Managing water to reduce poverty: water and livelihood linkages in a rural South African context

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1 Introduction

Since the Mar del Plata water conference in 1977 increasingly frequent water-related conferences have taken place globally that have developed a 'water crisis' narrative. The 'crisis' narrative lays the blame for the world's water predicament at the door of poor governance or resource mismanagement (WWAP 2003). However, this insight is hardly new given that it was identified at Mar del Plata 25 years ago (Biswas 2002). The rhetoric of sustainability, equity and efficiency underpin much of this water policy documentation though little is said on how to address the operationalization of such policy, successes to date or, and more critically, evidence from the poor in relation to how their livelihood strategies are constrained by water access and availability. Access to water for both domestic and productive purposes would be a very real and tangible benefit for the poor, in fact any human being, but the reality of developing economies and global funding agencies indicate that resources (financial, economic, human) are limited. Thus, choices need to be made that address specific problems: water resource management or poverty reduction. It is here posited that good water resource management does not equate with poverty reduction though there are strong linkages (particularly in the areas of health and food). This paper attempts to look at some of the linkages between water, livelihoods and poverty in relation to the global water crisis narrative using evidence from current research in South Africa.

The paper introduces the linkages between water and poverty, and provides the context for this research in section 2. The relationship between water and natural resource harvesting is discussed in relation to 'blue' and 'green' water, the 'hidden harvest' approach and valuation of non-market natural resources in section 3. How the livelihoods of rural people are related to water-dependent natural resource harvesting is illustrated in section 4 both in the context of the research catchment and the wider southern African region. Section 5 concludes with an analysis and discussion of the findings.

2 Water and poverty

The World Water Development Report (WWAP, 2003) states that "giving the poor better access to better managed water can make a big contribution to poverty eradication". Further, it is asserted that "poverty…is both a symptom and cause of the water crisis." Evidence for these statements emerges in sections on basic needs (symptom) and on a growing population's impact on ecosystem integrity and food demand (cause). Whilst the relationship between the poor and natural resources is intimately related by need, opportunity and availability this does not necessarily lead to unsustainable outcomes (Meach and Learns, 1996; Benhke and Abel, 1996). Further, it would be disingenuous to suggest the world's poor have anything but a proportionately minimal impact on water resources in comparison with the consumption patterns of the wealthy. For example, domestic water consumption by income profile and location reveals significant disparities across the world and within countries, which clearly identify the major water consumers as citizens in more industrialised countries or urban settings (Thompson et al., 2001; Gleick, 1996).

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NB: data tables for the analysis are available upon request.

Within the global 'water crisis' narrative is the asserted linkage between water and poverty. Two areas dominate this water-poverty relationship: health and food. Clearly, a healthy well-fed person is likely to be happier and fitter than someone suffering from water-related morbidity[2] who is hungry. Strategies to overcome these challenges are formulated within global development targets such as the Millennium Development Goals of halving the 1.1 billion without access to safe drinking water and halving the proportion of people suffering from hunger. But does this global prognosis truly reflect the causes (not symptoms) of the poor and constitute the best way to tackle poverty? Perhaps, poverty is such a multi-faceted and complex phenomenon moderated by social, economic, political, climatic etc conditions that it is simpler to evolve a sectoral strategy that broadly tackles the determinants of poverty? Water is an obvious entrée into this debacle.

Water is available in many guises. In a developing world context, water resources are accessed within a variable precipitation regime, a seasonal flow regime (rivers, streams), groundwater sources and, if you're lucky, in an improved water supply (reticulation). So, there are spatial, temporal and institutional dimensions to water availability. But deconstructing availability leads to issues of access to and use of the resource. Here, social and cultural issues are brought to the fore in terms of who gets what, who decides and how these processes occur. We have moved from a simple global solution to micro-level community and intra-household allocation mechanisms that determine actual outcomes for individuals and families. Do these linkages work both forward as well as backward? For example, if we analyse livelihoods in a catchment and the water use of the people living there can we confidently state that by providing more water (which form and when?) poverty will be reduced? Understanding what constitutes poverty is a first step in this process.

2.1 Poverty

Globally, there are an estimated 1.2 billion people who live on less than US$1 per day, the highest proportion living in Sub-Saharan Africa (SSA) where this incidence of poverty has risen from 18% in 1987 to 24% in 1998 (Chen and Ravallion, 2000). Whilst the widely toted 'dollar per day' marker is still used in poverty analysis the techniques employed have evolved into a broader church than purely income or consumption indicators of well-being. Poverty profiles are constructed to determine who is poor, the determinants of poverty are sought to know why they are poor, and, finally, interventions are considered against what if scenarios based on the preliminary studies.

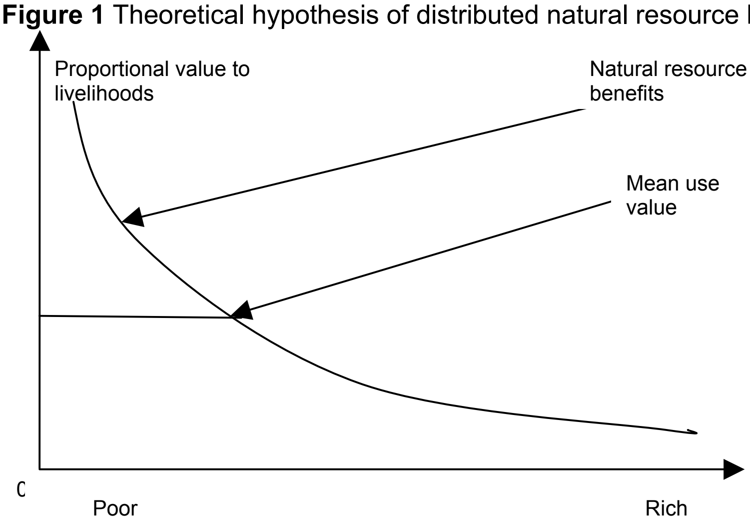
Poverty methodologies may focus on income or consumption measures, food intake measurements (calories per day), basic needs requirements or relative deprivation indicators based on racial, gender, ethnic or geographic groupings. The variety of methodologies available is indicative of the distribution and range of poverty across the world. The increased interest in water as a key determinant in poverty has led to the development of crude, aggregated water scarcity indicators (see Gleick et al., 2002 for a discussion) including a Water Poverty Indicator (WPI) (Sullivan, 2001). The latter asserts that "where there is 'water poverty', any measures to reduce income poverty are unlikely to be successful." Whilst little concrete evidence is offered for this assertion, the WPI grapples with linking water and poverty under this hypothesis. Water availability, access to safe water, clean sanitation and water collection time are variables considered in the analysis. The WPI does not include global cereal production yet in 1995 58% of production was derived from rainfed production (Rosegrant et al., 2003), which represents a considerable source of expenditure-saving and income-generation for the poor; other activities not included are the value of livestock and their significant levels of water use, the very real issues of cost recovery and targeted subsidies in water provision, etc. Though, Sullivan acknowledges the significant challenges and role of water quality in her 'water poverty gap' there

[2] Such as water-borne diseases (e.g. gastro-intestinal or diarrhoea), vector-borne (e.g. malaria, schistosomiasis) or water-washed diseases (e.g. scabies, trachoma).

appears little reason to believe that any one index[3] will ever fully grasp the multiple impacts of water on poverty, or better-said development[4]. This may not be the principal aim of the WPI yet the rationale behind developing a measure that reputedly reports on 'water poverty' from aggregate data yet does not adequately capture the locally-derived dimensions and determinants of poverty is questioned in terms of its likely impact on poverty reduction.

