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_c)	Transfers (Tr_{cR})		Enterprise income (TE)
Households	5			Wages (F)	Distributed profits (DP)		Transfers (Tr_h)		Foreign remittances (Tr_{hR})	Household income (TH)
Exogenous accounts Govern t.	6	Indirect taxes (T_A)	Tariffs (T)		Company taxes (T_c)	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 abroad (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:

$$\begin{aligned} TD_i &= X_i + C_i + G_i + I_i + M_{ij} + E_{iR} \\ Tsup_i &= Y_i + TC_i + M_{ji} + M_{Ri} \\ TD_i &= Tsup_i \end{aligned} \qquad (2)$$

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:

$$\begin{aligned} TFY_i &= W_i + Wg_i + W_{ij} + W_{iR} \\ TFE_i &= F_i + TF_i + CC_i \\ TFY_i &= TFE_i \end{aligned} \qquad (3)$$

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:

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

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

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

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

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

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).

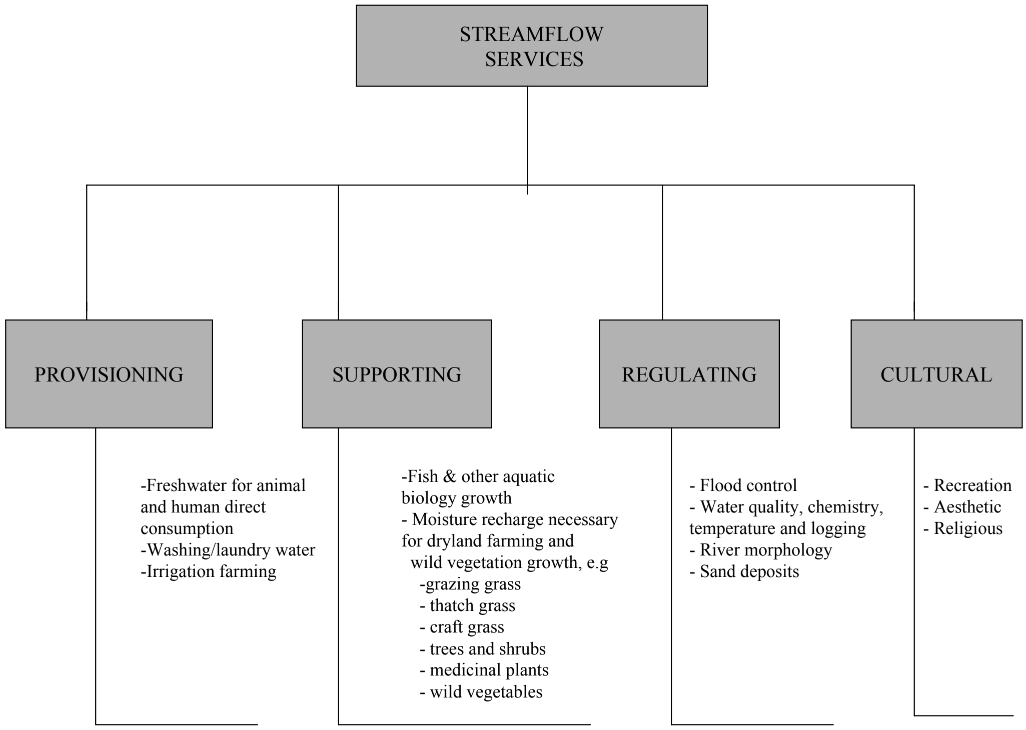
5.3 Streamflow service values associated with the LHWP

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.

