reviews the literature on the above listed four approaches to assessing IBWT and motivates modifications required to improve impact assessment of IBWT by integrating instream with offstream implications of such transfers into an economy-wide framework. Sections 3.2 and 3.3 review the literature on assessing direct and total (economy-wide) offstream effects of IBWT, respectively. In Section 3.4 the literature on assessing instream uses of IBWT is reviewed. Finally, Section 3.5 discusses the literature on studies that integrate instream with offstream benefits and costs of IBWT and provides the motivation for an integrated ecological-economic approach to assessment of IBWT through an economy-wide analytical framework to be adopted in this study.

3.2 Approaches to assessing direct offstream impacts of IBWT

The literature on IBWT schemes goes as far back as 50-60 years ago when the relatively older IBWT schemes were constructed in the United States and Australia. The fact that IBWT schemes were developed to meet water demand deficits in economic sectors has influenced the literature on the benefits of IBWT to be biased towards off-stream uses of water. As a consequence, the value of water in traditional off-stream uses is well documented, which include irrigated agriculture, industry, hydropower generation and household uses (Hassan & Lange, 2004; McKinney et al., 1999; Young, 1996; Gibbons, 1986). The earlier approaches only considered the direct impacts of IBWT on sectors that the transfers were intended for. Cost-benefit analysis (CBA) was the most common technique of project evaluation employed in assessing IBWT projects.

The CBA compares the discounted potential costs to benefits of IBWT and determines whether potential economic benefits of IBWT projects outweigh its costs, in which case the project is recommended for implementation (Gittinger, 1982). The costs normally consist of construction, operation and maintenance, relocation where people have to be relocated from project areas, opportunity cost of the land to be inundated, environment destruction as a result of a project and other costs associated with the schemes. Benefits usually include the value of tangible contribution to sectors the schemes are intended for, e.g. hydropower generation, flood control, irrigation, municipal and household water use. Most of the literature on CBA analyses of IBWT is found in unpublished technical feasibility studies and consultants reports, which are not easily accessible. A few examples of IBWT are provided below to show how CBA wass used in assessing IBWT.

Examples of IBWT include the old early 19th Century schemes in the US and Australia. In the US, examples include California, which has a variety of federal, state, and local IBWT developed over the past 85 years to meet rapidly growing demand. In 1913, the city of Los Angels built a 233-mile aqueduct to transfer water from the Owens valley in eastern Sierra Nevada. In 1937, a Central Valley Project (CVP) was funded by the federal government to divert water from the Sacramento-San Joaquin river delta to southern California (Howe and Easter, 1971). The scheme comprised 20 reservoirs, 11 power plants, 3 fish hatcheries, and 500 miles of canals. In a normal year, the scheme delivers 7 million acre-feet of water to irrigate 3 million acres of farmland and supply 2 million urban customers (Hirji, 1998). The CVP facilities were primarily constructed for river regulation, navigation, and flood control, but they also provide power generation and recreation.

The CVP was supplemented in 1960 by the State funded State Water Project (SWP), comprising 22 dams and reservoirs and a 444-mile aqueduct from the northern to the southern part of the state. Thirty percent of water from the scheme is used for irrigation in the San Joaquin Valley and 70 percent for residential, municipal, and industrial needs in the south (Howe and Easter, 1971). The benefits included in CBA analyses of these schemes focused on the improvement of the welfare of the farming communities, and the growth of cities and industries, as well as conservation benefits associated with relieved pressure on depleted groundwater aquifers, which had caused severe land subsidence.

In Australia examples include the Snowy Mountains hydroelectric scheme, which was constructed between 1949 and 1974. The scheme uses 16 major dams, 7 power stations, a large power pumping station, 245 km of tunnels, and 80 km of aqueducts to collect and divert 98 percent of the inflows to the Snowy Mountains into the Murray and Murrumidgee rivers for agricultural productivity and to meet urban demand in southeast Australia, including Sydney and Melbourne (Hirji, 1998). The CBA of this scheme assessed its benefits in terms of contribution of the scheme to annual energy requirements of southeast Australia and contribution of the scheme to agricultural productivity, regional output, income and employment. For example, the scheme meets 5 percent of the southeast's total annual energy requirements and provides 10-33 percent of flows in the Murray and 25-30 percent or regional output, income, and employment (Hirji, 1998). Like in the case of California, The CBA for this scheme did not derive the value of the water from the scheme for the multiple uses it was intended for.

These schemes were constructed at the time when there was little concern about the environment. As a consequence, their economic worthiness was based only on CBA analyses that did not pay much attention to ecological consequences of the schemes (Hirji, 1998). The result was serious unforeseen ecological consequences related to the schemes in all cases (see Hirji, 1998; and Howe and East, 1971 for details). To avoid this problem, today the economic viability of IBWT is also based on environmental impacts assessments (EIAs), which form an integral part of CBAs. EIAs may be defined as a formal process used to predict the environmental consequences of IBWT. They identify and measure all environmental costs of IBWT for inclusion in CBAs. EIAs therefore became an essential input to CBAs and the two assessments are complementary. As such, EIAs ensure that the potential environmental problems are foreseen and addressed at an early stage in the IBWT planning and design. More recent IBWTs have benefited from EIAs. Examples from developing countries include the Wanjiazhai Water Transfer Project (WWTP) in

China constructed in 1998 and the LHWP in Lesotho, Southern Africa constructed in 1987.

The WWTP entailed construction of a large dam and a water transmission facility, as well as institutional reforms, pollution control measures, and an industrial waste management and waste wastewater collection and treatment strategy. The project's main aim was to supply the water stressed province of Shaxi in China by improving the water quality and supply and reducing groundwater overdraft and saltwater intrusion into coastal cities, in order to enhance economic growth and relief human distress in the province (Hirji, 1998). The LHWP was aimed at transferring water from the Highlands of Lesotho to the Gauteng province in SA. Details of this project have already been discussed in Chapter II. Both schemes benefited from CBA and detailed EIAs. Despite the advantage of the EIAs that these schemes had, ecological implications of the schemes associated with modifications of the river flows downstream the project dams were not included in the EIAs before the implementation of the projects (Hirji, 1998; LHDA, 2002a). Other IBWT examples from developing countries, drawn from SA, include the Komati scheme that transfers water from the Komati basin to the Olifants River Catchment to supply Eskom electricity power stations, and the Tugela-Vaal scheme that transfers water from the Orange river in the central parts of the country to the Sundays river in the eastern part of the country for irrigation purposes (Basson et al., 1997).

Like in the case of CBA analyses of the older schemes, assessments of above IBWT focused on tangible benefits in terms of economic growth and social development and not necessarily the value of water being transferred. Thus, CBA studies in the IBWT examples given above primarily compared the costs of IBWT projects to the tangible economic benefits generated by the various uses of the extra water supplied by these projects. The main purpose of such studies was not the determination of the value of water, but rather to calculate the economic worthiness and viability of planned IBWT projects and the economic activities to be supported. Because of the growing water scarcity world-wide and increasing costs of IBWT, as well as heightened interest in natural resource preservation, it has become important to measure the economic value of water to better understand the demand behavior of its users. Understanding the demand behavior of water users provides useful policy information to guide decision-making and strategic planning for IBWT and allocation of water resources towards the goals of efficiency, equity and environmental sustainability (Hassan and Lange, 2004; McKinney, Cai et al., 1999; Young, 1996; Gibbons, 1986).

The following sub-sections give an overview of the literature that has been dedicated to valuing and studying demand patterns in competing off-stream uses to assist water management and allocation decisions achieve their economic efficiency and other societal goals. Two analytical methods, positive and normative models were employed to evaluate water values and characterize patterns of demand for water. Positive models attempt to provide pragmatic explanation of water use patterns based on observed water demand and supply behavior information, employing econometric techniques for specification of demand and supply functions. These models are typically structured on the basis of underlying microeconomic theory of the behavior of water users and suppliers. On the other hand, the normative models are premised on assumptions, and judgments simulating respective demand and supply decision situations and commonly employing mathematical programming techniques to solve the simulated optimization decision problem.

3.2.1 Positive approaches to the assessment of IBWT impacts

Market- and non-market-based approaches have been used in the literature to value water in different offstream uses. Market-based techniques include: direct estimation of water value from observed water prices, the sales comparison approach, the land-value differential approach, the least-cost alternative approach, the production function approach, the residual value method and change in net income approaches (Hassan and Lange, 2004; McKinney, Cai et al., 1999; Young, 1996; Gibbons, 1986). In the direct estimation of water demand functions, observed prices and quantities of water are used to derive water demand functions, which are then used to measure the marginal value of water, or total value from consumer and producer surplus. Demand functions were used to analyse water users' behavior and infer various demand elasticities. Gibbons (1986) and Schneider and Whitlach (1991) have summarized substantial literature on estimation of household demand for water.

More recent studies estimating demand for water include those by Lyman (1992), Hewitt and Hanemann (1995), and Dandy et al. (1997). Arntzen et al. (2000) also used direct estimation of demand functions for water use in urban households of Botswana. Examples in South Africa include King (2002), Dockel (1973) and Veck and Bill (2000). King (2002) applied econometric techniques to cross-sectional and time-series data to directly estimate demand functions for water use in small agricultural holdings, households and industry in the city of Tswane. Dockel (1973) applied the macro-econometric model to cross-sectional data to estimate demand functions for water use in households for Alberton and Thokoza residential areas of Johannesburg, and Veck and Bill (2000) repeated the study, using the econometric approach, to estimate demand function for water use in Thokoza. However, their results were not statistically significant.

In impact assessment of water transfers, the direct estimation of water value from demand functions was applied to the case of Zambesi River. Hoekstra et al. (2001), Seyam and Hoekstra (2000), Chapagain (2000), Seyam et al. (2001) introduced the "value flow concept" for water in river basins where the analysis of water value is integrated with the whole water system rather than considering only *in situ* direct values of water. In this approach, water valuation is not only limited to water value at the spot where it creates a direct benefit, but also includes indirect benefits (i.e. values generated downstream) of water. Hoekstra et al. (2001) and Chapagain (200) employed measured demand and supply functions to determine the total value of water used up- and down-stream the Zambesi River as the sum of producer and consumer surpluses. Their value calculations were carried out on annual basis and had a static character. Seyam et al. (2000) extended this methodology in two later studies to include the dynamics of the water system within a year, thus allowing the assessment of values on a monthly basis. Seyam et al. (2001) extended this model by showing how water system dynamics can in various ways affect the value of upstream water. Both attempts to model water dynamics however, were theoretical and lacked empirical applications.

In the sales comparison approach, the value of water is estimated by real estate appraisal techniques that link water rates or fees exacted for water diverted for residential purposes to the market value of purchasing or selling water rights (Saliba and Bush, 1987). The sales comparison method compares the price of a particular water right to the prices of similar rights that had been recently sold in the market. This method of calculating water values results in a band or range of prices within which the value of the water right could possibly fall. The approach is often used in pricing municipal and irrigation water (Saliba and Bush, 1987, Moncur and Pollock, 1988; Young, 1996; McKinney et al., 1999). This approach is similar to the land-value approach, in which case the value of the water right is calculated as the difference in land values between land with and without access to water or rights (McKinney et al., 1999).

The least-cost alternative method hinges upon water development investments. The value of water supply scheme is estimated as the cost of the next best alternative water supply infrastructure. Alternatively, the value of existing water supplies is estimated as the cost of developing new water supplies. This is the opportunity cost-based approach. It estimates the equivalent costs of an alternative or alternatives to acquiring the rights to already developed water supply systems. These costs can be derived from the costs of recycling of water or construction of a new water supply. The approach is commonly used in pricing water for industrial purposes and in hydropower production, but can be extended to municipal uses if it can be established that consumers would be willing to buy water at the prices equivalent to the costs of developing new water source (Saliba and Bush, 1987; Moncur and Pollock, 1988; McKinney, 1999).

Where input demand for water is not directly observable (i.e. no data on purchases of water at different prices), but water enters the production process as intermediate input, the production function approach is used to estimate the value of water in production (Hassan and Lange, 2004; Young, 1996; Freeman, 1993). In this case the quantity of water used in production is combined with other relevant data to estimate the production function of the product in question to deduce the marginal value product of water. This technique is mainly used in irrigated agriculture and industry. Pazvakawambwa and van Der Zaag (2000) used the production function approach to estimate the value of water in maize production in the Nyanyadzi smallholder irrigation scheme, Zimbabwe. The production function which included maize yield, rainfall, irrigation water and soil moisture status, was estimated using econometric techniques generating marginal value of water estimates of US$0.15/m^3 for total water and US$0.19/m^3 for irrigation water.

Acharya and Barbier (2000) also used the production function approach to value the Hadeija Nguru wetlands in recharging aquifers that supply irrigation water to local communities during dry seasons. The authors estimated the total value of these wetlands at Naira 5.5 million for an average farmer in the production of wheat and vegetables collectively. The production function approach has also been applied to the valuation of industrial water. Examples include Wang and Lall (1999) who applied this method to value water in industrial production in China and Renzetti (1988 and 1992) who estimated the value of water in industrial production for British Columbia and Canadian manufacturing firms, respectively.

Like in the production function approach, the residual value method is also used to measure the value of water as intermediate input in production. However, in this case data on price and quantity of water required for direct estimation of water demand functions as well as physical quantities of inputs and output to support production function estimation are unobservable. This method uses only data on production costs and revenue to determine a shadow price for water calculated as the difference between the total value of output (TVP) and the costs of all non-water inputs to production (see Hassan and Lange, 2004; Young, 1996 for details). Examples of studies that applied this approach include Bate and Dubourg (1997), who estimated the residual value of irrigation water in 5 crops in East Anglia from 1987 to 1991 using budget surveys' data. The estimated value of water ranged from 13.45 – 1428.84 British Pounds per hectare for the 5 crops included in the analysis (winter wheat, barley, oilseed rape, potatoes and sugar beet). Schiffler (1998) calculated residual value for fruit and vegetable crops in Jordan, also based on farm budget surveys at 0.714 Dinar/m^3 in fruit crops and 0.47 Dinar/m^3 in vegetable crops. MacGregor et al. (2000) used the residual value method to value irrigation water from the Stampriet Aquifer in Namibia, deriving an estimate of N$0.67/m^3 (where N$ stands for Namibian dollar).

The change in Net Income (CNI) approach measures the change in net income resulting from a change in water input. The approach is often used to compare the value of water under present allocation to the value that would be obtained under alternative allocations of water (Hassan and Lange, 2004). Louw and Schalkwyk (1997) used the 'change in the net income' approach to value irrigation water in the Olifants River Basin in the Western cape, South Africa. In this case study water is transferred from the Olifants River to irrigate about 21 503 ha of land. The value of irrigation water was calculated as the difference between net value of agricultural output with and without irrigation divided by the amount of water transferred to agriculture. The value of water was calculated as R9 474 per ha.

The non-market approaches to valuation of water include inferential valuation or revealed preference methods and stated preference or contingent valuation methods (CVM). In the inferential valuation approach, the value of water is inferred from the behavior revealed by water users where the value is imputed from implicit prices such as expenditures incurred by individuals to use water, e.g. travel cost (typically applied to assess the value of water quality and recreation-based benefits but can also be used to estimate the value of residential water to consumers). Inferential valuation also employs the hedonic methods (Cropper and Oates, 1992).

The inferential valuation method relies on the notion that the price of marketed goods can be decomposed into its attributes, and that an implicit price exists for each of these attributes. The approach is often used for the aesthetic or quality valuation of water resources. Irrigation water supply has also been valued using this approach, through estimation of the effect of availability of water on the value of farmland (Young, 1996). Another method is mitigation/averting/avoidance/defensive costs, expenditures or technology, mainly used to value water quality. This method relies on the fact that in some cases purchased inputs can be used to mitigate negative environmental effects. For example, farmers can increase the irrigated area and other inputs used to compensate for yield decrease due to salinisation and consumers can take actions to avoid drinking polluted groundwater or mitigate the health effects of poor quality of water. In this case the value of water is estimated by the value of inputs used in mitigating water quality changes (Cropper and Oates, 1992; Lee and Moffit 1993).

Stated preference or CVM approach to water valuation elicits direct responses of potential users to structured questions regarding the amount they are willing to pay for water services. Examples include Thomas and Syme (1988) in which the CVM approach was used to derive the marginal value of residential water in the Perth metropolitan area of Australia and Veck and Bill (2000) who used CVM to estimate the marginal value of residential water in Thokoza and Alberton residential areas of Johannesburg, South Africa. Another approach similar to CVM is conjoint analysis which, unlike the CVM, focuses on the resource's attributes, e.g. water quality. Details of these techniques can be found in Hassan and Lange (2004), Mckinney et al. (1999), Young (1996), Gibbons (1986). The positive approach to valuation of water requires data which are often not available and hence econometric techniques can not be applied. This is when the normative approach is useful and can be used to estimate water demand functions under different policy and institutional settings than have historically existed.

3.2.2 The normative approach to assessment of IBWT impacts

The normative approach uses mathematical programming optimization techniques to value water with various forms of the supply and demand functions of water generally embedded within an optimization framework determining efficient allocation of water between different offstream uses. The general feature of optimisation models is to specify an objective function (usually profits or benefits maximization or cost or loss minimization) subject to several constraints including production functions, water availability, and other institutional and behavioral constraints. Optimisation models may be applied to one sector, for example agriculture in which the objective may be to determine optimal allocation of water between different crops or to a number of sectors within a water basin in which the objective may be to determine the optimal allocation of water to different water users within a basin.

IBWT have predominately been aimed at supplying water for irrigation purposes. As a result, most of available literature employed mathematical programming techniques to assess benefits of IBWT in irrigated agriculture. Most of reviewed studies focus on multiple crops. The common objective in this case has been to determine the optimal reservoir releases' policies and irrigation allocations to multiple crops (Vedula and Kumar, 1996; Vedula and Mujumdar, 1992; Dudley and Scott, 1993, Bryant et al., 1993). In all cases stochastic dynamic programming (SDP) approach was used in which reservoir release and field water allocation decisions were integrated in a modeling framework, taking into account soil moisture dynamics and crop growth at the field level. Reservoir inflow and precipitation were considered stochastic, and water allocation among multiple crops included.

Vedula and Kumar (1996) and Vedula and Mujumdar (1992) studied water allocation in the Malaprabha irrigation scheme in India which transfers water from the Malaprabha River and stores it in the Malapha reservoir for irrigation purposes. Dudley and Scott (1993) study was conducetd in the Gwydir irrigation scheme where water is transferred from the Gwydir River to farms in the Gwydir valley of northern New South Wales for irrigation (Dudley et al., 1993) and Bryant et al. (1993) considered irrigated farms in Texas High Plains of the US. Other studies in this category include Paudyal and Manguerra (1990) who used a two-step (deterministic and stochastic) dynamic programming approach to solve the problem of optimal water allocation in a run-of-river-type irrigation project. Ziari et al. (1995) developed a two-stage model in which they simultaneously considered multiple crops, stochastic water supply and demand, water application, and risk attitude in evaluating the economic feasibility of small impoundments for supplemental irrigation in the Blacklands region of Texas, USA.

Conradie and Hoag (2003) used a static linear programming model to assess benefits of water transferred from the Fish and Sunday Rivers for irrigation in the Eastern Cape, South Africa. The Fish-Sunday irrigation scheme is aimed at abstracting water from these two rivers for irrigation in the Eastern cape. The model focused on citrus and fodder farms and was used to determine the value of irrigation water within the scheme with and without water trade. Water demand functions for the two crops were explicitly estimated in the model. Results indicated that the value of irrigated water increased with trade from R0.0423/m^3 to R0.0681/m^3 .

Fang and Nuppenau (2003) used a spatial water allocation model (SWAM) to assess the impact of water use efficiency in transferring water from the water source (rivers) through canals to irrigated farms in the Li Quan, Shaanxi Province of China, as a case study. Fan and Nuppenau explicitly estimated demand function for water in the project area using econometric techniques. They then integrated these results in the spatial mathematical programming model to determine optimal spatial water allocation and corresponding water values taking into account individual farmer's adoption of modern water saving technologies and improvements in water transit, contributed by the public sector, from sources to end of canals. The main contribution of the study was optimizing water allocation and choices of irrigation technology for farmers in the case study area.

Other studies include Bowen and Young (1985) in which a linear programming model was used to derive estimates of financial and economic net benefits to irrigation water supply in northern Nile delta of Egypt. The authors formulated linear programming models of representative farms and in the study area and reported total, average, and marginal net benefit functions. Lee and Howitt (1996) developed a nonlinear mathematical programming model that optimizes river water quality, resources allocation, production levels and total expenditures for water control and applied it to the Colorado river basin.

One problem with the studies reviewed above is that they all leave out ecological values of water in their assessments. When environmental uses of water are left out, optimization approaches can lead to ill-defined policies when it comes to water conservation, especially for in-stream uses of water. Secondly, these models are based on partial-equilibrium analysis and hence provide a rather narrow approach to the assessment of IBWT that ignores linkages between sectors and activities in terms of the water transfers' impacts. This implies that influences through and on other sectors are insignificant such that the partial equilibrium model will tell the whole story about benefits and costs of IBWT. The next section discusses economy-wide modeling approaches developed to account for indirect impacts through multi-sector linkages and multipliers in assessing IBWT.

3.3 Economy-wide modeling approaches to impact assessment of IBWT

Economy-wide modeling approaches emerged from the pioneering work of Leontief (1951) leading to the development of input output (I-O) models. Following Leontief work on multi-sector analysis, his I-O framework has been extended to more comprehensive economy-wide structures such as the social accounting matrix (SAM) and computable general equilibrium (CGE) models (Johansen, 1960; Defourny and Thorbeck, 1984; Pyatt and Round, 1985; Adelman and Robinson, 1989). The three types of models rely on macro-economic data of a country. Because, for many years, macroeconomic data of countries excluded environmental concerns, economy-wide analyses have historically focused on pure economic accounts.

3.3.1 I-O based models used in impact assessment of IBWT

Application of input-output techniques to the study of resource and environment problems began in the 1970s. I-O studies range from those designed to influence water management and allocation decisions within water basins (Carter and Ireri, 1970; Thoss and Wiik, 1974) and those designed to assess the impact of IBWT (Xikang, 2000; Sheets, 1998). Carter and Ireri (1970) developed inter-regional input-output model to study water allocation between California and Arizona. At the time, the two states were embroiled in a legal conflict over water allocation rights from the Colorado River. In an attempt to provide information relevant for water allocation policies with respect to industrial and agricultural production for these two states, Carter and Ireri (1970) used the I-O model framework to study, among other things, the extent and nature of economic interdependence between California and Arizona, technical water requirements of different sectors in California and Arizona and how these requirements are related to economic activity within California and between California and Arizona, the magnitudes of water congealed in the product flows between California and Arizona and the direct and indirect water requirements of sectors in both regions in response to changes in final demand for products in each state. The results indicated that while both states have strong bilateral trade links, California production sectors had larger output multipliers compared to their Arizona counterparts. Arizona was more water intensive in agricultural production while California was water intensive in agricultural processing, manufacturing, mining and services. Arizona sectors use more water per dollar of final demand than corresponding California counterparts which is indicative of the fact that California sectors are more efficient in their water-use patterns compared to Arizona, and that California exports more water (congealed in exports) than Arizona.

Thoss and Wiik (1974) developed a constrained multi-regional I-O model to study management of water quality in the four regions representing the main industrial area within the Rhur basin in Germany. The objective of the model was to maximize production or gross regional income subject to permissible levels of water pollution and minimum required standards of consumption, capital investment and other physical conditions of the system. The results indicated that the manufacturing sector was the most water polluter in all the four regions. In addition, they highlighted regions producing at sub-optimal levels in terms of excessive pollution suggesting which sectors should cut or increase production to optimize gross profits and reduce pollution levels. The main conclusion that emerged from this study was that environmental policy should not be left to administrators or to engineers and that it needs to be determined using economic principles.

Despite the use of I-O models in the analysis of water allocation and management problems, its use in impact assessment of IBWT was recent. Xikang (2000) used the input-occupancy-output model to conduct an economic valuation of a water transfer project in the Shanxi province of China. The project, known as the Wanjiazhai Yellow River-Shanxi Diversion Project (WYSDP), transfers water from the Yellow River to the water defficient Shanxi province. The project provides water for three energy bases in Taiyuan, Datong and Pingshu and transfers the total of 1.2 billion m^3. Xikang's (2000) model had two distinct characteristics. First, the model divided the water sector into three sub-sectors: (i) freshwater, (ii) recycled water and (iii) waste water treatment. Second, Xikang (2000) added the occupancy section to the input section in the conventional input-output table, where the occupancy section included fixed assets, circulating assets, labour and natural resources. Although the study yielded useful results on how the Shanxi province can save water, it only focused on offstream uses of water (i.e. agriculture, industry and domestic) and ignored instream uses of water.

While the studies reviewed here used more powerful analytical tools than the partial equilibrium and sector-based studies reviewed in Section 3.2, they suffer from small multipliers criticism inherent in the limiting structure of I-O models. Among other things, the I-O model treats households consumption as exogenous, and as a result, income distribution to households and expenditure thereof (the demand side), are not allowed to feed back into the economic system. When the focus is on households like in this study, The I-O is seriously limited as an assessment of welfare/income effects of instream losses on different income groups of households cannot be performed with the I-O model.

3.3.2 SAM based Models used in impact assessment of IBWT

Compared to the I-O model, the SAM is more powerful in analysing socio-economic issues as it integrates demand sectors into endogenous accounts' structure and shows how income is generated and distributed in an economy. Thus, SAM-based models include feedback linkages from income generation, distribution and spending. The models also allow disaggregation of households into different income groups depending on the study objectives, which is advantageous when analyzing income effects of an exogenous change on different characteristics of households like is the case in this study. SAM-based models were used to study economic growth, income distribution and developmental issues, especially in developing countries (Adelman, 1975; Adelman and Robinson, 1989; Pyatt and Round,1985). However, their application to the assessment of IBWT remains scarce. Existing related literature on the use of SAM-based models mainly focuses on water management and are mainly single-country studies.

Because of chronic water scarcity in Thailand which threatens development, Kumar and Young (1996) developed an analytical framework for integrated water resources management to illustrate how Thailand SAM may be extended to incorporate water resources and give examples of what the supply and demand functions for water would look like. This framework was based upon an integrated approach to demand and supply management of water resources and the implications for water pricing policies. Kumar and Young (1996) concentrated on modifications and extensions of the social accounting matrix and on demand and supply equations for water that reflect the true scarcity of water for different uses and from different sources.

On the contrary, Daren et al. (1998) used a SAM framework to analyse water allocation options in the Truckee River Operating Agreement (TROA). They developed a SAM for the study area to estimate interlinkages between economic sectors in the study area and simulated different water allocation patterns to determine how to allocate water efficiently to different users in the study area. Although these two studies greatly depart from the objectives of this research, they were the closest from the available literature. Nevertheless, these studies confirm the significance of integrating water concerns into economy-wide planning. The only shortcoming of the studies is negligence of other uses of water not directly linked to economic production (i.e. water required for instream or ecological reserve).

Conningarth Economists (2000a and b) adopted a multi-region and multi-country approach to the measurement of water benefits for the Komati and Thugela water transfer schemes. In their analyses, they measured the extent to which water transfer from rivers in the two respective river basins (for agricultural use in the Komati Basin and industrial use in the Thugela Basin) would generate employment and lead to economic growth in general. Both analyses demonstrated the significance of sectoral linkages through induced multiplier effects. The analyses however, had the shortcoming of ignoring ecological considerations of water transfer schemes (instream impacts). As a result, benefits measured do not portray the full social costs and benefits of the schemes.

Although the SAM-based approach is an improvement over the I-O approach and single sector approaches reviewed under Sections 3.1 and 3.2, the approach is based on rigid assumptions of fixed coefficient production technologies, excess resources and thus fixed prices, and lack of input and output substitution. The following section reviews CGE-based models which relax most of these restrictive assumptions.

3.3.3 CGE models used in impact assessment of IBWT

Computable general equilibrium (CGE) models date as far back as the 1960s to the pioneering work of the Norwegian Leif Johansen (1960). In his dissertation 'A multi-sectoral study of economic growth', he presented a numerical model that came to be known as the "MSG model". The model was primarily intended to be a tool for long-term economic forecasting and economic policy evaluation and is generally seen as the first CGE model (Bergman, 2002). Unlike SAM-based models that are built with restrictive assumptions, CGE models use relatively more flexible supply and demand structures. The most commonly used specifications are the constant returns to scale technology and homothetic consumers' preferences (Bergman, 2002). CGE models endogenously determine relative product and factor prices and the real exchange rate. They are particularly aimed at quantifying the impact of specific policies on the equilibrium allocation of resources and relative prices of goods and factors.

Although CGE models started as early as the 1960s, environmental CGE models started only in the early 1970s and were predominantly energy models. The econometric CGE model for energy policy analysis of Hudson and Jorgenson (1974) is one such example. This turned out to be the first of a large number of models developed to analyse energy policy issues in the wake of the oil price increases in 1973 and 1979 (Bergman, 2002). At the beginning of 1990s the focus shifted from energy supply problems to climate change related problems (Burniaux et al., 1992; Hill, 2001; Murthy et al., 1992; Bussolo et al., 2002). Most CGE models today are designed to elucidate various aspects of climate change or in some cases, acid rain policies, e.g., pollution from energy use and climate change (Bergman, 2002).

Despite the fact that the application of CGEs to environmental problems started three decades ago, their application to water issues has been rare and available literature only focuses on agricultural water management policies (Diao et al., 2002; Decaluwe et al., 1999; Mukherjee, 1996; Robinson and Gehlhar, 1995; Goldin and Roland-Host, 1995). The skewed focus perhaps resulted from the growing water scarcity and increased population pressures that has prompted many countries to adopt water-pricing mechanisms as their primary means to regulate irrigation water consumption. The first CGE water model was presented by Berck et al. (1991) with which they studied the impact of investment policies aimed towards the distribution of water in the San Joaquim Valley of Carlifonia in the United States. The model was disaggregated into 14 production sectors, six of which were agricultural, and it measured the impact of changes in water available for agricultural production on the economy. The authors made a restrictive assumption that water was exogenously supplied and agriculture was the only consumer of water. A simulated reduction in water availability generated diversification in production away from agriculture to livestock, accompanied by a decrease in GDP, as well as a reduction in agricultural income and labour demand.

Other studies, all focused on agricultural water pricing in Morocco, include Goldin and Roland-Host (1995), Decaluwe et al. (1999) and Diao et al. (2002). Goldin and Roland-Holst (1995) studied the relationship between trade reform and water management in Morocco in a CGE framework. Their CGE had four production sectors, two of which were agricultural. They analysed the impact of two policy scenarios on water demand: (i) increased water tariffs for agricultural water use, (ii) reduction in import duties, and (iii) combination of the two policies. They concluded that the third policy scenario resulted in a reduction in water demand, an increase in GDP and an improvement in household income. They however, assumed a restrictive production function for agriculture that does not allow for substitution between water and other inputs. They also assumed fixed water endowment.

Decaluwe et al. (1999) relaxed these restrictive assumptions in analysing three pricing strategies (Marginal pricing, Boiteux-Ramsey Pricing (BRP), and arbitrary price increases in agricultural water) to determine which is more effective in achieving optimal agricultural water allocation, recovery of total costs related to agricultural water infrastructures and reduction in the growing water scarcity problem in Morocco. They used four types of agents: households, firms, government and the rest of the world. To account for spatial water distribution they divided the country into two distinct regions, north and south. They found the BRP, combined with a reduction in distorted production taxes to be the most efficient in reducing water consumption with a positive impact on efficiency in terms of use and cost recovery. Johanson (2000) gives detailed literature on similar studies.

Robinson and Gehlhar (1995) used an 11-sector CGE model to determine the magnitude of Egyptian agricultural resource base (land and water) strains resulting from further population and GDP growth. The study particularly focused on two distortionary policies that characterised the Egyptian economy in 1986-88 (i.e. large, sectorally variegated output taxes and subsidies), which included major input subsidies and zero charges for water in agriculture. The model combined an optimizing, programming model of land and water use in agriculture with a simulation model of the non-agricultural sectors. Empirical results indicated that 1986-88 Egyptian policies were biased against agriculture and led to a water-conserving structure of agricultural production. As such, land, not water, was the binding constraint. The results also indicated that policy reform would increase both aggregate welfare and demand for water. Given the inelastic demand for water, policy reform on the output side would strain the existing system of water distribution since water would become much more valuable than land to agricultural producers. Given the initial policy bias against agriculture, policy reform would favor rural employment and lead to reduced pressure of rural-urban migration.

Mukherjee (1996) used a "Watershed Computable General Equilibrium (CGE) model" to analyse water allocation policies in South Africa, using the Olifantsriver Catchment in the Transvaal as a case study. The main objective of this study was to analyse different water allocation policies that can result in efficient and equitable water allocation between productive (agriculture, mining, industry and tourism) and consumptive (human and ecological) uses of water in South Africa. Although all the users mentioned above were included in the model, agriculture was given a more detailed technical specification since it is the largest water user in South Africa. The important conclusion the study arrived at was that SA needs improved efficiency in administrative allocations, and that the potential efficiency gains from improved water policies do not appear to exact tremendous price from the disadvantaged sectors, though small and targeted investments that would improve these sectors' productivity are likely to have great impact.

Economy-wide models discussed above have an advantage over the positive and normative models as they analyse economy-wide implications of IBWT and hence provides a holistic approach to impact assessment of IBWT. Despite this strength over partial equilibrium models, the studies reviewed above suffer from the major criticism of leaving out instream uses of water. Lack of integration of ecological values into IBWT impact assessment studies reviewed so far suggests that valuation of instream impacts of IBWT continue to be a challenge. The next section reviews studies that evaluated instream/ecological uses of water.

3.4 Approaches to assessing instream impacts of IBWT

Unlike offstream impact assessment of IBWT that started about 50 years ago, explicit estimation of instream/streamflow economic benefits of IBWT only started in the late 1980s (Gibbons, 1986). As a result, instream flow reservations for maintenance of riverine ecology are still largely based on biological and hydraulic, rather than economic criteria.

Available literature on the streamflow valuation largely centers around recreational values. Economists have used biological and economic assessment methods to evaluate the recreational fishing benefits of incremental streamflow changes (Johnson and Adams, 1988; Hansen and Hallam, 1991; Duffield et al., 1992; Harpman et al., 1993). Other studies have analysed quality of whitewater boating (Brown et al., 1991) and stream aesthetics for general shoreline use (Brown and Daniel, 1991). The common objective of these studies was to compare the economic values of instream flow to the value of competing off-stream consumptive uses such as irrigation or municipal withdrawals. These uses are typically marketed commodities or inputs to marketed commodities and hence their values are relatively well understood. However, instream uses are generally not marketed, requiring novel approaches for estimating their economic value.

A Multistage bioeconomic framework has been commonly used for estimating recreational fishing streamflow value (Johnson and Adams, 1988; Hansen and Hallam, 1991; Daffield et al., 1992; Harpman et al., 1993). The first step of this type of analysis comprises of estimating a fish production model with respect to streamflow. The second step involves the use of contingent valuation methods (CVM) to elicit from anglers the amount of money that they would be willing to pay (WTP) for increments in fish quality or the amount they would be willing to accept (WTA) for decrements of fish quality. This method employs Hicksian compensating measures: compensating variation and compensating surplus (Freeman, 1993) to measure the value of streamflow. Despite the fact that they are the best available methods for valuing non-marketed resources, CVMs have many shortcomings, which are well documented in the literature (e.g., Blamey and Common, 2000; Tietenberg, 2000; Dixon et al., 1994; Hanemann, 1991; Branden and Kolstad, 1991; Hufschmidt et al., 1983).

Recently, there has been a shift in the focus of streamflow valuation from its original recreational flows to agricultural and biodiversity valuation, with the main objective of measuring welfare impacts associated with modified streamflows. The work done on Hadejia-Nguru wetlands of Nothern Nigeria (Hollis, 1993) is a notable example. Earlier studies on these wetlands largely focused on the impact of diverting water to upstream uses on the agricultural and biological diversity productivity of floodplains downstream, and resultant welfare implications on the downstream users. The work on these wetlands was motivated by dam and reservoir projects, built and proposed, which will divert water from rivers that inundate Hadejia-Nguru wetlands, to meet irrigation and industrial demands of water upstream. Studies that analysed direct linkage between flooding of these wetlands and wetlands productivity demonstrated that diversion of water to upstream uses resulted in reduced wetland productivity and thus reduced riparian welfare (Barbier et al., 1993 and Barbier and Thompson, 1998), and led to shifts in farming patterns by downstream farmers from high value crops (e.g. rice in west Nigeria) to low value crops (millet) (Adams, 1985).

While these studies demonstrated the value of floodplain products and the impacts of diverting water away, on floodplain productivity and on riparian welfare, they made no attempt to explicitly estimate the economic relationship between streamflow/flooding and floodplain agricultural and biodiversity productivity. Recent studies (Acharya and Barbier, 2000 and Acharya, 1999) made such an attempt. In the said studies, the value of wetlands in recharging groundwater was analysed, using the production and cost function approaches and drawing on the hydrological and economic evidence. The said studies showed that the indirect effects of changes in instreamflows, and thus flood extent would cause groundwater levels to fall within the wetlands, resulting in welfare losses from reduced agricultural productivity and wild resource availability. LHDA (2002d) and Klassen (2002) used the same framework of Acharya and Barbier (2000) to value streamflow impacts of the LHWP. LHDA (2000d) and Klassen (2002) drew on hydrological, biophysical, economic and socio-economic information to value the impact of the LHWP on the capacity of the Lesotho Highlands rivers to provide regulating and supporting services to the growth of wild vegetation and fish, and resultant welfare impact on riparians residing in the vicinity of the rivers. The studies further used transportation costs to value the cultural services of the rivers, and mitigation costs against human and animal health to value the change in the quality of rivers' water as a result of the LHWP.

The production function approach has been suggested in the literature as a good approach to measuring values of environmental goods or services used in the production of final consumption goods (Freeman, 1993). In this approach, an environmental service or good is treated as an input in the production of some measurable output (Ellis and Fisher, 1987; Freeman, 1991 and 1993; Mäler, 1992). For example, the service of floods to recharge aquifers in floodplains enters the production function of floodplain products indirectly as an input in the production of such products (Acharya and Barbier, 2000; Archaya, 1999). Since the aquifer recharge function of the floods can be said to reduce irrigation costs, this reduction in costs can be represented as a shift in the marginal cost or supply curve for the agricultural product along a given demand curve. An environmental improvement would then involve a downward shift (to the right) of the supply curve of the agricultural product and the theoretical welfare impact measure of this change, would be the combined consumer and producer surplus changes. Detailed valuation techniques of instream uses of water are given in Chapter VI.