The point of departure here is that poor rural livelihoods are constrained by their access to and use of natural resources, which are often water dependent. It is therefore only possible to determine the role of water in poverty reduction given a sufficient understanding of those activities that are moderated by water availability. The hypothesis proposed suggests that the poor gain a proportionately higher value from natural resource harvesting and use than groups with access to other forms of production (formal labour, remittances, pension etc) (figure 1).

Figure 1 Theoretical hypothesis of distributed natural resource benefits to livelihood groups



2.2 Luvuvhu catchment, South Africa

South Africa (RSA) is a middle-income country in a challenging period of political, social and economic transformation. RSA is defined as water scarce due to a mean annual precipitation (MAP) regime below 500 mm/pa and is categorised as approaching absolute water scarcity by 2020-2030 (Seckler, 1999). The historical context has sculptured a landscape with a polarised distribution of natural and social resources configured along both racial, gender and geographic lines (Aliber, 2001; Carter and May, 1999; StatsSA, 1999). Income poverty in South Africa is concentrated in rural areas encompassing 31.4% of the population (StatsSA, 1999). The majority of the South Africa rural poor rely on subsistence agriculture (93%) with only 3% of the reported 1.2 million maize farmers selling their produce. Further indication of the importance of natural resources to rural livelihoods is the citation of water (domestic and productive) as the most needed assistance (34.5%), followed by finance (24.9%) and land (21.8%). In Limpopo province, as in the other 8 South African provinces, drought was reported as the main reason for crop failure (64.2%).

Limpopo Province (LP, formerly Northern Province) is one of the poorest provinces across a range of poverty indicators (table 1). The Luvuvhu catchment was chosen for the project due to

[3] The epistemological tradition of positivist or universal interpretations of knowledge and truth underpin much mainstream economic thinking whilst the intrepretivist or subjective understanding is more common to sociological and anthropological inquiry.
[4] The UN's Human Development Index is probably the best example of an index measurement but is characterised by not calling itself a 'poverty' measure and its reliance on multi-sectoral data (health, education, income, water etc).

the high-level of poverty in the province, the existing lack of analysis into the determinants of poverty, and the location of the former Venda homeland.

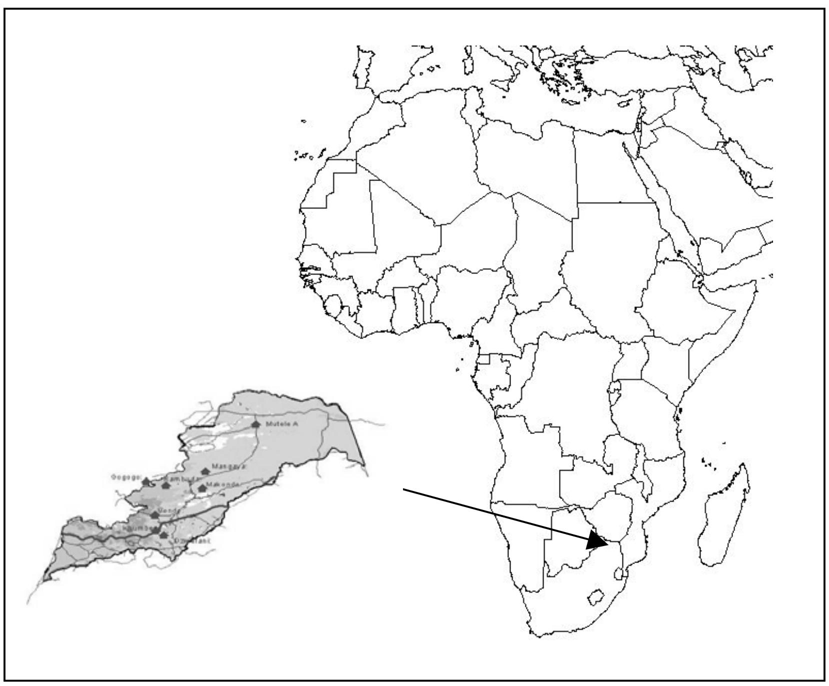
Table 1 Poverty profile of South African provinces

Province/ Poverty indicator	Poverty Rate (%)	Africans (%)	Tap inside (%)	Public tap (%)	No access to sanitation (%)
Limpopo Province	59.1	96.7	17.3	40.4	21
Eastern Cape	70.7	86.5	24.6	18.5	28.9
Free State	63.4	8.5	40.1	23.9	8.8
Gauteng	17.3	error	66.7	11.4	2.5
KwaZulu-Natal	51.9	81.8	39.1	18.4	15.1
Mpumalanga	57.3	89.2	36.4	20.1	8.6
Northern Cape	54.9	33.2	49.7	8.4	10.6
North West	62.1	91.2	29.5	31.5	6.4
Western Cape	28	20.9	75.4	7.7	5.4

Source: StatsSA

The Luvuvhu catchment covers 5,940 km² and forms part of the larger Limpopo river system (figure 2). The catchment is characterised by the Soutpansberg range (>1,500 ABSL) falling from the south-west to the north-east. In the upper, western reaches of the range, the precipitation regime (>1,000mm/pa) is higher, which is reflected by commercial forestry plantations (pine, blue gum) and large-scale irrigated agriculture (>100 hectares). Thohoyandou is the main urban settlement contributing significantly to the estimated catchment population of 606,767 people. The north-eastern section of the catchment is marked by lower rainfall and fragmented, rural communities that lead to the border of the Kruger National Park where the Luvuvhu river finally drains into the Limpopo at the Zimbabwe-Mozambique border.

Figure 2 Location of the Luvuvhu catchment



In January 2002, a purposive, random sample of 552 households was conducted in the Luvuvhu catchment. The objective of the survey was to better understand the linkages between water and poverty amongst a representative sample of the research catchment population. Three water variables determined the purposive component of the sampling strategy. They were a rainfall threshold (< or > 700mm/pa), a reticulated supply threshold, and irrigation infrastructure (table 2).

Table 2 Factorial sampling frame with random community selection

	Irrigation scheme (IS)		No irrigation scheme (NIS)	
	Reticulated supply good (need ≤50%)	Reticulated supply poor (need ≥75%)	Reticulated supply good (need ≤50%	Reticulated supply poor (need ≥75%)
<700mm	Makonde	Dzwerani	Mangaya	Mutele A
>700mm	Rambuda	Khumbe	Vondo	Gogogo

The survey was structured to elicit basic demographics at the household (HH) scale (size of HH, gender, age, education level, income, and employment of HH members); HH basic assets (water supply, fuel source, livestock, land); HH use of water resources for differing purposes (cooking/drinking, bathing/washing and laundry), and productive uses specifically related to agricultural production (kitchen-garden, orchard, dryland and irrigated production).

A literature review suggested that identifying a range of disaggregated social groups that conformed to the prevailing social structures might be the most appropriate strategy for understanding poverty-water linkages along with standard income quintiles. Households were categorised according to four nominal head criteria:

- Home husband (male head at home permanently);
- Migrant husband (wage-earning male head, home at least once per month and/or holidays);
- Female-headed (husband permanently absent, widow, divorcee or single female);
- Pension (one or more state pension recipients).

Complementing the quantitative research, qualitative inquiry was conducted between September 2002 and January 2003 in the communities (figure 3). Participatory methods such as semi-structured interviews, time-lines, seasonal diagrams, participant observation, focus groups, transect walks and key informant interviews added greater texture and depth, and filled gaps in the survey data.