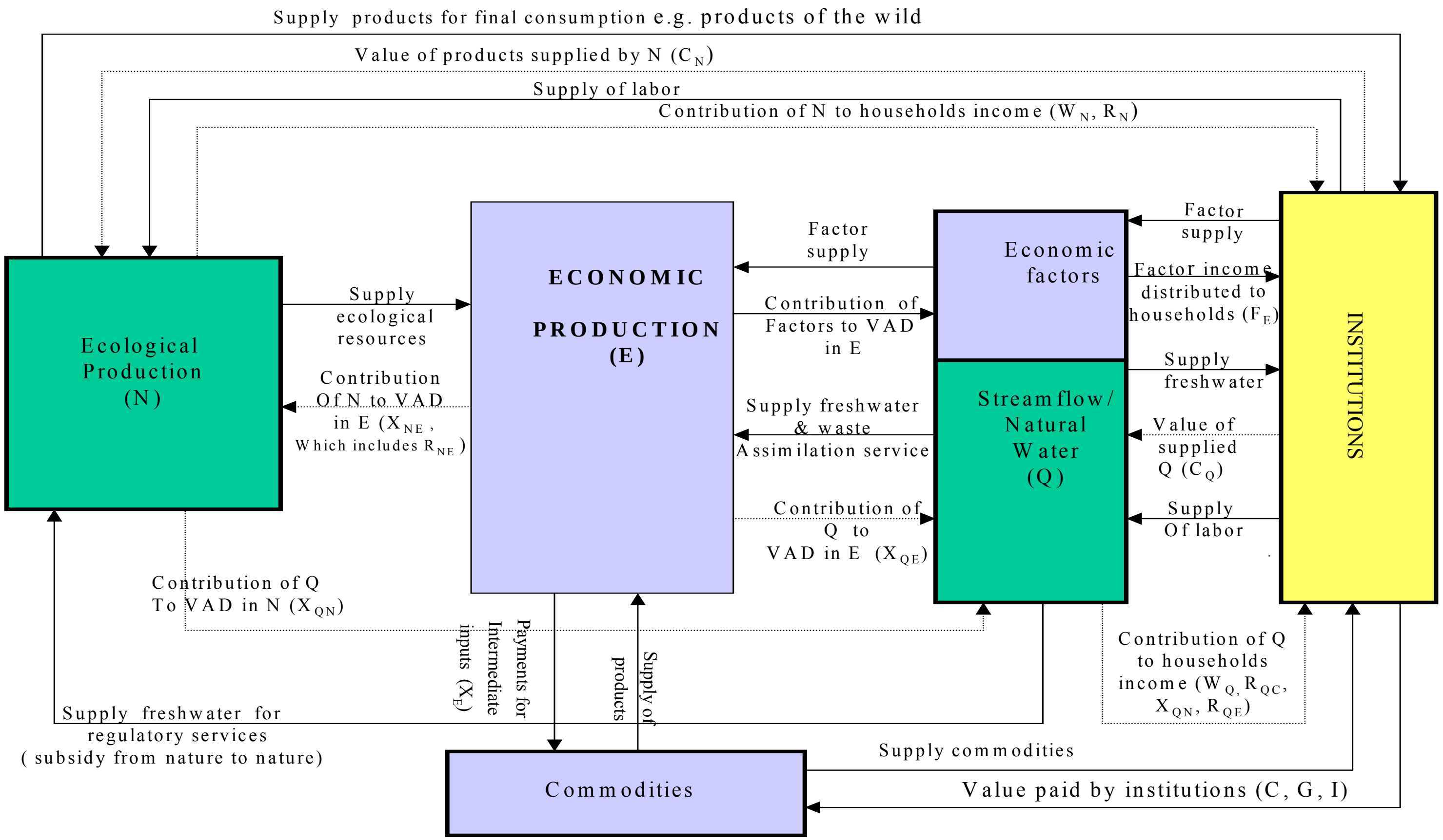
5.4 Economic-ecological model of streamflow benefits

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}):

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

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:

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

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

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

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:

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

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

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.

$$C_Q = W_Q + R_{QC} \quad \text{(Note that } Y_Q = C_Q + X_{QN} + X_{QE})^{12} \qquad (14)$$

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

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[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,

[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)

													ecological System		
						Socio-economic 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

$$EGDP = GDP + TY_N + TY_Q \quad (21)$$

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,

$$TY_N = X_{NE} + C_N \quad (22)$$

$$TE_N = W_N + R_N + X_{QN} \quad (23)$$

$$TY_N = TE_N \quad (24)$$

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,

$$TY_Q = X_{QEW} + X_{QEE} + C_Q + X_{QN} \quad (25)$$

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

[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.

$$TY_Q = TE_Q \qquad (27)$$

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

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

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

$$ETHE = THE + C_N + C_Q \qquad (29)$$

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

$$EDP = DP - V_Q \qquad (33)$$

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.