While the studies reviewed above make a breakthrough in the valuation of streamflows and criteria for making instream water allocation decisions, they are premised on partial equilibrium analysis like studies reviewed in Section 3.2. Additionally, by focussing only on streamflow benefits of IBWT, the studies offer 'piecemeal' solution to impact assessment of IBWT. The next section reviews the thread of literature that integrates streamflow with economic benefits/costs of IBWT in an economy-wide framework and provides the motivation for this study.

3.5 Integrated assessment of IBWT

Although off- and in-stream impacts of IBWT have historically been assessed separately, a new approach that integrates both assessments has emerged. Available literature predominantly employs mathematical programming techniques in assessing off- and in-stream impacts of IBWT. Integrated hydrologic-economic models for river basin management are used to assess impacts of IBWT on off-stream uses, mainly agriculture and water quality problems (salinity) caused by agriculture (Cai et al., 2003 and 2002; Rosegrant and Meinzen-Dick, 1996; Lefkoff and Gorelick, 1990; Booker and Young, 1994). While this group of studies are an improvement over studies that only focus either on off-stream or in-stream uses of water, they narrowly concentrate on single uses, i.e., agriculture for off-stream uses and water quality for instream aspects of water. Watanabe et al. (1981) considered a number of off-stream uses of water and water pollution problems in assessing impacts of allocating water within a river basin. He used a spatial optimisation model to demonstrate how water use can be optimised in different off-stream uses at minimum water pollution levels using the Yamato-River basin as the case study. Like preceding studies, Watanabe et al. (1981) only focused on one aspect of instream concerns of water, i.e., water quality.

Brown et al. (2002) developed a broader approach which included a variety of off-stream uses: hydropower, irrigation and urban water supply. In their model in-stream uses included flood control and recreation. Their model is a computer simulation model called AQUARIUS and is devoted to temporal and spatial allocation of water flows among competing off- and in-stream uses in a river basin. The model employs mathematical programming techniques and allows for explicit estimation of water demand. The model offers significant contribution to integrated assessment of IBWT impacts. However, it lacks empirical application. In addition, it narrowly focuses on flood control and recreation as in-stream uses of water within a river basin. Other studies that also developed methodology for integrating instream and offstream uses of water include Griffin and Hue (1993) and Giannias and Lekakis (1997).

Griffin and Hsu (1993) developed a conceptual framework, based on a single country, for addressing interface between off-stream and instream uses of water. They considered a case where water from a river basin is used for both off-stream and instream uses, located at different points along a river. In their framework, off-stream users divert water from streams for use in agriculture, industry and household consumption. Some water is returned back to streams after use. This affects both quantity and quality of water available for instream uses. In their study, Griffin and Hsu (1993) developed a highly stylised theoretical spatial model to determine optimal allocation of water between offstream and instream uses for different regions along the river. Their model captured essential details of hydraulic interdependencies among water users and assumed the world sans of transaction costs. While this model offers a good insight into how to integrate environmental into economic concerns in planning water developments, it lacks empirical application.

Giannias and Lekakis (1997) on the other hand developed a conceptual framework presenting a simple economic-ecologic model which examines input-output controls, social input prices, bilateral water trade, a water market for all water users, and a fixed water allocation agreement, as possible water policies for cross border river sharing. They demonstrated that these policies can satisfy the conditions for maximum joint economic benefits, while simultaneously working towards maintaining the functional integrity of river ecosystems. Their study provides a good analytical framework for exploitation of transboundary water resources and demonstrates the significance of cooperation between countries sharing such resources. Although this study makes significant contribution to economic theory of exploiting transboundary water resources, it’s weakness lies in the lack of empirical application, probably because of international lack of cooperation in the management of transboundary water resources. The LHWTS is a unique and probably one of the few transboundary water developments where there is already bilateral trade agreement between involved countries.

The studies reviewed above adopted a partial-equilibrium approach to assessing impacts of IBWT. Hence, they ignored important linkages between activity levels in different water-using and non-using sectors, which suggest that all decisions affecting sectoral production levels and processes invariably lead to repercussions (e.g. multiplier effects) in other parts of the economic system. Sheets (1998) employed an economy-wide approach, using the I-O technigue, to assess the impact of water transfer trom Turkey Creek Watershed into numerous dams. In his analysis he included both off- and in-stream uses of water. The Turkey Creek Watershed occupies 175, 700 acres and is located in Johnson and Pawnee Counties, Nebraska, and Marshall and Nemaha Counties in Kansa. The main objective of the water transfer was to abstract water from within the watershet and store it in 75 floodwater retarding dams with the aim of reducing floods and providing incidental recreation. The project would also reduce sedimentation, enhance wildlife habitat, enhance water quality, improve riparian health, and economic conditions by increasing incomes. Sheets (1998) used a multi-regional I-O model through the computer model he called IMPLAN to analyse regional impacts of the project with special emphasis on flood damage and recreation. The results showed that the project would yield tremendous benefits with respect to reduced flood damage and benefits accruing to incidental recreation. Although the study included instream uses of water, it narrowly focused on flood control and recreation services of streamflow only.

The review of related studies in this chapter has shown that offstream and instream impacts of IBWT have traditionally been assessed separately. Also, some attempts have been made towards integrating these impacts, which has contributed significantly to impact assessment of IBWT to ensure long-term sustainability of such transfers. Nevertheless, studies reviewed in this section only included a few instream aspects of IBWT (recreation, flood control and water quality). Many other aspects including instream resources like wild vegetables, medicinal plants, crafts grass, fuel wood, etc direly required for sustenance of riparians livelihoods in most cases were not included. In addition, most studies employed partial equilibrium techniques which only focus on direct benefits of IBWT. Even Sheets (1998) who integrated offstream with instream effects of IBWT in an economy-wide framework, used the I-O technique that suffers from the problem of small multipliers, and also narrowly focussed on flood control and recreational services of water as instream impacts of IBWT.

This study attempts to contribute to improved analytical approaches for assessing IBWT impacts by developing an ecological economy-wide framework using a SAM-based model that integrates ecological benefits of water. The model captures regulatory and supportive services of streamflows in the growth of wild vegetation and fish, cultural/recreational services of streamflows and the value of streamflows in maintenance of human and animal health (i.e. quality of streamflow). Because of the spatial and temporal nature of IBWT, the fact that they induce structural changes that affect relative prices, and because the LHWTS is a multi-country project, the dynamic multi-country ecological CGE or at-least, multi-country quasi-dynamic ecological CGE model would be appropriate for this analysis. However, because of data limitations, the multi-country ecological SAM (MC-ESAM) is a better substitute at this stage. The next chapter discusses the SAM analytical framework and details on the MC-ESAM follow in Chapter V.

PART TWO: APPROACH AND METHODS OF THE STUDY

Preamble

This part of the thesis covers the analytical approach used in this study and consists of four chapters. Chapter IV gives background to the SAM framework, which is also extended to a multi-country SAM. In Chapter V the methodology for integrating ecological components into the SAM structure is developed and the ecological social accounting matrix (ESAM) is derived. Finally, Chapter VI discusses techniques used in estimating the value of the ecological costs and benefits involved.

CHAPTER IV - THE SOCIAL ACCOUNTING MATRIX (SAM) ANALYTICAL FRAMEWORK

4.1 General structure of the SAM

The SAM framework is an extension of the Input-Output (I-O) data tables. It extends the sectoral linkage concept in the I-O matrix to include income distribution and expenditure on final demand. It is a comprehensive, disaggregated and consistent framework that captures the interdependence that exists within a socioeconomic system, i.e., for every income there should be a corresponding outlay or expenditure and both the receiver and sender of every transaction must be identified (Sadoulet and de Janvry, 1995). Accordingly, total expenditures by each account must exactly equal the total income of that account, hence the respective row and column sums for a SAM must equate and the SAM matrix will be square (McDonald, Kirsten and van Zyl, 1997). This double entry is the economic analog of physicists' laws of materials' balance and conservation of energy (Thorbecke, 2000).

The SAM incorporates, explicitly, various crucial relationships among variables such as the mapping of distribution of factors' income from production activities and the mapping of the distribution of households' income from factors' services. It can therefore be said that SAM captures the full circular flow of an economy. SAMs can be used as data framework or accounting systems representing a comprehensive and disaggregated snapshot of the socioeconomic system in a given year. Alternatively, they can be used as a conceptual framework and as basis for modeling to explore the impact of exogenous changes in such variables as exports, certain categories of government expenditures and investment on the whole interdependent socioeconomic system, e.g. the resulting structure of production, factors , and household income distribution. As such the SAM becomes the basis for simple multiplier analysis and the building and calibration of a variety of general equilibrium models (Thorbecke, 2000).

The chosen taxonomy and level of disaggregation of the SAM depends critically on the questions that the SAM methodology is used to answer. Notwithstanding, the general structure of a SAM consists of six types of accounts: (1) activities, (2) commodities, (3) factors (labor and capital); (4) the current accounts of the domestic institutions (households, enterprise and government); (5) the capital account; and (6) the rest of the world. Table 4.1 below represents the general structure of a SAM and each account of the SAM is discussed in the following paragraphs.

TABLE 4.1: The General Structure of a SAM

		EXPENDITURES **Endogenous Accounts**					**Exogenous Accounts**			
RECEIPTS		Activities	Commodities	Factors	Enterprises	Households	Government	Capital Acc.	Rest of the World	Total
Endogenous accounts		1	2	3	4	5	6	7	8	
Activities	1		Domestic supply (D)							Gross output (Y)
Comm.	2	Intermediate demand (X)				Household consumption (C)	Government consumption (G)	Investment consumption (I)	Exports (E)	Total demand (DA)
Factors	3	Factor payments (W)							Factor service exports (W_{DR})	Factor income (TF)
Enterprises	4			Gross profits (GOS)			Transfers (Tr_e)	Transfers (Tr_{eR})		Enterprise income (TE)
Households	5			Wages (F)	Distributed profits (DP)		Transfers (Tr_h)		Foreign remittances (Tr_{hR})	Household income (TH)
Exogenous accounts Governt.	6	Indirect taxes (T_A)	Tariffs (T)		Company taxes (T_e)	Direct taxes (T_h)			Tr_{gR}	Government income (TG)
Capital Acc.	7			Capital consumption (CC)	Retained earnings (S_C)	Household savings (S_h)	Government savings (S_g)		Capital transfers from abroard (Tr_{cR})	Total savings (TS)
Rest of the world	8	Factor service imports (W_{RD})	Imports (M)			Transfers abroad (Tr_{Rh})	Transfers abroad (Tr_{Rg})	Capital transfers abroad (Tr_{Rc})		Foreign exchange payments (TR)
Total		Total production expenditure (Y)	Aggregate supply (Tsup)	Factor expenditure (TF)	Enterprise expenditure (TE)	Household expenditure (TH)	Government expenditure (TG)	Total investment (TI)	Foreign exchange receipts (TR)	

Source: Adapted from McDonald et al. (1997)

The activity accounts record domestic production activities. The row entries identify the production of commodities by activities, while the column entries sub-divide production expenditures between intermediate inputs and value added. Value added is broken down into payments to different factors, indirect taxes (e.g., VAT, paid by activities) and certain types of imports. The column sums for the production accounts record the total inputs to activities and are equal to row sums, i.e., total outputs by activities. Effectively, the activities' accounts show the generation of output and income in an economy. Total value added is by definition gross domestic product (GDP).

The commodity accounts record the demand and supply of commodities. The column entries identify commodity transactions according to whether they are domestically made or imported, inclusive of tariff revenues. The row entries sub-divide transactions in commodities between intermediate and final demands, where final demands are disaggregated across different institutions, the capital account and exports, inclusive of export subsidies. In equilibrium, total demand for commodities is equal to total supply of commodities, i.e., the row and column totals equate. Therefore, the commodities' accounts record how the income generated by activity accounts is spent. Total spending on domestic goods is by definition GDP.

The factor accounts record the origin of income generated during production of income and as such, is the sum of payments to production factors. The sum of payments to factors by domestic activities net of foreign factor payments is by definition GDP at factor cost. These factor incomes must then be distributed between the institutions that ultimately own the factors. Expenditures by the factor accounts are recorded by the column entries. The institutions identified depend upon the nature of the economic system. Generally a SAM contains sub-accounts for households, government and firms (corporations and non-profit organizations). Incomes to institutions are then recorded as row entries with expenditures as column entries. Total institutional income is therefore another measure of GDP.

The final accounts are the capital account and the rest of the world account. The former refers to investment and its funding. Investments are recorded in the capital account column, whereas the funding of investment is made up of savings by institutions and transfers from abroad, e.g., foreign investments. Trade transactions are recorded in the rest of the world account. These transactions include, on the receipt side, households' consumption expenditures on imported final goods as well as imports of capital goods and raw materials. On the payment side they include receipts from exports and factor and non-factor income earned. The difference between total foreign exchange receipts and imports is by definition net capital received from abroad.

From the preceding discussion it is apparent that the SAM is a comprehensive accounting system showing economic activity flows in one year. Because of this important role SAMs can also be used as conceptual framework and basis for modeling effects of changes in economic flows. The next section discusses how SAMs can be used as analytical and modeling tools.

4.1.1 Using the SAM as basis for analytical purposes

To use the SAM for modeling involves an important task of deciding which of the accounts in the SAM table are endogenous and exogenous. It has been customary to consider the government, the rest of the world and capital accounts as exogenous and the factors, institutions, and production activities' accounts as endogenous (Sadoulet and de Janvry, 1995). This classification is adopted in grouping the SAM accounts in Table 4.1 above. Endogenous accounts are normally those that depend on a country's economic activity (Sadoulet and de Janvry, 1995). Exogenous accounts on the contrary are independent of economic activity and payments (exogenous row entries in Table 1) are normally referred to as injections into economic system (e.g. exports, investment and government expenditure). Contrarily, exogenous expenditures (exogenous column entries in Table 4.1) are normally referred to as leakages from economic system (e.g. imports, savings and government taxes).

Once the decision on the endogenous and exogenous accounts is made, the SAM framework can be used to estimate the effects of exogenous changes and injections such as an increase in the demand for a given production activity, government expenditures or exports on the whole system. Assuming excess production resources, any exogenous change in demand can be satisfied through a corresponding increase in demand-driven output without having any effect on prices. Thus, for any given injection anywhere in the SAM, influence is transmitted through the interdependent

SAM system. The total effects (direct, indirect and induced) of the injection on the endogenous accounts, i.e. the total outputs of the different production activities and the incomes of the various factors and socioeconomic groups, are estimated through the multiplier process and the analysis is short run since the SAM is a snapshot of an economy in a given year. Appendix A1 illustrates how the SAM works analytically.

SAMs are important tools for analysing social concerns (e.g. welfare implications of an exogenous change in institutional income) because they emphasize origins and distribution of income, as well as distribution of expenditure. They also emphasize dis-aggregation of institutions depending on study objectives (e.g. disaggregation of households if the objective is to study income origins and distribution to different socio-economic groups of households). The SAM analysis is particularly important for this study because the objective is to analyse the impact of reduced availability of streamflow/natural water supported ecological resources and services, as a result of natural water export by Lesotho to SA, on the welfare of households. In this case biological resources are seen as another income generating mechanism for the rural households in Lesotho.

However, the data used in compiling the SAM comes from national income accounts (SNA) which only includes values of marketed goods and services (see for example the literature in Ahmed et al., 1996 and Costanza, 1991). Therefore, the income measure in the SAM (usually GDP) does not include non-marketed values like ecological resources and services. As a result, GDP as measured by the SNA does not represent the true, sustainable income (Atkinson et al., 1999). Also, the SAM is essentially a short-term measure of total economic activity in a given year. Because of this, it is less useful for analysing policies concerned with income changes related to natural resources since changes in natural resources (e.g. reduction in availability of biological resources, like timber, due to reduced streamflows) happen over a long-term (El and Lutz,1996).

Although the analytical framework discussed in this section is based on a single country analysis, it is generic to all SAM-based models, irrespective of whether single region/country, or multi-region/country. The next section expands the general single country SAM to the multi-country structure as it relates to the study area, LHWP.

4.2 Multi-country SAM framework for the LHWP

The LHWP is a multi-regional and multi-country project. Hence it is critically important to analyse its impacts both at multi-regional and multi–country levels. At regional level, it is important to determine the impact of the project in the Vaal region, directly supplied by water from the LHWP, in South Africa and the Mohale and Katse regions, project areas, in Lesotho. While these are distinct regions in Lesotho and South Africa that will be directly affected by the project, the entire economies of the two countries will also be affected. It would thus make economic sense to perform the impact analysis at both the regional and country levels. This would, however, entail construction of five social accounting matrices: (i) for the project area in Lesotho, (ii) for the project area in South Africa, (iii) for the country of Lesotho, (iv) for the country of South Africa and (v) the multi-regional matrix which includes both regions and countries. Because of time and resource limitations, the study could not focus on regions directly affected by the project and the analysis is accordingly conducted at the national level for both countries. Accordingly, three instead of five SAMs need to be developed.

The multi-country SAM for the LHWP builds on the work of Conningarth Economists on economy-wide modeling of inter-basin water transfers between two regions in the Komati River Basin in SA (Conningarth Economists, 2000a) and between SA and Swaziland (Conningarth Economists, 2000b). However, this study improves on the two mentioned studies by directly integrating in the economy-wide model ecological aspects of transferring water from one basin to the other. The multi-country SAM for the LHWP comprises 3 countries: (i) Lesotho, (ii) South Africa and (iii) the rest of the world (see Table 4.2).

TABLE 4.2: Multi-country SAM framework for the LHWP

*Factors represent labour and capital, and **Institutions represent households and enterprises

			EXPENDITURES													
			Lesotho						**South Africa (SA)**						**ROW**	
			Activities	Commodities	Factors*	Institutions**	Government	Capital	Activities	Commodities	Factors	Institutions	Government	Capital		Total
RECEIPTS			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Lesotho	Activities	1		Y_i												Y_i
	Commodities	2	X_i			C_i	G_i	I_i		M_{ij}					E_{iR}	TD_i
	Factors	3	W_i				Wg_i		W_{ij}						W_{iR}	TFY_i
	Institutions	4			F_i	Tr_i	Trg_i					Tr_{ij}	TrI_{ij}		Tr_{iR}	TY_i
	Government	5	TA_i	TC_i	TF_i	T_i							Trg_{ij}		Trg_{iR}	TgY_i
	Capital	6			CC_i	SI_i	Sg_i					SI_{ij}		Sij	S_{iR}	TS_i
South Africa (SA)	Activities	7								Y_j						Y_j
	Commodities	8		M_{ji}					X_j			C_j	G_j	Ij	E_{jR}	TD_j
	Factors	9	W_{ji}						W_j				Wg_j		W_{jR}	TFY_j
	Institutions	10				Tr_{ji}	TrI_{ji}				F_j	T_{rj}	Trg_j		Tr_{jR}	TY_j
	Government	11							TA_j	TC_j	TF_j	T_j			Trg_{iR}	TgY_j
	Capital	12				SI_{ji}	Trg_{ji}	S_{ji}			CC_j	SI_j	Sg_j	A	S_{jR}	TS_j
ROW		13	W_{Ri}	M_{Ri}		Tr_{Ri}	Trg_{Ri}	S_{Ri}	W_{Rj}	M_{Rj}		Tr_{Rj}	Trg_{Rj}	S_{Rj}	B	TY_R
	Total	14	Y_i	$Tsup_i$	TFE_i	TE_i	TgE_i	TIE_i	Y_j	$Tsup_j$	TFE_j	TE_j	TgE_j	$TIEj$	TE_R	

Source: Adapted from Conningarth (2000b)

All the variables in Table 4.2 are defined in Table 4.3 below.

TABLE 4.3: Glossary of terms (variables) in the multi-country SAM*:

Variable	Definition	Variable	Definition	Variable	Definition
X_I	Intermediate consumption in i of own commodities	C_i	Final institutional consumption in I	TgE_I	Total government expenditures in i
W_I	Factor payments by activities in i to own factors	Tr_i	Institutional transfers in I	TgY_i	Total government income in i
TA_I	Net taxes paid by commodities in I	T_i	Institutional taxes in I	I_i	Investment consumption in i
W_{ji}	Factor payments by activities in i to j factors	SI_i	Institutional savings in I	S_{ji}	Foreign direct investment by i in j
W_{Ri}	Factor payments by i activities to the rest of the world factors	Tr_{ji}	Institutional transfers from i to j	S_{Ri}	Foreign direct investment by i in the rest of the world
Y_I	i's gross output	SI_{ji}	Institutional savings of i in j	TIE_i	Total investment expenditures in i
TC_I	Commodity tax in I	Tr_{Ri}	Institutional transfers from i to the rest of the world	TS_i	Total savings in i
M_{ji}	Imports in i from j	TE_i	Total institutional expenditures in I	E_{iR}	Exports of i to the rest of the world
M_{Ri}	i's imports from the rest of the world	TY_i	Total institutional income in I	W_{iR}	Factor payments by the rest of the world to factors in i
$Tsup_I$	i's total supply	G_i	Final government consumption in I	Tr_{iR}	Transfers from the rest of the world to institutions in i

TD_I	i's total demand	Wg_i	Factor payments by government in I	Trg_{iR}	Transfers from the rest of the world to government in I
F_I	Factor (labour and capital) incomes distributed to institutions in i	Trg_i	Government transfers to institutions in I	S_{iR}	Savings by the rest of the world in I
TF_I	Indirect taxes on factors in I	Sg_i	Government savings in I	TE_R	Total expenditures of the rest of the world
CC_I	Capital consumption in I	TrI_{ji}	Government transfers from i to j's institutions	TY_R	Total income of the rest of the world
TFE_I	Total factor expenditures in I	Trg_{ij}	Government transfers from i to government in j	A	Net capital inflow between i and j
TFY_I	Total factor incomes in i	Trg_{Ri}	Government transfers from i to the rest of the world	B	Net capital inflow between i and R

* i, j = Lesotho, South Africa and R = the rest of the world .

Since the SAM is a double entry accounting system, the following macroeconomic balances ensure double accounting in the case of the three-country SAM:

(i) Total expenditure on output of country i:

$$Y_i = X_i + W_i + TA_i + W_{ji} + W_{Ri} \quad (1)$$

Gross output in i (Y_i) equals the sum of intermediate expenditure in i (X_i), payments to i factors (W_i), net taxes in i (TA_i), payments to j factors (W_{ji}) and payments to R factors (W_{Ri}).

(ii) Total demand and supply in country i:

$$TD_i = X_i + C_i + G_i + I_i + M_{ij} + E_{iR}$$
$$Tsup_i = Y_i + TC_i + M_{ji} + M_{Ri} \quad (2)$$
$$TD_i = Tsup_i$$

Total demand in i (TD_i), is the sum of total intermediate demand in i (X_i), final institutional consumption in i (C_i), final government consumption in i (G_i), investment consumption in i (I_i), exports from i to j (M_{ij}), and exports from i to R (E_{iR}). For the SAM to balance TD_i must equal total supply in i ($Tsup_i$), which is the sum of domestic output in i (Y_i), commodity tax in i (TC_i), imports by i from j (M_{ji}), and imports by i from R (M_{Ri}).

(iii) Total Factor income in country i:

$$TFY_i = W_i + Wg_i + W_{ij} + W_{iR}$$
$$TFE_i = F_i + TF_i + CC_i \quad (3)$$
$$TFY_i = TFE_i$$

Total factor income in i (TFY_i) equals the sum of total factor payments by activities in i (W_i), remuneration of government employees in i (Wg_i), payments to i factors by j (W_{ij}), and payments to i factors by R (W_{iR}). This must equal total factor expenditure in i (TFE_i), measured by factor incomes distributed to households in i (F_i), interest payments on government capital and indirect taxes on factors in i (TF_i) and capital consumption/depreciation in i (CC_i).

(iv) Total institutional (households and enterprises) income:

$$\begin{aligned} TY_i &= F_i + Tr_i + Trg_i + Tr_{ij} + TrI_{ij} + Tr_{iR} \\ TE_i &= C_i + Tr_i + T_i + SI_i + Tr_{ji} + SI_{ji} + Tr_{Ri} \\ TY_i &= TE_i \end{aligned} \qquad (4)$$

Total institutional income in i (TY_i), is measured as the sum of total payments to i factors distributed to institutions in i (F_i), institutional transfers in i (Tr_i), government transfers to institutions in i (Trg_i), institutional transfers from j to i (Tr_{ij}), institutional transfers from j to i (TrI_{ij}), institutional transfers from R to i (Tr_{iR}). Income must equal total institutional expenditures, measured as the sum of institutional consumption expenditure in i (C_i), institutional transfers in i (Tr_i), institutional tax payments in i (T_i), institutional savings in i (SI_i), institutional transfers from i to j (Tr_{ji}), savings by i's institutions in j (SI_{ji}), institutional transfers from i to R (Tr_{Ri}).

(v) Government budget (internal balance):

$$\begin{aligned} TgY_i &= TA_i + TC_i + TF_i + T_i + Trg_{ij} + Trg_{iR} \\ TgE_i &= G_i + Wg_i + Trg_i + Sg_i + TrI_{ji} + Trg_{ji} + Trg_{Ri} \\ TgY_i &= TgE_i \end{aligned} \qquad (5)$$

Total government income (TgY_i) is measured as the sum of activity, commodity, and income taxes (i.e. TA_i, TC_i, and T_i, respectively); interest payments on government capital and indirect tax on factors (TF_I); government transfers from j to i (Trg_{ij}); and government transfers from R to i (Trg_{iR}). Income must equal total government expenditures (TgE_i), measured as the sum of government final consumption (G_i), factor payments by government (Wg_i), government transfers to instituions in i (Trg_i), government savings (S_i), government transfers to institutions in j (TrI_{ij}), and government transfers to governments in j (Trg_{ji}) and R(Trg_{Ri}).

(vi) Total savings and investment in country i:

$$
\begin{aligned}
TS_i &= CC_i + SI_i + Sg_i + SI_{ij} + S_{ij} + S_{iR} \\
I_i &= I_i + S_{ji} + S_{Ri} \qquad (6) \\
TS_i &= I_i
\end{aligned}
$$

Total savings in i (TS_i) is measured as the sum of allowance for capital consumption/ depreciation in i (CCi), i's institutional savings (SI_i), government savings (Sg_i), j's institutional savings in i, and capital flow (or foreign direct investment) from j and R to i ((S_{ij}) and (S_{iR}), respectively). Total savings in i (S_i) must equal total investment in i, measured by the sum of investment expenditure in i (I_i), capital flow from i to j (S_{ji}) and capital flow from i to R (S_{Ri}).

(vii) Trade Balance (i.e. external balance/balance of payments)

A) Trade balance between country i and j

$$
\begin{aligned}
&\text{Total foreign exchange receipts by i from j} = M_{ij} + W_{ij} + Tr_{ij} + TrI_{ij} + Trg_{ij} + SI_{ij} + S_{ij} \\
&\text{Total foreign exchange payments by i to j} = M_{ji} + W_{ji} + Tr_{ji} + TrI_{ji} + Trg_{ji} + SI_{ji} + S_{ji} \\
&\text{Total foreign exchange receipts by i from j} + \text{Total foreign exchange payments by i to j} + A = 0 \qquad (7)
\end{aligned}
$$

Where i,j = Lesotho, SA; and A = net capital inflow between Lesotho and SA.

B) Trade balance between country i and the rest of the world

$$
\begin{aligned}
&\text{Total foreign exchange receipts in i from R} = E_{iR} + W_{iR} + Tr_{iR} + Trg_{iR} + S_{iR} \\
&\text{Total foreign exchange payments by i to R} = W_{Ri} + M_{Ri} + Tr_{Ri} + Trg_{Ri} + S_{Ri} + B \\
&\text{Total foreign exchange receipts by i from R} + \text{total foreign exchange payments by i to R} + B = 0 \qquad (8)
\end{aligned}
$$

Where i = Lesotho, SA; R = ROW; and B = net capital inflow between ROW and Lesotho or RSA.

Net capital inflow is by definition the difference between foreign exchange receipts and payments. Equations (7) and (8) provide balance of payments closures ensuring that foreign expenditures in each country equal foreign payments. Ideally, total foreign exchange receipts should equal total foreign exchange. But in reality this rarely happens because of foreign borrowing. Therefore, A and B are balancing figures between foreign exchange receipts and payments. Appendix A2 shows how the multi-country SAM is used analytically.

This chapter has demonstrated how the multi-country analysis for the LHWP can be performed. But it has not shown how the ecological values associated with the LHWP water can be integrated in the modeling framework. The next chapter extends the economic SAM framework to integrate ecological-aspects and -values of the scheme.

CHAPTER V - INTEGRATING ECOLOGICAL IMPACTS INTO SOCIO-ECONOMIC ACCOUNTS

5.1 Introduction

Conventionally, benefits of water development projects are based solely on direct economic benefits. From the literature the SAM has been used as one approach for measuring the value of direct economic water benefits in a number of countries, e.g. South Africa (Conningarth Economists, 2000b), SA and Swaziland, (Conningarth Economists, 2000a), and USA, (Daren et al. 1998) (for more approaches see the Literature review chapter). However, because of the deleterious impacts of water development projects on the ability of freshwater ecosystems to provide their natural services, there has been a recent shift in paradigm to consider ecological values in assessing water benefits. This has historically been done as an ad hoc assessment and not directly integrated with direct benefits in macroeconomic models. Examples include valuation of Hadejia-Nguru wetlands of Northern Nigeria (Acharya and Barbier, 2000; Archaya, 1999; Hollis, 1993; LHDA, 2002d), and valuation of biological products supported by rivers downstream the LHWP in Lesotho (LHDA, 2002d).

While the SAM-based studies mentioned above provided economy-wide implications of direct water benefits (i.e. in economic production) they ignored ecological aspects of water developments. On the contrary, studies that accommodated these concerns (i.e.Acharya and Barbier, 2000; Archaya, 1999; Hollis, 1993; LHDA, 2002d) ignored the macro-economic inter-linkages between concerned sectors and the rest of the economy. For example, they only considered the agricultural sector with little consideration for linkages between this sector and other sectors of the economy. The result of these ad hoc assessments is usually incomplete information on the implications of water transfer developments, which may lead to misinformed policies. This study attempts to bridge this gap in the literature by combining the direct and indirect (ecological) benefits of water development projects in one analytical framework. This is a holistic approach that integrates ecological benefits with the structure of economic activities, and should provide comprehensive information on water development project benefits direly required by policy makers.

In this chapter, the approach followed to integrate ecological (also called streamflow) values in the SAM framework is developed. The single-country SAM developed in Chapter IV is used to demonstrate how ecological values can be integrated in the SAM framework. The single-country assumption is dropped in Chapter VII when the model developed in this chapter is applied empirically. The chapter begins by providing the motivation for integrating ecological values in the SAM framework in Section 5.2. Section 5.3 identifies streamflow service values associated with the LHWP and finally, Section 5.4 discusses the economic-ecological model of streamflow benefits.

5.2 Motivation for integrating ecological values in the SAM framework

To measure ecological and economic implications of water transferred from one basin to the other through a SAM framework, it is important that ecological values of water are integrated in the SAM. This is more important in developing countries where the bulk of the population living in rural areas directly derive livelihoods from ecological resources and services[4]. Unfortunately, conventional SAMs are derived from countries' system of national accounts (SNA) that usually capture values of only traded goods and services (Abel and Bernanke, 2000; El Serafy and Lutz, 1996, United Nations, 2003). Since many ecological resources and services are usually not traded (e.g. moisture recharge service provided by streamflows to riverbank agriculture) their contribution to national income is often attributed to other sectors (e.g. agriculture in this case) or underestimated in the SNA.

A number of studies in Southern Africa made attempts to measure the contribution of environmental products and services to national income. Examples include:

---

[4] see Cavendish (1999) and (1995), and Clarke et al. (1996) for detailed analysis on the link between rural households economics and ecosystems.

contribution of forests and woodlands to national income and wealth in South Africa (Hassan 2000, 2002 and 2003), Zimbabwe (Mabugu and Chitiga 2002,) and Swaziland (Hassan et al., 2002); the true value of water in Botswana, South Africa and Namibia (Lange et. al, 2003); the value of food and non-food ecological resources in Zimbabwe (Cavendish 1999 and 1995); and contribution of medicinal plants to national income in south Africa (Manders, 1998)[5]. Even in cases where such values were included, they were not clearly separated in the accounts, e.g. defensive environmental expenditures (El Serafy and Lutz 1996, Hueting 1996, El Serafy 1991, Hamilton and Clemens, 1999). In addition, the above studies, that attempted to correct measures of national income, did not place such corrections in an economy-wide analytical framework such as the SAM.

Therefore, to correctly evaluate the impacts of modifying streamflows on the capacity of affected ecosystems to provide services, and consequences for human wellbeing, it is crucial that such services are properly valued and integrated in the SAM stracture. Failing to do this can lead to distorted information about the true costs and benefits of the LHWP, especially relating to economic wealth and welfare generated by the scheme. The consequence may be misinformed policy actions and ill-advised strategic social choices that may lead to serious and irreversible environmental consequences, with harsh implications for human wellbeing in affected areas. The following discussion focuses on identifying stream-flow service values that are not captured by the Lesotho and SA SNA and adjusting the developed SAM framework accordingly to develop the ecological-social accounting matrix (ESAM).

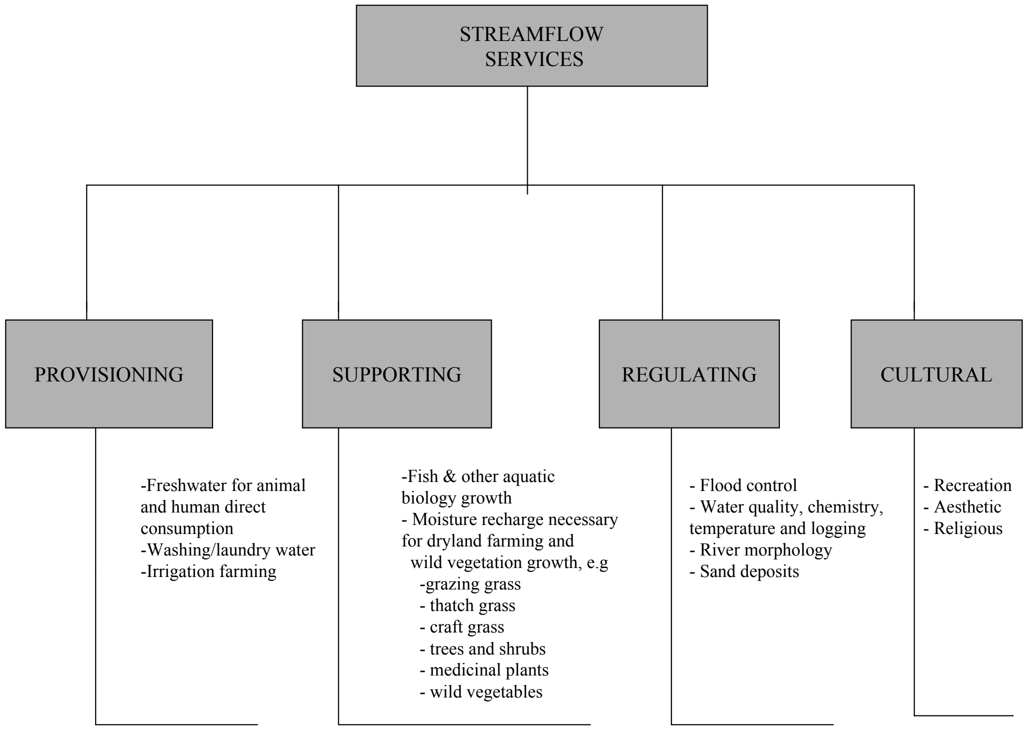
5.3 Streamflow service values associated with the LHWP

The LHWP was primarily aimed at abstracting water from the rivers that comprise the upper Orange river basin in the highlands of Lesotho and transfer or export it to the water deficient Vaal region in SA (TAMS Consultants, 1996). However, before the water leaves the boarders of Lesotho, it is used to generate hydropower. In Lesotho,

[5] These studies represent a small sample of the huge body of literature on measuring non-market values of ecosystems services.

the water from these rivers provides riparians living within the reaches of the rivers with a myriad of important services necessary for economic production and sustenance of livelihoods in general (LHDA, 2002c). Figure 5.1 below provides broad classification of these services with examples.

FIGURE 5.1: Streamflow Services (water as a natural resource)



Rivers' water is a source of fresh water for humans and animals (stock watering), and is also used productively for irrigation and provides moisture-recharge service for dryland crop production that takes place on the river banks. Stream flows support growth of biological products consumed directly by households or sold as intermediate inputs to production sectors. Examples include: thatch grass used for roofing purposes, craft grass used for making a variety of crafts like hats and baskets, medicinal plants used by riparians or sold to traditional healers and vendors who sell them to consumers for final consumption in urban areas, and wild vegetables, also used by riparians or sold for final consumption to consumers, mainly in urban areas (LHDA, 2002c). The rivers also regulate deposition of sand which is used by riparians for construction purposes. Other regulating services of rivers include flood control; water-quality, water-chemistry, water-temperature and water-logging regulatory services (LHDA, 2002b). Riparians also use rivers for cultural purposes and some religions use the rivers for baptism purposes (LHDA, 2002c).

Evidently, the Lesotho highlands natural water has important economic values in terms of the services rendered to the riparians. Unfortunately, these were not included in the EIA of the LHWP (LHDA, 2002a). Also, the national income accounts data do not capture most of these values (e.g. regulating and cultural services, as well as some provisioning and supporting services, e.g., freshwater, wild vegetables, medicinal plants and fuel wood used for direct consumption by households). Those that are captured (e.g. irrigation water and grass used in crafts making) are attributed to the wrong sectors that receive the services. Before the LHWP exclusion of some of these values was perhaps not important, in terms of impacts of modification of streamflows brought about by the project, since the services rendered by the rivers were not limiting to the riparians (LHDA, 2002d). But now, with the LHWP, the IFR studies (LHDA 2002a, b,c and d) have demonstrated that the modified flows will have significant negative impacts on some of the services in Figure 5.1. These studies have also shown that modifying streamflows of the rivers downstream the LHWP dams will lead to deleterious impacts on availability of biological products and services and thus, negatively impact riparians' welfare in Lesotho.

It is therefore crucial to measure and assess the impact of modifying the instream flow of the upper Orange River system on the future ability of the affected ecosystems to provide these services. This should be integrated into the SAM matrix describing the socio-economic structure of Lesotho and SA. But before doing this, it is critically important to understand inter-linkages between the economy and the services provided by the involved rivers, which we shall generally call ecology for simplicity. Equally important is mapping out the use of the water transferred to SA. This is of crucial importance for policy purposes and assessment of the value of the LHWP to SA (especially if SA has to internalize ecological costs on Lesotho).