Figure 3 Sampled communities in the Luvuvhu catchment

Summary un-weighted findings from the survey for social cohort and income quintiles are presented in tables 3 and 4.

Table 3 Household demographic characteristics by social cohorts

Household characteristics	Home husband	Migrant husband	Female-headed	Pension
Number of HHs in population	176 (32%)	94 (17%)	99 (18%)	183 (33%)
Average HH size	5.80	6.21	5.29	5.93
% HHs with private water tap	23	29	23	35
% HHs further than 200m to nearest water	50	60	54	56
% HHs with electricity	67	62	61	63
% HHs with pit latrine	72	70	64	73

Demographic data for the social cohorts indicate an average household size of 6 people with a range of 1-19. Improved water supply provision is poor and compounded by reliability problems exacerbated by the floods in 2000. Further, the majority of households report distance to water supplies greater than 200m, which is the maximum haulage distance stipulated in the Reconstruction and Development Programme following the new dispensation in 1994.

Table 4 Household demographic characteristics by income quintiles

Household characteristics	Bottom	40%	60%	80%	Top
Number of HHs in population	113 (20%)	117 (21%)	101 (18%)	111 (20%)	110 (20%)
Average HH size	5.25	5.04	6.00	6.32	6.59
% HHs with private water tap	19	26	17	37	41
% HHs further than 200m to nearest water	52	56	53	47	43
% HHs with electricity	63	58	58	61	77
% HHs with pit latrine	59	72	61	75	85

Income disaggregation reveals a clearer pattern in household size linked to wealth. Improved water provision is also positively associated with wealth. Informants report connection fees created a financial disincentive for poorer families to apply in conjunction with the administrative requirements. Distance to water source falls with wealth. Basic amenities such as electricity and ventilated improved latrines (VIPs) are disproportionately distributed to wealthier households.

Descriptive analysis of the distributed frequencies of household assets by social cohorts record the higher education attainment of male-headed households (table 5). Migrant husbands logically dominate access to full-time, formal employment with Home husbands and Female-headed households more reliant on part-time employment (seasonal agriculture, construction etc). Mean dryland field size ranges from 1 hectare (Female-headed) to 1.44 (Migrant husband and Pension). Kitchen gardens are an almost universal livelihood activity. Cattle data is slightly misleading as the data represent the mean across the cohort and not by owner household. Nevertheless, Female-headed households herd significantly lower numbers than the other three cohorts. Goat herds reflect a similar profile to the cattle data.

Table 5 Household asset characteristics by social cohorts

Household characteristics	Home husband	Migrant husband	Female-headed	Pension
Adult education equivalent score*	0.73	0.74	0.70	0.55
Mean full-time wages	0.53	0.89	0.43	0.28
Mean part-time wages	0.45	0.23	0.38	0.25
Mean number of pensions	0	0	0	1.17
Mean dryland area(Ha)	1.18	1.44	1.00	1.44
% HHs with kitchen gardens	90	91	89	93
Mean cattle herd size	1.48	1.41	0.60	1.51
Mean goat herd size	0.76	0.71	0.26	0.66

* calculated by sum of all adults with Grade 5 or above divided by total adults.

3 Water and natural resource harvesting

This section will discuss three inter-related trains of inquiry into the role of water in rural livelihoods and poverty. First, a hydrological perspective will be taken on how water is consumed within a catchment. The concept of blue and green water will be introduced as a useful framework for understanding water consumption and the distribution of that consumption by different livelihood groups. Second, natural resource harvesting methods will illustrate the contribution of the ‘hidden harvest’ approach to rural livelihoods. Third, a summary of natural resource economic evaluation will highlight methodological strengths and weaknesses in the research.

3.1 Is water blue or green?

Until recently water resource debates focused on water in the singular. Falkenmark (1995) highlighted that hydrologists consider water in various states or conditions, which have significant implications for land use and food security. Applying a simplistic categorisation, water can be blue (runoff, river water, groundwater etc) or green (transpiration from vegetation). Now, whilst to non-hydrologists this might appear pedantic its application to the livelihoods of the poor dependent on natural resources is critical. Globally, approximately 60% of food production depends on precipitation (i.e. green water); further, meat production from grazing on rangeland (fodder), woodfuel for energy, commercial forestry and many other rainfed products and services depend on green water (Savenije, 1998). In Africa, livelihood security and food security is significantly inter-related with the spatial and temporal variability of the precipitation regime, particularly in the northern and southern arid and semi-arid regions. Yet, the crucial role rainfall plays in the seasonal variation in the livelihood outcomes of the poor often appears to be lost in the wider debate of poverty and water resource management.

3.2 The ‘Hidden Harvest’

The rural poor harvest an extensive variety of food, energy, shelter, clothing, maintenance and social goods and services from their neighbouring environment (Scoones et al., 1992). This harvest has been called the ‘hidden harvest’ (IIED, 1997), to which green water is the most important input given adequate and equitable access and use rights. Due to the non-market values associated with the bulk of these ‘hidden’ goods and services there can be inadequate assessment of the significant contribution this harvest makes to the poor, particularly those without access to formal employment. Accordingly, national accounting ignores these values as they do not fall within standard economic processes and, more importantly, government may not create an institutional environment that adequately protects poor people’s access to (land tenure) and use of (social equity) these ‘green water’ resources. Whilst they may not be valued by national policy or legislation local people are more than aware of their economic and livelihood significance over the seasons and local institutions will regulate access and use rights that may not be compatible with wider national objectives of equity or poverty reduction, for example, the level of access and use of the natural resource base by women, youth and the elderly.

In South Africa, a number of recent studies have attempted to value the goods and services derived from rangeland or the natural resource base (Shackleton et al., 2001; High and Shackleton, 2000; Crookes et al., 2000; Shackleton et al., 1999a; Shackleton et al., 1999b). The methodologies are rooted in the ‘hidden harvest’ approach, which attempt to synthesise and exploit qualitative and quantitative research techniques (IIED, 1997). Due to the substantial technical difficulties of assessing goods and services that have no market value innovative techniques have been developed that at least provide some proxy or quasi-measure of the resource value. Some studies have provided only partial analyses due to the ‘heroic’ assumptions that would have had to be have made in order to provide a more rigorous valuation. As such, there are clear weaknesses in these incomplete analyses, which the authors acknowledge. Most notably, valuing the opportunity cost of labour has presented one of the most intractable problems with a percentage of the gross economic value of resource being used as a suitable proxy by those studies that attempt to account for time expended in harvesting (Crookes et al., 2000). Further, disaggregating the data by social groups in the research communities has not been attempted. This aggregate valuation allows no analysis of which social cohort benefits or not from particularly resources and the damage that this activity may make on the sustainability of the harvesting regime. Valuations derived from these studies are presented in table 6.

Table 6 Hidden harvest household valuation studies in Limpopo province, South Africa

		Valuation technique	Resource	Value (2000) (Rands/pa)
Community	Bushbuckridge[1]	GEV	Woodland	2217.85
	Ha-Gondo[2]	GEV	Woodland	3951.95
	Mogano[2]	GEV	Woodland	7903.89
	Bushbuckridge[3]	NEV	Cattle & Goat	1562.87
	Manganeng[4]	NEV	Cattle	431.89
	Makua[5]	NEV	Cattle	333.07
	Manganeng[4]	NEV	Crop	1057.59
	Makua[5]	NEV	Crop	1457.24
	Manganeng[4]	NEV	NEWP	317.34
	Makua[5]	NEV	NEWP	1327.93
	Manganeng[4]	NEV	EWP	-476.23
	Makua[5]	NEV	EWP	220.06
	Dingleydale[6]	GEV	Kitchen garden	1694

Legend: GEV: Gross economic valuation; NEV: Net economic valuation; NEWP: Non-edible woodland products; EWP: Edible woodland products.
Sources: 1: Shackleton et al., 2001; 2: Shackleton et al., 1999a; 3: Shackleton et al., 1999b; 4 & 5: Crookes et al., 2000; 6: High and Shackleton, 2000. Prices: US$1= R7.00 (2000).