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[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)

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

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)

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

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):

$$TY_N = X_{NE} + C_N$$
$$TE_N = W_N + R_N + X_{QN} \quad (39)$$
$$TY_N = TE_N$$

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):

$$TY_Q = X_{QEW} + X_{QEE} + C_Q + X_{QN}$$
$$TE_Q = Z_W + Z_E + W_Q + R_{QC} + X_{QN} + R_{QE} \quad (40)$$
$$TY_Q = TE_Q$$

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)

$$dEY = EM_2M_1dF \tag{41}$$

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

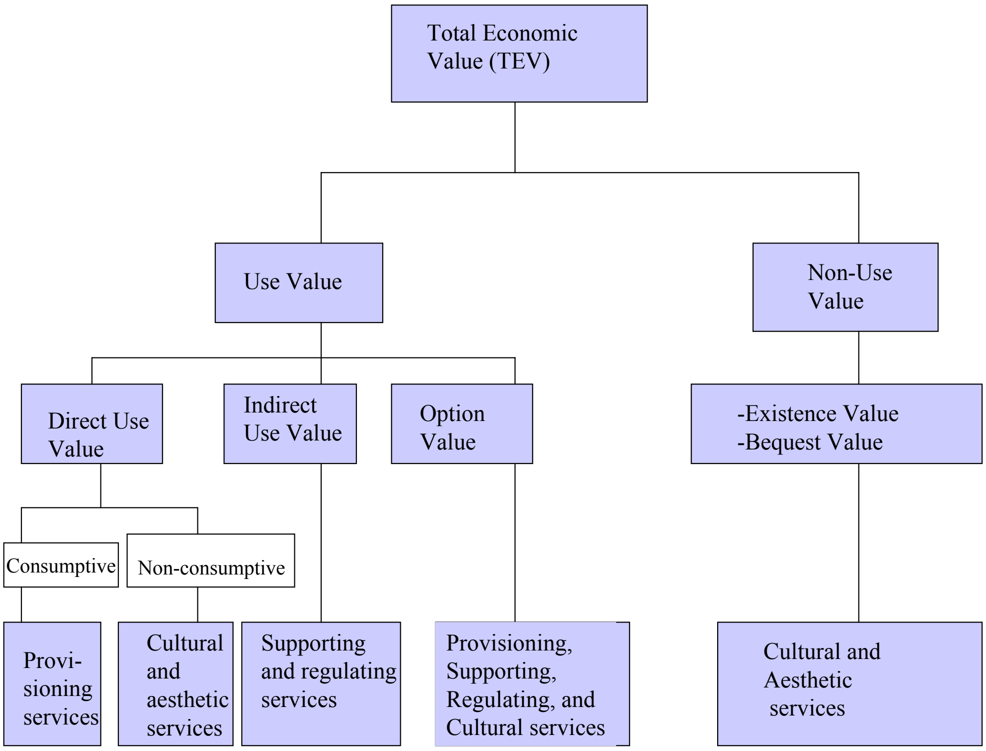
Valuation of ecological systems and the services they provide is premised on two distinct, but complementary valuation paradigms: anthropocentric and ecocentric paradigms. The anthropocentric valuation paradigm, also known as the utilitarian approach, has its foundation in neoclassical welfare economics. 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