From Lesotho the trans-caledon tunnel transports the water to SA, first into the Ash, then to the Wilge, Libenburg and finaly into the Vaal Dam where the water is mainly aimed at industrial expansion in the Gauteng province (Chutter, 1998). From the rivers in SA, the water can be abstracted directly for commercial irrigated agriculture within limited regulation. The water also supports dryland farming and can also be used for recreation purposes, e.g. fishing and swimming. It also supports other aquatic biota like fish and provides regulatory services (Figure 6.1). From the Vaal Dam the water is regulated and distributed by the Department of Water Affairs and Forestry (DWAF) to different users (mainly industry) (Basson, 1997).

Like in the case of Lesotho, some benefits of water are not captured in the national Accounts of SA. Even in cases where water values are captured in the national accounts, they are not clearly distinguished. For example, the SNA has the water account. But the conventional measurement of water value in this account currently includes the cost of water infrastructure only (DWAF, 1999). The value of the water resource and the water environmental assets (water quality attributes), which should form part of accumulation accounts of a country are not included (see United Nations, 2003; Pan, 2000, and Xikang, 1990).

Where some of these values are included, e.g. expenditures on improving water quality (investing in water environmental assets), such expenditures are not included as investment in water environmental assets. Rather, they are included in the SNA as consumption expenditures (El Serafy and Lutz 1996 and El Serafy 1991). It is therefore important to clearly map out water users in SA and explicitly identify and include water values not captured by the national income accounts. But before this can be done, it is important to understand the inter-linkages between streamflows/natural water and economic production on the one hand, and ecological production on the other. The following section develops the economic and ecological model that clearly maps out the relationship between natural water from the rivers below the LHWP dams and the economic and ecological production, respectively.

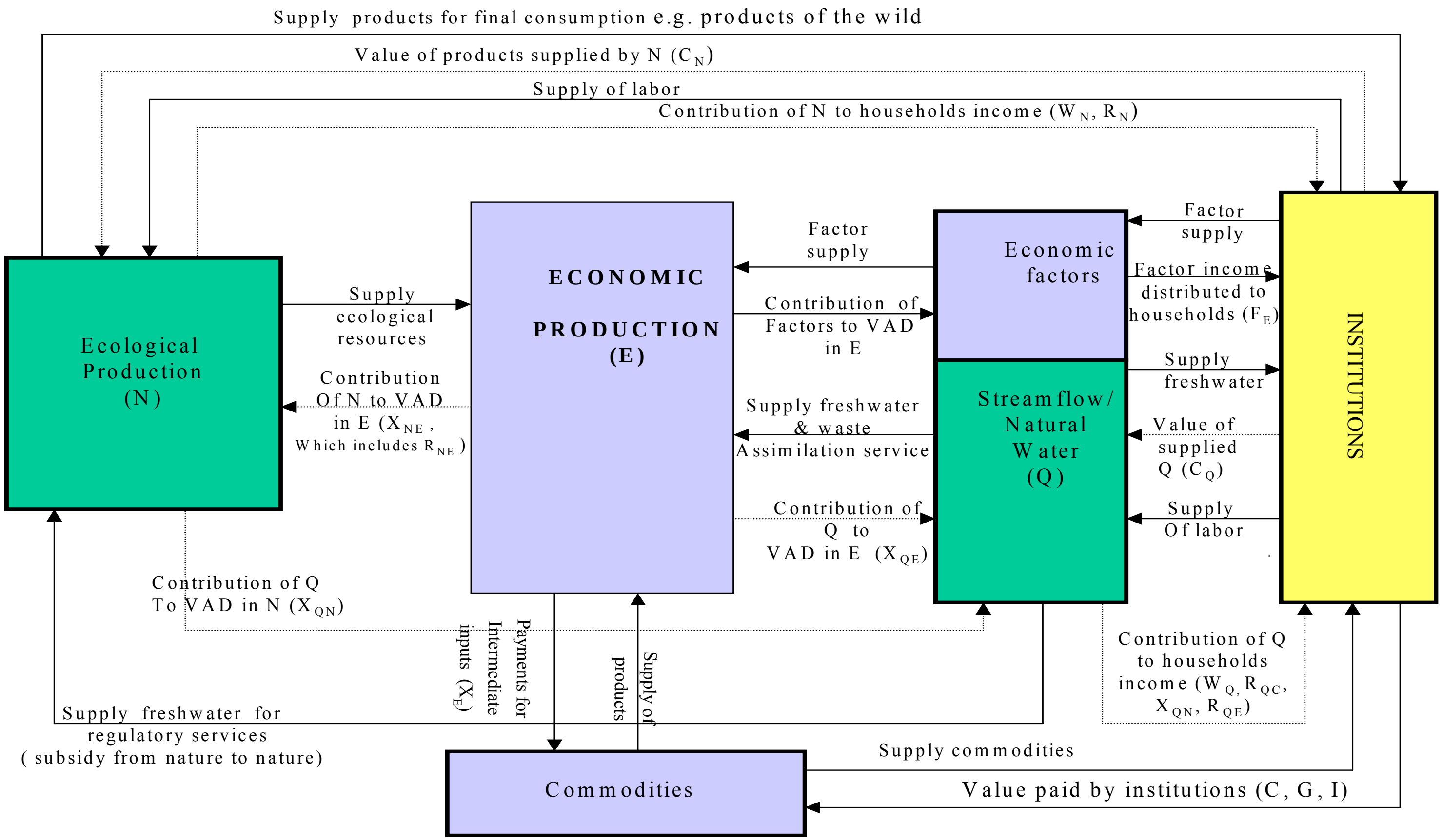
5.4 Economic-ecological model of streamflow benefits

5.4.1 A conceptual framework

Figure 5.2 below develops a conceptual framework that shows flows between water-related ecological and socio-economic systems, which are later formally modeled and presented in the ecological social accounting matrix (ESAM)[6]. The ESAM incorporates all major transactions within the socio-economic and ecological systems[7] and shows how benefits flow within and between systems (the dotted lines in the Figure denote unpaid benefits, i.e. subsidy from nature). The ecological system comprises two major activitiess: (i) ecological production (N)[8] and (ii) streamflow or the natural water (Q).

[6] Notations used in the Figure are defined in Appendix B
[7] It should be noted that ecological systems in this study only refer to those directly related to the LHWTS water.
[8] In this case ecological production refers to production of biological resources and services supported by streamflows (i.e. supporting and regulating streaflow services in Figure 5.1).

FIGURE 5.2: Flow diagram of ecological and socio-economic flows*



*The dotted lines in the diagram refer to implicit transactions representing income and expenditure by freshwater and ecological production segments of the system that do not take place through market exchange but are nonetheless real contributions made as implicit transfers. For example, households do not pay nature for harvesting its wild products (C_N) or for use of freshwater services (C_Q). Similarly, economic activities do not pay for the services of ecological processes (X_{NE}) and freshwater (X_{QE}). These values however, represent direct and indirect subsidies from nature to production and consumption activities using them in the form of natural resources rents dissipating to users.

The streamflow/natural water includes the water resource (water quantity) and water quality attributes, which in the system of integrated environmental and economic accounting (SEEA) language, are called water environmental assets (United Nations, 2003; Pan, 2000). Water environmental assets consist of environmental attributes of water including biochemical oxygen demand (BODs), chemical oxygen demand (CODs), and ammonium ion (NH_4^+) concentrations (Uniten Nations, 2003). Water quantity and quality form the natural capital and provide three types of services: (i) freshwater to support ecological production, (ii) freshwater for human consumption, and (iii) freshwater used as intermediate input and waste sink in economic production.

Collectively, the ecological system forms part of the accumulation accounts in the SAM parlance. Accordingly, this analytical framework makes the assumption that natural water from rivers downstream the LHWP dams (streamflows) have three main competing uses (services):

(i) Maintaining ecological production (i.e. for support of growth and availability of ecological resources and services), valued by X_{QN}.

(ii) Maintaining human wellbeing (i.e. fresh water for direct human consumption and water required for aesthetic/religious/cultural reasons), valued by $C_{Q,}$ and

(iii) Maintaining economic production (natural water required as an intermediate input in production and as waste assimilation amenity), valued by X_{QE}.

The following sections discuss the value of natural water/streamflow according to these three broad competing services.

5.4.2 Streamflow/natural Services to ecological production

Ecological production in this model uses two production factors: (i) natural water to support growth of biological resources and their services and (ii) economic factors (mainly labour) for harvesting biological resources. Ecological production is directly consumed by households (C_N) or used as intermediate inputs in economic production (X_{NE}):

$$Y_N = C_N + X_{NE} \qquad (9)$$

Where Y_N, C_N and X_{NE} measure gross value of ecological production, value of ecological products directly harvested by households for consumption and value of ecological products and services used as intermediate inputs in economic production, respectively. Since ecological production does not explicitly involve market transactions, some of its value goes missing from the SNA such as C_N, which represents a direct subsidy from nature to households harvesting these products. However, the value of ecological products and services used as intermediate inputs in economic production (X_{NE}) is included in the SNA as part of the VAD and hence economic surplus dissipating to owners of benefiting economic activities. Both C_N and X_{NE} contain various natural resource rents' components (rents for ecological production and freshwater services) that are realized as subsidies to different economic agents and institutions as will become clear later.

As said above, ecological production uses freshwater and economic factors, which are valued in Figure 5.2 as X_{QN} and W_N, respectively. The main economic factor used in ecological production in this model is labor efforts (i.e. the opportunity cost of labor needed for harvesting products from the wild)[9]. Suppliers of these factors and services are not directly compensated for the value of their contributions. Nevertheless, all that value (rents to ecological production and freshwater services of

[9] It is noteworthy to mention that although harvesting of biological products is labor intensive, sometimes capital is used (e.g. tools of harvesting). However, capital use in this case study in Lesotho is negligible and is usually made by riparians themselves using own labor and products from nature (e.g. wood). Notwithstanding, sometimes used capital includes few manufactured implements like axes for chopping wood, spades for digging roots, carts for transporting harvests, pangas for slashing grass etc.

nature), ends up dissipating directly or indirectly to institutions owning the various factors and economic activities employing such services of nature through C_N and X_{NE}.

This can be seen from the fact that according to the above, VAD in ecological production can be measured as:

$$VAD_N = Y_N - X_{QN} = C_N + X_{NE} - X_{QN} \quad (10)$$

Therefore one can derive the value of freshwater (streamflow) contribution to ecological production:

$$X_{QN} = C_N + X_{NE} - VAD_N \quad (11)$$

However, note that VAD_N is made up of the value of labor employed in harvesting products of N (W_N) and the rent to the natural ecological processes supporting N (R_N) and hence:

$$X_{QN} = C_N + X_{NE} - W_N - R_N \quad \text{Or alternatively:} \quad (12)$$

$$X_{QN} + R_N = (C_N - W_N) + X_{NE} \quad (13)$$

As said earlier, the above indicates that while households and firms are not explicitly paid for supplying the production factors and inputs to N they are compensated through C_N and X_{NE}. In other words, the actual value that households and firms get of N output includes natural resource rent components (X_{QN} and R_N). For instance, one can think of (C_N - W_N) as the net subsidy (or share of natures' rent) accruing to households whereas, X_{NE} measures what firms reap of nature's resource rent through ecological production as part of their business profits. One can split nature's rent R_N into two components here, the part accruing to households R_{NC} and that accruing to economic production R_{NE}.

Biological products and services of relevance to this study include fish, wild vegetables, medicinal plants, wood, crafts and thatch grass, and fine and rough sand. Some of these resources are harvested for final use in consumption and their value is measured by (C_N) (Pan, 2000). Examples of resources harvested for sale or direct use as intermediate products in economic production (X_{NE}) include medicinal plants sold to, or directly used by traditional healers, wild vegetables, fire and construction wood, sand used in brick-laying and construction, and crafts and thatch grass directly used by, or sold to crafts makers (LHDA, 2002c). In the case where harvested ecological products are sold in markets, they become economic products and hence form part of the commodities block in Figure 5.2 (United Nations, 2003). However, since not paid for, their value (X_{NE}), which includes nature's resource rent in economic production (R_{NE}), is absorbed in VAD of economic production.

Notwithstanding, trade in most of these resources mainly takes place in the informal markets and hence these values are often not included in national income. For example, riparians who harvest crafts-grass directly from nature either make crafts which they sell in the informal sector, or sell the grass to crafts' vendors who make and sell crafts in the informal sector. Therefore, except for the insignificant portion of the grass used in making crafts sold in the formal market, most of these resources are traded in informal markets. Because in this case benefits from these resources accrue directly to households, they form part of C_N as explained earlier and the corresponding nature's resource rent R_{NC}. This study assumes that total income transferred from ecological production to households (C_N) in the particular case study area are not included in the SNA. This comprises total income transferred from ecological production to households C_N (which equals the sum of W_N, X_{QN} and R_{NC} from the above discussion).

Under the category of regulatory and supportive streamflow service in ecological production discussed above, the following values comprise contribution of ecological production to GDP, and are either missing or improperly accounted for in the SNA[10]:

[10] Given information on these variables, one could isolate R_N and X_{QN} from the total value of ecological production. In this case study area information is available only on C_N, which is adequate since the focus of this study is on the total contribution of streamflow to households income through ecological production and hence no need to decompose that to its various components.

(i) Contribution of N to households' consumption (C_N),

(ii) Contribution of N to economic production (X_{NE})

(iii) Contribution of N to households' labor income (W_N), and ecological goods and services rent dissipating to households (R_{NC})

Availability of biological resources and services are crucially dependent on the water quantity and quality that provide supportive and regulatory services for their production. Part of the water from nature is also used for direct human consumption and economic production. If due to economic activities the capacity of the natural water (streamflow) to provide water for direct consumption by households and for maintenance of biological production diminishes, the availability of ecological resources diminishes, leading to reduced households' welfare. The next section discusses the value of natural water in direct human consumption followed by the value of natural water in economic production in Section 5.4.3.

5.4.3 Streamflow/natural water services to households' direct consumption

Households do not only use produced water, which we shall call C_W[11]. That is, the value of water distributed to households by the water supply sector (see Section 5.4.4 below). They also abstract or use water (quantity and quality) directly from streamflows or nature for direct consumption, the value of which is measured by (C_Q), or aesthetic/religious/spiritual/cultural purposes, also measured by (C_Q).

Since water from nature is free, its production function follows that of biological resources production (see Section 5.4.2). It is assumed that only two inputs (i.e. streamflow and labor (sometimes also capital) for collecting water are used in the production of natural water for direct human consumption. Accordingly, one can present total value of natural water directly consumed by households as

[11] C_W is not included in Figure 5.2 for simplicity.

$C_Q = W_Q + R_{QC}$ (Note that $Y_Q = C_Q + X_{QN} + X_{QE}$)[12] (14)

Where C_Q, W_Q and R_{QC} represent gross value of streaflow output for direct human consumption, the value of labor (and sometimes capital) used in collecting streamflow water and natural water resource rent accruing to households R_{QC}.

Production costs in this case are only labor costs associated with fetching the water (W_Q). While households pay C_W for water supplied by water utilities, they do not pay for freshwater services from nature. Thus, freshwater resource rent absorbed in consumption, R_{QC} is a subsidy from nature to households.

The SNA only includes the value of households' consumption of water distributed by water authorities (C_W). In the same manner, only factor income payments made by the water producing sector are included in the SNA. The contribution of streamflow/natural water to labor services (W_Q) and natural water rent dissipating to households from consumption of streamflow services (R_{QC}) are not included. Inclusion of both W_Q and R_{QC} (or C_Q) in the SNA is important as it increases households' purchasing power to expend on other products (i.e. saves households money by not having to buy water). Therefore, the SNA and thus SAM accounts in Table 4.2, must be extended to account for C_Q (R_{QC} and W_Q), where $C_Q = R_{QC} + W_Q$ from the above discussion.

5.4.2 Streamflow/natural water as intermediate input in economic production

Economic production also uses the quantity and quality of freshwater from streamflows as intermediate input. Some economic sectors abstract water from nature for direct use in production and some abstract water for distribution to other sectors, i.e. water supply utilities. Because of these two distinct economic uses of water, we split economic production between the water producing sector (W) and

[12] Discussion related to X_{QN} is handled in Section 3.4.2 and X_{QE} is discussed in the next section.

other economic sectors (E)[13]. We also split the value of intermediate use of raw water between these two activities as: (i) the value of water used as an intermediate input by the water supply sector (X_{QEW}) and, (ii) the value of natural water used as intermediate input by other economic sectors (X_{QEE}). Therefore, X_{QE} in Figure 5.2 equals $X_{QEW} + X_{QEE}$ (this distinction becomes clearer in the ESAM presented in Section 5.4.4 where a distinction is also made between the use of produced and natural water by different sectors).

Economic sectors return water that is no longer useful in its current state back to nature, or streamflows (i.e. water residuals), measured by Z[14]. Water residuals can also be re-absorbed by the economic system (e.g., the water used for hydropower generation in Lesotho is re-absorbed by the water sector and transferred to SA) [15]. In this case the value of the residual is not altered since it is assumed that the water is returned to nature in its original quantity and quality. But the water can also be returned in degraded quantity and quality (i.e. polluted water). The quantity and quality of water that remains instream after water abstraction by economic activities, or after waste disposal into the streams is also referred to as residual because it represents the condition of streamflow after economic production use. To make a distinction between the water producing sector and other economic sectors we denote the value of water residuals from the former as Z_W and those from the latter as Z_E (i.e. $Z = Z_W + Z_E$).

If the value of the water residual is less than that of raw water used as intermediate input in economic production (i.e. $Z_W - X_{QEW} < 0$ and/or $Z_E - X_{QEE} < 0$), it means that the opportunity cost of water use in economic production is positive, implying a negative externality or a cost to society. Economic production activities must then pay nature the water resource rent (R_{QE}) to internalize the water quantity/quality loss in terms of lost biological resources and services and harmful effects that insufficient and polluted water may have on humans. In this case $R_{QE} = R_W + R_E$, where R_W and R_E are water rents to be paid by the water supply sector, and other economic sectors,

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[13] This distinction, and related notations that follow, is not explicitly made in Figure 5.2 for simplicity.
[14] Water residuals are also not included in Figure 5.2 for simplicity.
[15] In this case the value of water residuals refer to the value of quantity and quality of natural water resulting from economic production.

respectively. It thus follows that:

$$X_{QEW} = Z_W + R_W \tag{15}$$

$$X_{QEE} = Z_E + R_E \tag{16}$$

and

$$R_W = X_{QEW} - Z_W \tag{17}$$

$$R_E = X_{QEE} - Z_E \tag{18}$$

$$Z_W \leq X_{QEW} \tag{19}$$

$$Z_E \leq X_{QEE} \tag{20}$$

If economic production activities do not internalize the costs, it means that the rent is absorbed into private profits. In this case production costs of the externality source sector is determined by ordinary total private production costs (TC_p). But due to the externality, there is extra cost to society (TC_e) that is not borne by the externality source sector. This damage is measured as the total sum of decrease in society utility due to the external effect on society and/or firms affected (Sterner, 2003). In this case the externality manifests itself as reduced output of biological resources, deterioration in human and animal health and reduced human welfare in general. If internalized, total social production costs (TC_s) would be the sum of total private production costs and total external costs to society (i.e. $TC_s = TC_p + TC_e$). If the external cost is not internalized, total production costs of the source sector are underestimated and the externality is absorbed into private profits (uncompensated damages to others).

With this background, the value of services of streamflow/natural water in economic production consists of:

i) The value of fresh water directly abstracted from nature by economic sectors for own use (X_{QEE}), e.g. water abstracted by agriculture for irrigation and used to provide moisture to dryland farming. In most cases this water is not paid for, and thus its value represent a subsidy to agriculture from nature. That value however, is captured in the SNA as part of VAD generated by agriculture and not attributed to the natural resource (sector).

ii) The value of freshwater abstracted from nature and processed by the water supply utilities for distribution to other sectors like agriculture, industry, and final consumers (X_{QEW}), or even for export to other countries. In this case water is considered a product and it enters the SNA (United Nations, 2003). However, the value is not allocated to the correct sector. Only costs associated with the water infrastructure and purification are correctly charged to water using sectors and correctly allocated to the water sector as revenue in the SNA.

iii) The value of water used by economic sectors as a sink for waste products from production (point pollution), i.e. waste amenities (also broadly measured as part of X_{QEE}). These water benefits are indirectly captured by the SNA as they contribute to improved VAD in sectors receiving, but not paying for this service.

External costs associated with the use of water in economic production (R_{QE}) is included in the SNA, but is not included as part of the cost of production in economic sectors. Rather, it is absorbed as VAD by water using economic sectors. This value thus needs to be measured and removed from profits of economic sectors and properly allocated to the source, which is natural water. Therefore, in the ecologically adjusted SNA and SAM, R_W and R_E in equations (17) and (18) must be subtracted from the GOS of source sectors to calculate operating surplus adjusted for water opportunity cost, and included in government income account as water rent since government is the custodian of natural resources on behalf of households, or else be directly included in households income. To meet the double entry requirements of the SAM this value should be paid as compensation to affected households. Detailed adjustments are given in the next section.

The preceding discussion has identified the various values of streamflow (natural water) services currently missing from or incorrectly accounted for in the SNA (i.e. R_{QC}, X_{QN}, and $R_{QE} = R_W + R_E$), demonstrating the importance of integrating ecological values in the SNA and conventional SAM. The next section shows how the adjustments identified above are integrated in the SAM to develop the ESAM, and the new (extended) macroeconomic balances of the ESAM are specified.

5.4.5 The ecological social accounting matrix (ESAM) for the LHWP

From the above discussions it is clear that some adjustments and extensions are needed on the SAM in Table 4.1 to integrate ecological values. Major adjustments are required on production and factors' accounts which have to be split between economic and ecological production and factors, respectively. Effectively a new set of accounts (ecological accounts) have to be introduced into the SAM, and existing production and factors accounts have to be adjusted with ecological values. Accordingly, corresponding accounts (e.g. households, enterprise and government accounts) have to be adjusted as well. The conventional SAM in Table 4.1 is therefore modified to account for the generation and allocation of ecological values identified in Figure 5.2 and discussed above to develop what we refer to as the ecological social accounting matrix (ESAM), presented in Table 5.1 below. The developed ESAM forms the analytical framework employed by this study. It gives a snapshot of economic and ecological flows in Figure 5.2 in a given year and uses a generic single country SAM as an example to show how ecological values can be integrated in the SAM framework.

TABLE 5.1: Schematic of basic Ecological Socail Accounting Matrix (ESAM)

						Socio-economic System							ecological System		
				EXPENDITURES											
				Endogenous accounts						Exogenous accounts					
	RECEIPTS		Water supplying sector	Other economic (E) activities	Produced Water (W)	Other conomic commodities	Economic factors	Households	Enterprises	Government	Capital account	Rest of the world	Ecological activities	Natural Water	Total
	Endogenous accounts		1	2	3	4	5	6	7	8	9	10	11	13	
Socio-economic system	Water supplying sector	1			Gross water output (Y_W)									Water residual (Z_W)	Gross output of produced water (ETY_W)
	Other economic (E) activities	2				economic output (Y_E)								Water residual (Z_E)	economic output (ETY_E)
	Produced water (W)	3	Intermediate demand (X_W)	Intermediate demand (X_{WE})				Household consumption (C_W)		Government consumption (G_W)		Water exports (E_W)			for produced water (ETD_W)
	Other economic commodities	4	Intermediate demand (X_{EW})	Intermediate demand (X_E)				Household consumption (C)		Government consumption (G)	Investment consumption (I)	Economic products' exports (E)			Total demand for economic commodities (ETD_E)
	Economic factors	5	Value added (EW_W)	Value added (EW_E)								Factor service exports (W_{ER})			Economic factor income (ETFY)
	Households	6					Wages (F_E)	Household transfers (Tr)	Distributed profits (EDP)	Transfers (Tr_h)		Foreign remittances (Tr_{hR})	Value added (W_N,R_{NC})	Value added (W_Q, R_{QC},X_{QN}, R_{QE})	Households income (ETHY)
	Enterprises	7					Gross profits (EGOS)			Transfers (Tr_C)		Transfers (Tr_{CR})			Enterprise income (ETEY)
	Exogenous accounts														
	Government	8	Taxes (T_{AW})	Taxes (T_{AE})	Tariffs (T_W)	Tariffs (T_{YE})		Direct taxes (T_h)	Company taxes (T_C)			Transfers (Tr_{gR})			Government income (ETGY)
	Capital account	9					consumption of capital (CC)	Household savings (S_h)	Retained earnings (S_C)	Government savings (S_g)		Capital transfers from abroad (Tr_{CR})			Total savings (TS)
	Rest of the world	10	Factor service imports (W_{RW})	Factor service imports (W_{RE})	Imports (M_W)	Imports (M_E)		Transfers abroad (Tr_{Rh})		Transfers abroad (Tr_{Rg})	Capital transfers abroad (Tr_{Rc})				Foreign exchange payments (TRY)
Ecological System	Ecological production	12		Intermediate demand (X_{NE})				Households consumption (C_N)							Gross ecological output (TY_N)
	Natural water (Q)	13	Intermediate demand (X_{QEW})	Intermediate demand (X_{QEE})				Households consumption (C_Q)					Intermediate demand (X_{QN})		Gross natural water output (TY_Q)
	Total		Total water production expenditures (ETE_W)	Total economic production expenditure (ETE_E)	Total supply of produced water ($ETsup_W$)	Total supply of economic commodities ($ETsup_E$)	Economic factor expenditure (ETFE)	Household expenditure (ETHE)	Enterprise expenditure (ETEE)	Government expenditure (ETGE)	Total investment (TI)	Foreign exchange receipts (TRE)	Total ecological production expenditure (TE_N)	Total natural water production expenditure (TE_Q)	

In the ESAM the use of streamflow/natural water by economic activities is explicitly split between the water production activity and other economic activities (i.e. X_{QE} in figure 5.2 is split into X_{QEW} and X_{QEE} in Table 5.1). This explicit presentation is important because water requirements for economic and human consumption in an economy are met from natural and produced water. As discussed earlier, water users directly abstract natural water from nature while produced water is distributed to users by the water supply sector. This sector abstracts water from nature and distributes it to users in either processed or raw (natural) state[16]. The explicit distinction between natural and produced water is necessary to show the proportional use of water between the two categories and also show which users (sectors) absorb the water rent.

According to discussions presented in the preceding section, the following adjustments to the SNA and consequently the SAM are needed:

a) By excluding the value of freshwater and other biological products and services supported by water resources, which are directly harvested for final consumption, the SNA underestimates total output or income. This value needs to be estimated and added to measures of income, i.e. GDP and GNP.

b) The value of water and other biological products directly harvested for use as intermediate inputs in economic production is included as part of the VAD in economic production. However, products harvested and sold in informal markets are excluded from GDP.

c) As the SAM also traces the distribution of the values in (a) and (b) to institutions, corrections are needed for that:

    (i) Income of Households who directly harvest water and other services for final consumption, and thus enjoying the total value of these ecological production activities. Part of this total value represents the contribution of labor to VAD in ecological production but also includes the resource rent to the natural water system, which dissipates to households harvesting under common property/open access. The

[16] In this study we assume that any water that is distributed by the water supply sector (or water authority) is produced water even if it is distributed in the raw/natural form (e.g. the water exported by Lesotho to SA is exported in the natural form by the Lesotho water sector).

correction in this case involves paying this additional value estimates in (a) above to households either through government transfer or directly. In this study we assume that these transfers are made to households directly. Households then spend that additional income to 'pay' nature (e.g. 'buy' ecological products and natural water).

(ii) The value of water and ecological products used in economic production (E) is received by economic activities and hence rents on those are transferred to business owners (government or private enterprises) as a subsidy from nature. These values (resource rents) must be estimated, reallocated to ecological production and natural/freshwater services, which in turn will transfer them to households directly . Households are already receiving and spending that value on final demand sectors (e.g. consumption, savings, transfers etc.), but in the conventional SNA, this value is part of enterprise profits distributed to households and not a subsidy transfer from nature to households.

(d) As the quantity and/or quality of water is extracted (degraded), the stock of water resource assests is affected and hence such change in the value of the asset needs to be accounted for. Although adjusting the SNA for depreciation or appreciation of asset values is the most important correction to measures of sustainable income and welfare, the SAM structure represent flows of value in current period and does not contain assets components. Accordingly, this study did not make an attempt to account for changes in asset values (apart from quality aspects and capacity of the ecosystem to supply products in future, this is not major for a renewable freshwater resources).

According to (a) the conventional measure of total output (GDP) excludes the value of output of ecological production (TY_N) and natural water (TY_Q). GDP adjusted for missing ecological values (EGDP) is then measured as

$$EGDP = GDP + TY_N + TY_Q \tag{21}$$

Where on one hand, TY_N is the missing value of biological products and services which comprises biological products used as intermediate inputs in economic production (X_{NE}) and for direct consumption from nature and products sold in informal markets (C_N)[17]. On the other hand, TY_Q is the missing value of natural water which consists of water used as intermediate input by the water producing (X_{QEW}) and other economics sectors (X_{QEE}), biological production (X_{QN}) plus water directly consumed by households (C_Q).

According to the SAM double entry principle, TY_N must equal ecological production expenditure (TE_N) measured as the sum of contribution of ecological production to labor payments (W_N), ecological resources rent dissipating to households (R_N), and 'payment' for natural water (streamflow) used in ecological production (X_{QN}).

Therefore,

$$TY_N = X_{NE} + C_N \tag{22}$$

$$TE_N = W_N + R_N + X_{QN} \tag{23}$$

$$TY_N = TE_N \tag{24}$$

Accordingly TY_Q must equal total production expenditure of natural water (TE_Q) measured as the sum of the value of residuals from economic production (Z_W and Z_E), contribution of natural water to factor payments (W_Q) and natural water resource rent from biological and economic production (X_{QN} and R_{QE}, respectively).

Therefore,

$$TY_Q = X_{QEW} + X_{QEE} + C_Q + X_{QN} \tag{25}$$

$$TE_Q = Z_W + Z_E + W_Q + X_{QN} + R_{QC} + R_{QE} \tag{26}$$

[17]However, in this study we assume that all products from ecological production are sold in informal markets. Hence X_{NE} is zero and thus all of TY_N, represented by C_N, is missing from the conventional measure of GDP.

$$TY_Q = TE_Q \tag{27}$$

Where,

$X_{QEW} = Z_W + R_W$

$X_{QEE} = Z_E + R_E$

$X_{QN} = C_N + X_{NE} - W_N - R_N$

$C_Q = W_Q + R_{QC}$

Households income adjusted for ecological values (ETHY) is therefore measured as

$$ETHY = THY + W_N + W_Q + R_N + R_{QN} + R_{QC} + R_{QE} \tag{28}$$

Where THY is the conventional measure of total household income in Table 4.1.

Households were already spending R_{QE} as will be clear later. But now they must spent new income (W_N+R_N+X_{QN}) and (W_Q+R_Q) on buying ecological services (i.e. biological products C_N) and freshwater (C_Q), respectively. Therefore, household expenditures adjusted for ecological values (ETHE) is measured as

$$ETHE = THE + C_N + C_Q \tag{29}$$

Where THE measures total households expenditure excluding ecological resources and services as shown in Table 4.1.

According to point (b) above, the conventional measures of output and income include values of freshwater and biological products and services used as intermediate inputs in economic production. However, these values are erroneously included as part of VAD of the sectors receiving natural water services and not paid to the source sector (natural water). Adjustment then requires estimating and reallocating these values to source sectors. Since in this study we assume that all biological products are sold in the informal markets, the adjustment is only required for freshwater service values. Therefore, the VAD adjusted for freshwater services is as follows:

(i) VAD of the water supply sector adjusted for freshwater service values (EW_W)

$$EW_W = W_W - R_W \tag{30}$$

Where W_W is value added to water supply activity (that includes freshwater value) in the conventional SAM (see Table 4.1), and R_W is the value added by natural water in water supply activity.

(ii) VAD of other economic activities adjusted for freshwater service values (EW_E)

$$EW_E = W_E - R_E \tag{31}$$

Where W_E is value added to other economic activities (including freshwater value) in the conventional SAM (see Table 4.1), and R_E is the value added by freshwater in other economic activities.

As a result of these adjustments, factor income decreases, thereby affecting enterprise profits. If we let $R_W + R_E = V_Q$, then enterprise profits adjusted for freshwater services (EGOS) is

$$EGOS = GOS - V_Q \tag{32}$$

In this case V_Q is transferred to households as water rent and not as factor income received from the water supply (W) and other economic activities (E).

Because of this adjustment, enterprise profits distributed to households will fall and the adjusted distributed profits (EDP) is

$$EDP = DP - V_Q \tag{33}$$

Where DP represents the value of distributed profits in the conventional SAM that includes the water rents.

This therefore means that households' income will fall by V_Q. However, the freshwater service values allocated to natural water have to be directly transferred as water rent ($R_W + R_E = R_{QE}$) to households as owners of natural resources. Consequently, households income will not change. In summation then, these adjustments will not cause any change to conventional income measures, but both economic factor and enterprise incomes will fall. Accordingly, their respective expenditure measures will fall. The ESAM in Table 5.1 shows how the conventional SAM is extended with the above adjustments. Because of the double entry principle of the SAM, all accounts linked to the adjustments above change. As a result the ESAM shows totals of such accounts as ecologically adjusted by adding an E in the row and column totals.

Clearly, the conventional measures of output and income overestimate private (enterprise) profits by not allocating water resource rents to the source sector, natural water. It is also clear that conventional income measures like GDP underestimate income by not including contribution of ecological resources and services. The ESAM in Table 5.1 thus represents 'true' output and income measures[18]. The following macroeconomic balances show how the conventional SAM macroeconomic balances change with the inclusion of ecological values.

[18] It is noteworthy to indicate that these do not depict the global sustainable measures of output and income since the extended values only depict the picture of water resources and water environmental assets that are basin specific. Other water resources and other facets of natural resources (e.g. cropland, indigenous forests, and other ecosystems), and environmental assets (e.g. air, solid wastes), which all comprise accumulation accounts of a country and indicators of sustainable development according to SEAM and SEA are not included (United Nations, 2003; Pan, 2000; De Haan and Keuning, 1996).

(i) Gross output of water supply sector extended with ecological values (ETY_W)

$$ETY_W = Y_W + Z_W$$
$$ETE_W = TE_W + X_{QEW} \quad (34)$$
$$ETY_W = ETE_W$$

ETY_W is measured as the sum of gross output of W (Y_W) and the value of water residual from W production (Z_W). ETY_W must equal ETE_W, measured as the sum of conventional total expenditures (TE_W) and natural water used as intermediate input in W production (X_{QEW}).

(ii) Gross output of other economic activities extended with ecological values (ETY_E)

$$ETY_E = Y_E + Z_E$$
$$ETE_E = TE_E + X_E + X_{QEE} \quad (35)$$
$$ETY_E = ETE_E$$

ETY_E is the sum of gross output of E (Y_E) and the value of water residual from production of E (Z_E). ETY_E must equal adjusted total expenditures (ETE_E), measured as the sum of conventional total expenditures (ET_E), the value of biological products used as intermediate inputs in economic production (X_E) and the value of natural water used as intermediate input in the production of E (X_{QEE}).

(iii) Total factor income extended with ecological values (ETFY)

$$ETFY = EW_W + EW_E + W_{ER}$$
$$ETFE = FE + EGOS + CC \quad (36)$$
$$ETFY = ETFE$$

ETFY is measured as the sum of value added to water supply sector (EW_W) and other economic activities (EW_E), respectively, adjusted for the value of freshwater services, and the value of factor service exports (W_{ER}). ETFY must equal total factor expenditures (ETFE), measured by the sum of wages (FE), adjusted profits EGOS (see equation 32).

(iv) Total household income adjusted for ecological services value (ETHY)

$$ETHY = FE + Tr + EDP + Tr_h + Tr_{hR} + W_N + R_N + W_Q + R_{QC} + X_{QN} + R_{QE}$$
$$ETHE = THE + C_N + C_Q$$
$$ETHY = ETHE \qquad (37)$$

ETHY is measured as the sum of wages distributed to households (FE), households transfers (Tr), enterprise distributed profits adjusted for freshwater services value (EDP), government transfers (Tr_h), foreign transfers (Tr_{hR}), transfer from ecological production and natural water, respectively, to households (W_N and W_Q), natural resources rents R_N, R_{QC}, X_{QN}, and R_{QE}. ETHY must be equal total household expenditure extended for ecological services values (ETHE), measured as the sum of conventional measure of household income (THE) and consumption 'expenditure' on biological resources (C_N) and natural water (C_Q).

(v) Total enterprise income adjusted for ecological services values (ETEY)

$$ETEY = EGOS + Tr_C + Tr_{CR}$$
$$ETEE = EDP + T_C + S_C \qquad (38)$$
$$ETEY = ETEE$$

ETEY is measured as the sum of profits adjusted for freshwater service values (EGOS) and government (Tr_C) and foreign (Tr_{CR}) transfers, respectively. ETEY must equal total enterprise expenditure adjusted for ecological services values (ETEE), measured as the sum of adjusted enterprise profits distributed to households (EDP), company tax (T_C) and company savings (S_C).

Accordingly, ecological system balances are explicitly specified as follows:

(vii) Ecological production

Gross output of ecological activities (TY_N) must equal total ecological production expenditure (TE_N):

$$TY_N = X_{NE} + C_N$$

$$TE_N = W_N + R_N + X_{QN} \tag{39}$$

$$TY_N = TE_N$$

This study assumes that all the benefits of ecological goods and services directly accrue to households because even those ecological goods and services that are traded, are traded in the informal markets. This implies that $X_{NE} = 0$ and hence, $TY_N = C_N$.

(viii) Natural water

Natural water income (TY_Q) must equal natural water total production expenditures (TE_Q):

$$TY_Q = X_{QEW} + X_{QEE} + C_Q + X_{QN}$$

$$TE_Q = Z_W + Z_E + W_Q + R_{QC} + X_{QN} + R_{QE} \tag{40}$$

$$TY_Q = TE_Q$$

The extensions made in this section explicitly show that the SNA, and therefore the SAM in Table 4.1, underestimates the output and income measures of economic activity by excluding the value of ecological resources and services. They also demonstrate that the value of the contribution of natural water to economic production is underestimated by not being explicitly shown in the SNA. Ecologically adjusted macroeconomic balances represented by equations (34) – (40) thus more accurately depict the 'true' output and income. Explicit inclusion of the value of natural water in the SNA is highly crucial in assessing impact of water developments that alter quantity and quality attributes of natural water. The impact may be assessed on the economy of a country at large, but more importantly, on the welfare of the people who derive livelihoods directly from biological resources and services supported by the natural water. The following section shows how the ESAM can be used to measure the impact of water policies that affect the capacity of the natural water/streamflow ecosystem to provide biological goods and services.