3.3 Non-market time-use estimates

The South African 'Time Use Survey' (StatsSA, 2001) offers guidance in estimating the average minutes per day that South Africans spend undertaking their daily activities. The data provides the first nationally representative survey in the developing world of figures that may be applied to the activities associated with harvesting non-market resources from a rural context (table 7).

Table 7 Mean minutes per day per activity for adults >10 years age

Activity	Description	*Men*	*Women*	*Population*
Farming	Crop farming, including kitchen garden	145	181	164
Livestock	Tending	118	67	111
Fuelwood	Collecting	109	113	112
Water	Collecting	46	62	57
Wild herbs, fruit, etc	Collecting	164	72	123

Time use estimates offer a critical insight into arriving at a more complete and coherent understanding of the net economic valuation of the hidden harvest. For example, Ironmonger (1993) illustrated the anomalies in standard national accounting procedures (table 8), which has been adapted for the case of rural water collection.

Table 8 Ironmonger's matrix of differential accounting for the same output

<table>
<tr><td colspan="2" rowspan="2">Water for domestic use</td><td colspan="2">Use of capital</td></tr>
<tr><td>Market
(monetary production)</td><td>Household</td></tr>
<tr><td rowspan="2">Use of labour</td><td>Market
(monetary production)</td><td>1. Water vendor
(buy and deliver)</td><td>2. Pay domestic worker to carry water</td></tr>
<tr><td>Household</td><td>3. Own delivery from water vendor</td><td>4. Own labour used to carry water</td></tr>
</table>

Each cell illustrates a different scenario for water collection. However, whilst all the cells result in the same final output (water at home) each cell is not treated equally by the system of national accounts (SNA 93) in South Africa. Specifically, cell 1 would be fully recorded in national accounts (and its contribution to GDP) while cell 4 would not be recorded at all. In the context of valuing different land uses at the catchment scale it is critical that accounting procedures are comparable in order not to distort the analysis. As such, measurement and values for time collecting rangeland goods and services need to be approximated in order to derive a net valuation that compares one land use (e.g. rangeland) with a substitute or competitive alternative (e.g. forestry).

3.4 Valuing natural resources

Budlender and Brathaug (2002) discuss a range of methodological issues for valuing non-market activities:

1. Input or ouput values: the former is often preferred due to the difficulty of valuing non-market outputs. However, the latter corrects for different productivity levels, which may be generated by different input values for a uniform product (say, a meal cooked either by an electric stove or from fuelwood). Leisure time is another imponderable, which is often managed by purpose rather than nature of activity.
2. Which wage rate: mean, opportunity cost, generalist or specialist? The opportunity cost normally generates the highest wage and the generalist the lowest.

3. Net or gross wage? Commentators suggest using the gross wage for unpaid labour.
4. Estimating time spent. The main issue here is the inclusion of more than one activity at a time, i.e. a 24 hour approach or a 'full minutes' measure.
5. Whose time? The report sampled only adults over 10 years age.

Within the scope of the CAMP study, several parameters delimit the wider issues that are discussed above. First, the nature of rural livelihoods in the Luvuvhu catchment is primarily involved in 'outputs', i.e. fuelwood, thatch grass, milk etc. Though processing and value-addition does occur for some products (marula berries into beer, wood into cutlery, mopane worms into a preserved product) the resources to quantify these secondary processing activities have not been captured (or recorded elsewhere) and are assumed to be either minimal or partially accounted for by other harvesting activities, i.e. woodfuel and water collection for boiling mopane worms, excluding the discounted value of the cooking pot. It is recognised that these 'output' values will underestimate the total economic value but the authors believe it is better to provide a conservative valuation than weaken the validity of the results by too many 'heroic' assumptions.

Second, any society has a spectrum of wage rates that can be applied to capture the time spent in non-market activities. The generalist or local effective wage rate has been adopted here as the most appropriate proxy for estimating the value of each hour spent in non-market activities. However, it can be argued that this wage rate represents the private opportunity cost of labour and not the social opportunity cost, which economic theory[5] suggests may be higher if negative externalities (degradation, pollution etc) occur (van Kooten and Bulte, 2000; Perman et al, 1999). Imputed wage rates may act as a proxy for inefficient or lack of land markets (e.g., in rural areas under Tribal Authority systems), which would otherwise exact an economic rent (here, charge/fee) for the rights to harvest the resource, thus imposing a restriction (not necessarily equitable) on harvesting and access (Gordon, 1954). Renewable resource harvesting theory suggests that open access resources (for example, gathered from communal rangelands) tend to be inefficient for two reasons:

- Private property rights do not exist or are not enforced and monitored;
- A 'crowding diseconomy' occurs with over-investment in harvesting equipment (capital) that is economically inefficient[6].

For these reasons, gross valuations that do not adequately encompass the wider social costs that may occur when unsustainable renewable resource harvesting leads to degradation of the resource base, which can lead to development of a less-valuable (or palatable) vegetation regime (Crookes et al., 1997: 61) or resource (groundwater) exhaustion (KAWAD, 2001). Gross valuations based on figures that do not either account for the social (opportunity costs) or environmental costs (degradation, unsustainable harvesting) of the resource exploitation are thus misleading and may result in inappropriate policy. Arntzen (1998) conducted both a private and social (opportunity) cost analysis for the value of communal rangelands in Botswana, which not only accounted for subsidies and other processing costs but also incorporated two wage rates that reflected social and private incentives and returns from resource harvesting (water and land). The results reported that a 7 year average value per hectare for communal rangelands 25% lower for society than private concerns.

Third, gross wage rates will be used due to the rural context of the study and the absence of taxation on informal employment.

[5] Natural and environmental economic theory in particular, which address renewable natural resource harvesting.
[6] A common example is the fishery where over-investment in technology (boats) under harvesting quotas or falling stock is socially inefficient. The same analogy can be applied to tractors and ploughing.

Fourth, a 'full minutes' measure will be employed as certain adjustments will be made to the Time Use survey to more accurately reflect the local conditions and behaviour in the Luvuvhu catchment.

Fifth, it is recognised that children under 10 years do contribute to household production but the authors feel that in the realm of the harvesting activities being analysed adequate household time evaluations are being made. However, the intra-household allocation of resources is not being fully assessed, which is due to resource constraints and the catchment scale of the inquiry.

4 Water and livelihoods

The emergence of "livelihoods"[7] in development theory and research can be traced to the writings of Amartyra Sen (1981) on famines and hunger in Asia. The core of livelihoods thinking is based upon an understanding of the asset profile of the poor, the risks and challenges they face, and the institutional environment that facilitates or impedes their efforts to escape poverty. The livelihoods framework has provided the methodological touch-stone for this research and the investigation into the role of water in livelihoods and poverty. The diagnostic platform that the livelihoods framework provides allows a clear and comprehensible '*aide memoire*' of the context, issues and variables that are likely to moderate livelihood assets, opportunities and outcomes. However, it is limited in the insights it can make into the social distribution of resources and opportunities or the relative importance that an environmental shock or institutional impact may make on a particular livelihood or household. The role that water plays in livelihoods in rural areas in the developing world is manifold: health, agriculture, domestic collection, flood/drought, livestock, renewable natural resources, ceremonial etc. With land, it can be argued that water is the most critical input into a sustainable livelihood in Africa (see Gowing, 2003).