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

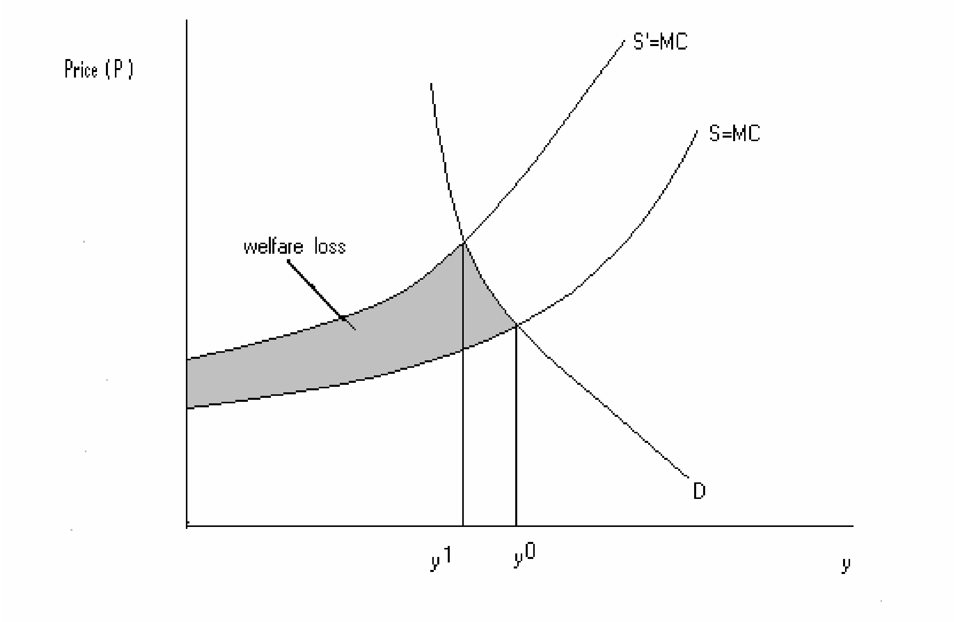
Where y is production of medicinal plants, and the marginal product of q is positive.

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



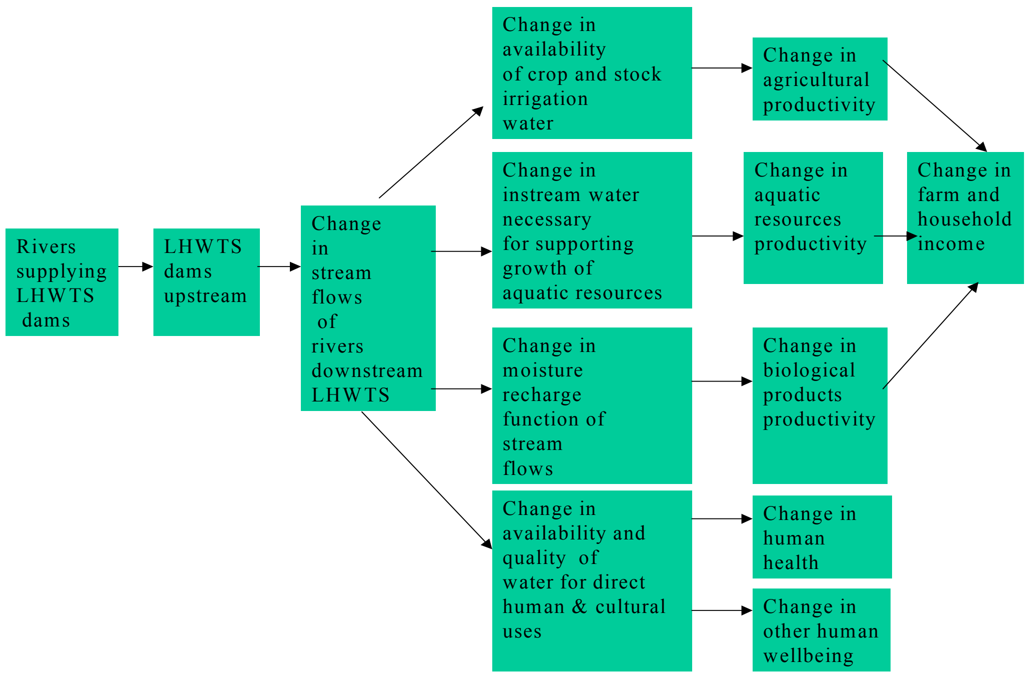
Source: Freeman (1993).

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:

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

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 (1)	Latin name/description (2)	Impact (+/-) (3)	Onset period (years) (4)	Impact value (W_{q_i}) (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).