5.4.6 Using the ESAM to measure impacts of the LHWP

The above sections have demonstrated the significance of natural water (streamflows) in economic and ecological production. But most importantly, the sections have shown that economic production can modify natural water/streamflows through water abstraction and waste amenities. These activities can diminish the capacity of streamflow capacity to supply ecological goods and services, thereby affecting human wellbeing. It has also been shown that ecological resources and services are another source of income for households deriving livelihoods from them (i.e. W_N and R_N). Therefore, reduction in availability of these resources will definitely reduce households' income. This section extends the conceptual frameworks developed in this Chapter and Chapter IV and shows how the multipliers matrix change with the inclusion of ecological values in the conventional SAM. In other words, the section discusses how the ESAM can be used as a conceptual framework.

The adjustments made in the ESAM have effected notable changes on the structure of the conventional SAM, and thus the accounting multiplier matrix (which is the basis for the SAM analysis) developed in Chapters IV (see Section 5.4.4 above). Because of the changes, both endogenous and exogenous incomes of the conventional SAM changed. To accommodate these changes in the analytical framework, the endogenous and exogenous matrices of the conventional SAM derived in Chapter IV and Appendix A have changed as presented in Appendix C.

To analyse the impact of the exogenous change in households' income due to the exogenous change in ecological production (resulting from change in streamflows of the rivers downstream the LHWP dams in Lesotho) on the households' welfare and general economies of Lesotho and SA, we therefore use the following equation (see detailed derivation in appendices A and C)

$$dEY = EM_2 M_1 dF \tag{41}$$

Where M_1 is the intra-country multiplier matrix that shows multiplier effects that result from linkages wholly within each country taken separately. M_2, on the other hand, is the inter-country multiplier matrix and captures all the repercussions between the accounts of one country and those of the other, but excludes all of the within country effects.

However, before we continue with the analysis we need to know the link between streamflows and availability of biological resources and services on the one hand, and availability of biological resources and riparian welfare (measured by households income), on the other. Section 5.4 has demonstrated that households derive labor incomes and resource rents from biological resources and services production, i.e. W_N and R_N, respectively. The section demonstrated that households also receive labor income and rents from natural water, i.e. W_Q and X_{QN}, R_{QC} and R_{QE}, respectively (It is assumed that without the project R_{QE} is zero). Therefore, the link between households welfare, measured by their income, and streamflows is the 'income' or subsidy they receive from ecological production and direct consumption of natural water. To measure the impact of modifying streamflows on the welfare of the households, and the general economies of Lesotho and SA we therefore, introduce the external shock through external households incomes $[(W_N + R_N + X_{QN} = C_N)$ and $(W_Q + R_{QC} = C_Q)]$. We then measure impact on the endogenous incomes through total multipliers (direct, indirect and induced) using the above equation.

The discussion in this chapter clearly demonstrates the inter-linkages between the socio-economic and ecological accounts. The challenge now is how to adjust published national accounts for both SA and Lesotho to reflect these ecological values related to the LHWP. This involves estimation for the identified values and adjusting the existing accounts accordingly. Chapter VI discusses estimation techniques available in the literature, identifies ecological services included in this study and techniques employed in valuing them as well as determined values.

CHAPTER VI - VALUING INSTREAM FLOW BENEFITS AND ASSOCIATED WELFARE IMPACTS

6.1 Introduction

As explained in the preceding chapter, data used for the development of the multi-country SAM are deficient in terms of values of ecosystem services provided by the modified flows in a number of ways:

(i) Some of the water flow services are used as intermediate input in economic production activities and thus contribute to VAD generated by these sectors. However, the value of the contribution of these services to sectoral VAD is not known and not attributed to its source, natural water supply. One challenge this study attempts to address is to estimate such value and attribute to its source. To avoid double counting, this value is merely used to adjust the conventional accounts in the SNA, and is not added to GDP.

(ii) Other values of water flow services are missing from the SNA due to the fact that such benefits are directly enjoyed by households at no explicit cost (i.e., they are freely harvested and not considered produced or traded).

This chapter therefore endeavors to determine the value of water flow services currently not properly treated by and/or missing from the SNA based on which the multi-country economic SAM was constructed. This task involves determining the value of water flow services contributing to VAD generated by economic production activities (water resource rent) and attribute that value to its source (natural water supply). Also, the Chapter endeavors to determine the value of water flow services directly enjoyed by households for final consumption.

Some of the biological resources and services discussed above have market prices as they are often traded in informal markets (e.g. crafts and thatch grass, timber, medicinal plants, fish and non-cultivated vegetables). However, some services have no prices, e.g. recreational/religious/cultural and moisture recharge services of natural water. Various methods were used in the literature to determine values of fresh water resources and their services in such cases.

This chapter reviews relevant literature on techniques for valuing streamflow services and discusses necessary steps followed in valuing streamflow services. The Chapter also shows how the techniques identified in the literature were used to value streamflow services associated with the LHWP. The chapter proceeds with identifying valuation paradigms of environmental goods and services in the following section, followed by the economic concept of value in Section 6.3. Available ecosystem services' valuation techniques are discussed in Sections 6.4 and 6.5. Lastly, the procedure followed in determining streamflow value associated with the LHWP is discussed in Section 6.6.

6.2 Valuation of ecological services

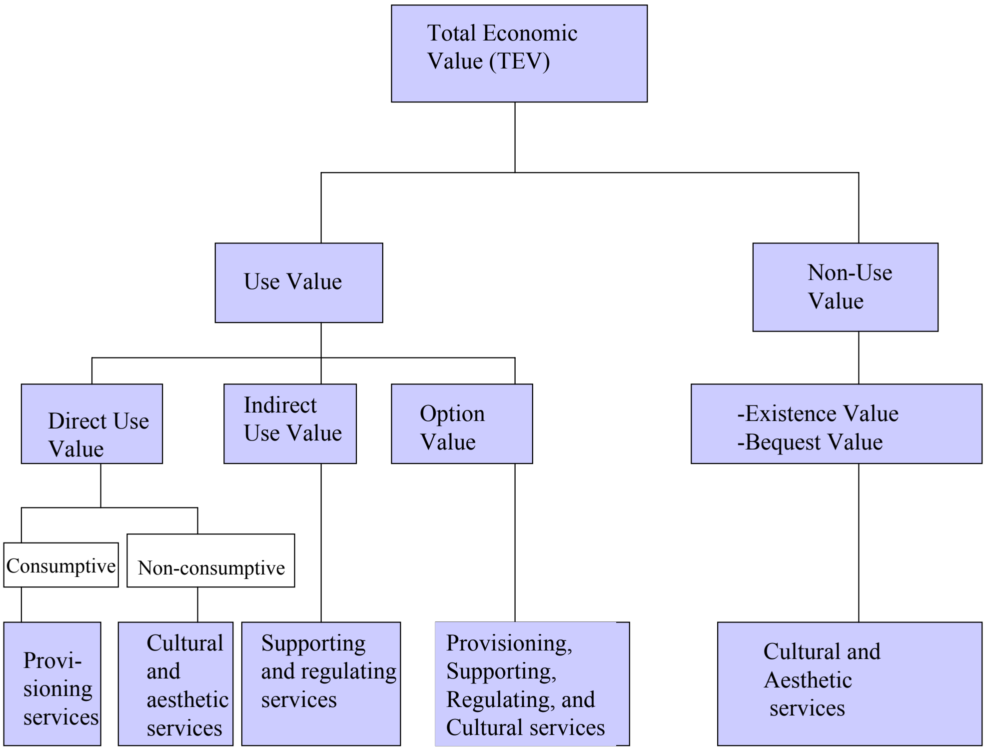
Valuation of ecological systems and the services they provide is premised on two distinct, but complementary valuation paradigms: anthropocentric and ecocentric paradigms. The anthropocentric valuation paradigm, also known as the utilitarian approach, has its foundation in neoclassical welfare economics. According to this approach, an ecological value is estimated from the utility humans derive from using ecological services. The paradigm is based on the principles of humans' preference satisfaction (welfare) (MEA, 2003). It then follows that the basis for deriving measures of economic value of the environment and goods and services it provides is their effects on human welfare (Freeman, 1993). Contrarily, humans can value the environment and its services for their pure existence or intrinsic value. This form of valuation is purely premised on altruistic and ethical or ecocentric concerns not directly related to satisfaction of material human needs. This study adopts the anthropocentric approach to value measurement. This decision does not ignore the importance or validity of the intrinsic value of instream benefits but is based on the task set for this study, which is to determine welfare implications of modifying stream flows. The following section explains the economic concept of value which is adopted in this study.

6.3 The concept of economic value

The concept of economic value has its foundation in the neoclassical welfare economics. The basic premise of welfare economics is that the purpose of economic activity is to increase the well-being of individuals who make up the society. Also, that each individual is the best judge of how well-off he or she is in a given situation by revealing preferences for different trade-offs (Freeman, 1993). Therefore, the anthropocentric value derives from the economic concept of value and is determined by peoples' willingness to make trade-offs. The anthropocentric value is easily derived in the case of marketed goods, where the willingness to make trade-offs is revealed through their market decision to pay a monetary price for the good in question. In this case, societal value of a good is measured as the total of consumers' and produces' surplus (for details see, for example, Pearce and Turner, 1990; Freeman , 1993; Kahn, 1998; Tietenberg, 2000; Russsel, 2001).

The Utilitarian approach to valuing ecological services uses the concept of total economic value (TEV) framework. The framework typically disaggregates TEV into two categories: use and non-use values. Figure 6.1 below provides the schematic of these categories of value as they relate to streamflow services' values.

FIGURE 6.1: Schematic for Streamflow services Total Economic Valuation (TEV)



Source: Adapted from the MEA (2003).

In the case of stream flows, use values refer to the value of instream resources and services used by riparians for consumption or production purposes. They include tangible and intangible goods and services that are either currently used directly (direct use values) or indirectly (indirect use values) or have a potential to provide future options of use values (option values). Direct use comprises consumptive (leading to reduction in streamflow, e.g. irrigation and residential water) or non-consumptive uses (no reduction in sntreamflow, e.g. reacreational and cultural amenities). Indirect use values include regulatory and supportive services of intream flows, where instream water is used as intermediate input for production of final goods and services to riparians (e.g. fish and wild vegetables). Option values comprise the value held by riparians for preserving the option to use instream services in future, either directly or indirectly, even though they may not currently be deriving any utility.

Riparians also hold value for knowing that some instream services exist (for cultural and religious reasons), even if they never use that resource directly. This kind of value is usually known as existence value, or bequest value where the resource is left to posterity. Utalitarian non-use values comprise the value that riparians hold for knowing that instream water exists, even if they never use it directly. The main difference between the utilitarian and ecocentric paradigms in this regard is that the former has no notion of intrinsic value and the latter has no notion of human utility.

6.4 Techniques for valuing stream flow services

Not all ecological services are traded in the market, especially in the case of intangible services like regulating, supporting and cultural services of stream flows. Even in the case of traded services, like provisioning services where ecological products like medicinal plants and crafts grass are sold in the market, their prices are often distorted or incomplete due to various types of externalities like lack of property rights. Ecological resources do not have private ownership and as such may be referred to as common pool resources (Sterner, 2003). These type of resources are characterized by costly exclusion, and there is typically rivalry in use (Sterner, 2003).

The consequence of this externality is a divergence between private and social values as markets fail to capture and reflect the full social value of these services. Unfortunately, SNA, which is the basis for decision making and policy design, is based on information of produced goods that are traded in the market. As a result the information provided by SNA is deficient and can lead to misguided policies, especially in the case of water developments. Because of the failure of markets to determine values for non-marketed ecological services, there are two major classes of techniques for measuring the value on non-market goods identified by literature:

i) Revealed preference approaches, and
ii) Stated preference approaches (Kahn, 1998).

Table 6.1 below gives different techniques under each approach [details can be obtained from standard natural resource and environmental economics texts, e.g. Freeman (1993), Dixon et al. (1994), Tieternberg (2000), Pearce and Turner (1990), Kahn (1998), Russel (2001)].

TABLE 6.1: Methods for estimating Environmental Values

	REVEALED PREFERENCE (OBSERVED BEHAVIOR)	STATED PREFERENCE (HYPOTHETICAL)
DIRECT	***Direct Observed***	***Direct Hypothetical***
	Competitive market price Simulated markets	Bidding games Willingness-to-pay Questions
INDIRECT	***Indirect Observed***	***Indirect Hypothetical***
	Travel cost Hedonic property values Referendum voting Contingent referendum Mitigation/prevention values Productivity/cost measures	Contingent ranking Contingent activity

Source: Adapted from Freeman (1993).

Revealed preference approaches look at decisions people make regarding activities that utilize or are affected by instream flow services, to reveal the value of the service. As such, streamflow service values are inputed from behavior of indivisuals observed in markets. For tradable goods and services this behavior is depicted by the willingness-to-pay- or the demand-function. Therefore, values are derived from preferences revealed by consumers' behavior, hence why the approach is also referred to as the 'revealed preference' approach. Since the choices are based on prices, the data reveal values directly in monetary units. For traded environmental goods and services, consumers have the opportunity to reveal their preferences for such a good compared to other substitutes or complementary commodities through their actual market choices, given relative prices and other economic factors.

However, many environmental systems' services, like stream flow services, are not privately owned and not traded and hence their demand curves cannot be directly observed and measured. In some cases though, ecological resources, though not privately owned, are traded in the informal markets, e.g. medicinal plants, wild vegetables, thatch grass and fish. In such cases values are derived from 'surrogate' informal markets (Tietenberg, 2000; Pearce and Turner, 1990; Kahn, 1998; Russell, 2001). In cases where the resource is not traded at all, e.g. water used by riparians for residential use, the cost of access to water measured by the time taken and distance traveled to the water source can be used to estimate the value of water (travel cost method). These approaches typically focus on measuring direct use values and are not particularly useful in measuring indirect use values (Kahn, 1998).

Stated preference methods elicit values directly from individuals, through survey methods. The values are derived from hypothetical markets where individuals state their preferences for ecological services through surveys. For example, to determine the value of streamflow services, riparians can be directly asked what value they place on modifications of river flows downstream the LHWP dams. That is, how much compensation they would be willing to accept because of reduced flows of rivers, or how much they would be willing to pay to have increased releases from the dams into the rivers downstream the dams. Bidding games or willingness to accept/pay questions are used in this case (see Freeman, 1993; Kahn, 1998; Dixon et al., 1994 for details). With this information the demand curve or willingness to pay function for the stream flow can be derived and its total value estimated from the derived function (consumer surplus).

When ecological services or goods enter production functions of marketed goods as productive inputs, their values can be observed indirectly through examination of changes in product and factor prices and in the producer's quasi-rents. The production and cost function approaches were used to estimate such ecosystems' service values. Although rivers downstream the LHWP provide provisioning services like water for residential and recreational, and/or cultural uses, their most important role is in the provisioning of regulatory and supportive services to cultivated and non-cultivated agriculture. For cultivated agriculture, streamflows provide irrigation water and moisture recharge service for dryland agriculture. For non-cultivated agriculture, streamflows support growth of aquatic resources (e.g. fish) and provide moisture required for growth of ecological resources (non-cultivated agriculture) (e.g. wild vegetables) important for livelihoods of riparians. These resources are sold in the informal markets while some are directly consumed by households. Clearly, these services enter production functions of the mentioned ecological resources.

For illustration we assume that production of marketed non-cultivated ecological product (e.g. medicinal plants) requires only two production inputs: (i) streamflow (q) for moisture support and labor (L) for harvesting the product. Therefore its production function can be represented by

$$y = y(L,q)$$

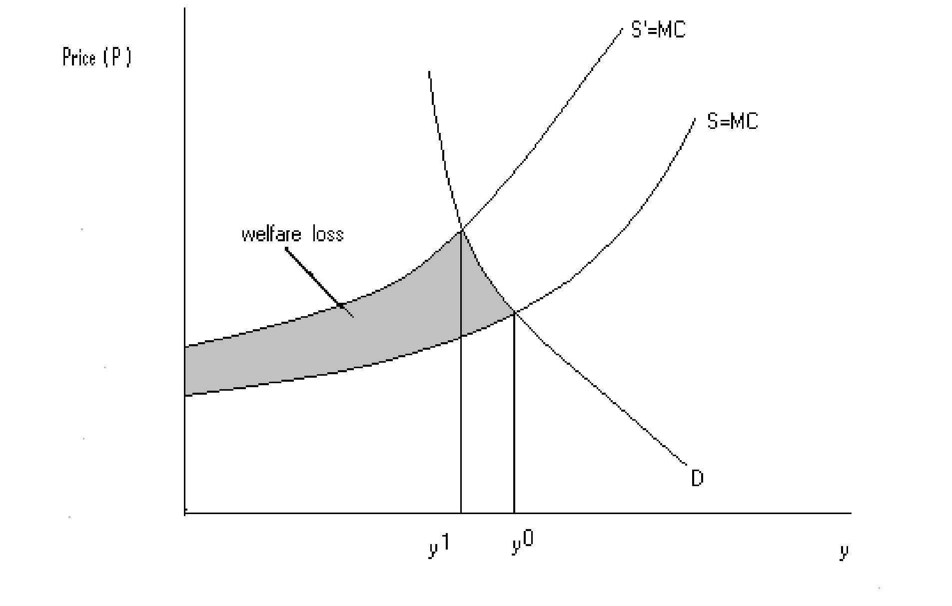
Where y is production of medicinal plants, and the marginal product of q is positive.

With given labour price and assuming cost-minimising behaviour, the corresponding cost function function is $C = C(pl)$ where pl is the price of labour. In this case the price of labour can be measured as the value of time spent in looking for and harvesting medicinal plants. If the plants are bountiful, the price of labour will be relatively lower than when they are scarce. Because of the positive marginal productivity of q, if q decreases, availability of medical plants reduces, thereby increasing C. The increase in C can be represented by a shift in a marginal cost or supply curve for good y along a given demand curve. Reduction in moisture support (Δq) would then involve a supply shift inward and to the left from S to S', as illustrated in Figure 6.2. This shift would result in a fall in y from y^0 to y^1. The shaded area between the old (S) and the new (S') supply curves indicates the theoretically preferred measure of welfare loss, i.e. the change in combined consumer and producer surplus (Ellis and Fisher, 1987).

Accordingly, the change in welfare from change in q can be estimated based on either of the two alternative and dual measures: (i) the value of marginal product of q derived from the production function, or (ii) from the cost function of an industry (which can be interpreted as the shaded area in Figure 6.2). Therefore, for non-marginal decline in q (i.e. from q^0 to q^1), one would integrate over the shaded area in Figure 6.2 to measure the corresponding welfare loss, given labor cost information and the values of y^0 and y^1 (i.e. $P(y^0)$ and $P(y^1)$, respectively, where P is price of y). This analysis is essentially short-run, focusing on the changes in quasi-rents to firms and on consumer surpluses. It is however, appropriate to use the short-run analysis[19] since in the long-run, quasi-rents are competed away, except for those accruing to specialized factors owned by firms (Freeman, 1993).

[19] This assumes that ecological resources' production is characterized by perfectly competitive markets

FIGURE 6.2: Change in combined consumer and producer surplus from a shift in product cost curves



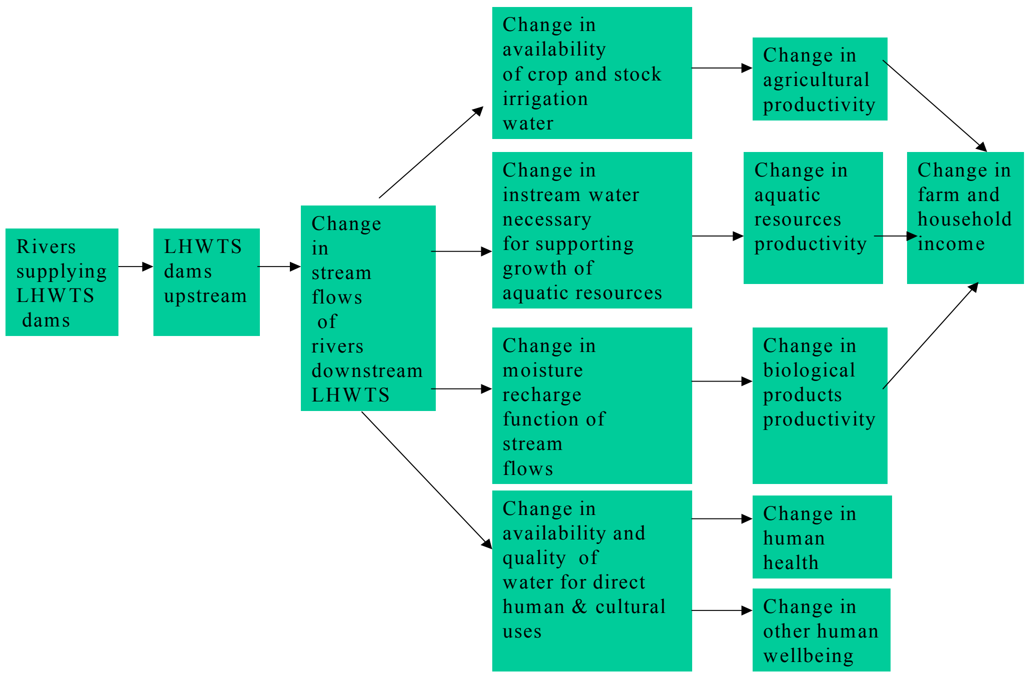
Source: Freeman (1993).

6.5 Measuring the value of stream flow services

From the preceding section, it is clear that applying valuation to value changes in ecological services require knowledge about change in the flow of benefits resulting from an environmental system change, and thus knowledge about the change in the physical flow of benefits. Therefore, the supreme task in ecological services' valuation in this case is quantifying the biophysical relationships. In the case of stream flow services identified in Chapter V, the following biophysical relationships had to be quantified before values could be inferred. Figure 6.3 below maps biophysical relationships that need to be quantified in order to estimate values of changes in stream flow services.

FIGURE 6.3: Biophysical changes necessary for Valuing stream flow changes of rivers

downstream the LHWP



Source: Adapted from MEA (2003).

Considering streamflow supportive service for agricultural productivity, valuing the change in agricultural productivity resulting from change in stream flows requires first distinguishing between irrigated and dryland agriculture. For irrigated agriculture it is necessary to first determine how abstracting water from rivers for transfer to LHWP dams will change stream flows. Second, how changes in the water flow affect availability of water for irrigation purposes. Third, how changes in water availability affect agriculture productivity. For dryland farming of produced and wild agriculture, it is important to know how changes in the availability of stream flow will affect the moisture recharge function of stream flows and how changes in moisture levels affect dryland farming. In the case of recreation and cultural services, only two steps of biophysical relationships are necessary. First, how abstracting water from the rivers will change streamflows and second, how the change in streamflows will affect reacreational and cultural use of the rivers. It is only after these biophysical relationships have been quantified that valuation can take place.

6.6 The Empirical valuation model for the study area

The above sections identified generic streamflow services associated with the LHWP. The sections further laid conceptual framework for valuing streamflow services. Because of data limitations, this study could only include effects of modified water flows in Lesotho. This section discusses data on streamflow services identified as relevant for riparians living within reaches of the rivers downstream the LHWP dams in Lesotho and procedures followed in valuing these services, and impacts of modifying flows of rivers downstream the LHWP dams.

6.6.1 Data and sources

This study does not attempt to derive streamflow values associated with the Lesotho Highlands rivers. Rather, it used the streamflow values derived in IFR studies commissioned by the LHDA (LHDA, 2002d). Another study by Klassen (2002) later confirmed the values of the IFR studies. The values derived by these two studies were believed to be credible because they adopted theoretically sound valuation procedures, discussed in the above sections. As a result, this study would have arrived at more or less similar values. However, both LHDA (2002d) and Klassen (2002) did not provide the conceptual framework adopted in obtaining the derived values. Therefore, this study developed the conceptual framework necessary for valuing studied ecological resources and services and linked the developed framework to the derived values to show how valuation techniques discussed in Section 6.4 were used in this particular case and that values derived by LHDA (2002d) and Klassen (2002) are consistent with the developed conceptual framework. To get to the final values of studied ecological resources and services, LHDA (2002d) used information from biophysical and socioeconomic studies (LHDA, 2002b and c). Details of procedures followed in the estimation process of these values are given in Appendix D and relevant LHDA documents (i.e. LHDA 2002b, c, and d). Table 6.2 below gives a list of streamflow/ecological resources and services that were identified as relevant for maintenance of livelihoods of households residing within the reaches of the Lesotho Highlands rivers in the mountain areas of Lesotho. The conceptual framework relevant for valuing resources identified in Table 6.1 is given in Sections 6.7.3 and 6.7.4. The sections also provide the derived ecological resources and services values.

6.6.2 Streamflow services included

The Socio-economic component of IFR studies identified three main services that riparians derive from streamflows of the LHWP. The first is the regulating and supporting services that streamflows provide for growth and maintenance of ecological resources (i.e. 1 – 18 in Table 6.2 below). The second, is the provisioning service where riparians use water from the rivers for drinking purposes and the third is the cultural and religious services provided by streamflows to riparians. The second and third groups of services are reported as services 19 – 21 in Table 6.2.

TABLE 6.2: Streamflow resources and services identified as important for maintenance of riparians' livelihoods

	Resource	Latin name/description
1	Reeds	*Phragmites australis,* used for crafts making
2	Thatch grass	*Hyparrheria hirta,* most important thatch grass within riparian zone
3	Leloli	*Cyperus marginatus,* used for crafts making
4	Veg wetbank	Wetbank annuals
5	Veg drybank	Drybank lower dynamic and back dynamic
6	Shrubs	Wetbank shrubs and trees (*Salix zone)* and drybank shrubs and trees
7	Willow tress	Wetbank shrubs and trees (*salix zone)*
8	Poplar trees	*Populas canescens*
9	Medicinal plants Dry	Drybank lower dynamic and back dynamic
10	Medicinal plants Wet	Wetbank annuals
11	Cereals	Agriculture within rirarian zone
12	Pulses	"
13	Yellowfish	Smallmouth yellowfish
14	Catfish	Rock Catfish
15	Trout	Trout
16	Coarse Sand	Estimated quantity of sand in the system
17	Fine Sand	"
18	Forage	Grazing forage
19	Baptism	Pool depth and number
20	Lesisure	Pool depth and number
21	Human health	Quality of drinking water in Rivers

Source: Adapted from LHDA (2002d) and Klassen (2002).

6.6.3 Valuing streamflow benefits of ecological resources

Streamflow benefits are valued in terms of the value of supportive and regulating services provided by streamflows to the growth of ecological resources identified in the Table above. The indirect observed technique was used to measure the value of streamflow in the production process of ecological resources, i.e. "the productivity/cost measures" in Table 6.1. To demonstrate how this technique works it is assumed that the production of y_i (an ecological resource) requires a water input

Q (streamflow) and labor input (L), where i = 1, 2, …, 18 represent resources 1 – 18 in Table 6.2, and Q and L are vectors representing attributes of streamflow (quality and quantity) and labor, respectively. The aggregate production function for the resource i can be expressed as:

$$y_i = y_i(Q, L) \qquad \forall \text{ i} \tag{42}$$

and the associated costs of producing y_i as

$$C_i = P_l L_i \qquad \forall \text{ i} \tag{43}$$

where $C_i = C_i(y_i, Q_i)$, C_i represents minimum costs associated with producing y_i during a single growing season and P_l is the wage rate of labor harvesting y_i, L_i labor required to harvest resource i, and Q_i is streamflow required to produce y_i. If we assume that there exist an inverse demand curve for the aggregate output y_i, then

$$P_i = P_i(y_i) \qquad \forall \text{ i} \tag{44}$$

Where P_i is the market price of y_i, and all other marketed input prices are assumed constant. If the functional relationship between ecological resources and streamflow exists and if we denote social welfare arising from producing y_i as S_i, we can measure S_i as the area under the demand curve (44), less the cost of the inputs used in production (43)[20]

$$S_i = S_i(Q, L) = \int P_i(y_i)dy - P_l(L_i) \qquad \forall \text{ i} \tag{45}$$

Therefore, for a non-marginal change in streamflow from Q^o (old level) to Q^1 (new level), the welfare change measure associated with the change in regulatory and supportive services of streamfow is the resulting change in the value of production

[20] We assume that the demand function in (46) is compensated so that welfare can be measured by the appropriate areas. Welfare change is the sum of the consumer and producer surplus measures (see Figure 6.2)

(y_i) less the change in production costs, in this case labor costs (Archaya, 1999; Freeman, 1993, Ellis and Fisher, 1986). If the initial and final output levels y^0 and y^1 (i.e. ecological resources output before and after the LHWP, respectively) are known, then the change in welfare resulting from non-marginal change in streamflow can be measured as:

$$S_i = \int_0^{y^0} P_i(y)dy - C_i(y^0, Q^0) - \int_0^{y^1} P_i(y)dy + C_i(y^1, Q^1) \tag{46}$$

Where $C_i(y^0, Q^0)$ represents harvest costs of the intial output of y_i at the initial quantity and quality of streamflow, and $C_i(y^1, Q^1)$ represents harvest costs of the final output of y_i at the final quantity and quality of streamflow (see Freeman, 1993). Equation (46) is the same as integrating over the shaded area in Figure 6.2.

Using price, quantity and other relevant information from socio-economic data in LHDA (2002c), the IFR economic valuation study (LHDA, 2002d) calculated the (initial) value of resources 1 – 18 in Table 6.2 before the LHWP (i.e., $P_i(y_i^0)$ and the derived values are given in column 4 of Table 6.3. Further, using information from IFR biophysical and sociological studies (LHDA 2002b and c, respectively), and following steps necessary for valuing impact of streamflow changes of rivers downstream the LHWP dams outlined in Figure 6.3, the IFR economic valuation study (LHDA, 2002d) derived the (final) value of resources 1-18 in Table 6.2 after the LHWP (i.e., $P_i(y_i^1)$ and calculated the change in the value of the said resources due to the LHWP [i.e., $P_i(y_i^0) - P_i\ (y_i^1)$]. These are reported in column 5 of Table 6.4 as $\Delta P_i y_i = P_i(y_i^0) - P_i(y_i^1)$. For details on the calculation of these values refer to Sections D4.1 and D4.4 of Appendix D.

These values are therefore consistent with the developed conceptual framework.

However, harvest costs, in terms of the opportunity cost of labor used to harvest the resources was not estimated. Therefore in this case study the change in welfare associated with the change in streamflow is estimated as:

$$S_i = \int_0^{y^0} P_i(y)dy - \int_0^{y^1} P_i(y)dy \qquad (47)$$

Following the economic-ecological model developed in Chapter V, we let:

$$\sum_i P_i(y_i) = Y_N$$

Given that $C_N = W_N + R_N + X_{QN} = Y_N$ from Section 5.4.2, then

$$C_N = \sum_i P_i(y_i) = Y_N$$

Therefore, M46.19 millions in Table 6.2 represents $C_N = W_N + R_N + X_{QN}$ and M8.86 millions measures change in C_N (i.e. $\sum_i [P_i(y_i^0) - P_i(y_i^1)]$) as a result of the LHWP. Unfortunately the data collected by IFR studies was not sufficient to isolate the values of W_N, R_N and X_{QN} from Y_N. As a result, these values have not been estimated in this study.

It is notable from Table 6.4 that some of the impacts will be felt within the first two years of impoundment of the dams while others will not be felt until after 10 years. From the table 60% of the economic losses are due to lost firewood (mainly shrubs and trees) and over 20 % are due to lost fish resources. In total, some 153, 000 people, living in 32, 700 households are likely to be affected. The average loss per household amounts to about M276 per year (at 2000 prices). This roughly represents about 10% of annual household cash income as total annual household cash income for households directly affected by the project in Lesotho is estimated to be between M2500 and M5000 (Klassen, 2002).

TABLE 6.3: Streamflow resources and services values

	Resource	Latin name/description	Total value ($P_i(y_i^0)$) (millions at 2000 prices in Maloti[21])	Value per household (Maloti at 2000 prices)
(1)	(2)	(3)	(4)	(5)
1	Reeds	*Phragmites australis,* used for crafts making	0.18	5.6
2	Thatch grass	*Hyparrheria hirta,* most important thatch grass within riparian zone	0.45	13.44
3	Leloli	*Cyperus marginatus,* used for crafts making	0.29	8.96
4	Veg wetbank	Wetbank annuals	2.03	62.72
5	Veg drybank	Drybank lower dynamic and back dynamic	2.90	88.48
6	Shrubs	Wetbank shrubs and trees (*Salix zone)* and drybank shrubs and trees	21.67	663.04
7	Willow tress	Wetbank shrubs and trees (*salix zone)*	1.27	39.2
8	Poplar trees	*Populas canescens*	1.60	49.28
9	Medicinal plants Dry	Drybank lower dynamic and back dynamic	0.45	13.44
10	Medicinal plants Wet	Wetbank annuals	0.07	2.24
11	Cereals	Agriculture within rirarian zone	0.66	20.16
12	Pulses	"	0.03	1.12
13	Yellowfish	Smallmouth yellowfish	8.22	252
14	Catfish	Rock Catfish	0.81	24.64
15	Trout	Trout	1.74	52.64
16	Coarse Sand	Estimated quantity of sand in the system	0.78	23.52
17	Fine Sand	"	1.36	41.44
18	Forage	Grazing forage	1.60	49.28
	Total		46.19	1416.8

Source: Adapted from LHDA (2002d) and Klassen (2002)

[21] Maloti (M) is the local currency of Lesotho which is pegged on the SA Rand (R) on par basis. The M/R value in the year 2000 in relation to the US dollar was US$1=M??

TABLE 6.4: Ecological resoucres' value losses due to change in streamflow condition of rivers downstream the LHWP structures (millions at 2000 prices in Maloti)

Resource (1)	Latin name/description (2)	Impact (+/-) (3)	Onset (years)[22] (4)	Impact value ($\Delta P_i y_i$) (5)
Reeds	*Phragmites australis,* used for crafts making	+	1 – 2	0
Thatch grass	*Hyparrheria hirta,* most important thatch grass within riparian zone	+	1 - 2	0
Leloli	*Cyperus marginatus,* used for crafts making	+	1 – 2	0
Veg wetbank	Wetbank annuals	-	1 – 2	0.17
Veg drybank	Drybank lower dynamic and back dynamic	-	1 – 2	0.57
Shrubs	Wetbank shrubs and trees (*Salix zone)* and drybank shrubs and trees	-	2 – 10	5.21
Willow tress	Wetbank shrubs and trees (*salix zone)*	-	2 – 10	0.35
Poplar trees	*Populas canescens*	-	2 – 10	0.16
Medicinal plants Dry	Drybank lower dynamic and back dynamic	-	1 – 2	0.09
Medicinal plants Wet	Wetbank annuals	-	2 – 10	0.01
Cereals	Agriculture within rirarian zone	?	No impact	0
Pulses	"	?	No impact	0
Yellowfish	Smallmouth yellowfish	-	1 – 2	1.44
Catfish	Rock Catfish	-	1 – 2	0.15
Trout	Trout	-	1 – 2	0.36
Coarse Sand	Estimated quantity of sand in the system	+/-	1 – 2	0
Fine Sand	"	+/-	1 – 2	0
Forage	Grazing forage	-	1 – 2	0.09
Animal health	Diseases and nutrition associated with modified river flows	-	1 - 2	0.26
Total				8.86

Source: LHDA (2002d) and Klassen (2002).

6.6.4 Valuing provisioning and cultural services of streamflow

Instream Flow Requirements studies indicated that modification of flows of the Lesotho Highlands Rivers will reduce the quantity and quality of water in the Rivers for use by riparians for cultural and religious purposes. They also indicated that reduced quality of water will lead to serious health impacts for humans. Like in the case of regulatory and supportive services of streamflows, we use indirect observed

[22] The number of years it will take for ecological losses to be felt.

techniques to value provisioning and cultural services of streamflows. To show how the riparians welfare will be impacted upon by change in the provisioning of these services, we proceed as follows.

We assume that riparians derive the same utility from the use of the Lesotho Highlands Rivers so that their individual utility functions can be aggregated and represented by the function:

$$U = U(X, Q) \qquad (48)$$

Where U represents riparians' utility, X is the vector of private goods quantities consumed by riparians $(X = x_1,..., x_i,..., x_n)$ and Q is a vector of streamflow services. That is, (i) water for direct consumption by riparians and water used by riparians for (ii) cultural and (iii) religious purposes $(Q = q_1, q_2, q_3)$. If we assume that the riparians maximize utility subject to a budget constraint:

$$P.X = M \qquad (49)$$

Where P is the price of private goods and M is money income. Then demand functions for private goods can be derived as:

$$x_i = x_i(P, M, Q) \qquad (50),$$

the indirect utility function as:

$$V = V(P, M, Q) \qquad (51)$$

and the aggregated expenditure function as:

$$E = E(P, Q, U) \qquad (52)$$

where E is the minimum expenditure on market goods that riparians require to produce utility level U, given P and Q. Therefore, to measure the value of change in streamflow, we need to determine the amount by which E will increase to keep society on the initial utility level U. If we let W_{q_i} be the measure of the value of change in streamflow in providing service i, then the change in society welfare resulting from reduction in stream flow can be measured by the function:

$$W_{q_i} = \int_{q_i^0}^{q_i^1} [\partial E(P, q_i, U) / \partial q] dq \qquad (53)$$

Where i = 1, 2, 3 = quality and quantity of streamflow for provision of freshwater for direct human consumption, for cultural purposes and for religious purposes; and q_i^0 and q_i^1 represent streamflow for provision of service i before and after the LHWP, respectively. The IFR studies adopted the steps necessary for valuing streamflow changes of rivers downstream the LHWP outlined in Figure 6.3 to determine the ultimate quantity and quality of instreamflows that will remain after the LHWP for direct human consumption and cultural and religious uses (LHDA 2002b, c and d). To measure the extent to which riparian expenditures would increase due to deteriorated quality of the River flows, IFR studies used mitigation costs to determine the costs associated with curing the riparian illnesses likely to occur as a result of degraded quality of the rivers' water (for details refer to Section D4.3 of Appendix D and LHDA, 2002d). To measure the extent to which riparians expenditures would increase due to loss of cultural and religious services of the rivers, the IFR studies used transport cost method to determine the cost of accessing alternative sites (see Section D4.2 of Appendix D and LHDA, 2002d for details). The derived values are reported in Table 6.4 below.

TABLE 6.5: Value of lost cultural and religious services and drinking water provided by streamflows of the LHWP (millions at 2000 prices in Maloti)

Resource	Latin name/description	Impact (+/-)	Onset period (years)	Impact value (W_{q_i})
(1)	(2)	(3)	(4)	(5)
Baptism	Pool depth and number	-	2 – 10	0.06
Lesisure	Pool depth and number	-	2 – 10	0.01
Public health	Diseases associated with modified river flows	-	1 –2	0.17
Total				0.24

Source: Adapted from LHDA (2002) and Klassen (2002)

Where the 'onset period' column in Table 6.5 represents the number of years it will take for the impact to be felt.