Capturing the inputs that water makes into livelihoods is less straight-forward than identifying the linkages. Informed by the role of water in natural resource harvesting there are six areas which the research has identified that are significant to livelihoods in the Luvuvhu catchment, the rural areas of South Africa more generally, and in rural southern Africa as a whole:

- Water collection;
- Livestock;
- Non-edible woodland products;
- Edible woodland products;
- Dryland agricultural fields; and,
- Kitchen gardens.

4.1 Water collection

Poignantly, water collection is mentioned in the Bible[8] along with the 'hewers of wood'. Numerous studies have attempted to capture the 'how much' and 'who' of African water collection that it is sufficient for this research to correlate its limited analysis with these more comprehensive studies (Thompson et al., 2001; Rosen and Vincent, 1999). The research data indicates that women under 30 years are the main water collectors and, on average, two people collect per household per day collect water. Accordingly, time use per household, excluding households who recorded no gatherers, will be recorded as 124 minutes per day.

In relation to the quantity of water collected per person per household, a small random sample (n=10) of households across the catchment recorded a mean value of 13.72 litres/capita/day (lcd). This figure corresponds well to other rural water consumption surveys across Africa.

[7] Readers are referred to the following texts: Hussein, 2002; Ellis, 2000; Carney, 1998; Scoones, 1998.
[8] Joshua 9 (27): "***And Joshua made them that day the hewers of wood and drawers of water…***"

The main findings for the social cohorts are:

- Almost 80% of all households are willing-to-pay (WTP) for an improved water supply;
- The minimum WTP is 0.013 Rands/litre (Female-headed) with the highest figure is 0.019 Rands/litre (Pension);
- The annual WTP at the household level ranges from R343 (Female-headed) to R550 (Pension);
- Female-headed and Home husband households have the highest frequency of water collectors, which reflects their lower level of improved water delivery and results in a higher estimated opportunity cost of labour;
- Cost benefit ratios indicate that for all cohorts water collection is not economically viable; further it highlights the larger, imputed collection costs (‘drudgery’) borne by Female-headed households, which is compounded by their lower WTP that is likely to be a function of their modest income stream.

The main descriptive findings for the income quintile classes are:

- The bottom 60% of households report a higher level of WTP than the top 40%;
- The lowest WTP is 0.013 Rands/litre (3rd quintile) with the highest figure 0.018 Rands/litre (2nd quintile);
- The annual WTP at the household level ranges from R388 (bottom quintile)to R550 (4th quintile);
- The bottom and 3rd quintile have the highest frequency of water collectors, which directly reflects their lower level of improved water supply (19% and 17% respectively);
- Cost benefit ratios record that the bottom three quintiles hover around one third of the value for economic viability whilst the top two quintiles are well-above half the required value.

Overall, water collection is not economically viable for any group. The findings are sensitive to the two main financial inputs (labour and WTP values). The calculated opportunity cost of labour is one third of the value used as the lowest generalist wage rate in South Africa (StatsSA, 2001) and it is thus considered as a proxy for a private cost rather than a social cost. Further, the WTP values are disproportionate to income and current level of improved water supply. Female-headed households have the lowest recorded income and the poorest level of service, which contributes to higher collectors per household. This pattern is more clearly revealed in the quintile data. Finally, it should be noted that the wealthier classes have higher household sizes, which lead to higher imputed water costs but these costs are inequitably borne by females under 30 years.

4.2 Livestock

The two main livestock classes identified in the Luvuvhu catchment were cattle and goat. Given that no primary production data was collected in the survey, two secondary sources were identified that extensively addressed the livelihood valuation of cattle and goat in Limpopo province (Shackleton et al., 2001, incorporating Shackleton et al., 1999b; Crookes et al., 2000).

Annualized cattle valuation estimates are presented in tables 9 and 10.

Table 9 Estimated cattle annualized valuation for social cohorts (Rands/pa; 2000)

Valuation/ cohort	Cattle-owning				Non-cattle owning
	Home husband	Migrant husband	Female-headed	Pension	All cohorts
Average herd size	18.64	19	7.38	12.55	0
Net annual value (HH)	5103.25	5225.79	1270.32	3030.20	177.97
Net annual value (head)	240.87	242.13	139.22	208.54	n/a
Cost benefit ratio (HH)	2.34	2.38	0.79	1.62	2.40
Water use (m^3/herd/pa)	309.42	315.40	122.51	208.33	not known

The main findings from these descriptive data for social cohorts are:

- Home husband and Migrant husband households dominate cattle ownership;
- All non-owning quintiles record a positive net annual value though costs of labour (collection) have not been estimated;
- Female-headed households are the only cohort to record a non-viable cost benefit ratio, which is explained by a lower herd size and annual income stream but equivalent costs of management, in particular labour;
- The economies of scale in cattle ownership favour male-headed households, which have been able to build up larger stocks over time;
- Water use is obviously a factor of stock size and the greatest water use (and by association land/fodder) impact is made by Home husband and Migrant husband households.

Table 10 Estimated cattle annualized valuation for income quintiles (Rands/pa; 2000)

Valuation/ cohort	Cattle-owning					Non-cattle owning
	Bottom	2nd	3rd	4th	Top	All quintiles
Average herd size	7.5	6.89	15.25	15.56	19.58	0
Net annual value (HH)	1311.17	1103.52	3949.28	4054.81	5423.22	177.97
Net annual value (head)	141.92	127.26	226.06	227.68	244.07	n/a
Cost benefit ratio (HH)	1.81	1.70	2.97	3.00	3.40	3.40
Water use (m^3/herd/pa)	124.50	114.37	253.15	258.30	325.03	not known

The main findings from these descriptive data for income quintiles are:

- Herd size increases with income wealth;

- All quintiles record a viable economic cost benefit ratio;
- All non-owning quintiles record a positive net annual value though costs of labour (collection) have not been estimated;
- Cattle water use by quintile ranges from 114 m^3/pa to 325 m^3/pa;
- Income poorer quintiles have a lower natural resource (water and land/fodder) impact than wealthier quintiles.

Valuing the contribution of goats to livelihoods follows a similar methodology though the benefit stream is dominated by milk and meat. Within the Luvuvhu catchment, informants indicated that goat production was becoming a more popular livelihood activity substituting for cattle due to the greater resilience of goats under drought conditions. Tables 11 and 12 report on the descriptive findings for social cohorts and income quintiles.

The main findings of the descriptive data for social cohorts are:

- Only 13% of households own goats across the sample;
- Mean herd size ranges from 2.89 (Female-headed) to 6.38 (Home husband);
- All cohorts record an annual net value loss on herding activities;
- Opportunity cost of labour has been adjusted to account for households that also own cattle;
- Non-owning goat households record a positive return though only damage costs have been calculated;
- Goat herding is not a viable economic activity for any owning group with the lowest score recorded by the Female-headed households (0.16) and the highest score recorded by the Migrant husbands (0.29;
- Water use is proportional to herd size and ranges from 8 m^3/pa (Female-headed) to 19 m^3/pa (Home husband).