Following the economic-ecological model developed in Chapter V, $\sum_i W_{q_i} = W_Q + R_{QC} = C_Q$ in the ESAM (Table 5.1). Therefore, M0.24 million in Table 6.4 represents $C_Q = W_Q + R_{QC}$. From the two valuation techniques (Sections 6.7.3 and 6.7.4) the total value of ecological resources and services, $C_N + C_Q = W_N + W_Q + R_N + R_{QC} + X_{QN}$ = M46.19 + M0.24 = M46.43 millions (at 2000 prices) and the total impact of the LHWP on mountain households (i.e. the mountain households living within the reaches of the affected rivers) welfare due to lost ecological services is M8.86 + M0.24 = M9.00 millions (at 2000 prices). This value is used in the next chapter to analyse the impact of modified flows of the rivers downstream the LHWP dams in Lesotho on both Lesotho and SA economies.

The M9.00 millions Maloti welfare loss due to lost ecological resources and services' resulting from the LHWP is highly insignificant compared to the project's direct economic benefits to both Lesotho and SA outlined in Chapter II. However, the loss is highly significant for households residing downstream the project dams and within the reaches of the project's rivers. It is estimated that if Phase II of the LHWP were to be implemented, the total ecological costs would amount to M20.00 millions due to more sites and households being affected downstream of the project structures (LHDA, 2000). Given that the treaty flows of Phases III and IV were also not based on the IFR of the relevant rivers, one can assume that with their implementation, these losses would more than double with more sites and households affected downstream the new structures of the project. Hence, for long-term sustainability of livelihoods of the households in the affected project areas, ecological losses have to be compensated as discussed in Chapter VIII.

6.6.5 Limitations of the estimated streamflow service values

The data used in valuing impact of changes in streamflow services suffer from the following weaknesses:

- Valuation focused exclusively on direct and indirect use values, i.e. values associated with the actual use by people of specific resources, and omitted non-use values of ecological resources, in particular lost option, bequest and existence values of ecological streamflow services (See LHDA 2002d and Klassen 2002 for details). Therefore, the values used in this study should be considered as the lower boundary of streamflow services and resources in Lesotho.
- The valuation study made a critical assumption that any reduction in availability of a resource will reduce the resource use by the same percentage. This can only be true in cases where the resource is currently scarce and therefore controlled through some rationing mechanism. This rationing already exists for most resources except for sand and fish. Sand is therefore not included in the assessment of losses while fish is included because it was found to be under threat already due to changes in the environment.
- The assessment of losses excludes resources that will increase in abundance

(e.g. reeds, thatch, leloli, sand, reservoir fish, and the Orange River Mudfish). However, these resources are currently not limiting, and thus increase in their abundance will not add much value to riparians. This is confirmed by the fairly small value of these resources (about 2 – 4% of total value of all streamflow services) (see Table 6.2). Hence this omission will only slightly overestimate the total net losses suffered. In any case, it is not appropriate to net out gains and losses for this kind of exercise, as they are of different nature and might accrue to different people (Klassen, 2002).

- There is considerable uncertainty over the ecological resource and service losses due to variation in hydrological conditions. As such the losses can vary greatly between M7.56m and M10.98m (2000 prices) (see LHDA 2002d). For the poor communities, the risk associated with the uncertain nature of these losses might pose additional problems as they are not well equipped to deal with such risks (Klasen, 2002).

PART THREE: EMPIRICAL MODEL, RESULTS AND CONCLUSIONS

CHAPTER VII - THE EMPIRICAL MULTI-COUNTRY-ESAM MODEL

7.1 Introduction

In this chapter the generic model developed in Chapter V is adjusted to fit the data available for this study. As mentioned earlier, biophysical data necessary for measuring impacts of transferring water from Lesotho to SA downstream the LHWP dams is only available for Lesotho. As a result, streamflow services' values only exist for the country of Lesotho. Also, From Chapter VI, data are available for regulating and supporting, and provisioning services of streamflows. Regulating and supporting services are measured by the value of resources supported by these services. These values only apply to resources accruing directly to households. There are no values of resources used as intermediate inputs in production. Therefore, for the empirical model, there is no need to adjust the VAD and business profits to reallocate benefits to ecological production.

In the same manner, IFR studies only calculated provisioning services of streamflows directly accruing to households. The studies did not measure the value of streamflows in cultivated agriculture or any form of economic production. Hence, necessary adjustments for the value of natural water in economic production are not made in this study. In summary, in the empirical model, the conventional multi-country SAM (MC-SAM) is adjusted with ecological resource values and services (i.e. regulating and supporting services of streamflows) directly accruing to households and values of water used by riparians for consumption and cultural purposes (provisioning and cultural services of streamflows). The Chapter is divided into three sections. The next section discusses data used in compiling the multi-country SAM for Lesotho and SA. Section 7.3 presents the macroeconomic MC-SAM and discusses how the microeconomic MC-SAM is disaggregated. Finally, the baseline microeconomic MC-ESAM for the two countries is presented in Section 7.4.

7.2 Data needs and Multi-country SAM (MC-SAM) for the study area

Compiling the MC-SAM required the following sources of data: (i) social accounting matrices of both Lesotho and South Africa, and, (ii) Macro-economic data on inter-country linkages. South African SAM for the year 2000 (Conningarth Consultants, 2000)[23] and the Lesotho SAM for the same year (Conningarth Consultants, 2002) were used to compile the MC-SAM. Supply and Use Tables (1999) from Statistics South Africa (Statssa) were used to derive proportions for some data in the South African SAM where necessary. For inter-country linkages, the RSA Reserve Bank and the Lesotho Central Banks' bulletins were used as well as other macroeconomic data published by the Bureau of Statistics in Lesotho and Statssa. Section 7.2.1 below discusses the compilation of the macroeconomic MC-SAM (MACROSAM), followed by the microeconomic MC-SAM (MICROSAM) in 7.2.2.

7.2.1 Multi-Country MACROSAM

When compiling a SAM it is important to commence with a macroeconomic SAM as it provides the main macroeconomic characteristics and magnitudes of the economies involved. The MACROSAM also sets the basic data framework for further development of the MICROSAM. It is highly aggregated and consists of control

[23] It is noteworthy to mention that the Depertment of Statistics South Africa (Statssa) recently published the 1998 RSA official SAM (25 November, 2002). However, this SAM cannot be used in this analysis because at the time the analysis commenced, the SAM was not yet published. However, both SAMs used the Statssa 1998 Supply and Use Tables and the Reserve Bank statistics as their data basis. Consequently, it is felt that there are not major differences between the two. The Conningarth's SAM has also been used before as an analytical tool for several government projects, e.g. Thukela project (Conningarth, 2000b). Additionally, the new Statsa SAM is based on the 1993 Integrated National Accounts system and the integrated accounts produced by the Reserve bank. These accounts are not yet accessible to the public. The Lesotho and Conningarth's RSA SAMs on the contrary are not based on the Integrated system of accounts. The two SAMs are therefore compatible. Because of

totals for major SAM accounts only, e.g. for each country it consists of only one activity, commodity, factor demand, value-added, factor payments, foreign trade, tax and savings characteristics, domestic demand and supply, and all domestic and international monetary transfers. As the first step of compiling the MC-ESAM, the multi-country MACROSAM was developed and it is a 22 x 22 matrix presented in Table 7.1 below. The cell descriptions of the matrix are given in Appendix.

all these reasons, it is justifiable to continue using the Conningarth's RSA SAM and not the new Stassa SAM.

TABLE 7.1: MACROSAM for Lesotho and South Africa for the year 2000 (in million Maloti)

Lesotho

LESOTHO				Current accounts							Capital account	
						Factors		Institutions			Government	All other sectors
				Activities	Commodities	Labour	Capital (GOS)	Enterprises	Households	Government		
				1	2	3	4	5	6	7	8	9
		Activities	1	-	7,817	-	-	-	-	-	-	-
		Commodities	2	5,591	-	-	-	-	4,736	1,288	489	1,990
Current accounts	Factors	Labour	3	2,180	-	-	-	-	-	867	-	-
		Capital	4	1,904	-	-	-	-	-	147	-	-
	Institutions	Enterprises	5	-	-	-	1,074	-	-	-	-	-
		Households	6	-	-	4,601	-	528	53	58	-	-
		Government	7	-81.9	1,532	-	367	184	304	82	-	-
Capital Accounts		Government	8	-	-	-	155	-	-	164	-	-
		All other sec	9	-	-	-	465	362	163	-	-	-
	RSA											
		Activities	10	-	4,508	-	-	-	-	-		
		Commodities	11	-	-	-	-	-	-	-		
Current accounts	Factors	Labour	12	-	-	163	-	-	-	3		
		Capital	13	-	-	-	195	-	-			
	Institutions	Enterprises	14	-	-	-	-	-	-	-	-	
		Households	15	-	-	-	-	-	1	-	-	
		Government	16	-	-	-	-	-	-	-	-	
Capital accounts		Government	17	-	-	-	-	-	-	-	-136	
		All other sec	18	-	-	-	-	-	-	-	-	-800
	REST of WORLD	ROW										
		Factor payme	19	-	-	29	49	-	0	4	-	-
		Goods & serv	20	-	237	-	-	-	-	-	-	-
		Capital	21	-	-	-	-	-	-	-	-34	-200
		Residual	22	-	-	-	-	-	-	-	-	-
		Total	23	9,593	14,094	4,793	2,305	1,074	5,257	2,613	319	990

Table 7.1 continued

				South Africa													
						Current accounts					Capital account		Rest of the world				
LESOTHO				Activities	Commodities	Factors		Institutions			Government	All other	Factor	Goods &	Capital	Residual	Total
						Labour	Capital (GOS	Enterprises	Households	Government		sectors	ments&transf	services			
				10	11	12	13	14	15	16	17	18	19	20	21	22	23
		Activities	1	-	944	-	-	-	-	-	-	-	-	832	-	-	9,593
		Commodities	2	-	-	-	-	-	-	-	-	-	-	-	-	0	14,094
Current accounts	Factors	Labour	3	-	-	1,746	-	-	-	-	-	-	-	-	-	-	4,793
		Capital	4	-	-	-	203	-	-	-	-	-	51	-	-	-	2,305
	Institutions	Enterprises	5	-	-	-	-	-	-	-	-	-	-	-	-	-	1,074
		Households	6	-	-	-	-	-	14	-	-	-	3	-	-	-	5,257
		Government	7	-	-	-	-	-	-	181	-	-	45	-	-	0	2,613
Capital Accounts		Government	8	-	-	-	-	-	-	-	-	-	-	-	-	-	319
		All other se	9	-	-	-	-	-	-	-	-	-	-	-	-	-	990
	RSA																-
		Activities	10	-	1,112,105	-	-	-	-	-	-	-	-	249,296	-	-	1,365,909
		Commodities	11	687,341	-	-	-	-	555,818	45,215	19,071	116,520	-	-	-	-4,187	1,419,778
Current accounts	Factors	Labour	12	308,288	-	-	-	-	-	115,425	-	-	348	-	-		424,227
		Capital	13	356,624	-	-	-	-	-	-	-	-	14,418	-	-		371,237
	Institutions	Enterprises	14	-	-	-	219,031	-	-	51,337	-	-			-		270,368
		Households	15	-	-	422,018	-	208,501	10,603	26,922	-	-	259		-	0	668,304
		Government	16	13,656	79,644	-	8,439	28,397	99,369	7,176	-	-	479		-	0	237,160
Capital accounts		Government	17	-	-	-	16,790	-	-	-15,868	-	-			136		922
		All other se	18	-	-	-	95,843	33,390	2,386	-	-	-			1,736		132,555
	REST of WORL	ROW															-
		Factor paym	19	-	-	460	35,229	80	114	6,775			-	-	-	-	42,740
		Goods & ser	20	-	226,974								-	-	-	-	227,211
		Capital	21	-							-18,149	16,035	-	-	-2,816	-	-5,164
		Residual	22	-		3	-4,298			-3			-	-	-	-	-4,298
		Total	23	1,365,909	1,419,667	424,227	371,237	270,368	668,304	237,160	922	132,555	15,603	250,128	-944	-4,187	

The MACROSAM was derived from Lesotho and RSA year 2000 SAMs. The process involved simple aggregations of accounts except in the case of economic flows between the two countries. It was difficult to get data on these flows, especially trade flows, from the South African side because of the nature of trade agreement between the two countries. Lesotho and South Africa are members of the Southern African Customs Union (SACU) together with Botswana, Swaziland and Namibia. South Africa does not treat these respective countries individually in its statistics (pers. comm. with South African Revenue Services (SARS) officials, November, 2002), rather it lumps them together as SACU countries. In the case of financial flows, RSA residents do not consume financial services in Lesotho except for RSA citizens residing in Lesotho. On the contrary, Lesotho residents always cross borders to buy financial services in South Africa. As a result, data on flows between the two countries mainly came from the Lesotho side. The Lesotho SAM provided the basis for the split between the rest of the world (ROW) and RSA. This information was used to split the ROW accounts in the RSA SAM into Lesotho and the ROW.

7.2.2 Multi-country MICROSAM

After the MACROSAM, the next step is the construction of the MICROSAM, and MACROSAM control totals help with ensuring consistency in the MICROSAM. Like the MACROSAM, the MICROSAM was derived from the SA and Lesotho year 2000 SAMs. The construction of the MICROSAM was a lot tedious compared to the MACROSAM since most of account classifications (e.g. households) were different in the Lesotho and RSA SAMs. Consequently, they had to be normalised to induce uniformity in the multi-country SAM. In some cases, the disaggregations in both SAMs were not in the format conducive for the multi-country SAM and had to be adjusted.

The most tricky and challenging aspect of the multi-country MICROSAM was deriving inter-country flows. This section describes the disaggregation of the

MICROSAM, data sources and data adjustments carried out. Because of adequate data, the MICROSAM was populated and balanced manually, although in some cases assumptions had to be made to derive appropriate data distributions.

7.2.3 Disaggregation of the MICROSAM into MC-SAM

The major objective of this analysis is to measure economic and ecological benefits/costs of the LHWP through a multi-country ESAM analysis. The rationale for using the multi-county approach is to determine if there are spill-over benefits/costs due to welfare impacts resulting from loss of ecological resources (resulting from modified stream flows below the LHWP dams in Lesotho, between Lesotho and SA) and policy implications of such spill-overs. The disaggregation of the MICROSAM was therefore motivated by this focus.

The production accounts are disaggregated into ten production sectors which include activity and corresponding commodity accounts that define major production sectors of a country according to the System of National Accounts. The SAM distinguished four production factors in each country: skilled, semi-skilled and unskilled labor and capital. Because of the significance of welfare implications of ecological resources in Lesotho, Lesotho households were disaggregated into 4 categories: (i) Mountain households high-income, (ii) Mountain households low-income, (iii) Other households high-income, and (iv) Other households low-income households. The ecological impacts of the LHWP are likely to be mostly felt by the rural mountains populations residing within the reaches of the rivers downstream the LHWP dams in Lesotho. Hence, an ideal households classification, that would better address the objectives of this study, would be the 10 categories according to geographic and income distribution found in the Lesotho year 2000 SAM (see Table 7.2 below).

TABLE 7.2: Lesotho Households Classification

Household No.	Description

1	Urban high-income
2	Urban low-income
3	Lowlands high-income
4	Lowlands low-income
5	Foothills high-income
6	Foothills low-income
7	Senqu River Valley (SRV) high-income
8	SRV low-income
9	Highlands high-income
10	Highlands low-income

These classifications were also used in the 1995 (the most recent) household budget survey for Lesotho (BOS, 1995). However, the classifications are only unique to Lesotho and for uniformity, the above four mentioned classifications, which also conform to RSA data were used in the MC-SAM.

The government, capital and rest of the world accounts were aggregated in the MC-SAM. Important areas of impact that the MC-SAM is intended for is on households welfare and general economic output of the two countries. In Lesotho it is important to know to what extent households are affected by loss of ecological resources and to what extent this impact is translated into the rest of the economy and SA economy, with specific focus on output of different economic sectors and effect on employment generated by these sectors. In SA, it is important to know, to what extent different economic sectors in SA will be affected if SA were to internalise ecological losses in Lesotho, and how this would affect the rest of SA and Lesotho economies, with emphasis on impact on economic output, employment generation and households welfare in the two countries. Table 7.3 below lists the accounts of the MC-SAM. The MC-SAM has 61 accounts, 56 endogenous and 5 exogenous. Details on the SAM compilation and the populated SAM are reported in Appendix F (see Table F8 in

Appendix F).

TABLE 7.3: MICROSAM accounts

Acc. No.	LESOTHO Description	Acc. No.	SOUTH AFRICA Desription
	ENDOGENOUS ACCOUNTS		
	A. Production		**A. Production**
1	Agriculture	32	Agriculture
2	Mining and quarrying	33	Mining and quarrying
3	Manufacturing	34	Manufacturing
4	Electricity	35	Electricity
5	Water	36	Water
6	Construction	37	Construction
7	Trade and accommodation	38	Trade and accommodation
8	Transport and communication	39	Transport and communication
9	Financial and business services	40	Financial and business services
10	Community services	41	Community services
	B. Factors		**B. Factors**
21	Skilled labor	52	Skilled labor
22	Semi-skilled labor	53	Semi-skilled labor
23	Unskilled labor	54	Unskilled labor
24	Capital (GOS)	55	Capital (GOS)
	C. Institutions		**C. Institutions**
25	Enterprises	56	Enterprises
26	Urban-High income households	57	High income households
27	Urban-Low income households	58	Low income households
28	Rural-High income households		
29	Rural-Low income households		
	EXOGENOUS ACCOUNTS		
30	**D. Government**	**59**	**D. Government**
31	**Combined capital**	**60**	**Combined capital**
		61	**The Rest of the World**

7.3 The Multi-country ESAM

As explained at the beginning of this chapter, data required to measure streamflow resources and services' values only exist for Lesotho. Therefore, to develop the

ESAM, only the Lesotho SAM in the MC-SAM was adjusted with streamflow services values. Monetary values derived for streamflow services and resources in Chapter VII indicate that ecological production contributed approximately M46.43 million to Lesotho's GDP in the year 2000. This means that the Lesotho GDP for 2000 was underestimated by this amount in the country's system of national accounts. This money directly accrued to rural mountain households living within the reaches of the rivers downstream the LHWP dams in Lesotho in terms of streamflow resources and services they directly use to sustain their livelihoods.

Therefore, the following adjustments were made to the Lesotho SAM:

(i) The SAM was extended with two external accounts, ecological production and natural water, to account for contribution of the two activities to the economy of Lesotho, which is M46.16 and M0.24 million, respectively. These values represent C_N and C_Q, respectively, from Chapter IV.

(ii) These values were distributed to appropriate institutions, i.e. rural households, under the assumption that high- and low-income rural households use 20% and 80%, respectively, of the total value of streamflow resources and services' value. This assumption is based on personal discussions with officials at the Bureau of Statistics (BOS) in Lesotho. Thus, in the case of ecological production, M9.24 and M36.95 million were allocated to high- and low-income mountain households, respectively. For natural water M0.05 and M0.19 million were allocated to high- and low-income mountain households, respectively.

(iii) High- and low-income mountain households spent the money received from ecological production and natural water on ecological resources and services and on natural water and services consumed according to proportions assumed in (ii) (i.e. M9. 24 and M36.95.01 million, respectively, for ecological resources and M0.05 and M0.19 million, respectively).

The MC-ESAM has 63 accounts comprising of 56 endogenous and 7 exogenous accounts and is reported in Appendix G. The MC-ESAM is used to perform the analysis in the next Chapter.

CHAPTER VIII - RESULTS OF THE EMPIRICAL ANALYSIS AND POLICY SIMULATIONS

8.1 Introduction

This chapter presents the LHWP impact results derived from the MC-ESAM. As outlined in Chapter II, the project commenced in 1986 and the water royalties and hydropower benefits started flowing in 1998. These benefits, and other indirect benefits associated with the project outlined in Chapter II, were already included in the Lesotho and SA SAMs for the year 2000 that were used in compiling the MC-ESAM. As such, direct and indirect economic benefits of the LHWP are already included in the MC-ESAM. Therefore, the LHWP impact results presented in this chapter only relates to ecological impact of the project. Also, the project impact analysis could not be compared between the with- and without-project scenarios because, as mentioned before, the SAMs used in this study already included some of the project effects. The next section discusses the multiplier matrix derived from the MC-ESAM. The results of the impact of the LHWP on the economies of Lesotho and SA, due to lost ecological services of the highlands rivers downstream the LHWP dams in Lesotho are presented in Section 8.3. Lastly, different policy scenarios that can be used to mitigate/compensate ecological losses resulting from the LHWP are discussed in Section 8.4.

8.2 MC-ESAM Multiplier Analysis

The MC-ESAM was used to examine intersectoral linkages within (intra-country) and between (inter-country) Lesotho and SA in terms of the multipliers generated from external shocks into each of the endogenous elements of the MC-ESAM. Detailed derivation and discussions of the intra-country (M_1) and inter-country (M_2) multiplier matrices are found in Appendices A and C. Table 8.1 presents a summary of intra-country multipliers from selected MC-ESAM accounts. In Table 8.2, a summary of inter-country multipliers is presented. The complete multiplier matrix for the MC-ESAM is given in Appendix H.

TABLE 8.1: Summary table of MC-ESAM Intra-country multipliers on selected accounts (Maloti)

INTRA-COUNTRY MULTIPLIERS										
	LESOTHO					SOUTH AFRICA				
	Total production multipliers (1)	Own-sector multipliers (direct) (2)	With other sectors (indirect) (3)	Induced employ-ment (4)	Induced house-holds income (5)	Total production multipliers (1)	Own-sector multipliers (direct) (2)	With other sectors (indirect) (3)	Induced employ-ment (4)	Induced house-holds income (5)
Agriculture	3.03	2.03	1.12	0.52	0.80	4.83	1.90	2.93	0.48	0.84
Mining and quarrying	1.46	1.14	0.35	0.13	0.19	4.44	1.23	3.21	0.60	0.92
Manufacturing	1.90	1.50	0.47	0.14	0.21	4.15	2.40	1.76	0.41	0.63
Electricity	4.14	2.29	1.95	0.48	0.81	5.07	2.05	3.02	0.57	1.00
Water	2.20	1.49	0.78	0.29	0.69	6.32	3.28	3.04	0.47	0.91
Construction	4.38	2.59	1.91	0.35	0.55	6.04	2.31	3.72	0.62	0.92
Trade and accommodation	3.50	1.83	1.79	0.51	0.79	5.44	2.41	3.03	0.65	1.03
Transport and communication	3.04	1.74	1.40	0.38	0.58	5.40	2.34	3.06	0.64	1.01
Real estate, business and financial services	2.60	1.86	0.83	0.35	0.64	5.19	2.92	2.27	0.55	0.97
Government, domestic and other community services	1.81	1.92	1.81	0.36	0.52	5.62	1.95	3.68	0.88	1.18

Starting with intra-country multipliers in Table 8.1, for each country column 1 shows total production multipliers of each production sector. Column 2 shows direct multipliers. It shows the effect of external injection on total output/income of the endogenous account involved. Using the agriculture sector as an example, direct multipliers show the impact of a unit (say M1.00) injection in the sector on its total output. In the case of Lesotho, M1.00 injection in the agricultural sector increases the sector's total output by M2.03 on average. Direct multipliers are also called 'open-loop' multipliers. Column 3 shows indirect/induced multipliers. These multipliers show transmission of income from initial endogenous account (in this case production activity) to factors, institutions and then back to initial account in the form of consumption demand (Sadoulet and de Janvry, 1995). These multipliers are often called 'closed-loop', which is the algebraic statement of the circular flow of income (Pyatt and Round, 1985). Columns 4 an 5 show employment and household incomes generated by external injections in the endogenous accounts.

In Lesotho the sector with the highest total production multiplier is construction (M4.38), followed by electricity (M4.14). This is not surprising because construction activities associated with the LHWP were still going on in the year 2000 and water transfer to SA and hydropower generation had just begun in 1998. The construction sector also has the highest own multiplier. For this sector, every M1.00 injected into the sector generates total income of M2.59 on average for the sector. Despite the fact that the sector has the highest total and own-sector production multipliers, it is not the best sector in terms of employment and household income generation. The best sector in this regard is agriculture.

In the case of SA, the water sector has the highest total production multiplier and the highest own-sector production multiplier. However, it is the government sector that has the highest potential for employment and income generation. For every R1.00 injected in this sector, R0.88 worth of employment is created and R1.18 income is generated for households. Although the results discussed above are important for understanding the economies of the countries studied here, they do not include income linkages between Lesotho and SA. Table 8.2 below shows such linkages. The multipliers presented in Table 8.2 show effects of exogenous change in one country (e.g. Lesotho) on the incomes of endogenous accounts of the other country (e.g. SA).

TABLE 8.2: Summary table of MC-ESAM Inter-country multipliers on selected accounts (Maloti)

INTER-COUNTRY MULTIPLIERS										
	LESOTHO, SA					SA, LESOTHO				
	Total production multipliers (1)	Own-sector multipliers (direct) (2)	With other sectors (indirect) (3)	Induced employ-ment (4)	Induced house-holds income (5)	Total production multipliers (6)	Own-sector multipliers (direct) (7)	With other sectors (indirect) (8)	Induced employ-ment (9)	Induced house-holds income (10)
Agriculture	0.010	0.002	0.008	0.004	0.004	2.20	0.37	1.83	0.24	0.09
Mining and quarrying	0.010	0.000	0.011	0.004	0.005	3.08	0.76	2.32	0.41	0.14
Manufacturing	0.008	0.004	0.005	0.003	0.003	2.80	1.54	1.26	0.28	0.09
Electricity	0.010	0.000	0.010	0.004	0.004	1.84	0.04	1.80	0.21	0.07
Water	0.053	0.031	0.010	0.009	0.012	0.88	1.54	0.87	0.10	0.04
Construction	0.010	0.000	0.011	0.004	0.005	2.37	0.01	2.36	0.25	0.09
Trade and accommodation	0.014	0.004	0.011	0.004	0.005	1.93	0.20	1.73	0.22	0.08
Transport and communication	0.012	0.002	0.011	0.005	0.005	2.49	0.53	1.96	0.28	0.10
Real estate, business and financial services	0.007	0.001	0.007	0.003	0.003	2.28	0.90	1.38	0.25	0.09
Government, domestic and other community services	0.010	0.001	0.010	0.004	0.004	2.48	0.28	2.20	0.30	0.09

Columns 1 and 6 of the table show total production multipliers for Lesotho production sectors generated by external production shocks in SA, and vice versa. Columns 2 and 7 show own-sector/direct multipliers for each country and consist of income effects transmitted from an endogenous account in one country to an endogenous account in another. These are also referred to as open-loop multipliers. Columns 3 and 8 show income effects transmitted from an endogenous account in one country through the corresponding account in the other country to other accounts in that country and to the originating country, due to induced effects, i.e. complete round of effects between the two countries. These are also called closed-loop or circular multipliers. Lastly, columns 4 and 9, and 5 and 10, show employment and household income, respectively, generated in one country due to external production shocks in onothe country.

The multipliers in columns (Lesotho, South Africa) are uniformly and generally low compared to those under columns (South Africa, Lesotho). As Reinert and Roland-Holst (1998) put it, this reflects the 'hub-and-spoke' nature of both economies. Exogenous expenditures in Lesotho have large impacts on SA as can be seen in the columns (South Africa, Lesotho). This reflects the dependence of the Lesotho economy on SA imports. On the contrary, SA has a more diversified import structure compared to Lesotho. Consequently, exogenous expenditures in SA have small impacts on Lesotho. From Table 8.3, the manufacturing sector in the columns (SA, Lesotho) has the highest production multiplier. This means that for every M1.00 increase in demand for manufactured products in Lesotho, total output of the manufacturing sector in SA increases by R1.54 on average. Due to effects induced by this increase, other sectors output increase by R1.26 and total growth impact induced by the manufacturing sector in SA is R2.80. Also, From the households intra- and inter-country multipliers in Table 8.3 below, Lesotho households have strong multipliers with the manufacturing sectors of Lesotho and SA. Table 8.3 presents multipliers that show linkages between Lesotho households income and that of production sectors in Lesotho and SA. The columns (Lesotho, Lesotho) show inter-linkages within Lesotho while the columns (SA, Lesotho) show linkages from Lesotho households to SA production sectors.

Considering the Mountain households, who will be directly affected by the LHWP, for every increase of M1.00 in the high-income Mountain households' income, the manufacturing sector of Lesotho grows by M1.07 and that of SA by 1.189 on average. In the case of low income households, M1.00 increase in their income leads to M0.79 increase in total output of the Lesotho Manufacturing sector and R0.91 increase in total output of the SA manufacturing sector on average.

TABLE 8.3: Direct multipliers between households and production sectors (Maloti)

	Lesotho, Lesotho				South Africa, Lesotho			
	Mountains - High income	Mountains - Low income	Other - High income	Other - Low income	Mountains - High income	Mountains - Low income	Other - High income	Other - Low income
Production								
Agriculture	0.581	0.288	0.471	0.380	0.170	0.108	0.151	0.141
Mining and quarrying	0.004	0.003	0.004	0.005	0.037	0.028	0.036	0.037
Manufacturing	1.070	0.794	1.039	1.037	1.189	0.907	1.144	1.173
Electricity	0.025	0.020	0.041	0.038	0.044	0.035	0.042	0.044
Water	0.012	0.012	0.030	0.023	0.014	0.011	0.013	0.014
Construction	0.022	0.018	0.025	0.031	0.012	0.010	0.011	0.012
Trade and accommodation	0.250	0.109	0.270	0.206	0.243	0.194	0.233	0.249
Transport and communication	0.064	0.055	0.076	0.106	0.187	0.148	0.180	0.196
Real estate, business and financial services	0.225	0.353	0.152	0.230	0.377	0.359	0.340	0.387
Government, domestic and other community services	0.114	0.241	0.221	0.549	0.109	0.101	0.115	0.152

Although the manufacturing sector has the highest own-sector multiplier in Table 8.2, the mining sector has the highest total multiplier (R3.08). For every M1.00 increase in demand for mining products in Lesotho, the SA mining sector grows by R0.76 on average. But because of strong backward and forward linkages that this sector has with the rest of production sectors in SA, total growth in other sectors is R2.32 on average (see Table 8.2). Dependence of Lesotho economy on that of SA is also seen from employment and household income generation in SA induced by external shocks in Lesotho. A M1.00 increase in demand for products from each of Lesotho production sectors yields approximately R0.25 worth of employment on average for SA labor and generates approximately R0.45 income for SA households (see columns 9 and 10 of Table 8.2).

Skilled and un-skilled SA labor benefit more than semi-skilled labor from employment generated by demand increase in Lesotho and high-income households benefit more than low-income households from the income generated (see Appendix H). On the contrary, external demand increase in SA has very insignificant impact on Lesotho labor employment and on households' income generation (see columns 4 and 5 of Table 8.2). Because of the 'Hub and spoke' nature of the two economies, ignoring ecological losses to Lesotho households resulting from the LHWP will not only hamper the economy of Lesotho, but also that of SA. The next section presents results derived from analyzing the impact of lost ecological services on the economies of Lesotho and SA.

8.3. Impact of lost ecological services on the economies of Lesotho and SA

To analyse the impact of the LHWP (on the capacity of the project rivers' to provide different ecosystem services) on the economies of SA and Lesotho, The value of the lost services was introduced in the MC-ESAM as an external reduction in Mountain households income. It should be noted that this income fall does not emanate from the general project. The project has significant direct economic benefits bound to increase incomes of both the economy of Lesotho and SA. The income loss referred to here is that resulting from lost ecological services. As such, all income effects that follow only refer to ecological losses as a result of the project and not the general project.

The results of the impact analysis are reported in Table 8.4 below. The loss of ecological services (as seen in Chapter VII) represents 0.74% and 4.66 % fall in high- and low-income Mountains households, respectively. But due to multiplier effects, the fall represents 0.81% and 4.81% fall in income for high- and low-income Mountain households, respectively (see Table 8.4).

Because of the inter- and intra-linkages that exist between Lesotho and SA (see the multipliers matrix in Appendix H), the loss of ecological services does not only affect households directly affected by the LHWP, i.e., the Mountains households, but also other households in Lesotho and SA, though the percentage loss is low. Other high-income and low-income households of Lesotho are likely to loose income of M1.89 and M0.20 million on average, respectively. In SA high- and low-income households are likely to loose income of M2.38 and M0.65 million, respectively. In addition, because of direct and induced multipliers, the loss in ecological services is also likely to affect economic production in both Lesotho and SA.

In both countries production sectors likely to suffer most are manufacturing sectors with income loss of M7.63 and M8.66 million, respectively. However, in terms of proportion to total income of respective sectors, the losses are very insignificant (0.08% and 0.0008%, respectively). The fact that the manufacturing sector is likely to be the worst hit by the impact of lost ecological values, and that the SA manufacturing sector is likely to loose most money is not surprising given the strong multipliers that Mountain households have with manufacturing sectors of the two countries, and strong forward multipliers that the SA manufacturing sector has with that of Lesotho (see Appendix H).

TABLE 8.4: Impact of lost ecological services in Lesotho due to the LHWP (2000 million Rands)

	Total income in Lesotho	Total income in SA	Change in Lesotho Income	% Change	Change in SA Income	% Change
Agriculture	2687.51	94302.5	-3.11	-0.12	-1.08	-0.0011
Mining	47.4007	115668	-0.03	-0.07	-0.27	-0.0002
Manufacturing	9397.77	1047034	-7.63	-0.08	-8.66	-0.0008
Electricity	435.636	57711.5	-0.19	-0.04	-0.33	-0.0006
Water	370.289	17621.6	-0.11	-0.03	-0.10	-0.0006
Construction	5019.6	148571	-0.17	-0.00	-0.10	-0.0001
Trade	1889.19	361783	-1.23	-0.07	-1.83	-0.0005
Transport	763.269	275261	-0.51	-0.07	-1.40	-0.0005
Business	1518.67	503838	-2.94	-0.19	-3.26	-0.0006
Community services	1557.63	163895	-1.93	-0.12	-0.92	-0.0006
FACTORS						
Skilled labor	1348.69	189838	-0.55	-0.04	-0.77	-0.0004
Semi-skilled labor	1389.2	90238.8	-0.58	-0.04	-0.37	-0.0004
Unskilled labor	2055.11	144150	-0.75	-0.04	-0.77	-0.0005
Capital	2304.98	371237	-1.71	-0.07	-2.37	-0.0006
INSTITUTIONS						
Enterprises	1073.98	270368	-0.80	-0.07	-1.40	-0.0005
Mountain households high-income	240.19	-	-1.92	-0.80	-	-
Mountain households low-income	154.44	-	-7.43	-4.81	-	-
Other households high-income	4,362.69	-	-1.89	-0.04	-	-
Other households low-income	545.94	-	-0.20	-0.04	-	-
SA high income	-	513684	-	-	-2.38	-0.0005
SA low-income	-	154620	-	-	-0.65	-0.0004
Total	**37162.18**	**4519821.40**	**-33.71**	**-0.09**	**-26.66**	**-0.0006**

Again, due to induced multipliers, Lesotho and SA factors are likely to loose employment, with SA factors loosing by higher magnitudes compared to those of Lesotho because of strong forward multipliers that SA has with Lesotho (see Appendix H). For example, the impact of lost ecological values is likely to lead to total fall in employment of M1.88 and M1.91 million for Lesotho and SA, respectively, with unskilled labor likely to be the hardest hit in both countries (see Table 8.4). In the case of capital, both counties are likely to loose M1.71 and M2.37 million for Lesotho and SA, respectively.

The total impact is likely to be -M33.79 million (at 2000 prices) for the economy of Lesotho, which is equivalent to only 0.09% of total national income. In SA the total impact is likely to be -M26.66 million, which is highly insignificant compared to SA national income (0.0006%). It is not surprising that the percentage changes are this small because of the size of the impact compared to the sizes of both Lesotho and SA economies. Notwithstanding, the important result remains that, if unaccounted for and mitigated against or compensated, ecological losses due to water transfer projects can have significant negative impacts on riparians and to some extend, the general economies of involved countries.

The total impact of instream losses in Lesotho is notably small compared to the LHWP water rent or royalties of approximately US$45 millions annually payable to the government of Lesotho by SA. This therefore shows that the LHWP is highly beneficial to the people of Lesotho and that the instream losses can simply be offset through compensation or mitigation measures to ensure sustainable livelihoods of households involved. Since SA is the ultimate beneficiary of the LHWP, it should compensate for the instream losses. The next section therefore simulates different policy scenarios to analyse how the compensation money, if paid, can be used to increase the welfare of riparians.

8.4 Policy simulations

The results in Table 8.4 clearly show that the loss of ecological services in Lesotho due to the LHWP will affect the welfare of households directly affected by the project in Lesotho, and that due to direct (open-loop) and indirect/induced (closed-loop) multiplier effects, other households in Lesotho and SA, as well as entire economies of the two countries will also be affected, though at insignificant rates. The ecological services losses assessed in this study were never included in the EIA of the LHWP. Therefore, evidently the LHWP has an un-anticipated externality amounting to M8.99 million, which is absorbed by sectors directly benefiting from water from the LHWP at a cost to households directly affected by ecological services loss in Lesotho. For the project to achieve Pareto improvement required for sustainable development, the ecological losses identified in this study need to be internalized, either through mitigation activities or direct compensation by the country and sectors absorbing the externality as profits or benefits.

The water from the LHWP is planned for ultimate use in SA for industrial and residential expansion, though it is used for hydropower generation in Lesotho before it leaves it's boarders. As a result, this study assumes that the externality of ecological services loss is absorbed by SA and thus has to be internalized by activities in SA that benefit from such water. The externality was divided among all the water-using sectors in SA. To distribute the cost between these sectors the proportions of water supplied to the sectors by SA water authorities were used. Table 8.5 below gives a list of such activities (column 1), total water supplied to them (column 2), percentage of supply to total water available (column 3), total income of each activity as calculated in the MC-ESAM (column 4) and amount required from each activity to internalize the externality (column 5). This was calculated by using percentages in column 3 to split R9 million between all the water using activities. For example, in the case of agriculture, the amount required to intenalise the externality is 76.9% of R9 million, which equals R6.92 million, representing only 0.007% of total agricultural income.

TABLE 8.5: Quantity of water supplied to different users in SA by water authorities[24] and amount required to internalize the externality from each sector

Production Use	Total water supply (million m^3)	% supply	Total income in millions of Rands (at 2000 prices)	Amount required to internalise externality (millions of Rands at 2000 prices)	as a % of total income
(1)	(2)	(3)	(4)	(5)	(6)
Agriculture	10322	76.9	94302.49	6.92	0.00734
Mining	237	1.77	115668.43	0.16	0.00014
Electricity	216	1.61	1047034.24	0.12	0.00001
Manufacturing	185	1.38	57711.45	0.14	0.00025
Construction	34	0.25	148570.96	0.02	0.00002
Trade	145	1.08	361783.45	0.10	0.00003
Transport	105	0.78	275260.68	0.07	0.00003
Business services	186	1.39	503837.79	0.12	0.00002
Government	197	1.47	163895.26	0.13	0.00008
Social Use					
High income households	1249	9.3	513684.0746	0.84	0.00016
Low income households	547	4.08	154619.9475	-0.37	-0.00024
Total	**13423**	**100**	**3436368.78**	**-9.00**	**-0.00026**

Source for water supply figures: Adapted from Crafford et al. (2001).

Three policy scenarios for internalizing the externality were considered:

(i) Money paid by SA to internalize ecological services loss is transferred to households directly affected by the project in Lesotho.

(ii) Money paid by SA to internalize ecological services loss used to finance agricultural programs in Lesotho.

(iii) 70 % of the money paid by SA to internalize ecological services loss used to finance agricultural programs and 30% transferred to affected households in Lesotho.

The first scenario analyses the impact of pure cash transfer to compensate Mountain households for lost ecological services. However, since cash transfers cannot be

[24] The water supply authorities consist of the Department of Water Affairs and Forestry/Catchment Management Areas (DWAF/CMA), irrigation boards, water boards, District Councils and Local Authorities.

administered annually and thus are not sustainable in the long-term, other scenarios that promise benefits to current and future households were considered. Scenario 2 analyses the impact of using the money paid to internalise ecological costs to support agricultural programs that can possibly mitigate against loss of resources like firewood, vegetables and fish. The third scenario analyses the impact of using some of the money to compensate affected households (cash transfer), and the rest to support agricultural programs. Table 8.6 reports the results of the three policy simulations.

It should be noted that these are mere policy scenarios used to show the results of spending compensation money, if given, in three different ways. To assess the benefit of increased expenditure on agricultural related products, the measures of gross domestic product (GDP) for the general economies of Lesotho and SA, and income that will finally accrue to households are used as proxies to measure welfare impacts of increased demand/expenditure on agricultural products and induced demand on products that have forward and backward linkages with the agricultural sector. Spending on agriculture and benefits thereof is effected through consumers' demand. It would be more appropriate to assess benefits of increased spending on agriculture through the welfare function or a comparative type of analysis such as those using returns from investment in Research and development (R&D). However, the analysis employed in this study cannot allow this type of assessment. Also, since the analysis of benefits from increased expenditure on agriculture is not the main focus of this study, it is appropriate to use GDP and household incomes as proxies for welfare measurement.

From Table 8.6 Scenario 1 is the most effective in restoring affected households welfare. Mountain high- and low-income households' income increased by exactly the same magnitude by which it initially fell and so does the income of the rest of the households in Lesotho and the Lesotho economy in general. The impact of this scenario on SA economy is highly insignificant (-0.001%), which is not surprising given the size of the economy relative to the size of the externality. It is only the agricultural sector whose income falls by a relatively bigger magnitude (-0.013%) compared to other sectors (0.001%) because the sector is highly water intensive.

In the case of Lesotho Scenarios 2 and 3 are the most effective in increasing national economic growth with both scenarios promising 0.12% and 0.10% growth on average, respectively. However, the scenarios are not strong in restoring affected households welfare. In scenario 2, affected households income increases by 0.3% and 0.16% for high- and low-income Mountain households, respectively, which is far lower that the percentage fall in the households respective income resulting from the externality (i.e. 0,74% and 4.66%, respectively). For scenario 3, the situation is better. The income increases by 0.57% and 3.25% for high- and low-income Mountain households, respectively. While the scenario is not as powerful as scenario 2 in boosting economic growth, it is slightly better than scenario 1 since it promises a 0.10% growth in economy compared to only 0.09% promised by scenario 1.

Considering employment generation, scenario 2 is the most effective in Lesotho. The scenario promises to generate total employment of M8.44 million with unskilled labor and capital getting the highest employment with M3.20 and M3.83, respectively (see Table 8.6). Notably, the impact of scenario 2 on both factors is almost the same. This is because the intensity of the two factors in agricultural production in Lesotho is almost the same. That is, a M1.00 external injection into Lesotho agriculture creates employment of M0.35 and M0.43 for unskilled and capital factors, respectively. Nonetheless, the fact that the capital factor has a higher multiplier explains why scenario 2 benefits high-income compared to low-income households (see Table 8.6).

TABLE 8.6: Effects of different policy scenarios on economies of Lesotho and SA (2000 million Rands)

	Scenario 1				Scenario 2				Scenario 3			
	Change in Lesotho income	% Change	Change in SA income	% Change	Change in Lesotho income	% Change	Change in SA income	% Change	Change in Lesotho Income	% Change	Change in SA income	% Change
Agriculture	3.10	0.12	-12.15	-0.013	18.26	0.68	-10.13	-0.011	8.16	0.30	-11.60	-0.012
Mining	0.03	0.07	-0.26	0.000	0.03	0.06	-0.32	0.000	0.03	0.06	-0.31	0.000
Manufacturing	7.61	0.08	-0.68	0.000	5.86	0.06	-2.67	0.000	7.03	0.07	-2.38	0.000
Electricity	0.19	0.04	-0.68	-0.001	0.26	0.06	-0.70	-0.001	0.21	0.05	-0.72	-0.001
Water	0.11	0.03	-0.20	-0.001	0.15	0.04	-0.20	-0.001	0.12	0.03	-0.21	-0.001
Construction	0.17	0.00	-0.20	0.000	0.24	0.00	-0.21	0.000	0.19	0.00	-0.21	0.000
Trade	1.22	0.06	-2.46	-0.001	1.07	0.06	-2.57	-0.001	1.17	0.06	-2.70	-0.001
Transport	0.51	0.07	-1.95	-0.001	0.36	0.05	-2.05	-0.001	0.46	0.06	-2.16	-0.001
Business	2.94	0.19	-2.62	-0.001	0.89	0.06	-3.15	-0.001	2.26	0.15	-2.87	-0.001
Community services	1.93	0.12	-0.63	0.000	1.13	0.07	-0.93	-0.001	1.66	0.11	-0.91	-0.001
FACTORS												
Skilled labor	0.54	0.04	-0.62	0.000	0.33	0.02	-0.76	0.000	0.47	0.04	-0.76	0.000
Semi-skilled labor	0.57	0.04	-0.33	0.000	1.08	0.08	-0.36	0.000	0.74	0.05	-0.38	0.000
Unskilled labor	0.73	0.04	-1.20	-0.001	3.20	0.16	-1.12	-0.001	1.56	0.08	-1.26	-0.001
Capital	1.70	0.07	-3.90	-0.001	3.83	0.17	-3.63	-0.001	2.41	0.10	-4.02	-0.001
INSTITUTIONS												
Enterprises	0.79	0.07	-2.30	-0.001	1.78	0.17	-2.14	-0.001	1.12	0.10	-2.37	-0.001
Mountain households high-in	1.92	0.80	-	-	0.30	0.13	-	-	1.38	0.57	-	-
Mountain households low-inc	7.44	4.82	-	-	0.16	0.10	-	-	5.01	3.25	-	-
Other households high-incom	1.87	0.04	-	-	4.15	0.10	-	-	2.63	0.06	-	-
Other households low-income	0.20	0.04	-	-	0.75	0.14	-	-	0.38	0.07	-	-
SA high income	-	-	-3.87	-0.001	-	-	-3.88	-0.001	-	-	-4.12	-0.001
SA low-income	-	-	-1.33	-0.001	-	-	-1.29	-0.001	-	-	-1.38	-0.001
Total	**33.56**	**0.09**	**-35.39**	**-0.001**	**43.84**	**0.12**	**-36.09**	**-0.001**	**37.00**	**0.10**	**-38.37**	**-0.001**

In the case of SA, the best scenario is 1. The general economy of SA contracts by M35.29 million compared to M36.09 and M38.37 millions promised by scenarios 2 and 3, respectively. In all the scenarios, the agricultural sector is likely to suffer most, with the three scenarios promising loss of income for the sector of M12.15, M10.13 and M11.60 millions by scenarios 1, 2 and 3, respectively. Expectantly, scenario 3 is still the worst in terms of SA households income generation. Compared to the other scenarios, scenario 3 promises total households income loss of M5.50 millions compared to M5.10 and M5.17 millions promised by scenarios 1 and 2, respectively. High-income households are likely to suffer most (see Table 8.6). This results from the fact that they are the owners of capital, which is likely to loose most in all the scenarios.

CHAPTER IX - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

9.1 Summary

This study developed a general methodology that can be applied to integrating environmental sustainability aspects into economic development planning in the case of exploiting water resources through inter-basin transfers. Using the LHWP between Lesotho and SA, the study used the multi-country ecological social accounting matrix (MC-ESAM) for Lesotho and SA to integrate ecological implications of the LHWP in the economic benefits of the project. The study further used the developed MC-ESAM multiplier analysis to analyse the impact of lost ecological servies downstream the LHWP dams in Lesotho on the general economies of both Lesotho and SA. The results revealed that:

- The LHWP has significant direct and indirect economic benefits for countries involved in the project. For Lesotho the benefits consist of water royalties, hydropower and other benefits related to projects' construction. For SA the benefits comprise increased water supply for industrial and residential expasion in the Vaal region.
- Downstream the LHWP dams in Lesotho reside 150 000 riparians who reside within the reaches of the project rivers downstream the LHWP dams.
- Along and within the project rivers downstream the LHWP dams are a host of ecological (streamflow) resources and services supported by flows of these rivers, valued at M46.43 millions (see Tables 6.3 and 6.5).
- Riparians use the ecological resources and services to sustain their lives
- Due to the LHWP, the flows of project rivers downstream the LHWP dams will reduce with detrimental effects to streamflow resources and services, and resultant deleterious implications for livelihoods of riparians depending on the resources and services for wellbeing sustenance. Riparians welfare loss is

estimated to be M9 millions annually (see Table 6.4). This loss was not anticipated, and therefore not included in the EIA of the LHWP.

- While the loss of ecological resources and services is small, it is significant to populations residing downstream the LHWP dams and within the reaches of the project dams.
- The ecological resources and services' loss is very small compared to the LHWP's direct economic benefits and the water rents/royanties and thus can be easily compensated to restore the welfare of populations directly affected.

Because the SAM uses the SNA as database and that the SNA only includes values of resources/products and services traded in markets, ecological resources and services values, like the ones identified in the case study area, were not included in the Lesotho SAM used in this study. This means that the Lesotho GDP was underestimated by M46.43 millions in 2000. The MC-ESAM multiplier analysis indicated that not only mountain households, directly disturbed by the project, will be affected by loosing ecological services, but also the rest of households and the general economy of Lesotho due to direct, and indirect/induced multiplier affects. Because of strong economic links that exist between Lesotho and SA, i.e. Lesotho strongly depends on SA for imports, even SA households and general economy are likely to be affected by lost ecological resources and services in the mountain areas of Lesotho due to the project, though the impact is small in percentage terms because of the size of the impact compared to the size of SA economy.

Clearly, the LHWP has an externality in terms of the value of instream/ecological impacts of the LHWP. Since these impacts were never included in the EIA of the project, it means that SA, which is the ultimate beneficiary of the LHWP water, absorbs the externality as profits. Three policy simulation scenarios were analysed to determine the impact of internalizing the externality by SA on the welfare of households directly affected by the project in Lesotho, the rest of the households in

Lesotho and SA, and the general economies of both countries. Analysed policy scenarions were as follows:

(i) Money paid by SA to internalize ecological services loss is transferred to households directly affected by the project in Lesotho.

(ii) Money paid by SA to internalize ecological services loss used to finance agricultural programs in Lesotho.

(iii) 70 % of the money paid by SA to internalize ecological services loss used to finance agricultural programs and 30% transferred to affected households in Lesotho.

The first scenario (cash grants) was found to be the most effective in improving affected households welfare in Lesotho, but not sustainable and relatively ineffective in improving general economic growth. However, the second scenario was found to be the most effective in the general growth of Lesotho economy and employment of unskilled labor because of strong backward and forward linkages that agriculture has with other sectors within the Lesotho economy. In the case of SA, the least costly scenario was found to be scenario 1.

The ecological resources and services' loss of the LHWP derived in this study is significantly small compared to the project's direct economic benefits to both Lesotho and SA as outlined in Chapter II. Since SA is the ultimate beneficiary of the LHWP water, and thus absorbs the externality of lost ecological resources and services, it should compensate directly affected populations in Lesotho for welfare losses associated with the project in addition to the water royalties that it is already paying to Lesotho. The above policy scenarios are possible options that can be used to guide the administration of the compensation..

9.2 Conclusion

This study has clearly demonstrated that inter-basin water transfer projects undoubtedly have significant direct economic impacts necessary for socio-economic development of economies involved in the project, they can seriously affect the capacity of water ecosystems to provide services and thus negatively impact on households' welfare, and that ignoring these effects can result in un-intended unsustainable development in the long-run. Leaving out instream/ecological effects of IBWT results in source sectors enjoying higher profits by not paying for the externality they cause. The value of lost instream benefits should be allocated to affected households. Because of interlikages that exist between different sectors in an economy and between economies, instream/ecological impacts of IBWT are likely to affect, not only those households directly linked to such projects, but also the entire economies of countries involved. In conclusion therefore, it is important to assess and measure instream/ecological impacts of IBWT, integrate the measured impacts into economic systems involved and analyse total impacts through an economy-wide framework to get a holistic measure of the impacts of intended inter-basin water transfer projects before implementing such projects.

While the impacts were relatively small for SA, they fall large on certain social groups of Lesotho people. It should be noted that the impact results have major limitations in that they did not include many important ecological values as indicated in Chapter VI and hence estimates are on the low side. Notwithstanding, the impact results have demonstrated that the LHWP is good for the country of Lesotho because of its direct benefits and water rents are highly significant compared to the instream losses of the project. These losses can thus be simply circumvented by mitigation measures or compensation for the affected households to ensure sustainable livelihoods. The results of this study have useful implications for future phases of the LHWP. If Lesotho and SA were to consider further phases of the project, it would be crucial to identify and quantify instream flows in an integral way before such phases are implemented to ensure sustainable development.

9.3 Policy implications

Important messages for policy decisions arise from the results of this study. While it is not debatable that IBWT are imperative for social and economic development, the results demonstrate that it is critical to consider and assess ecological consequences of IBWT before such transfers are implemented to ensure sustainable development of populations directly affected by the transfers. The affected parties in this case must be identified and compensated accordingly by sectors or countries absorbing the rent associated with ecological uses of water to ensure Pareto optimality.

The results of this study have also demonstrated the significance of assessing IBWT through an economy-wide framework. Because of interlinkages that exist between sectors within economies and between countries as demonstrated by the results of this study, implications of IBWT are felt by the general economies of the countries involved and the magnitude of impact in each country depends on the size of economies involved, degree of dependency in trade and factor employment, among others. It is therefore important that implications of IBWT are assessed through economy-wide models to help policy makers analyse distributional implications of such transfers even before they can be implemented. This would enable them make more informed and sustainable policy decisions.

A model that integrates ecology and multiple economic systems used in this study has clearly demonstrated the significance of analyzing IBWT impacts using an integrated approach. Although the empirical analysis and simulation results yielded small magnitudes in general, these magnitudes were significant for groups of people directly affected by the project in Lesotho. The results clearly showed that ecological implications of water transfers can have far reaching effects, depending on the magnitude of the transfers relative to the general economies of the countries involved. If this type of integrated approach is not followed in assessing impacts of IBWT, populations directly affected by the project may face unintended unsustainable livelihoods in the long-term.

In conclusion therefore, it is imperative that before IBWT transfers are implemented, feasibility studies of such transfers carefully identify and measure instream/ecological implications of such projects before they can be implemented, and these should be integrated into economic implications of IBWT to ensure informed policy decisions that can lead to sustainable development. This integrated approach to impact analysis of IBWT is critically important at this point because the other phases of the LHWP are yet to be negotiated and the results of this study should help the project managers make informed decisions concerning further phases of the scheme.

9.4 Study limitations

While this study has produced insightful results and made important contribution to methodologies that can be used to assess impacts of IBWT, it has some limitations. To effectively measure the impact of the LHWP on the two countries involved using an economy-wide framework, it is important to assess the impact first on distinct project areas, and then on the general economies of countries involved. Based on the SAM analysis employed in this study, this requires five SAMs:

(i) The SAM for the project area in Lesotho (i.e. Katse and Mohale areas in the mountains region).

(ii) The SAM for the project area in SA (i.e. the Vaal region)

(iii) The general SAM for Lesotho

(iv) The general SAM for SA

(v) The multi-country SAM for the two countries, that integrates and clearly show the regional SAMs for the project areas and interlinkages that exist between project areas and general economies of own countries, between project areas themselves, projects areas and the rest of the world and between the two general economies and between the two general economies and the rest of the world.

This approach is data intensive, which rarely exist, especially in developing countries. Therefore, this study did not use regional SAMs of project areas. Instead the analysis was performed on the general SAMs of the two countries.

To effectively apply the ESAM developed in Chapter V, it is important that environmental values/rents be measured and allocated to the source sectors e.g. Y_N, C_N, Y_Q, C_Q, W_Q, W_{NE}, R_N, X_{QN}, R_{QC} and R_{QE} in Table 5.1. However, because of data limitations, only aggregate values, i.e. Y_N, C_N, Y_Q and C_Q were estimated. In addition, this study only considered use values of streamflows and ignored non-use values of streamflows. Also, because of data limitations, ecological aspects of the LHWP related to SA were not included. Hence, this study was not adequate in integrating environmental values in the empirical MC-ESAM.

This analysis would have yielded more meaningful results if the analysis compared the scenario before the LHWP to that with the project. However, because this study used social accounting matrices for the year 2000, when the LHWP was already operational, for both Lesotho and SA, this could not be done. Consequently, this study could not isolate the total project impact.

IBWT schemes are often built over a number of years and their impacts, both economic and environmental, happen over time. As a result, a static model, used in this analysis, cannot tell the full story. Also, the SAM methodology used in this study makes restrictive production/technology and price assumptions. The CGE model on the other hand is more powerful than the SAM as it relaxes some of the restrictive assumptions made by the SAM. For this analysis, a better model would have been a dynamic CGE model that allows for temporal effects of IBWT and relaxes the SAM restrictive assumptions.

The accounting multipliers adopted in this study are derived from average expenditure propensities. Thus the multipliers assume unitary expenditure elasticities and that average and marginal expenditure propensities are equal. The inherent assumption is that computed average expenditure propensities are constant over any incremental exogenous injection. While this assumption may be easily rationalized for all other elements of expenditures like in the case of labor payments where the economy is operating below capacity in all sectors and labor incomes are proportional to employment levels, it is certainly unrealistic for the expenditure pattern of households. The study would have greatly benefited from data on household marginal expenditure propensities. In addition, the SAM is based on rigid assumptions of fixed coefficient production technologies, excess resources and thus fixed prices, and lack of input and output substitution.

9.5 Recommendations for further research

In view of the above limitations, the following are recommended for further research:

- The study be repeated using the multi-regional SAM to be able to gauge the LHWP impacts on both regions directly affected by the project and the general economies of the countries involved. This is crucial as the level of impact differs between areas directly disturbed and the general economy. Also, it is recommended that the analysis be repeated with the pre- and post-project SAMs to be able to isolate total project impact.
- More data that can enable isolation of ecological services and resources rents studied here be collected and the values be estimated.
- Data on non-use values of streamflow services and resources not included in this study be collected and the left out values be included to ensure adequate treatment of environmental values associated with the LHWP.
- Streamflow services and resources value impacts of the LHWP in SA be measured and included in this type of analysis.

- To avoid weaknesses of the static model used in this study, the same study be extended to a dynamic CGE analysis.

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APPENDICES

APPENDIX A - SAM MULTIPLIER ANALYSES

A1 Single country multiplier analysis

Table A.1 presents a simplified general SAM framework. The simplified SAM presents the five groups of endogenous accounts represented by the general SAM in Table 4.1 (in Chapter IV), the consolidated account for the 3 groups of exogenous accounts, and the corresponding leakages.

TABLE A.1: Simplified schematic SAM

		EXPENDITURES						
		Endogenous Accounts					**Sum of Exogenous Accounts**	
RECEIPTS		Activities	Commodities	Factors	Enterprises	Households		Total
Endogenous accounts		1	2	3	4	5	6	
Activities	1		T_{12}				F_1	Y_1
Comm.	2	T_{21}				T_{25}	F_2	Y_2
Factors	3	T_{31}					F_3	Y_3
Enterprises	4			T_{43}			F_4	Y_4
Households	5			T_{53}	T_{34}		F_5	Y_5
Sum of Exogenous accounts	6	L_i	L_2	L_3	L_4	L_5	R	
Total		Y_1	Y_2	Y_3	Y_4	Y_5		

Source: Adapted from Thorbecke (2000) and Shiferaw and Holden (2000).

In Table A.1 the T_{ij} represents endogenous accounts. The exogenous injections from government expenditures, investment and exports, respectively are represented by vectors F_i and the corresponding leakages from taxation, imports and savings are represented by vectors L_i in the row of consolidated exogenous accounts. Through income and expenditure linkages within the SAM, changes in exogenous accounts given in the F vectors will determine the level of income of endogenous accounts (Y_i for i endogenous accounts). R represents the consolidated payment between exogenous accounts.

For analytical purposes, the endogenous part of the SAM accounts is converted into the corresponding matrix of average expenditure propensities or coefficients. This is obtained by dividing each element in a given column of endogenous accounts by the sum total of that column. Thus

$$A_n = T_{ij} Y_n^{-1}$$

From Table A.1, this will result in the SAM coefficient matrix of endogenous accounts given by:

$$A_n = \begin{bmatrix} 0 & A_{12} & 0 & 0 & 0 \\ A_{21} & 0 & 0 & 0 & A_{25} \\ A_{31} & 0 & 0 & 0 & 0 \\ 0 & 0 & A_{43} & 0 & 0 \\ 0 & 0 & A_{53} & A_{54} & 0 \end{bmatrix} \quad \text{(A1)}$$

For endogenous accounts, the total income Y_n can therefore be computed as

$$Y_n = A_n Y_n + F \quad \text{(A2)}$$

which implies that row totals of endogenous accounts can be obtained by multiplying the average expenditure propensities for each row by the corresponding column sum and adding exogenous income F. Equation (A2) can be rewritten as

$$Y_n = (I - A_n)^{-1} F = M_a F \quad \text{(A3)}$$

and the corresponding leakages can be derived as

$L_i = A_l Y_n$, and thus

$$\mathrm{L_i} = \mathrm{A_l}(\mathrm{I} - \mathrm{A_n})^{-1}\mathrm{F} = \mathrm{A_l}\mathrm{M_a}\mathrm{F} \qquad \text{(A4)}$$

provided that $(I - A_n)^{-1}$ exists, where A_l is the vector of aggregate average propensities to leak obtained by dividing the elements of $\mathrm{L_i}$ by the column totals Y_n (Pyatt and Round, 1979; Shiferaw and Holden, 2000).

This inverse $(I - A_n)^{-1}$ is the accounting multiplier matrix M_a which relates endogenous incomes Y_n to injections, F. Thus, endogenous incomes Y_n can be derived by pre-multiplying injection F by a multiplier matrix. Changes in endogenous incomes (dY_n) resulting from changes in injections (dF) can be expressed as

$$dY_n = (I - A)^{-1} dF = M_a dF \qquad \text{(A5)}$$

To determine the overall impact of exogenous changes on the leakages in terms of induced demand for imports, increased government revenue and general savings, we use the equation

$$dL = A_l M_a dF \qquad \text{(A6)}$$

The accounting multiplier matrix M_a has a limitation. It implies unitary expenditure elasticities, i.e. the average expenditure propensities A_n are assumed to equal marginal expenditure propensities. While this assumption may be easily rationalised for all other elements of A_n, e.g. (e.g. labour payments where the economy is working below capacity in all sectors and labour incomes are proportional to employment levels), it is certainly unrealistic for the expenditure pattern of households. A better alternative is the fixed-price SAM-based models (Thorbecke, 2000; Shiferaw et al., 2000; Defourny and Thorbecke, 1984, Pyatt and Round 1979). Fixed-price models are based on the assumption that activity levels may vary while prices are fixed. This assumption is justified in the presence of excess capacity and unused resources in production sectors. The multiplier matrix is derived from marginal expenditure propensities, which we shall call C_n[25]. The propensities correspond to observed income and expenditure elasticities of different agents under the assumption that prices remain fixed. Based on fixed price multipliers, equation (A3) becomes

$$Y_n = (I - C_n)^{-1} F = M_c F \tag{A7}$$

and changes in incomes (dY_n) resulting from changes in injections (dF) can be expressed as

$$dY_n = C_n dY_n + dF = (I - C_n)^{-1} dF = M_c dF \tag{A8}$$

The advantage of the fixed-price multiplier matrix is that it allows any non-negative income and expenditure elasticities to be reflected in M_c (Thorbecke, 2000).

The accounting and fixed-price multiplier models comprise traditional SAM models that emphasize quantity and income effects of injections. They are based on neoclassical assumption of excess capacity and unused resources in production activities, implying that prices are not responsive to activity level. This implies that a classical dichotomy between prices and quantities holds true and prices can be computed independently of activity levels. Nevertheless, SAM-based models can also be used to examine price formation. In this case SAM approach is used to analyze price formation and cost transmission mechanisms in economies with institutional rigidities (Roland-Host and Sancho, 1995; Panethimitakis et al., 2000).

[25] If unitary income elasticity is assumed, average and marginal expenditure propensities are equal.

Price-based models depart from the neoclassical assumptions of excess capacity and consider cases where there are institutional rigidities, with effects on price formation and cost transmission mechanisms. Price-based models are therefore suitable for cases where prices are implicitly indexed to commodity prices or cost-of-living effects (Roland-Host et al., 1995). Notwithstanding, the two approaches work in a similar manner. In the fixed-price model, prices are independent of activity level changes and are constant. In price-based models, activity levels are independent of price changes and are constant. For illustration let p_n be price index for endogenous accounts and substitute it for y_n in equation (A7) above. Then,

$$p_n = (I - A_n)^{-1} v = M_a v \qquad \text{(A9)}$$

where v is a row vector of sums of exogenous costs. Therefore, price changes resulting from changes in exogenous costs can be expressed as

$$dp_n = A_n dp_n + dv = (I - A_n)^{-1} dv = M_a dv \qquad \text{(A10)}$$

Fixed-price and price-based models work the same way except the former assumes excess capacity while the latter assumes institutional rigidities. Since the emphasis of this analysis is on income distributional impacts emanating from quantity/expenditures effects, accounting multipliers are employed and the guiding assumption of excess production capacity is adopted.

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A2 Multi-country SAM multiplier analysis

The SAM analytical framework developed in Appendix A1 is also applicable here. However, the multiplier decomposition differs a little in this case because of the multi-country case. This Appendix expands the framework developed in Appendix A1 to briefly explain how the multiplier analysis works in the case of three countries.

For analytical purposes the accounts in Table 4.2 are grouped into endogenous and exogenous accounts in the simplified multi-country SAM in Table B.1 below. Endogenous accounts comprise commodities, activities, factors, households and enterprises accounts for both countries. Exogenous accounts consist of government, capital and the ROW accounts for both countries. In Table B.1

i) T_{ii} represents endogenous accounts within Lesotho or SA

ii) T_{ij} are the endogenous accounts between Lesotho and SA

iii) F_i refer to injections from exogenous into endogenous accounts of Lesotho or SA,

iv) L_i refer to leakages from endogenous into exogenous accounts of Lesotho or SA,

v) R are transactions between exogenous accounts of both Lesotho and SA, and

vi) Y_i is total income in Lesotho or SA (where i,j = Lesotho or SA).

From Table B.1 we derive the matrix of average expenditure propensities from the endogenous part of the matrix as follows:

$$A_{ij} = T_{ij} Y_j^{-1} \qquad \text{(A11)}$$

TABLE B1: Simplified multi-country SAM schematic

Payments	Receipts	Endogenous Accounts		Exogenous Accounts	Total
Endogenous Accounts		Lesotho	South Africa		
	Lesotho South Africa	T_{11} T_{21}	T_{12} T_{22}	F_1 F_2	Y_1 Y_2
Exogenous Accounts		L_1	L_2	R	
Total		Y_1	Y_2		

For endogenous accounts, the total income Y_i in each country can therefore be computed as

$$Y_1 = A_{11}Y_1 + A_{12}Y_2 + F_1 \qquad \text{(A12)}$$

$$Y_2 = A_{21}Y_1 + A_{22}Y_2 + F_2 \qquad \text{(A13)}$$

Following Round (1985) and Reint and Roland-Holst (1998 and 2001), equations (A12) and (A13) may be written as

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} + \begin{bmatrix} F_1 \\ F_2 \end{bmatrix} \qquad \text{(A14)}$$

which is solved as

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} (I - A_{11})^{-1} & 0 \\ 0 & (I - A_{22})^{-1} \end{bmatrix} \left\{ \begin{bmatrix} 0 & A_{12} \\ A_{21} & 0 \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} + \begin{bmatrix} F_1 \\ F_2 \end{bmatrix} \right\} \qquad \text{(A15)}$$

Equation (A15) then becomes

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} 0 & D_{12} \\ D_{21} & 0 \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} + \begin{bmatrix} (I - A_{11})^{-1} & 0 \\ 0 & (I - A_{22})^{-1} \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \end{bmatrix} \tag{A16}$$

Where $D_{12} = (I - A_{11})^{-1} A_{12}$ and $D_{21} = (I - A_{22})^{-1} A_{21}$

Therefore,

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} I & -D_{12} \\ -D_{21} & I \end{bmatrix}^{-1} \begin{bmatrix} (I - A_{11})^{-1} & 0 \\ 0 & (I - A_{22})^{-1} \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \end{bmatrix} \tag{A17}$$

or $\quad Y = M_2 M_1 F \qquad$ (A18)

Where Y and F are stacked vectors of endogenous account incomes and exogenous expenditures, respectively, and M_1 and M_2 are multiplier matrices. M_1 is the intra-country multiplier matrix. It shows the multiplier effects that result from linkages wholly within each country taken separately. M_2 is the inter-country matrix. It captures all of the repercussions between the accounts of one country and those of the other, but excludes all of the within country effects.

Changes in endogenous incomes (dY) (e.g. production activity and factor incomes, and resultant incomes accruing to different socio-economic groups in each country) resulting from changes in injections (dF), (e.g. change in water exports from Lesotho to South Africa), can therefore be expressed as

$$dY = M_2 M_1 dF \tag{A19}$$

Analyzing the impact of the LHWP using single country SAM analysis would only depend on M_1, and would thus underestimate the impact of the scheme as it would ignore the inter-linkages and trade flows between Lesotho and SA. It would also ignore important issues of welfare distribution between different socio-economic household groups in the two countries.

APPENDIX B – GLOSSARY OF ESAM NOTATIONS

Notation	Explanation
1. Ecological production (N) block	
Y_N	Gross value of ecological production
X_{QN}	Value of streamflow input in ecological production
R_N and, R_{CN} and R_{EN}	Total ecological goods and services rent, rent dissipating directly to households and business sector, respectively
W_N	The value of labor used in harvesting ecological resources
C_N	The value of ecological resourcess and services directly harvested by households for consumption
X_{NE}	The value of ecological resources and services directly used as intermediate inputs in economic production
2. Stream flow (Q) block	
Y_Q	Total value of natural water available for direct consumption by households
R_Q and, R_{QC} and R_{QE}	Total streamflow rent absorbed from provisioning services of streamflow and streamflow rent dissipating to households and business sector, respectively.
W_Q	Value of labor used in collecting streamflow water
C_Q	Gross value of streamflow output for direct human consumption
3. Economic(E) block	
X_{QE}	Total value of streamflow used in economic production
X_{QEW}	Value of streamflow used by water supply activity
X_{QEE}	Value of streamflow used by other economic acativities
EW_W	Payments by water supply activity to economic production factors
EW_E	Payments by other economic activities to economic production factors
C	Value of economic goods and services consumed by households
G	Value of economic goods and services consumed by government
I	Value of economic goods and services consumed for investment purposes

APPENDIX C – MULTI-COUNTRY ESAM MULTIPLIER ANALYSIS

To accommodate changes brought about integration of ecological/streamflow values in the analytical framework developed in Chapter IV, both endogenous and exogenous matrices of the conventional SAM have changed as follows (see Chapter IV and Appendix A for details on derivation of the equations that follow in the case of a conventional SAM):

(i) Ecologically adjusted matrix of endogenous accounts

$$EA_n = E(T_{ij}Y_n^{-1}) \qquad \text{(C1)}$$

Where EA_n = ecologically adjusted marginal expenditure propensities

ET_{ij} = ecologically adjusted endogenous incomes, and

EY_n^{-1} = ecologically adjusted total endogenous incomes

(ii) While the exogenous accounts matrix was represented by (F) in Appendix A1, the ecologically adjusted matrix of exogenous accounts is now represented by (EF).

Therefore, for the endogenous accounts, the total ecologically adjusted income EY_i can be computed as

$$EY_n = E(A_nY_n) + EF \qquad \text{(C2)}$$

Thus,

$$EY_n = (I - EA_n)^{-1}EF = EM_aF \qquad \text{(C3)}$$

In the multi-country case, equation (A11)

$$EA_{ij} = E(T_{ij}Y_j^{-1}) \qquad \text{(C4)}$$

Where i,j = Lesotho or SA, and the endogenous incomes in each country are calculated as

$$\begin{bmatrix} EY_1 \\ EY_2 \end{bmatrix} = \begin{bmatrix} (I-EA_{11})^{-1} & 0 \\ 0 & (I-EA_{22})^{-1} \end{bmatrix} \left\{ \begin{bmatrix} 0 & EA_{12} \\ EA_{21} & 0 \end{bmatrix} + \begin{bmatrix} EF_1 \\ EF_2 \end{bmatrix} \right\} \qquad \text{(C5)}$$

Thus,

$$\begin{bmatrix} EY_1 \\ EY_2 \end{bmatrix} = \begin{bmatrix} 0 & ED_{12} \\ ED_{21} & 0 \end{bmatrix} \begin{bmatrix} EY_1 \\ EY_2 \end{bmatrix} + \begin{bmatrix} (I-EA_{11})^{-1} & 0 \\ 0 & (I-EA_{22})^{-1} \end{bmatrix} \begin{bmatrix} EF_1 \\ EF_2 \end{bmatrix} \qquad \text{(C6)}$$

Where $ED_{12} = (I-EA_{11})^{-1}EA_{12}$ and $ED_{21} = (I-EA_{22})^{-1}EA_{21}$

Therefore,

$$\begin{bmatrix} EY_1 \\ EY_2 \end{bmatrix} = \begin{bmatrix} I & -ED_{12} \\ -ED_{21} & I \end{bmatrix}^{-1} \begin{bmatrix} (I-EA_{11})^{-1} & 0 \\ 0 & (I-EA_{22})^{-1} \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \end{bmatrix} \qquad \text{(C7)}$$

or $$EY = EM_2M_1F \qquad \text{(C8)}$$

Change in the endogenous income (dY) resulting from changes in exogenous injections (dF) can therefore be expressed as

$$dEY = EM_2M_1dF \qquad \text{(C9)}$$

Where (E) in all the equations denotes ecologically adjusted values.

APPENDIX D – LHWP STREAMFLOW VALUATION ANALYSIS

D1 Data used in evaluating streamflow services of the Lesotho Highlands Rivers

The data used to measure impacts of modification of streamflows downstream the LHWP dams came from the instream flow requirements (IFR) studies: biophysical, socio-economic and economic consequensces (LHDA 2002a, 2002b and 2002c). These studies were backed by 22 relevant technical/specialist assessments (see LHDA 2002 (b) for details). The three studies, including the hydrological study, were synthesised into one, final report: Summary of main findings for Phase 1 development (LHDA 2002a).

The main objective of the IFR studies was to identify and value the biophysical, social, and economic consequences of modifying the river flows downstream the LHWP dams in Lesotho through the Phase 1 of the project, and provide guidance on suitable mitigation and compensation measures for possible losses to be incurred by downstream riparians.

Therefore, the IFR study was designed to determine possible changes to downstream ecosystems as a result of modified streamflows, and consequences for wellbeing of downstream communities. The study assessed four possible streamflow scenarios:

(i) Minimum degradation, representing flow releases that would result in the minimum degradation of riverine ecosystems,

(ii) Treaty, where flow releases are based on the treaty requirements, i.e. 0.5 and 0.3 m^3s^{-1} for Katse and Mohale dams, respectively and a constant release of 0.6 m^3s^{-1} through Matsoku weir,

(iii) Design limitation, where flow releases would be restricted by capacities of the outlet devices in the LHWP structures, and

(iv) The fourth scenario which was designed as a mid-point between the design limitation and treaty scenarios, with the the volumes of water allocated for river maintenance between those allocated in the other scenarios (for details on the four scenarios readers are referred to IFR study reports.

This study focuses on the Treaty Scenario, which is the current scenario guiding flow of releases downstream the LHWP structures (i.e. dams and weirs).

D2 Study area

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The study area was confined to rivers within Lesotho. It included the Malibamatso River downstream of Katse Dam, the Matsoku River downstream of the Matsoku Weir, the Senqunyane River downstream of Mohale Dam, and the mid- and lower-reaches of the Senqu River downstream of the confluence with the Malibamatso River. Study rivers were divided into eight IFR reaches[26] (Figure 2.5) based on hydrological and geomorphological criteria. Reaches extend from the LHWP structure (dam/weir) to a major confluence, or between mafor confluences, or from a major confluence to the national border. Specific sites[27] were selected for data collection within these eight reaches. These sites were delineated according to the needs of the social and biophysical aspects of the study. The following Sites and Reaches were included in the study:

IFR 1 IFR Reach 1 - comprises the Matsoku River from the site of the Matsoku Weir to the confluence with the Malibamats'o River; length is ~30 km; IFR Site 1 is near the village of Seshote (29^{0}15'21"S, 28^{0}33'51"E);

IFR 2 IFR Reach 2 - is the Malibamats'o River from Katse Bridge to the confluence with the Matsoku River; length is ~17.5 km; IFR Site 2 is a short distance below Katse Bridge (29°21'08"S, 28°31'32"E);

[26] lengths of river represented by each IFR site. Reaches are defined by the locations of major confluences, geomorphology and degrees of habitat integrity (LHDA 2002 (b)).
[27] IFR sites are defined as ~1 km long sections of rivers that are representative of the river reach on which they are situated. They extend to the 1:100 year flood line on either side of the river (LHDA, 2002 (b)).