Table 11 Estimated goat annualized valuation for social cohorts (Rands/pa; 2000)

Valuation/ cohort	**Goat-owning**				**Non-goat owning**
	Home husband	Migrant husband	Female-headed	Pension	All cohorts
Average herd size	6.38	5.15	2.89	4.29	0
% of HH class with goats	12	14	9	15	0
Net annual value (HH)	-908.25	-729.43	-882.07	-914.67	177.97
Net annual value (head)	-142.36	-141.64	-305.22	-213.21	n/a
Cost benefit ratio (HH)	0.28	0.29	0.16	0.21	3.38
Water use (m^3 /herd/pa)	19.14	15.45	8.67	12.87	not known

Table 12 Estimated annualized goat valuation for income quintiles (Rands/pa; 2000)

Valuation/ cohort	**Goat-owning**					**Non-goat owning**
	Bottom	2nd	3rd	4th	Top	All quintiles
Average herd size	5.25	3.77	4.73	3.89	6.94	0
% of HH class with goats	7	11	15	17	15	0
Net annual value (HH)	-885.22	-1018.59	-815.28	-974.55	-702.72	177.97
Net annual value (head)	-168.61	-270.18	-172.36	-250.53	-101.26	n/a
Cost benefit ratio (HH)	0.25	0.17	0.25	0.18	0.36	3.40
Water use (m^3/herd/pa)	15.75	11.31	14.19	11.67	20.82	not known

The main findings of the descriptive data for income quintiles are:

- Mean herd size ranges from 3.77 (2nd quintile) to 6.94 (top quintile);
- Higher income quintiles have larger goat herds than poor quintiles;
- All cohorts record an annual net value loss on herding activities;
- Opportunity cost of labour has been adjusted to account for households that also own cattle;
- All quintiles record goat production as economically unviable with the the lowest value recorded by the 2nd quintile (0.17) and the highest value recorded by the top quintile (0.36);
- Water use is proportional to herd size and ranges from 11 m^3/pa (2nd quintile) to 20 m^3/pa (top quintile).

4.3 Non-edible woodland products

StatsSA (1999) report that 70% of rural households in Limpopo province use wood for cooking. The main source of the wood is the *veld* (rangeland or savannah). Almost ¾ of wood collection is collected from over a kilometre away implying significant time use costs. 13% of respondents reported that there was an insufficient supply available. More recent studies by Shackleton et al. (1999a) and Crookes et al. (2000) support the critical role that wood from communal rangeland resources has in the livelihoods of the rural population both as a source of fuel for cooking and also for a wider range of construction and miscellaneous activities.

Shackleton et al. (2001) record a wide range of uses and gross values for wood from communal rangeland resources. The Luvuvhu survey did capture relative fuelwood use by social and income classifications, which has been supplemented by informant interviews. Specific investigation was made of the household use across the year (kg/pa), observation of woodfuel collectors (who, when, how often) and an effective market replacement rate for the wood (Rands/pa).

The data from the Luvuvhu study are presented in tables 13 and 14.

Table 13 Estimated non-edible woodland products by social cohorts

Valuation/ community	Home husband	Migrant husband	Female-headed	Pension
% HHs cooking with wood	92	91	96	97
% HHs buying wood	15	14	16	20
Net annual value (all uses/HH)	-155.60	-144.69	-173.25	-176.47
Cost benefit ratio (HH)	0.88	0.89	0.87	0.88
Water use (m^3 /HH/pa)	884.88	860.84	889.39	994.55

A number of observations may be made on the results from the social cohort data:

- Wood for cooking is significant for almost all households in each cohort;
- Wood purchase occurs across all cohorts with the Migrant husbands recording the lowest percentage (14%) and Pensioners recording the highest percentage (20%);
- Opportunity of labour costs are the most significant cost associated with wood use;
- Net annual values range from –R145 pa (Home husband) to –R176 pa (Pension);
- All cohorts record a non-viable cost benefit ratio though it is marginal;
- Water use estimates range from 861 m^3/pa (Migrant husband) to 995 m^3/pa (Pension).

Table 14 Estimated non-edible woodland products by income quintiles

Valuation/ community	Bottom	2nd	3rd	4th	Top
% HHs cooking with wood	96	98	96	94	87
% HHs buying wood	9	17	15	14	19
Net annual value (all uses/HH)	-47.70	-166.85	-88.39	-264.60	-219.11
Cost benefit ratio (HH)	0.96	0.88	0.93	0.82	0.84
Water use (m^3 /HH/pa)	984.61	994.55	974.66	944.82	745.91

The main findings from non-edible wood products for income quintiles are:

- Wood for cooking is significant for almost all households in each quintile;
- Wood purchase occurs across all cohorts with the bottom quintile the lowest percentage (9%) and the top quintile recording the highest percentage (19%);
- Opportunity of labour costs are the most significant cost associated with wood use;
- Net annual values range from –R48pa (bottom quintile) to –R264 pa (4^{th} quintile);
- All cohorts record a non-viable cost benefit ratio;
- Water use is substantial with the top quintile recording the lowest usage (746 m^3/pa).

4.4 Edible woodland products

Edible woodland products (EWP) encompass the myriad herbs, fruit, vegetables, grubs (such as the Mopane worm), game and other food stuffs that are seasonally and spatially distributed in rangelands. Scoones et al. (1992) argue that simplified accounting that does not adequately capture the significant range of EWP impacts most heavily on the poor as they suffer disproportionately from land use conversion (e.g. extensive agriculture or deforestation in the Amazon). The vast majority of EWP are non-marketable goods, which are difficult to quantify and value. Shackleton et al. (2001) reviewed studies across Southern Africa and, in particular, in Limpopo province, which have been adjusted to act as proxy values for this study (appendix 9). Unfortunately, no social disaggregation has been conducted in any of the earlier studies and it was unfeasible to gain a clear indication of the contribution from the livelihoods survey. As such, an unsatisfactory but expedient method of acknowledging the contribution of EWP is to apply the proxy values to each income quintile. The qualitative research did provide indications of the contribution of EWP by social cohort. Seasonal diagrams and other participatory exercises provide useful and indicative information of the contribution of EWP to livelihoods.

Due to the limitations in conducting any robust social or income differentiation on the value of EWP to households it is considered appropriate to assign the mean gross value to all groups (R1206.23) and deduct the opportunity cost of labour in collection. Time use estimation for collecting wild herbs, fruit, hunting etc is more problematic in that there is no clear indication from the survey data of how best to estimate the frequency with which individuals undertake these activities by both income quintiles and social cohorts. Reference to seasonal calendars offers guidance for time use profiles by social cohorts (table 15).

Table 15 Percentage of year collecting wild fruit, vegetables etc by social cohort

		Home husband	Migrant husband	Female-headed	Pension	Mean across classes
Rangeland resources	1. Wild fruits	0.36	0.17	0.25	0.31	0.27
	2. Wild vegetables	0.22	0.17	0.19	0.31	0.22
	3. Fuelwood	1.00	1.00	1.00	1.00	1.00
	Mean across all	0.53	0.45	0.48	0.54	0.50
	Mean across 1 & 2	0.29	0.17	0.22	0.31	0.25

Note: This data is derived from seasonal diagrams conducted in 3 communities (Khumbe, Mangaya and Mutele A). Where data was unrecorded the lowest value in the same category was used as a conservative proxy, except for fuelwood, which was always recorded as 12 months pa. For Home husband cohort, an outlier of 10 months pa was recorded for hunting in rangelands (classified under wild vegetables etc) this has been replaced by 3 months, which reflects non-hunting time use across the catchment.

Counter-intuitively, female-headed households record the second lowest time use for collecting wild fruits, herbs, vegetables etc. However, these data do not accurately reflect the intensity (hours per day/month) or importance of the resources for each household. They do provide an indication of the magnitude of effort or time in contrast to fuelwood collection, which allows a proxy time use measure to be calculated. Given the lack of rigour in the disaggregation across social cohorts and the inability to disaggregate by income quintiles it is suggested that a time use calculated by the mean across cohorts for wild fruits and vegetables is applied (e.g. 0.25).