IFR 3 IFR Reach 3 - is the Malibamats'o River between the confluences of the Matsoku and Senqu rivers; length is ~35 km; IFR Site 3 is at Paray (29°29'52"S, 28°39'04"E);

IFR 4 IFR Reach 4 - is the Senqu River between the confluences of the Malibamats'o and Tsoelike rivers; length is ~115 km; IFR Site 4 is at Sehonghong (29°44'20"S, 28°45'19"E);

IFR 5 IFR Reach 5 - is the Senqu River between the confluences of the Tsoelike and Senqunyane rivers; length is ~90 km; IFR Site 5 is at Whitehills (30°03'56"S, 28°24'28"E);

IFR 6 IFR Reach 6 - is the Senqu River from the confluence with the Senqunyane River to the Lesotho/South Africa border; length is ~150 km; IFR Site 6 is at Seaka Bridge (30°21'48"S, 28°11'30"E);

IFR 7 IFR Reach 7 - is the Senqunyane River from the site of the Mohale Dam to the confluence with the Lesobeng River; length is ~90 km; IFR Site 7 is at Marakabei (29°32'09"S, 28°09'15"E);

IFR 8 IFR Reach 8 - is the Senqunyane River between the confluences of the Lesobeng River and the Senqu rivers; length is ~40 km; IFR Site 8 is upstream of the Senqunyane-Senqu confluence (30°02'11"S, 28°13'21"E) (LHDA, 2002b)

The socio-economic data was collected in eight villages in these reaches from 1, 680 households distributed over 32 clusters, 4 in each one of the eight IFR river reaches (See Figure 2.5 for the location of these Sites and Reaches).

D3 The identified Streaflow services and necessary data for value impacts

Sociological study identified populations at risk (PAR) and benefits they derive from concerned rivers. These benefits were grouped into three broad classifications:

(i) General social benefits, including cultural and subsistence use of affected rivers

(ii) Public health

(iii) Animal (livestock) health

Livestock were specifically included as they are a key feature of the economy and culture of rural communities in Lesotho (LHDA 2002c). General social benefits comprise of ecological resources supported by streamflow ecosystem. These resources are crucial for maintenance of livelihoods of PAR. They also include cultural and religious uses/services of instream flows. Table 6.2 in Chapter VI gives a list of these resources and services (LHDA 2002c).

D4 Procedures followed in valuing ecological resources and services' value impacts

To value impacts of streamflows on the availability of resources and services supplied thereof, it is imperative to first have information on the biophysical changes in resources and services concerned. The biophysical study of the IFR reports estimated how modification of the flows of rivers downstream the LHWP structures would impact the streamflow resources and services identified in Table 6.2 at optimum, found to be the 16^{th} year of the project's operation beginning 1996 (LHDA, 2002b). Biophysical data was combined with information collected from sociological surveys and animal and human health experts to measure the direction and magnitude of changes in the availability of ecological resources and changes in both public and animal health. Social data was also used in calculating monetary values of these changes. Mitigation costs for diseases were used to calculate public and animal health impacts. Table 6.4 in Chapter VI shows how availability of the resources identified will change as a result of modification of streamflows of rivers downstream the LHWP structures. The Table also shows values of these changes. The next sections provide detailed explanation on how values and value impacts of ecological resources and services of relevance to the PAR were derived.

D4.1 Value impacts of ecological resources

To assist in the measurement of value impacts of ecological resources, the following information was collected with respect to resources importance through detailed socio-economic surveys:

- Critical nature of usage, signifying the importance of the resource for the livelihoods of the affected populations
- Number of households harvesting the resource within the particular IFR reach
- Annual amounts harvested per household and local prices where available
- Frequency of use, signifying how often the resource is harvested or utilized within the annual cycle
- Availability of alternative resources , signifying that other alternative resources can be found in other accessible areas

First, the baseline values of the resources were derived (i.e. resources 1-18 in Table 6.2, Chapter VI). To do this, quantities of ecological resources harvested were multiplied by their local prices as given by the PAR. These were resource prices prevailing in the informal markets and the derived values are reported in column 4 of Table 6.3. Given the baseline values of the ecological resources, the next step was to derive the value impacts of the LHWP with respect to the availability of the identified ecological resources and services. To achieve this, the following steps were followed:

1. Historical hydrological data for each site and reach were analysed and estimations made on how the project will affect the flow in all the identified sites. Table D1 below gives the historical mean annual requirements (MAR) of the rivers in the selected sites and how the MAR will be affected by the LHWP.

Table D1: Hydrological summary of Sites downstream the LHWP structures (millions of cubic meters per annum (MCM $^{a-1}$)

IFR Site	Historical MAR	Treaty Scenario	
	MCM a^{-1}	MCM a^{-1}	As % of MAR
1	87	35	40
2	554	22	4
3	774	128	17
4	1572	831	53
5	1924	1194	62
6	3330	2171	65
7	355	48	13
8	592	158	27

Source: LHDA (2002e)

2. Given the above hydrological information, biophysical specialists conducted field studies at each site to determine biophysical components, including geomorphology, water quality, aquatic biota, riparian vegetation and riverine wildlife.
3. The corresponding biophysical consequences of reductions in flow levels at each site were then assessed by specialists relative to the present day condition of the rivers and flows and assigned as a range of expected changes in ecological resources and services, based of field data and on specialist knowledge of the biotic communities and/or species. The ranges were used to circumvent uncertainty inherent in predicting flow requirements and the consequent levels of resource loss.
4. For the impact value calculations, the mid-point of these ranges was used as the ultimate reduction in the ecological resource as a result of the project. This percentage was assumed to translate into the percentage value reduction of the particular resource. Therefore the losses associated with

the LHWP were derived by multiplying the likely percentage reduction in resource availability (column 3 of Table D2) with the currently used value of that resource (column 6 of Table D2).

The biophysical data provided percentage changes in resource supply, but not the current stock of natural resources. As a result, indicated losses could not be translated into actual losses unless it was assumed that a percentage loss in an ecological resource or service translates directly into a similar percentage loss to the households (LHDA, 2002d). Therefore, The IFR economic assessment made a critical assumption that any reduction in availability of a resource will reduce the resource use by the same percentage. This can only be true if the resource in question is currently scarce and therefore controlled through some rationing mechanism. Notwithstanding, the economic assessment demonstrated that such rationing exists for most resources except for sand. Hence sand is not included in impact values. Table D2 below illustrates how impact values were derived using Reach 1 as an example.

Table D2 was compiled for each of the eight Reaches and thus resource value impacts were calculated for each reach. To get total value impact for each resource, value impacts for that particular resource were aggregated across all the eight reaches. Since the value estimations done by the IFR studies were based on 1999 prices, for this study the values were converted to 2000 prices.

Table D2: Value impact of ecological resources loss due to the LHWP, Treaty scenario, Reach 1 (1999 Prices)

Riparian Resource	Reduction (%)	Mean Reduction (%)	Annual Quantity used	Unit Price (Maloti)	Annual Direct Use Value (Maloti)	Value Losses (Maloti)
Veg wetbank (bags)*	0-5	3	65,272	2.31	150,778	3769
Veg drybank (bags)*	20-40	30	105,095	2.05	215,449	64633
Shrubs (bundles)	20-60	40	238,632	6.96	1,660,879	664351
Willow trees (number)	25-50	38	4,163	49.50	206,069	77276
Poplar trees (number)	0-40	20	6,539	37.41	244,624	48925
Medicinal plants Dry **	20-40	30			18,826	5648
Medicinal plants Wet**	0-5	3			2,580	65
Yellowfish (kgs)	80-100	90	6,172	10	77,150	69435
Catfish (kgs)	80-100	90	1,806	12.5	18,060	16254
Trout (kgs)	80-100	90	3,432	15	52,480	16332
Forage (tonnes)	0-5	3	1,160***	380	440,678	11,017

Source: LHDA (2002e)

*Wetbank and drybank refer to different zones where uncultivated vegetables are found.

**Medicinal plants did not have a standard unit of measurement, some were measured in terms of number of roots while some in number of handfuls per year. In the estimation, the plants were separated into dry- and wet-bank and also those harvested as handfuls or as roots. Their values were calculated separately for plants extracted as roots or in handfuls and individual totals aggregated for each reach.

**Quantity in this case refers to annual production of forage

D4.2 Valuation of Cultural, spiritual and recreational use of the LHWP Rivers

For Baptism and Leisure use of pools downstream the LHDA dams, baseline information on pool depth , number and water quality was compared with biophysical changes in these components. Biophysical studies indicated that the project will severely affect the availability and quality of water available for baptism and leisure purposes in most reaches. The transport-cost method was used to value this impact. It was assumed that loss of leisure and baptism services from the LHWP Rivers will force affected communities to revert to alternative sites.

Using information on the number of affected households and alternative sites to recreational and religious services obtained from detailed socio-economic surveys, transportation cost to the alternative sites per household per reach was calculated. The costs for all households in a reach were aggregated to get total transportation cost. Table D3 below shows how baptism and leisure impact values were derived.

Table D3: Value impact of baptism and leisure services loss due to the LHWP (1999 prices)

	BAPTISM			LEISURE		
Reach	No. of households using the service	Household transportation cost to alternative site (Maloti)	Total cost (Maloti)	No. of households using the service	Household transportation cost to alternative site (Maloti)	Total cost (Maloti)
1	-	-		-	-	
2	62	11.00	682	770	9.20	7084
3	273	11.00	3003	3,372	9.20	31, 022
4	497	11.00	5467	686	11.00	755
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	242	11.00	2662	686	11.00	7, 546
8	50	11.00	550	183	11.00	2, 013
Total			12364			55, 211

Source: calculated from data in LHDA (2002c)

For Reaches 1, 5 and 6, the biophysical experts found that there will be negligible effects on baptism and leisure services. Hence they were not included in value impact analysis. Total value impact of baptism and leisure services of streamflows are reported in Table 6.5 in the year 2000 prices. It is notable that the same household transportation costs to alternative sites were assumed. This is clearly not plausible but does not affect the impact results greatly because their value contribute a fairly small percentage to the total impact value of the LHWP (i.e. 0.8%).

D4.3 Valuation of Public health

To value public health impact, the following information was taken into consideration:

- Diseases that can potentially be caused by modified river flows to the PAR
- Data on extent of river use by members in the PAR
- Predicted biophysical changes that could influence people's health

Health experts identified the following water-borne and water-washed diseases as health risks for the PAR: diarrhoea, skin and eye, anthrax, malaria, schictosmiasis, nutritional changes. Nutritional changes impact value was not included in this analysis because it is already included in ecological resource losses/value impacts. A baseline severity level was decided upon for each health risk in each social reach taking the above factors into consideration. A future severity level was then decided upon for each health risk, in each social reach and for each scenario based on relevant biophysical changes. Diarrhoeal diseases were found to be the only risk that the PAR were likely to suffer from in all the reaches. Therefore, value impact of changed streamflows on human health was assessed on the cost of programs necessary to mitigate diarrhoeal diseases.

The mitigation strategy proposed by human health experts comprised:

- Immunisation of children against all diseases to increase their resistance to infections
- Construction of ventilated-improved pit latrines (VIPs)

- Provision of safe drinking water; and
- Education that deals with the health risks associated with drinking from the river and unsafe sanitation.

A distinction was made between present and future health risks and the difference between the two, identified as the incremental risk, was used in the computation of mitigation costs. The costs of mitigating diarrhoeal diseases comprised of costs of immunising children, construction of pit latrines and an educational program aimed at reducing direct drinking of river water and adopting safe sanitation methods. The steps followed in estimation of mitigation costs were:

1. Calculation of total costs for each mitigation component
2. Calculation of costs attributable to the project by weighting each component total by the associated incremental risk
3. Aggregation of weighted costs across all mitigation components to derive the total attributable mitigation cost for each reach; and finally
4. Reducing the attributable mitigation cost to an annual basis using appropriate assumptions.

Health specialists found that 67% of children in the affected areas were already immunised, meaning that immunisation had to be increased by 33% to bring it to 100%. This cost was first estimated and then weighted by the incremental risk for each reach. This approach was also followed for the other mitigation components. For illustration, consider Reach 2 and immunisation program for 374 children which cost M760.00 and incremental health risk of 30%. Multiplying the two gives M591.00 (at 1999 prices), which is the immunisation costs attributable to the LHWP. This calculation wss repeated for all mitigation programs and a total derived for each reach. The cost of public health associated with the LHWP is reported in Table 6.5 at the year 2000 prices.

D4.4 Valuation of Animal health

The biophysical components of the IFR study provided information on the main changes in key species, communities and features in the study rivers as represented by the eight IFR sites. The collected information was used to predict the likely impacts on domestic animal health and productivity. Biophysical components of relevance to animal health and production were:

- Geomorphology
- Water quality
- Vegetation, and,
- Macroinvertebrates

On the basis of changes in these factors, animal health specialists identified pulpy kidney infections, internal parasites, bluetongue, African horse sickness and anthrax as possible health risks for the animals in the affected areas. The cost of programs necessary to mitigate against these diseases was used to estimate the animal health value impact of the LHWP. First, the present-day probability that an animal will contract the disease or face the health risk was identified. Then the level of predicted future risk was identified based on the relevant biophysical changes. Then, the cost of programs necessary for preventing and mitigating against the identified health risks were used to value streamflows in maintaining animal health in all the reaches. The mitigation method used was vaccination against the identified diseases while the preventative method used included vaccines, staff costs, transport and subsistence. The costs were weighted by incremental animal health risk, which is the difference between the present and predicted future risk.

For illustration, consider IFR Reach 2 where vaccine costs for internal parasites cost M11, 552.00, technician M2, 962.00, Veterinary Surgeon M1, 481.00, transport M1, 111.00 and subsistenceM3, 456.00, all of which total M20, 562.00. Given the health incremental risk of 17.5%, the cost attributable to the LHWP is M3, 598 (at 1999 prices). This calculation was repeated for all diseases and a total derived for each reach. Aggregating the reach value impacts derived the total impact. Animal health impact value of the LHWP is reported in Table 6.4 at the year 2000 prices.

APPENDIX E – MACROSAM CELL DESCRIPTION

Cell Code[28]	Description
C1:R2	Intermediate demand in Lesotho
C1:R3	Remuneration of labor in Lesotho
C1:R4	Remuneration of capital in Lesotho
C1:R7	Activity subsidies in Lesotho
C2:R1	Domestic supply in Lesotho
C2:R7	Indirect taxes on products in Lesotho
C2:R10	Commodity imports by Lesotho from RSA
C2:R20	Commodity imports by Lesotho from the rest of the world
C3:R6	Labor payments distributed to households in Lesotho
C3:R12	Remuneration of RSA labor working in Lesotho
C3:R19	Remuneration of foreign labor other than RSA working in Lesotho
C4:R5	Dividends and interests to enterprises in Lesotho
C4:R7	Property income for Lesotho government
C4:R8	Consumption of capital for Lesotho government
C4:R9	Consumption of capital for Lesotho private sector
C4:R13	Property income payable to RSA
C4:19	Property income payable to ROW
C5:R6	Enterprise profits distributed to households in Lesotho
C5:R7	Corporate taxes collected by Lesotho government
C5:R9	Enterprise savings in Lesotho
C6:R2	Lesotho households consumption expenditure
C6:R6	Transfers between households in Lesotho
C6:R7	Households transfers and income tax collected Lesotho government
C6:R9	Households savings in Lesotho
C6:R15	Lesotho households transfers to RSA households
C6:R19	Lesotho households transfers to ROW households
C7:R2	Lesotho Government consumption expenditure
C7:R3	Labor remuneration by Lesotho government
C7:R4	Capital remuneration by Lesotho government
C7:R6	Transfers to households by Lesotho government
C7:R7	Total subsidies by Lesotho government
C7:R8	Lesotho government savings
C7:R12	Labor payments by Lesotho government to RSA labor working in Lesotho
C7:R19	Factor payments by Lesotho government to ROW factors working in Lesotho
C8:R2	Lesotho Government investment expenditure
C8:R17	Lesotho government borrowing from RSA
C8:R21	Lesotho government borrowing from ROW

[28] C and R stand for column and row, respectively.

C9:R2	Lesotho private sector's investment expenditure
C9:R18	Lesotho private sector's borrowing from RSA
C9:R21	Lesotho private sector's borrowing from ROW
C10:R11	Intermediate demand in RSA
C10:R12	Labor remuneration in RSA
C10:13	Capital remuneration in RSA
C10:R16	Indirect taxes on activities collected by RSA government
C11:R1	Commodity imports by RSA from Lesotho
C11:R10	RSA domestic supply
C11:R16	Indirect taxes on products collected by RSA government
C11:20	Commodity imports by RSA from ROW
C12:R3	Remuneration of Lesotho labor by RSA activities
C12:R15	Distribution of labor payments to RSA households
C12:R19	Remuneration of foreign labor other than Lesotho's by RSA activities
C13:R4	Property income in RSA payable to Lesotho
C13:R14	Dividends and interests to enterprises in RSA
C13:R16	Property income for RSA government
C13:R17	Consumption of capital for RSA government
C13:R18	Consumption of capital for other sectors in RSA
C13:R19	Property income in RSA payable to ROW
C14:R15	Enterprise profits distributed to households in RSA
C14:R16	Corporate taxes collected by RSA government
C14:R18	Enterprise savings in RSA
C14:R19	Enterprise profits distributed to ROW households
C15:R6	Transfers from RSA households to Lesotho households
C15:R11	RSA households consumption expenditure
C15:R15	Household transfers in RSA
C15:R16	Transfers and Income tax paid by RSA households to RSA government
C15:R18	Households savings in RSA
C15:R19	Households transfers to ROW households
C16:R7	Transfers from RSA government to Lesotho government
C16:R11	Consumption expenditure by RSA government
C16:R12	Labor remuneration by RSA government
C16:R14	RSA government transfers to RSA enterprises
C16:R15	Government transfers to RSA households
C16:R16	Total subsidies paid by RSA government
C16:R17	RSA government recurrent deficit
C16:R19	RSA transfers and factor payments to ROW
C17:R11	RSA government investment expenditure
C17:R21	RSA government borrowing from the ROW
C18:R11	RSA private investment expenditure
C18:R21	RSA private savings in the ROW
C19:R4	Property income payable to Lesotho from ROW
C19:R6	ROW households transfers to Lesotho households
C19:R7	ROW transfers to Lesotho government

C19:R12	ROW remuneration to RSA labor
C19:13	Property income payable to RSA from ROW
C19:15	ROW households transfers to RSA households
C19:16	ROW transfers to RSA government
C20:R1	ROW Imports from Lesotho
C20:R10	ROW imports from RSA
C21:R17	ROW government savings in RSA
C21:R18	ROW private savings in RSA
C21:R21	Balance on ROW current account

APPENDIX F - DERIVATION OF THE MULTI-COUNTRY MICROSAM

The 2000 RSA and Lesotho SAMs were used to derive the multi-country MICROSAM. In some cases, the data was either highly aggregated or split in a form not conducive for this analysis. In such cases data adjustments were performed using assumptions and information from other sources. The following paragraphs give details on how some of the data, not readily available from the two countries' SAMs, were derived. Major data derivations were done on inter-country flows. In the case of intra-country flows, major adjustments were carried out on RSA data to derive a split between electricity and water accounts.

F.1 Adjustments to inter-country flows:

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F.1.1 Household transfers

For the purpose of this analysis, Lesotho households in the multi-country SAM were split into four classifications according to geographic and income distribution: Mountain-low income, Mountain-high income, Other-low income and Other-high income households. The rationale for doing this is because the Mountainl-low income riparians will be the hardest hit from the loss of ecological resources. In the case of RSA, the split is between the low and high-income households. This was mainly to ensure compatibility between households in both countries. Both Lesotho and RSA 2000 SAMs do not give any disaggregated data pertaining to inter-country household transfers. Only aggregate transfer values are given, e.g., total transfers from households in RSA to households in Lesotho vice versa are given as 13.61 and 1 million Rands, respectively. To disaggregate these values according to the above household classifications, a number of assumptions were made.

In the case of transfers from Lesotho to RSA, it was assumed that low income H/Hs in Lesotho do not transfer any money to H/Hs in RSA and that high income H/Hs in Lesotho transfer money to low income households in RSA (mainly to students). A split of transfers from H/Hs in RSA to H/Hs in Lesotho was done based on the assumptions summarized in Table F.1 below.

TABLE F.1: Distribution of households transfers from RSA to Lesotho

		South Africa		
		High income	**Low income**	**Total (million Rands)**
Lesotho	Urban high income	100%	-	8.87
	Urban low income	20%	80%	0.09
	Rural high income	80%	20%	3.06
	Rural low income	20%	80%	1.59
Total				13.61

F1.2 Institutional transfers

Transfers from Lesotho to RSA were assumed to be transfers to educational institutions, i.e., payment by the Lesotho government for Lesotho students studying in RSA. This is a credible assumption since Lesotho government sponsors more than 95 % of Lesotho students studying in South Africa.

F1.3 Factors

Factor payments by Lesotho to RSA and vise-versa, as well as payments by Lesotho to ROW and vise versa are given in the Lesotho 2000 SAM. Factor payments by South Africa to the ROW were derived from the Lesotho and RSA SAMs by deducting RSA payments to Lesotho in the Lesotho SAM from RSA payments to the ROW value in the RSA 2000 SAM, i.e.

RSA factor payments to ROW in the multi-country SAM

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RSA factor payments to ROW in RSA 2000 SAM

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RSA factor payments to Lesotho in Lesotho 2000 SAM

F2 *Adjustment* to Intra-country flows

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F2.1 Split between water and electricity in the RSA SAM

In the RSA 2000 SAM, the electricity and water accounts are aggregated. To split the two, 1999 Use and Supply Tables published by Statistics South Africa (Statssa) were used to derive income and expenditure shares in the case of income and expenditure accounts, respectively. These shares were then multiplied with the aggregate value in the SAM to split water and electricity values. The underlying assumption was that there were no substantial differences in use and supply of water and electricity between 1999 and 2000. The split was done for both commodity and activity accounts.

F2.1.1 Electricity and water activity income accounts

These comprise exports and supply accounts. Exports were derived from the 2000 Lesotho SAM. For supply accounts the derived shares are as follows (derived from Supply Table, Statssa 1999)

TABLE F2: Supply Shares of electricity and water industries in SA

	Industry Supply shares	
Products	Electricity	Water
Electricity	100%	-
Water	-	100%
Civil engineering	100%	-
Accommodation and catering	100%	-

F2.1.2 Electricity and water Activity expenditure accounts

Electricity and water expenditure accounts comprise (i) intermediate consumption, (ii) factor compensation, and (iii) net taxes. The split in all cases was derived from 1999 Use Table (Statssa). The derived expenditure shares are reported in respective Tables below.

(i) Intermediate consumption

TABLE F3: Intermediate expenditure shares for Electricity and Water Industries on different commodities in SA

	Industries				
Commodities	Electricity - 1999 million Rands	Water - 1999 million Rands	Total	Electricity expenditure share (%)	Water expenditure share (%)
Agricultural products	9.71	-	9.71	1.00	-
Mining and quarrying	3,952.16	136.93	4,089.09	0.97	0.03
Processed food	29.75	-	29.75	1.00	-
Beverages and tobacco	-	-	-	-	-
Textiles and clothing	6.35	-	6.35	1.00	-
Leather and footwear	-	1.87	1.87	-	1.00
Wood, furniture, paper, printing and publishing	58.86	65.47	124.33	0.47	0.53
Chemical products	191.72	275.51	467.23	0.41	0.59
Bricks and other non-metalic mineral products	10.15	5.72	15.87	0.64	0.36
Steel, metal production and machinery	1,334.03	396.28	1,730.31	0.77	0.23
Other manufacturing	2.65	112.56	115.21	0.02	0.98
Electricity	1,374.15	427.29	1,801.44	0.76	0.24
Water	121.37	4,092.64	4,214.01	0.03	0.97
Building construction	661.37	-	661.37	1.00	-
Civil engineering	589.50	-	589.50	1.00	-
Trade	32.67	10.70	43.37	0.75	0.25
Accommodation and catering	54.28	7.71	61.99	0.88	0.12
Transport and communication	227.26	148.99	376.25	0.60	0.40
Real estate, business and financial services	1,031.67	374.44	1,406.11	0.73	0.27
Government, domestic and other community services	11.70	13.84	25.54	0.46	0.54

(ii) Factor compensation

The Use Table only gives the aggregated value for employee compensation. The derived expenditure shares were applied across the board of employee classifications (skilled, semiskilled and unskilled), e.g., it was assumed that 90% of employee expenses were paid by the Electricity industry across the board (see Table F4 below).

TABLE F4: Factor Expenditure shares for electricity and water in SA

Factors	Electricity expenditures - 1999 million Rands	Water expenditures - 1999 million Rands	Total	Electricity expenditure share	Water expenditure share
Labor	18, 841	2, 900	21741	.9	.1
Capital (GOS)	11, 466	2, 200	13666	.84	.16

(iii) Taxes and subsidies

The Use Table reports net taxes only. It was therefore difficult to split the tax and subsidy figure between electricity and water. However, given that the water sector receives a lot of subsidies, it was assumed that all the tax was paid by the Electricity industry while the Water industry received all the subsidies. This is a very crude assumption, but probably the best in the absence of better information.

F2.1.3 Electricity and water commodity income accounts

TABLE F.5: Intermediate income shares for water and electricity from different activities in SA

Activities	Electricity Use - 1999 million Rands	Water Use - 1999 million Rands	Total	% Use - Electricity	% Water - water
Agricultural products	452.27	225.71	677.98	0.67	0.33
Mining and quarrying	3,733.23	426.56	4,159.79	0.90	0.10
Processed food	452.71	74.07	526.78	0.86	0.14
Beverages and tobacco	172.21	142.91	315.12	0.55	0.45
Textiles and clothing	251.36	57.76	309.12	0.81	0.19
Leather and footwear	27.81	2.12	29.93	0.93	0.07
Wood, furniture, paper, printing and publishing	640.63	91.89	732.52	0.87	0.13
Chemical products	1,383.65	88.56	1,472.21	0.94	0.06
Bricks and other non-metalic mineral products	508.58	35.04	543.62	0.94	0.06
Steel, metal production and machinery	5,052.05	121.64	5,173.69	0.98	0.02
Other manufacturing	98.53	10.08	108.61	0.91	0.09
Electricity	1,374.15	121.37	1,495.52	0.92	0.08
Water	427.29	4,092.64	4,519.93	0.09	0.91
Building construction	81.81	54.53	136.34	0.60	0.40
Civil engineering	105.92	37.06	142.98	0.74	0.26
Trade	1,340.37	280.16	1,620.53	0.83	0.17
Accommodation and catering	551.18	183.69	734.87	0.75	0.25
Transport and communication	1,904.38	416.01	2,320.39	0.82	0.18
Real estate, business and financial services	1,011.04	587.97	1,599.01	0.63	0.37
Government, domestic and other community services	1,202.06	609.70	1,811.76	0.66	0.34

(iv) Final demand consumption: Households and Government

(a) Households

TABLE F.6 (a): Households water and electricity (aggregated) consumption in SA

	Households use – 1999 million Rands	% shares
Electricity	10, 146	0.83
Water	2, 0491	0.17

It is noteworthy to mention that the Use Table does not disaggregate households (e.g. into low and high income like in the multi-country SAM). Therefore, to disaggregate electricity and water use according to these household classifications, the use proportions (for aggregated water and electricity value) available in the RSA SAM and reported in Table 6awas used. Table F.6 below reports the disaggregated households' water and electricity expenditure shares (also water and electricity income shares from households).

TABLE F.6 (b):Households water and electricity consumption (disggregated) in SA

	Water and electricity* - 2000 million Rands	% shares
High income households	11, 442	.80
Low income households	2, 917	.20

*Aggregate values from RSA 2000 SAM

Applying these shares to proportions in Table F.6 (a), the following expenditure shares for low and income households were derived and used to split water and electricity value between high and low income households in the multi-country SAM.

TABLE F.6(c): Households water and electricity consumption shares in SA

	Electricity income share	Water income share	Total
High income households expenditure shares	.66	.14	.8
Low income households expenditure shares	.17	.03	.2
Total	.83	.17	

The percentage shares in the shaded boxes were then used to split water and electricity use between high and low income households.

(b) Government

TABLE F.7: Government electricity and water consumption in SA

	Total Use – 1999 million Rands	% Shares
Electricity	323	.53
Water	292	.47
Total	615	1

F2.1.4 Electricity and water commodity expenditure accounts

Commodity expenditures are on imports, commodity supply and taxes. Imports expenditures are given in the Lesotho SAM. To split commodity supply, expenditure shares of 75% and 25% derived from Supply table (Statssa, 1999) for electricity and water, respectively were used. To split tax payments, a crude measure was used. Statssa does not publish disaggregated tax and subsidy figures. Only net taxes are published. Percentage shares of both electricity and water in total net taxes were calculated as 81% and 19%, respectively. These shares were applied to the aggregate value of water and electricity in RSA 2000 SAM to derive a split between water and electricity subsidies and taxes in the multi-country SAM. The disaggregated MC-SAM is presented in Appendix Table F8 below.

TABLE F8: Micro MC-SAM for Lesotho and SA for the year 2000 (Million Maloti)

			COUNTRY A: LESOTHO																		
				ENDOGENOUS ACCOUNTS																	
			Activities										Factors:	Labour		Capital	Institutions:	Households			
			Agriculture	Mining and quarrying	Manufacturing	Electricity	Water	Construction	Trade and Accommodation	Transport and communication	Real estate, business & services	Government, domestic & other community services	Skilled	Semi-skilled	Unskilled	GOS	Enterprises	Mountains - High income	Mountains - Low income	Other - High income	Other - Low income
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
ENDOGENOUS ACCOUNTS	Agriculture	1	1,193.49	0.00	655.71	0.19	-	10.36	18.06	0.08	0.18	4.74	-	-	-	-	-	47.70	10.57	628.62	49.82
	Mining and quarrying	2	0.96	5.88	26.66	-	0.24	34.10	0.15	0.31	0.02	1.81	-	-	-	-	-	0.06	0.00	-	-
	Manufacturing	3	188.77	0.54	2,380.15	26.99	2.37	1,077.03	201.91	104.45	20.42	243.42	-	-	-	-	-	126.47	58.69	2,215.50	248.31
	Electricity	4	6.23	0.11	27.21	243.55	1.34	9.58	20.45	8.96	1.71	16.41	-	-	-	-	-	-	-	26.14	0.91
Country A: Lesotho	Water	5	3.98	0.05	8.38	4.24	120.11	7.33	10.17	3.44	1.63	22.51	-	-	-	-	-	-	-	44.29	0.54
	Construction	6	7.07	0.03	17.52	21.93	-	3,065.84	14.33	2.30	3.86	12.89	-	-	-	-	-	-	-	-	-
Activities	Trade and accommodation	7	2.62	0.00	2.35	0.45	0.01	0.65	781.34	3.11	1.65	6.02	-	-	-	-	-	25.63	5.22	530.05	44.01
	Transport and communication	8	1.63	0.65	49.04	2.83	0.30	26.83	64.03	315.95	6.42	45.42	-	-	-	-	-	3.02	1.72	74.14	14.45
	Real estate, business & financial services	9	8.08	0.05	175.23	20.22	1.62	147.24	142.23	26.76	674.68	163.90	-	-	-	-	-	14.54	21.14	42.47	12.44
	Government, domestic & other community services	10	-	0.11	139.03	-	-	18.97	3.47	3.33	1.83	707.74	-	-	-	-	-	3.16	14.82	332.97	138.59
Factors:	Skilled	11	3.31	1.31	89.83	25.91	24.65	110.15	102.47	37.31	120.34	99.13	-	-	-	-	-	-	-	-	-
Labour	Semi-skilled	12	112.20	1.38	132.20	24.72	23.51	201.52	216.68	50.08	57.04	24.23	-	-	-	-	-	-	-	-	-
	Unskilled	13	452.87	0.97	120.79	3.61	3.44	47.67	18.49	18.29	38.19	17.68	-	-	-	-	-	-	-	-	-
Capital	GOS	14	462.87	2.90	314.52	60.05	126.31	262.33	259.43	80.94	299.17	35.45	-	-	-	-	-	-	-	-	-
Institutions:	Enterprises	15	-	-	-	-	-	-	-	-	-	-	-	-	-	1,073.98	-	-	-	-	-
Households	Mountains - High income	16	-	-	-	-	-	-	-	-	-	-	2.61	70.78	106.65	-	48.75	1.41	-	-	-
	Mountains - Low income	17	-	-	-	-	-	-	-	-	-	-	-	0.29	92.98	-	-	3.52	3.65	6.34	-
	Other - High income	18	-	-	-	-	-	-	-	-	-	-	1,285.95	1,253.08	1,328.28	-	479.24	-	-	1.96	-
	Other - Low income	19	-	-	-	-	-	-	-	-	-	-	-	3.11	457.27	-	-	2.11	-	28.31	5.70
	Agriculture	20	218.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Country B: RSA	Mining and quarrying	21	-	25.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Manufacturing	22	-	-	3,881.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Electricity	23	-	-	-	0.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Activities	Water	24	-	-	-	-	0.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Construction	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trade and accommodation	26	-	-	-	-	-	-	0.81	-	-	-	-	-	-	-	-	-	-	-	-
	Transport and communication	27	-	-	-	-	-	-	-	77.51	-	-	-	-	-	-	-	-	-	-	-
	Real estate, business & financial services	28	-	-	-	-	-	-	-	-	216.91	-	-	-	-	-	-	-	-	-	-
	Government, domestic & other community services	29	-	-	-	-	-	-	-	-	-	85.86	-	-	-	-	-	-	-	-	-
Factors:	Skilled	30	-	-	-	-	-	-	-	-	-	-	51.11	-	-	-	-	-	-	-	-
Labour	Semi-skilled	31	-	-	-	-	-	-	-	-	-	-	-	52.65	-	-	-	-	-	-	-
	Unskilled	32	-	-	-	-	-	-	-	-	-	-	-	-	59.44	-	-	-	-	-	-
Capital	GOS	33	-	-	-	-	-	-	-	-	-	-	-	-	-	195.20	-	-	-	-	-
Institutions:	Enterprises	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Households	High income	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Low income	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.65	-
EXOGENOUS ACCOUNTS	Government	37	12.96	6.49	1,172.99	0.65	66.31	-	35.14	26.37	63.19	65.90	-	-	-	366.99	184.00	2.87	1.46	274.53	25.14
Lesotho exogenous accs	Capital	38	-	-	-	-	-	-	-	-	-	-	-	-	-	620.00	362.00	0.30	0.15	156.52	6.03
SA exogenous accs	Government	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Capital	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ROW	41	11.52	1.35	204.31	0.01	0.00	-	0.04	4.08	11.42	4.52	9.02	9.29	10.49	48.80	-	0.01	-	0.19	-
Discrepancy		42	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total			2,687.51	47.40	9,397.77	435.64	370.29	5,019.60	1,889.19	763.27	1,518.67	1,557.63	1,348.69	1,389.20	2,055.11	2,304.98	1,073.98	230.94	117.43	4,362.69	545.95

Table F8 Continued

			COUNTRY B: RSA																	EXOGENOUS ACCOUNTS						
				ENDOGENOUS ACCOUNTS																						
			Activities										Factors:	Labour		Capital	Institutions:	Households		Lesotho exogenous accounts		RSA exogenous accounts				
			Agriculture	Mining and quarrying	Manufacturing	Electricity	Water	Construction	Trade and accommodation	Transport and communication	Real estate, business & financial services	Government, domestic & other community services	Skilled	Semi-skilled	Unskilled	GOS	Enterprises	High income	Low income	Government expenditure	Capital	Government expenditure	Capital	ROW	Discrepancy	Total
			20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	
ENDOGENOUS ACCOUNTS	Agriculture	1	25.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16.44	0.00	-	-	-	26.51	2,687.51
	Mining and quarrying	2	-	0.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.74	0.00	-	-	1.91	-30.76	47.40
	Manufacturing	3	-	-	398.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	533.38	316.30	-	-	829.65	425.37	9,397.77
	Electricity	4	-	-	-	0.52	-	-	-	-	-	-	-	-	-	-	-	-	-	65.00	-	-	-	-	7.54	435.63
Country A: Lesotho	Water	5	-	-	-	-	110.12	-	-	-	-	-	-	-	-	-	-	-	-	22.15	-	-	-	-	11.36	370.29
	Construction	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	98.43	2,162.61	-	-	-	-387.21	5,019.60
Activities	Trade and accommodation	7	-	-	-	-	-	-	299.40	-	-	-	-	-	-	-	-	-	-	143.20	0.00	-	-	-	43.46	1,889.19
	Transport and communication	8	-	-	-	-	-	-	-	92.48	-	-	-	-	-	-	-	-	-	112.38	0.00	-	-	0.01	-48.03	763.27
	Real estate, business & financial services	9	-	-	-	-	-	-	-	-	1.45	-	-	-	-	-	-	-	-	131.47	0.09	-	-	-	-64.93	1,518.67
	Government, domestic & other community services	10	-	-	-	-	-	-	-	-	-	17.05	-	-	-	-	-	-	-	159.80	-	-	-	-	16.75	1,557.63
Factors:	Skilled	11	-	-	-	-	-	-	-	-	-	-	359.03	-	-	-	-	-	-	375.26	-	-	-	-	-	1,348.69
Labour	Semi-skilled	12	-	-	-	-	-	-	-	-	-	-	-	168.50	-	-	-	-	-	377.14	-	-	-	-	-	1,389.20
	Unskilled	13	-	-	-	-	-	-	-	-	-	-	-	-	1,218.47	-	-	-	-	114.63	-	-	-	-	-	2,055.11
Capital	GOS	14	-	-	-	-	-	-	-	-	-	-	-	-	-	203.20	-	-	-	147.00	-	-	-	50.80	-	2,304.98
Institutions:	Enterprises	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,073.98
Households	Mountains - High income	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.60	-	-	-	-	-	0.15	-	230.94
	Mountains - Low income	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.24	10.27	-	-	-	0.07	-	117.43
	Other - High income	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.33	-	-	-	-	-	2.83	0.01	4,362.69
	Other - Low income	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.34	1.71	47.73	-	-	-	0.34	-	545.94
	Agriculture	20	41,741.38	30.15	33,060.99	6.85	-	583.62	522.44	2.28	18.80	97.32	-	-	-	-	-	10,363.92	6,018.96	-	-	192.63	22.55	7,813.48	-6,391.80	94,302.49
Country B: RSA	Mining and quarrying	21	163.80	18,581.88	22,450.94	3,313.79	102.49	2,052.67	32.02	132.96	76.73	88.94	-	-	-	-	-	81.83	143.43	-	-	153.80	37.62	63,842.18	4,387.74	115,668.43
	Manufacturing	22	11,915.62	11,515.05	456,930.03	938.51	499.22	21,368.84	22,334.55	19,517.64	18,881.41	15,750.88	-	-	-	-	-	177,401.62	71,165.62	-	-	21,394.78	68,941.71	134,351.79	-9,754.87	1,047,034.24
	Electricity	23	433.50	3,521.12	8,287.50	28,516.70	89.67	1,090.75	2,082.51	1,960.78	1,081.54	367.71	-	-	-	-	-	9,496.49	2,421.19	-	-	581.06	-	-0.29	-2,219.05	57,711.45
Activities	Water	24	213.51	391.24	639.93	313.84	12,210.55	96.11	502.46	430.41	635.19	189.43	-	-	-	-	-	1,945.06	495.91	-	-	119.01	-	-0.09	-560.99	17,621.65
	Construction	25	160.38	695.37	-	906.62	-	83,636.22	1,770.87	524.52	2,732.80	639.57	-	-	-	-	-	-	-	-	-	1,999.51	61,255.51	2,125.83	-7,876.25	148,570.96
	Trade and accommodation	26	2,715.74	4,474.66	43,976.83	701.70	224.17	3,793.79	179,278.27	13,991.93	9,574.62	11,036.66	-	-	-	-	-	50,514.88	19,477.20	-	-	1,615.68	1,960.26	12,990.25	5,455.98	361,783.45
	Transport and communication	27	2,723.89	10,620.30	25,560.05	739.39	492.93	3,372.77	12,046.10	139,372.45	6,543.86	1,287.64	-	-	-	-	-	39,071.63	17,353.35	-	-	1,401.59	56.11	8,986.17	5,564.94	275,260.68
	Real estate, business & financial services	28	1,163.40	2,036.57	27,539.08	931.85	344.66	4,598.19	26,186.38	9,355.44	289,704.95	6,845.31	-	-	-	-	-	92,337.56	15,300.43	-	-	5,189.68	3,317.23	12,421.14	6,349.02	503,837.79
	Government, domestic & other community services	29	401.59	3,332.36	23,582.35	7.95	9.33	510.86	614.44	1,089.08	1,695.95	70,145.76	-	-	-	-	-	35,372.61	6,856.29	-	-	12,567.26	-	6,765.71	857.85	163,895.26
Factors:	Skilled	30	934.27	3,941.84	21,232.59	1,531.52	170.17	3,046.80	14,744.98	9,404.56	31,523.98	38,098.99	-	-	-	-	-	-	-	3.35	-	65,011.54	-	142.66	-	189,838.35
Labour	Semi-skilled	31	395.27	1,352.28	8,902.17	661.11	73.46	781.30	23,095.38	6,298.49	14,758.25	2,598.36	-	-	-	-	-	-	-	-	-	31,200.88	-	69.20	-	90,238.81
	Unskilled	32	6,371.44	16,624.78	46,251.90	4,192.92	465.88	9,666.18	13,002.88	20,637.17	5,024.79	2,504.25	-	-	-	-	-	-	-	-	-	19,212.59	-	135.94	-	144,150.15
Capital	GOS	33	19,137.38	23,557.23	73,415.02	13,899.02	2,647.43	8,914.82	54,652.27	44,869.13	107,382.19	8,149.48	-	-	-	-	-	-	-	-	-	-	-	14,417.80	-	371,236.97
Institutions:	Enterprises	34	-	-	-	-	-	-	-	-	-	-	-	-	-	219,030.98	-	-	-	-	-	51,337.00	-	-	-	270,367.98
Households	High income	35	-	-	-	-	-	-	-	-	-	-	176,430.92	73,688.83	116,250.21	-	141,622.86	1,813.82	118.18	-	-	3,649.27	-	109.94	0.05	513,684.07
	Low income	36	-	-	-	-	-	-	-	-	-	-	12,416.94	16,080.74	27,150.37	-	66,878.13	5,309.75	3,361.27	-	-	23,272.73	-	149.27	-0.04	154,619.95
EXOGENOUS ACCOUNTS	Government	37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	82.00	-	180.80	-	45.20	0.01	2,613.00
Lesotho exogenous accs	Capital	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	164.00	-	-	-	-	-	1,309.00
SA exogenous accs	Government	39	1,123.94	466.83	61,430.83	1,049.17	181.58	5,058.03	2,481.01	1,786.17	14,202.74	5,519.71	-	-	-	8,439.00	28,397.00	87,578.22	11,790.78	-	-	7,176.00	-	482.00	-	237,163.00
	Capital	40	-	-	-	-	-	-	-	-	-	-	-	-	-	112,632.99	33,390.00	2,273.95	112.05	-	-936.00	-15,868.00	-	1,872.01	-	133,477.00
	ROW	41	4,682.35	14,526.45	193,385.94	-	-	-	8,137.51	5,795.20	-1.45	558.19	628.11	300.75	-468.89	35,228.80	80.00	111.05	3.35	3.63	-234.00	6,775.20	-2,114.00	-2,816.00	-	264,897.24
Discrepancy		42	-	-	-	-	-	-	-	-	-	-	3.34	-	-	-4,298.00	-	-	-	-	-	-	-	107.29	-	-4,187.36
Total			94,302.49	115,668.43	1,047,034.24	57,711.45	17,621.64	148,570.96	361,783.45	275,260.68	503,837.79	163,895.26	189,838.35	90,238.81	144,150.15	371,236.97	270,367.98	513,684.07	154,619.95	2,613.00	1,309.00	237,163.00	133,477.00	264,897.24	-4,187.36	

APPENDIX G – MULTI-COUNTRY ECOLOGICAL SOCIAL ACCOUNTING MATRIX (MC-ESAM)

			COUNTRY A: LESOTHO																		
				ENDOGENOUS ACCOUNTS																	
			Activities										Factors:	Labour		Capital	Institutions:	Households			
			Agriculture	Mining and quarrying	Manufacturing	Electricity	Water	Construction	Trade and Accommodation	Transport and communication	Real estate, business & services	Government, domestic & other community services	Skilled	Semi-skilled	Unskilled	GOS	Enterprises	Mountains - High income	Mountains - Low income	Other - High income	Other - Low income
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
ENDOGENOUS ACCOUNTS	Agriculture	1	1,193.49	0.00	655.71	0.19	-	10.36	18.06	0.08	0.18	4.74	-	-	-	-	-	47.70	10.57	628.62	49.82
	Mining and quarrying	2	0.96	5.88	26.66	-	0.24	34.10	0.15	0.31	0.02	1.81	-	-	-	-	-	0.06	0.00	-	-
	Manufacturing	3	188.77	0.54	2,380.15	26.99	2.37	1,077.03	201.91	104.45	20.42	243.42	-	-	-	-	-	126.47	58.69	2,215.50	248.31
	Electricity	4	6.23	0.11	27.21	243.55	1.34	9.58	20.45	8.96	1.71	16.41	-	-	-	-	-	-	-	26.14	0.91
Country A: Lesotho	Water	5	3.98	0.05	8.38	4.24	120.11	7.33	10.17	3.44	1.63	22.51	-	-	-	-	-	-	-	44.29	0.54
	Construction	6	7.07	0.03	17.52	21.93	-	3,065.84	14.33	2.30	3.86	12.89	-	-	-	-	-	-	-	-	-
Activities	Trade and accommodation	7	2.62	0.00	2.35	0.45	0.01	0.65	781.34	3.11	1.65	6.02	-	-	-	-	-	25.63	5.22	530.05	44.01
	Transport and communication	8	1.63	0.65	49.04	2.83	0.30	26.83	64.03	315.95	6.42	45.42	-	-	-	-	-	3.02	1.72	74.14	14.45
	Real estate, business & financial services	9	8.08	0.05	175.23	20.22	1.62	147.24	142.23	26.76	674.68	163.90	-	-	-	-	-	14.54	21.14	42.47	12.44
	Government, domestic & other community services	10	-	0.11	139.03	-	-	18.97	3.47	3.33	1.83	707.74	-	-	-	-	-	3.16	14.82	332.97	138.59
Factors:	Skilled	11	3.31	1.31	89.83	25.91	24.65	110.15	102.47	37.31	120.34	99.13	-	-	-	-	-	-	-	-	-
Labour	Semi-skilled	12	112.20	1.38	132.20	24.72	23.51	201.52	216.68	50.08	57.04	24.23	-	-	-	-	-	-	-	-	-
	Unskilled	13	452.87	0.97	120.79	3.61	3.44	47.67	18.49	18.29	38.19	17.68	-	-	-	-	-	-	-	-	-
Capital	GOS	14	462.87	2.90	314.52	60.05	126.31	262.33	259.43	80.94	299.17	35.45	-	-	-	-	-	-	-	-	-
Institutions:	Enterprises	15	-	-	-	-	-	-	-	-	-	-	-	-	-	1,073.98	-	-	-	-	-
Households	Mountains - High income	16	-	-	-	-	-	-	-	-	-	-	2.61	70.78	106.65	-	48.75	1.41	-	-	-
	Mountains - Low income	17	-	-	-	-	-	-	-	-	-	-	-	0.29	92.98	-	-	3.52	3.65	6.34	-
	Other - High income	18	-	-	-	-	-	-	-	-	-	-	1,285.95	1,253.08	1,328.28	-	479.24	-	-	1.96	-
	Other - Low income	19	-	-	-	-	-	-	-	-	-	-	-	3.11	457.27	-	-	2.11	-	28.31	5.70
	Agriculture	20	218.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Country B: RSA	Mining and quarrying	21	-	25.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Manufacturing	22	-	-	3,881.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Electricity	23	-	-	-	0.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Activities	Water	24	-	-	-	-	0.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Construction	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trade and accommodation	26	-	-	-	-	-	-	0.81	-	-	-	-	-	-	-	-	-	-	-	-
	Transport and communication	27	-	-	-	-	-	-	-	77.51	-	-	-	-	-	-	-	-	-	-	-
	Real estate, business & financial services	28	-	-	-	-	-	-	-	-	216.91	-	-	-	-	-	-	-	-	-	-
	Government, domestic & other community services	29	-	-	-	-	-	-	-	-	-	85.86	-	-	-	-	-	-	-	-	-
Factors:	Skilled	30	-	-	-	-	-	-	-	-	-	-	51.11	-	-	-	-	-	-	-	-
Labour	Semi-skilled	31	-	-	-	-	-	-	-	-	-	-	-	52.65	-	-	-	-	-	-	-
	Unskilled	32	-	-	-	-	-	-	-	-	-	-	-	-	59.44	-	-	-	-	-	-
Capital	GOS	33	-	-	-	-	-	-	-	-	-	-	-	-	-	195.20	-	-	-	-	-
Institutions:	Enterprises	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Households	High income	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Low income	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.65	-
	Government	37	12.96	6.49	1,172.99	0.65	66.31	-	35.14	26.37	63.19	65.90	-	-	-	366.99	184.00	2.87	1.46	274.53	25.14
EXOGENOUS ACCOUNTS	Capital	38	-	-	-	-	-	-	-	-	-	-	-	-	-	620.00	362.00	0.30	0.15	156.52	6.03
Lesotho ex. Accs.	Ecological production	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.24	36.95	-	-
	Natural water		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.19	-	-
RSA ex. Accs.	Government	##	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Capital	##	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ROW	##	11.52	1.35	204.31	0.01	0.00	-	0.04	4.08	11.42	4.52	9.02	9.29	10.49	48.80	-	0.01	-	0.19	-
Discrepancy		##	-	-	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total			2,687.51	47.40	9,397.77	435.64	370.29	5,019.60	1,889.19	763.27	1,518.67	1,557.63	1,348.69	1,389.20	2,055.11	2,304.98	1,073.98	240.23	154.57	4,362.69	545.95

APPENDIX G continued

			COUNTRY B: RSA									
			ENDOGENOUS ACCOUNTS									
			Activities									
			Agriculture	Mining and quarrying	Manufacturing	Electricity	Water	Construction	Trade and accommodation	Transport and communication	Real estate, business & financial services	Government, domestic & other community services
			20	21	22	23	24	25	26	27	28	29
ENDOGENOUS ACCOUNTS	Agriculture	1	26.02	-	-	-	-	-	-	-	-	-
	Mining and quarrying	2	-	0.33	-	-	-	-	-	-	-	-
	Manufacturing	3	-	-	398.08	-	-	-	-	-	-	-
	Electricity	4	-	-	-	0.52	-	-	-	-	-	-
Country A: Lesotho	Water	5	-	-	-	-	110.12	-	-	-	-	-
	Construction	6	-	-	-	-	-	-	-	-	-	-
Activities	Trade and accommodation	7	-	-	-	-	-	-	299.40	-	-	-
	Transport and communication	8	-	-	-	-	-	-	-	92.48	-	-
	Real estate, business & financial services	9	-	-	-	-	-	-	-	-	1.45	-
	Government, domestic & other community services	10	-	-	-	-	-	-	-	-	-	17.05
Factors:	Skilled	11	-	-	-	-	-	-	-	-	-	-
Labour	Semi-skilled	12	-	-	-	-	-	-	-	-	-	-
	Unskilled	13	-	-	-	-	-	-	-	-	-	-
Capital	GOS	14	-	-	-	-	-	-	-	-	-	-
Institutions:	Enterprises	15	-	-	-	-	-	-	-	-	-	-
Households	Basotho - High income	16	-	-	-	-	-	-	-	-	-	-
	Basotho - Low income	17	-	-	-	-	-	-	-	-	-	-
	Other - High income	18	-	-	-	-	-	-	-	-	-	-
	Other - Low income	19	-	-	-	-	-	-	-	-	-	-
	Agriculture	20	41,741.38	30.15	33,060.99	6.85	-	583.62	522.44	2.28	18.80	97.32
Country B: RSA	Mining and quarrying	21	163.80	18,581.88	22,450.94	3,313.79	102.49	2,052.67	32.02	132.96	76.73	88.94
	Manufacturing	22	11,915.62	11,515.05	456,930.03	938.51	499.22	21,368.84	22,334.55	19,517.64	18,881.41	15,750.88
	Electricity	23	433.50	3,521.12	8,287.50	28,516.70	89.67	1,090.75	2,082.51	1,960.78	1,081.54	367.71
Activities	Water	24	213.51	391.24	639.93	313.84	12,210.55	96.11	502.46	430.41	635.19	189.43
	Construction	25	160.38	695.37	-	906.62	-	83,636.22	1,770.87	524.52	2,732.80	639.57
	Trade and accommodation	26	2,715.74	4,474.66	43,976.83	701.70	224.17	3,793.79	179,278.27	13,991.93	9,574.62	11,036.66
	Transport and communication	27	2,723.89	10,620.30	25,550.05	739.39	492.93	3,372.77	12,046.10	139,372.45	6,543.86	1,287.64
	Real estate, business & financial services	28	1,163.40	2,036.57	27,539.08	931.85	344.66	4,598.19	26,186.38	9,355.44	289,704.95	6,845.31
	Government, domestic & other community services	29	401.59	3,332.36	23,582.35	7.95	9.33	510.86	614.44	1,089.08	1,695.95	70,145.76
Factors:	Skilled	30	934.27	3,941.84	21,232.59	1,531.52	170.17	3,046.80	14,744.98	9,404.56	31,523.98	38,098.99
Labour	Semi-skilled	31	395.27	1,352.28	8,902.17	661.11	73.46	781.30	23,095.38	6,298.49	14,758.25	2,598.36
	Unskilled	32	6,371.44	16,624.78	46,251.90	4,192.92	465.88	9,666.18	13,002.88	20,637.17	5,024.79	2,504.25
Capital	GOS	33	19,137.38	23,557.23	73,415.02	13,899.02	2,647.43	8,914.82	54,652.27	44,869.13	107,382.19	8,149.48
Institutions:	Enterprises	34	-	-	-	-	-	-	-	-	-	-
Households	High income	35	-	-	-	-	-	-	-	-	-	-
	Low income	36	-	-	-	-	-	-	-	-	-	-
	Government	37	-	-	-	-	-	-	-	-	-	-
EXOGENOUS ACCOUNTS	Capital	38	-	-	-	-	-	-	-	-	-	-
Lesotho ex. Accs	Ecological production	39	-	-	-	-	-	-	-	-	-	-
	Natural water		-	-	-	-	-	-	-	-	-	-
RSA ex. Accs	Government	##	1,123.94	466.83	61,430.83	1,049.17	181.58	5,058.03	2,481.01	1,786.17	14,202.74	5,519.71
	Capital	##	-	-	-	-	-	-	-	-	-	-
	ROW	##	4,682.35	14,526.45	193,386.94	-	-	-	8,137.51	5,795.20	1.45	558.19
Discrepancy		##	-	-	-	-	-	-	-	-	-	-
Total			94,302.49	115,668.43	1,047,034.24	57,711.45	17,621.64	148,570.96	361,783.45	275,260.68	503,837.79	163,895.26

			Factors:	Labour		Capital	Institutions:	Households		EXOGENOUS ACCOUNTS								
										Lesotho exogenous accounts				RSA exogenous accounts				
			Skilled	Semi-skilled	Unskilled	GOS	Enterprises	High income	Low income	Government expenditure	Capital	Ecological production	Natural water	Government expenditure	Capital	ROW	Discrepancy	Total
			30	31	32	33	34	35	36	37	38	39		40	41	42	43	
ENDOGENOUS ACCOUNTS	Agriculture	1	-	-	-	-	-	-	-	16.44	0.00	-	-	-	-	-	26.51	2,687.51
	Mining and quarrying	2	-	-	-	-	-	-	-	5.74	0.00	-	-	-	-	1.91	30.76	47.40
	Manufacturing	3	-	-	-	-	-	-	-	533.38	316.30	-	-	-	-	829.65	425.37	9,397.77
	Electricity	4	-	-	-	-	-	-	-	65.00	-	-	-	-	-	-	7.54	435.63
Country A: Lesotho	Water	5	-	-	-	-	-	-	-	22.15	-	-	-	-	-	-	11.36	370.29
	Construction	6	-	-	-	-	-	-	-	98.43	2,102.61	-	-	-	-	-	307.21	5,019.60
Activities	Trade and accommodation	7	-	-	-	-	-	-	-	143.20	0.00	-	-	-	-	-	43.46	1,809.19
	Transport and communication	8	-	-	-	-	-	-	-	112.38	0.00	-	-	-	-	0.01	48.03	763.27
	Real estate, business & financial services	9	-	-	-	-	-	-	-	131.47	0.09	-	-	-	-	-	64.93	1,518.67
	Government, domestic & other community services	10	-	-	-	-	-	-	-	159.80	-	-	-	-	-	-	16.75	1,557.63
Factors:	Skilled	11	369.03	-	-	-	-	-	-	376.26	-	-	-	-	-	-	-	1,348.69
Labour	Semi-skilled	12	-	168.50	-	-	-	-	-	377.14	-	-	-	-	-	-	-	1,389.20
	Unskilled	13	-	-	1,218.47	-	-	-	-	114.63	-	-	-	-	-	-	-	2,055.11
Capital	GOS	14	-	-	-	203.20	-	-	-	147.00	-	-	-	-	-	50.80	-	2,304.98
Institutions:	Enterprises	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,073.98
Households	Basotho - High income	16	-	-	-	-	-	0.60	-	-	-	9.24	0.05	-	-	0.15	-	240.23
	Basotho - Low income	17	-	-	-	-	-	0.06	0.24	10.27	-	36.95	0.19	-	-	0.07	-	154.57
	Other - High income	18	-	-	-	-	-	11.33	-	-	-	-	-	-	-	2.83	0.01	4,362.69
	Other - Low income	19	-	-	-	-	-	0.34	1.71	47.73	-	-	-	-	-	0.34	-	545.94
	Agriculture	20	-	-	-	-	-	10,363.92	6,018.96	-	-	-	-	192.63	22.55	7,813.48	6,391.80	94,302.49
Country B: RSA	Mining and quarrying	21	-	-	-	-	-	81.83	143.43	-	-	-	-	153.80	37.62	63,842.18	4,387.74	115,668.43
	Manufacturing	22	-	-	-	-	-	177,401.62	71,165.62	-	-	-	-	21,394.78	68,941.71	134,351.79	9,754.87	1,047,034.24
	Electricity	23	-	-	-	-	-	9,496.49	2,421.19	-	-	-	-	581.06	-	0.29	2,219.05	57,711.45
Activities	Water	24	-	-	-	-	-	1,946.06	496.91	-	-	-	-	119.01	-	0.09	660.99	17,621.65
	Construction	25	-	-	-	-	-	-	-	-	-	-	-	1,999.51	61,266.51	2,126.83	7,876.26	148,570.96
	Trade and accommodation	26	-	-	-	-	-	50,514.88	19,477.20	-	-	-	-	1,616.68	1,960.26	12,990.26	5,455.98	361,783.45
	Transport and communication	27	-	-	-	-	-	39,071.63	17,363.35	-	-	-	-	1,401.59	56.11	8,986.17	5,564.94	275,260.68
	Real estate, business & financial services	28	-	-	-	-	-	92,337.56	15,300.43	-	-	-	-	5,189.68	3,317.23	12,421.14	6,349.02	503,837.79
	Government, domestic & other community services	29	-	-	-	-	-	35,372.61	6,856.29	-	-	-	-	12,567.26	-	6,765.71	857.85	163,895.26
Factors:	Skilled	30	-	-	-	-	-	-	-	3.35	-	-	-	65,011.54	-	142.66	-	189,838.35
Labour	Semi-skilled	31	-	-	-	-	-	-	-	-	-	-	-	31,200.88	-	69.20	-	90,238.81
	Unskilled	32	-	-	-	-	-	-	-	-	-	-	-	19,212.59	-	135.94	-	144,150.15
Capital	GOS	33	-	-	-	-	-	-	-	-	-	-	-	-	-	14,417.80	-	371,236.97
Institutions:	Enterprises	34	-	-	-	219,030.98	-	-	-	-	-	-	-	51,337.00	-	-	-	270,367.98
Households	High income	35	176,430.92	73,608.83	116,250.21	-	141,622.86	1,813.02	118.18	-	-	-	-	3,649.27	-	109.94	0.05	513,684.07
	Low income	36	12,416.94	16,000.74	27,160.37	-	66,878.13	5,309.75	3,361.27	-	-	-	-	23,272.73	-	149.27	0.04	154,619.95
	Government	37	-	-	-	-	-	-	-	82.00	-	-	-	180.80	-	45.20	0.01	2,613.00
EXOGENOUS ACCOUNTS	Capital	38	-	-	-	-	-	-	-	164.00	-	-	-	-	-	-	-	1,309.00
Lesotho ex. Accs	Ecological production	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	46.19
	Natural water		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24
RSA ex. Accs	Government	##	-	-	-	8,439.00	28,397.00	87,578.22	11,790.78	-	-	-	-	7,176.00	-	482.00	-	237,163.00
	Capital	##	-	-	-	112,632.99	33,390.00	2,273.95	112.05	-	936.00	-	-	15,868.00	-	1,872.01	-	133,477.00
	ROW	##	620.11	300.75	468.89	35,228.80	80.00	111.05	3.35	3.63	234.00	-	-	6,775.20	2,114.00	2,816.00	-	264,897.24
Discrepancy		##	3.34	-	-	4,298.00	-	-	-	-	-	-	-	-	-	107.29	-	4,187.36
Total			189,838.35	90,238.81	144,150.15	371,236.97	270,367.98	513,684.07	154,619.95	2,613.00	1,309.00	46.19	0.24	237,163.00	133,477.00	264,897.24	4,187.36	

APPENDIX H – MULTIPLIER MATRIX FOR THE MC-ESAM

			LESOTHO																		
			Production										Factors				Institutions				
			Agriculture	Mining and quarrying	Manufacturing	Electricity	Water	Construction	Trade and Accommodation	Transport and communication	Real estate, business & services	Government, domestic & other community services	Skilled	Semi-skilled	Unskilled	GOS	Enterprises	Mountains - High income	Mountains - Low income	Other - High income	Other - Low income
LESOTHO			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Production																				
	Agriculture	1	2.033	0.056	0.229	0.250	0.154	0.255	0.281	0.201	0.164	0.214	0.450	0.455	0.432	0.110	0.237	0.581	0.288	0.471	0.380
	Mining and quarrying	2	0.003	1.142	0.005	0.005	0.002	0.024	0.003	0.004	0.002	0.006	0.004	0.004	0.004	0.001	0.002	0.004	0.003	0.004	0.005
	Manufacturing	3	0.656	0.143	1.498	0.753	0.347	1.098	0.766	0.687	0.391	0.766	0.993	0.994	0.994	0.239	0.512	1.070	0.794	1.039	1.037
	Electricity	4	0.029	0.012	0.016	2.291	0.025	0.032	0.067	0.063	0.019	0.065	0.039	0.038	0.037	0.009	0.019	0.025	0.020	0.041	0.038
	Water	5	0.017	0.006	0.007	0.047	1.489	0.018	0.029	0.023	0.013	0.052	0.028	0.027	0.025	0.006	0.014	0.012	0.012	0.030	0.023
	Construction	6	0.027	0.006	0.014	0.309	0.010	2.586	0.056	0.032	0.021	0.060	0.024	0.024	0.025	0.006	0.012	0.022	0.018	0.025	0.031
	Trade and accommodation	7	0.120	0.030	0.033	0.124	0.086	0.086	1.828	0.102	0.093	0.098	0.258	0.257	0.238	0.061	0.132	0.250	0.109	0.270	0.206
	Transport and communication	8	0.041	0.036	0.025	0.067	0.027	0.059	0.140	1.739	0.040	0.125	0.073	0.072	0.079	0.017	0.037	0.064	0.055	0.076	0.106
	Real estate, business & financial services	9	0.100	0.025	0.077	0.291	0.064	0.225	0.329	0.185	1.858	0.430	0.145	0.149	0.177	0.036	0.078	0.225	0.353	0.152	0.230
	Government, domestic & other community services	10	0.127	0.032	0.068	0.110	0.070	0.112	0.117	0.100	0.082	1.919	0.211	0.207	0.282	0.048	0.104	0.114	0.241	0.221	0.549
	Factors																				
	Skilled	11	0.037	0.042	0.030	0.194	0.120	0.104	0.155	0.125	0.166	0.184	1.058	0.057	0.064	0.014	0.029	0.056	0.062	0.060	0.085
	Semi-skilled	12	0.120	0.046	0.042	0.198	0.123	0.158	0.264	0.159	0.100	0.095	0.081	1.081	0.080	0.019	0.042	0.086	0.059	0.085	0.083
	Unskilled	13	0.359	0.039	0.063	0.086	0.049	0.093	0.090	0.093	0.083	0.085	0.101	0.102	1.099	0.025	0.053	0.124	0.074	0.105	0.096
	GOS	14	0.427	0.102	0.119	0.501	0.579	0.293	0.430	0.313	0.435	0.248	0.204	0.205	0.206	1.049	0.106	0.233	0.180	0.214	0.213
	Institutions																				
	Enterprises	15	0.199	0.048	0.056	0.233	0.270	0.136	0.200	0.146	0.203	0.115	0.095	0.096	0.096	0.489	1.049	0.109	0.084	0.099	0.099
	Mountains - High income	16	0.034	0.007	0.008	0.026	0.021	0.019	0.028	0.020	0.019	0.015	0.016	0.065	0.066	0.025	0.053	1.022	0.011	0.015	0.014
	Mountains - Low income	17	0.018	0.002	0.003	0.005	0.003	0.005	0.005	0.005	0.005	0.005	0.007	0.008	0.053	0.002	0.004	0.021	1.028	0.007	0.005
	Other - High income	18	0.465	0.128	0.132	0.524	0.377	0.362	0.533	0.388	0.393	0.368	1.190	1.139	0.887	0.265	0.568	0.259	0.198	1.247	0.262
	Other - Low income	19	0.084	0.010	0.015	0.024	0.014	0.024	0.025	0.024	0.022	0.022	0.031	0.033	0.254	0.008	0.016	0.039	0.018	0.032	1.034
	SUMMARY																				
	Total intra-country production multipliers		3.026	1.456	1.905	4.136	2.204	4.382	3.500	3.035	2.602	1.815									
	Own sector intra-country multipliers		2.033	1.142	1.498	2.291	1.489	2.586	1.828	1.739	1.858	1.919									
	Linkages with other sectors		1.120	0.346	0.474	1.955	0.785	1.908	1.788	1.396	0.826	1.815									
	Induced households income		0.800	0.194	0.215	0.811	0.686	0.547	0.791	0.583	0.641	0.525									
SOUTH AFRICA																					
	Production																				
	Agriculture	20	0.367	0.084	0.141	0.102	0.054	0.124	0.108	0.105	0.084	0.110	0.150	0.151	0.147	0.041	0.075	0.170	0.108	0.151	0.141
	Mining and quarrying	21	0.030	0.764	0.047	0.029	0.014	0.050	0.029	0.032	0.023	0.034	0.036	0.036	0.036	0.010	0.018	0.037	0.028	0.036	0.037
	Manufacturing	22	0.916	0.819	1.536	0.881	0.424	1.204	0.908	0.973	0.720	1.029	1.145	1.149	1.144	0.319	0.564	1.189	0.907	1.144	1.173
	Electricity	23	0.041	0.094	0.062	0.038	0.017	0.045	0.036	0.047	0.038	0.045	0.044	0.044	0.044	0.014	0.021	0.044	0.035	0.042	0.044
	Water	24	0.014	0.026	0.015	0.011	0.007	0.013	0.011	0.015	0.014	0.015	0.014	0.014	0.014	0.004	0.006	0.014	0.011	0.013	0.014
	Construction	25	0.011	0.026	0.013	0.010	0.005	0.012	0.010	0.014	0.017	0.015	0.012	0.012	0.012	0.004	0.006	0.012	0.010	0.011	0.012
	Trade and accommodation	26	0.226	0.338	0.285	0.192	0.096	0.244	0.203	0.267	0.221	0.267	0.245	0.246	0.245	0.077	0.115	0.243	0.194	0.233	0.249
	Transport and communication	27	0.175	0.344	0.207	0.151	0.074	0.187	0.171	0.527	0.169	0.204	0.189	0.190	0.190	0.060	0.089	0.187	0.148	0.180	0.196
	Real estate, business & financial services	28	0.317	0.440	0.376	0.340	0.144	0.379	0.364	0.400	0.900	0.480	0.361	0.362	0.369	0.114	0.169	0.377	0.359	0.340	0.387
	Government, domestic & other community services	29	0.100	0.151	0.124	0.088	0.046	0.110	0.092	0.107	0.093	0.284	0.120	0.120	0.126	0.036	0.056	0.109	0.101	0.115	0.152
	Factors																				
	Skilled	30	0.084	0.136	0.108	0.083	0.041	0.099	0.086	0.107	0.117	0.146	0.134	0.097	0.099	0.029	0.046	0.096	0.083	0.093	0.108
	Semi-skilled	31	0.044	0.064	0.052	0.043	0.022	0.051	0.048	0.058	0.057	0.054	0.047	0.085	0.047	0.014	0.022	0.048	0.039	0.045	0.049
	Unskilled	32	0.110	0.206	0.122	0.079	0.039	0.104	0.083	0.117	0.078	0.099	0.102	0.102	0.130	0.029	0.049	0.106	0.080	0.100	0.104
	GOS	33	0.329	0.475	0.335	0.272	0.158	0.312	0.280	0.354	0.379	0.326	0.299	0.301	0.301	0.173	0.144	0.312	0.252	0.292	0.309
	Institution																				
	Enterprises	34	0.194	0.280	0.197	0.161	0.093	0.184	0.165	0.209	0.223	0.192	0.177	0.177	0.178	0.102	0.085	0.184	0.149	0.172	0.183
	High income	35	0.306	0.494	0.347	0.262	0.136	0.314	0.273	0.352	0.337	0.361	0.339	0.336	0.330	0.116	0.146	0.311	0.253	0.296	0.320
	Low income	36	0.087	0.137	0.094	0.072	0.039	0.086	0.075	0.097	0.093	0.091	0.086	0.090	0.089	0.037	0.040	0.086	0.068	0.081	0.086
	SUMMARY																				
	Total inter-country production multipliers		2.197	3.084	2.796	1.841	0.881	2.368	1.933	2.486	2.279	2.482									
	Own sector Inter-country multipliers		0.37	0.76	1.54	0.04	1.54	0.01	0.20	0.53	0.90	0.28									
	Linkages with other sectors		1.83	2.32	1.26	1.80	0.87	2.36	1.73	1.96	1.38	2.20									
	Induced households income		0.09	0.14	0.09	0.07	0.04	0.09	0.08	0.10	0.09	0.09									

APPENDIX H continued

			SOUTH AFRICA																
			Production										Factors				Institutions		
			Agriculture	Mining and quarrying	Manufacturing	Electricity	Water	Construction	Trade and accommodation	Transport and communication	Real estate, business & financial services	Government, domestic & other community services	Skilled	Semi-skilled	Unskilled	GOS	Enterprises	High income	Low income
LESOTHO			20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	Production																		
	Agriculture	1	0.002	0.002	0.001	0.002	0.004	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.005	0.001	0.001	0.001	0.001
	Mining and quarrying	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Manufacturing	3	0.004	0.004	0.004	0.004	0.011	0.005	0.005	0.005	0.003	0.004	0.005	0.005	0.012	0.002	0.003	0.003	0.004
	Electricity	4	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Water	5	0.000	0.000	0.000	0.001	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
	Construction	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Trade and accommodation	7	0.001	0.002	0.001	0.001	0.003	0.002	0.004	0.002	0.001	0.002	0.002	0.002	0.003	0.001	0.001	0.001	0.002
	Transport and communication	8	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.002	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.001
	Real estate, business & financial services	9	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.000	0.000	0.001	0.001
	Government, domestic & other community services	10	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.000	0.001	0.001	0.001
	Factors																		
	Skilled	11	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.000	0.000	0.001	0.001
	Semi skilled	12	0.001	0.001	0.000	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.000	0.000	0.001	0.001
	Unskilled	13	0.003	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.001	0.002	0.002	0.002	0.011	0.001	0.001	0.002	0.002
	GOS	14	0.002	0.001	0.001	0.002	0.013	0.001	0.002	0.002	0.001	0.001	0.002	0.002	0.003	0.001	0.001	0.001	0.001
	Institutions																		
	Enterprises	15	0.001	0.001	0.000	0.001	0.006	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001
	Basotho - High income	16	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
	Basotho - Low income	17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
	Other - High income	18	0.003	0.004	0.002	0.003	0.010	0.004	0.004	0.004	0.003	0.004	0.005	0.005	0.010	0.001	0.002	0.002	0.003
	Other - Low income	19	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
	SUMMARY																		
	Total intra-country production multipliers		**0.010**	**0.010**	**0.008**	**0.010**	**0.053**	**0.010**	**0.014**	**0.012**	**0.007**	**0.010**							
	Own sector intra-country multipliers		**0.002**	**0.000**	**0.004**	**0.000**	**0.031**	**0.000**	**0.004**	**0.002**	**0.001**	**0.001**							
	Linkages with other sectors		**0.008**	**0.011**	**0.005**	**0.010**	**0.010**	**0.011**	**0.011**	**0.011**	**0.007**	**0.010**							
	Induced households income		**0.004**	**0.005**	**0.003**	**0.004**	**0.012**	**0.005**	**0.005**	**0.005**	**0.003**	**0.004**							
SOUTH AFRICA																			
	Production																		
	Agriculture	20	1.899	0.103	0.165	0.101	0.098	0.140	0.116	0.112	0.101	0.130	0.150	0.156	0.157	0.075	0.126	0.147	0.199
	Mining and quarrying	21	0.041	1.230	0.068	0.168	0.056	0.084	0.038	0.040	0.033	0.044	0.045	0.046	0.046	0.021	0.036	0.044	0.053
	Manufacturing	22	1.162	1.059	2.395	0.965	0.993	1.442	1.139	1.160	1.000	1.338	1.379	1.409	1.419	0.661	1.120	1.366	1.635
	Electricity	23	0.082	0.141	0.078	2.054	0.100	0.111	0.097	0.102	0.077	0.094	0.106	0.106	0.106	0.049	0.083	0.106	0.110
	Water	24	0.035	0.038	0.022	0.060	3.280	0.031	0.035	0.036	0.033	0.036	0.037	0.037	0.037	0.017	0.028	0.037	0.037
	Construction	25	0.026	0.040	0.018	0.093	0.022	2.313	0.047	0.033	0.048	0.043	0.028	0.028	0.028	0.013	0.021	0.028	0.028
	Trade and accommodation	26	0.467	0.488	0.420	0.445	0.460	0.541	2.408	0.611	0.464	0.702	0.592	0.603	0.606	0.282	0.478	0.589	0.685
	Transport and communication	27	0.374	0.504	0.296	0.366	0.462	0.421	0.441	2.341	0.343	0.387	0.440	0.452	0.454	0.213	0.362	0.435	0.540
	Real estate, business & financial services	28	0.578	0.625	0.515	0.657	0.696	0.767	0.940	0.781	2.920	0.901	0.942	0.928	0.929	0.416	0.705	0.955	0.826
	Government, domestic & other community services	29	0.162	0.216	0.176	0.166	0.155	0.187	0.178	0.184	0.171	1.948	0.265	0.262	0.262	0.118	0.200	0.267	0.242
	Factors																		
	Skilled	30	0.152	0.196	0.155	0.194	0.172	0.212	0.243	0.226	0.279	0.685	1.194	0.194	0.195	0.089	0.151	0.195	0.196
	Semi-skilled	31	0.077	0.090	0.074	0.094	0.087	0.097	0.206	0.131	0.136	0.125	0.094	1.095	0.095	0.044	0.074	0.094	0.101
	Unskilled	32	0.247	0.309	0.179	0.283	0.215	0.306	0.206	0.283	0.140	0.178	0.156	0.159	1.160	0.074	0.126	0.155	0.181
	GOS	33	0.764	0.688	0.469	0.907	0.922	0.640	0.788	0.794	0.881	0.618	0.544	0.548	0.551	1.253	0.428	0.544	0.579
	Institution																		
	Enterprises	34	0.451	0.406	0.277	0.535	0.544	0.378	0.465	0.468	0.520	0.365	0.321	0.323	0.325	0.739	1.253	0.321	0.342
	High income	35	0.643	0.720	0.497	0.768	0.692	0.724	0.807	0.794	0.758	0.984	1.486	1.377	1.370	0.568	0.962	1.557	0.592
	Low income	36	0.193	0.199	0.134	0.228	0.214	0.194	0.220	0.220	0.210	0.199	0.224	0.339	0.360	0.221	0.375	0.158	1.181
	SUMMARY																		
	Total inter-country production multipliers		**4.825**	**4.444**	**4.153**	**5.075**	**6.324**	**6.037**	**5.440**	**5.400**	**5.189**	**5.623**							
	Own sector Inter-country multipliers		**1.899**	**1.230**	**2.395**	**2.054**	**3.280**	**2.313**	**2.408**	**2.341**	**2.920**	**1.948**							
	Linkages with other sectors		**2.927**	**3.214**	**1.758**	**3.021**	**3.043**	**3.724**	**3.032**	**3.059**	**2.269**	**3.675**							
	Induced households income		**0.836**	**0.920**	**0.630**	**0.996**	**0.905**	**0.918**	**1.027**	**1.014**	**0.968**	**1.182**							