No survey or secondary information is available on the gender of collector (s) so the population mean, as opposed to male or female scores, of 123 minutes per day will be used (StatsSA, 2001). Weighting the annual hours by 0.25 indicates a total household time use of 187.06

hours/pa. Applying the wage rate of R1.73 hour indicates a household labour cost of R323.62 pa. Therefore, the net household EWP valuation across social and income groups suggests a value of R882.61 pa with a viable cost benefit ratio of 3.73.

4.5 Dryland agricultural fields

In the Luvuvhu catchment, dryland fields are areas of land allocated by the local Tribal Authority and sanctioned by the Department of Agriculture. In principle, anyone can apply at a community meeting (*khoro*) to the headman for a plot of land. If accepted, a letter is written to the tribal chief. This is followed by authorisation and measurement by the local Department of Agriculture. As such, dryland operates in a quasi-market system though the authority and ultimate tenure resides with the Tribal Authority. Minor payments are made to each of the three tiers during this process, which vary between and within Tribal Authorities. An average annual land rent is R15 per hectare (US$2.14; 2000). In practice, informants and observation revealed that the more productive plots were allocated by influence or networks (kin, business etc) within the communities. Family, wealth and network associations appeared the key to gaining access to and use of the most prized plots (i.e. riparian land or with a good soil profile). Further, the land rent and varying headman's one-off fee constrained poorer households from gaining access at all. This situation was also compounded by the reported high costs of traction and seeds, essential inputs for even the most basic cultivation.

The survey data captured data on the estimated size of a household's dryland plot, annual inputs, crops grown and any sale of produce. This data is complemented by crop productivity estimation by emerging farmers, which is compared with secondary sources (table 20). A replacement cost approach is adopted for valuing the household crop yield by the equivalent, local price of crushed maize (mealie meal). This was estimated to R3, 500 per tonne (1,000 kg) based on the current market price of an 80kg bag costing R280. A maize crop water requirement was estimated at 3,000 m^3/ha/pa (FAO, 1998).

Table 16 Dryland data by social cohorts

	Home husband	Migrant husband	Female-headed	Pension
% class with plot	55	57	46	63
% sample	18	10	8	21
Mean plot size (Ha)	1.18	1.44	0.99	1.44
Reported input costs (Rs/HH/pa)	487.87	795.57	367.76	479.54
Net annual value (Rs/HH)	140.74	727.44	-392.75	1043.47
Net annual value (Rs/Ha)	119.27	505.17	-396.72	724.63
Cost benefit ratio (HH)	1.04	1.17	0.90	1.26
Water use (m^3 /HH/pa)	3540	4320	2970	4320

Some preliminary findings can be made from the descriptive data for income quintiles:

- 57% of households report owning a dryland field;
- Female-headed households proportionately fall behind the other cohorts in terms of the percentage of cohort that report a plot (46%);
- Pension and Migrant husband households record the largest plot size (1.44 Ha);
- Input costs range from R368 (Female-headed) to R796 (Migrant husband);
- Net annual value (Rs/HH) varies from –R393 (Female-headed) to R1043 (Pension);

- The net annual value for economic productivity of land (Rs/Ha) varies from –R397 (Female-headed) to R725 (Pension);
- All cohorts show a viable economic performance apart from Female-headed households (0.90), which is explained by their smaller plot size but similar labour costs;
- Crop water consumption ranges from 2970 m^3/pa (Female-headed) to 4320 m^3/pa (Migrant husband and Pension).

Table 17 Dryland data by income quintiles

	Bottom	2nd	3rd	4th	Top
% class with plot	47	56	62	54	65
% sample	10	12	11	11	13
Mean plot size (Ha)	0.88	1.04	1.18	1.83	1.50
Reported input costs (Rs/HH/pa)	326.74	404.77	503.37	813.98	557.04
Net annual value (Rs/HH)	-730.13	-257.76	125.24	2050.63	1172.37
Net annual value (Rs/Ha)	-829.69	-247.85	106.14	1120.56	781.58
Cost benefit ratio (HH)	0.81	0.93	1.03	1.47	1.29
Water use (m^3/HH/pa)	2640	3120	3540	5490	4500

Some preliminary findings can be made from the descriptive data:

- The bottom quintile has the lowest proportion of plot ownership (0.47);
- The top two quintiles record the largest plot sizes (1.83 Ha and 1.50Ha);
- Input costs range from R326.74 (bottom) to R813.98 (4^{th});
- Net annual value varies from –R730 (bottom) to R2051 (4^{th});
- The net annual value for economic productivity of land (Rs/Ha) varies from –R830 (bottom) to R1121 (4^{th});
- The bottom two quintiles record a non-viable cost benefit ratio;
- Crop water consumption ranges from 2640 m^3/pa (bottom) to 5490 m^3/pa (4^{th}).

4.6 Kitchen gardens

There is growing interest in the role of kitchen gardens in rural livelihoods, primarily as an expenditure-saving strategy (Hope et al., in press; Waughray et al., 1998). Recent studies have attempted to value the productive potential of kitchen gardens in Limpopo province (High and Shackleton, 2001; Perez de Mendiguren and Mabelane, 2001). Again, the distributional impacts across a community have not been assessed, which limits the policy options given the initial favourable gross values that have been estimated. In particular, kitchen gardens have the potential to provide food security for poorer households if improved water supply provision reaches the entire community. Thus, buffering poorer families from the ‘hungry season’ if the reticulated ‘virtual water network’ is reliable and sufficient to irrigate winter/dry season crops. Important questions concern the distributional nature of water supply within and between communities, the additional water quantity to buffer the dry season uptake and the potential savings from kitchen gardens across the seasons. Further, the marginal productivity per m^3 water is a key question for policy-makers investigating the allocative efficiency and equity of water in water scarce countries.

A kitchen garden is characterised as a plot of land immediately adjacent or on the main home compound, which is generally fenced. The estimated kitchen garden size in the Luvuvhu catchment was 400m^2 or 0.04 hectare. This fits well with the estimation made by Perez de Mendiguren and Mabelane (2001) but is substantially smaller (one order of magnitude) than High and Shackleton (2001), who estimated a plot as 0.4 ha, i.e. approximately the size of a football pitch.

There are a number of methodological issues which have yet to be resolved satisfactorily in the data analysis:

- Variation in area and intensity of productivity across the year, e.g. it is likely that a wider area is planted if there are good summer rains but a more modest plot is planted in the dry season even if the reticulated supply is fairly reliable;
- Multi-cropping and harvesting;
- Estimating other inputs (excluding labour);
- Lack of reliable agronomic data on productivity;
- Estimating crop water irrigation use.

In the analysis presented here there are a number of assumptions and estimates made due to lack of published agronomic data on kitchen garden production.

First, a productivity figure of 15 t/ha has been approximated from both a modest cropping regime across the year and down-grading the 58 t/ha estimate from a Zimbabwe study (Waughray et al., 1998; appendix X?). Crop water use has been estimated at 13,991 m^3/ha/pa dervied from a three crop rotation of maize, onion and tomato across the year. If full water application were made on the kitchen garden (0.04ha) this would require a household supply of 559.64 m^3/HH/pa. Whether the infrastructure could handle this supply volume is thought unlikely. The volume is one order of magnitude greater than the minimum basic human need requirement (9 m^3/pax/pa or 54 m^3/HH/pa), which the government is struggling to deliver in the remote and rural areas of South Africa. Rainfall would reduce the water demand from non-reticulated sources but the low intensity of the cropping regime is likely to encompass this difference.

Second, the estimate for other inputs (not labour) has been taken from reported dryland inputs. A figure of R300 per year is applied per kitchen garden. Third, unravelling the contribution of rain water, piped irrigation and other occasional water (grey water) has been attempted applying survey data on who and how often households are irrigating so that an estimate across the different livelihood classes can be made. This is the actual water usage under a situation of poor supply in most communities.

Summarised findings from the kitchen garden data analysis are presented in tables 18 and 19.

Table 18 Kitchen garden data by social cohorts

	Home husband	Migrant husband	Female-headed	Pension
% class with kitchen garden	90	91	89	93
Mean crops sold (Rs/pa)	7.59	52.15	20.68	42.82
% Irrigate ‘every few’ days dry season	52.84	63.83	50.51	45.36
Net economic value (Rs/HH/pa)	-102.67	-58.42	-87.52	-64.88
Cost benefit ratio (HH)	0.95	0.97	0.96	0.97
Water use (m^3/HH/pa)	359.31	404.85	316.56	321.10

Preliminary findings from the descriptive data for social cohorts indicate that:

- Kitchen gardens are an almost universal livelihood strategy for all groups;

- The majority of production is for own-consumption, i.e. food security;
- Percentage of households reporting irrigating the kitchen garden ‘every few’ days range from 45% (Pension) to 64% (Migrant husband);
- Net economic values range from –R103 (Home husband) to –R58 (Migrant husband);
- All cohorts record a marginally non-viable cost benefit ratio;
- Water use ranges from 317 m^3/pa (Female-headed) to 405 m^3/pa (Migrant husband).

Table 19 Kitchen garden data by income quintiles

Valuation/community	Bottom	2nd	3rd	4th	Top
% class with kitchen garden	88	95	88	87	96
Mean crops sold (Rs/pa)	131.00	27.68	30.62	46.91	131.79
Irrigate ‘every few’ days dry season	48.67	52.14	48.51	48.65	60.91
Net annual value (Rs/HH)	19.49	-83.99	-81.13	-64.52	19.08
Cost benefit ratio (HH)	1.01	0.96	0.96	0.97	1.01
Water use (m^3/HH/pa)	331.82	339.61	343.54	327.72	391.75

Preliminary findings from the descriptive data for income quintiles indicate that:

- Kitchen gardens are an almost universal livelihood strategy for all groups;
- The majority of production is for own-consumption, i.e. food security;
- Percentage of households reporting irrigating the kitchen garden ‘every few’ days range from 49% (4th) to 61% (Top);
- Net annual values range from –R84 (2nd) to R19 (Bottom);
- All cohorts record a cost benefit ratio on the margin;
- Water use ranges from 328 m^3/pa (4th) to 392 m^3/pa (Top).

5 Results and discussion

The six water-related livelihood activities discussed in section 4 constitute the core of livelihood activities but do omit three areas of importance: orchards, micro-enterprises and small-scale irrigated agriculture. Orchards are defined in this context as fruit trees grown within the immediate vicinity of the home. The distribution of trees is governed by the rainfall regime with communities in the region with MAP below 700mm/pa unable to sustain an orchard, in particular Mutele A and Mangaya. As the research methodology is intended to be replicable in a Tanzanian catchment with a low rainfall regime they are excluded from this current analysis.

Second, the treatment of micro-enterprises is problematic for a number of reasons. Only two activities were commonly identified by this research, beer brewing and brick-making. Very few community members undertook beer brewing due to demand constraints, input (maize) inflation and competition (bottled beer). However, beer brewing is an interesting and wide-spread activity in rural communities as it is one of the few female-run activities. Interviewing the brewers did identify that the majority were from wealthy cohorts in the communities often widows of migrant workers. Following the limited water-impact and number of brewers per community this analysis excludes this enterprise.

Third, brick-making is produced from two sources: clay, open access pits and market-priced, cement supplies. Sand for the cement variety is widely available and mined as an open access resource. Whilst both types of brick production are dependent on water inputs (green or blue) the actual usage by individuals is complicated by a variety of demand and preference factors that are beyond the scope of this study[9].

Finally, small-scale irrigation is occurs in two manifestations in the Luvuvhu area: former state schemes and entrepreneurial riparian/irrigated plots. The former is represented only by Khumbe in the research communities due to the widespread collapse of the schemes following state withdrawal in the early 1990s (Perret, 2002; Kamara et al., 2001; Singini and van Rooyen, 1995). Whilst Khumbe in itself is an interesting case-study the results are not representative of the catchment and therefore are not included here. Second, riparian farming using small diesel pumps is a growing area, which has several ramifications with the application of the National Water Act (RSA, 1998). The qualitative research explored the opportunities and constraints that these farmers face and the issue of land access within the community institutional structure. The findings are not representative of the catchment and will be reported later.

The results are illustrated with reference to two criteria introduced earlier: green and blue water, and households able to access and use the natural resource base. Access to and use of the natural resource base is moderated by cultural, economic and institutional factors in the Luvuvhu catchment. Whilst it is beyond the scope of this paper to adequately address all these issues the results are presented in a format that will allow a clearer understanding of the economic benefits and associated water use by reference to a simple household classification. First, ‘alpha’ households are those which use the resource base across all six natural resource harvesting categories indicated in section 4. Second, ‘beta’ households refer to those households whose activities are restricted to a limited availability of natural resources: water collection, NEWP, EWP and kitchen gardens. Further, beta economic valuation includes the benefits accruing to non-owning livestock households. Tables 20 and 21 present the net economic valuation for social cohorts by alpha and beta classifications.

Table 20 Net economic valuation for alpha social cohorts

Net economic value (Rs/HH/pa)		Home husband	Migrant husband	Female-headed	Pension
	Water collection	-611.13	-553.98	-779.35	-481.22
	Livestock (own) 1. Cattle	5103.25	5225.79	1270.23	3030.20
	2. Goat	-908.25	-729.43	-882.07	-914.67
	NEWP	-155.60	-144.69	-173.25	-176.47
	EWP	882.61	882.61	882.61	882.61
	Dryland	140.74	727.44	-392.75	1043.47
	Kitchen gardens	-102.67	-58.42	-87.52	-64.88
Total		**4348.95**	**5349.32**	**-162.10**	**3319.04**

Two activities dominate the economic outcomes for the alpha class cohorts:

- Cattle herds above 10 (i.e. all but Female-headed) generate significant annual economic benefits, particularly for Home husband and Migrant husband;

[9] See Crookes et al., (2000) and Perez de Mendiguren and Mabelane, (2001) for attempts to quantify the impacts and returns from this activity.

- Dryland economic viability is determined by plot size with Migrant husbands and Pension households (1.44 ha) generating benefits sufficient to surpass the threshold of costs mainly determined by labour costs.

Table 21 Net economic valuation for beta social cohorts

Net economic value (Rs/HH/pa)		Home husband	Migrant husband	Female-headed	Pension
	Water collection	-611.13	-553.98	-779.35	-481.22
	Livestock (own) 1. Cattle	177.97	177.97	177.97	177.97
	2. Goat	177.97	177.97	177.97	177.97
	NEWP	-155.60	-144.69	-173.25	-176.47
	EWP	882.61	882.61	882.61	882.61
	Dryland	0	0	0	0
	Kitchen gardens	-102.67	-58.42	-87.52	-64.88
Total		**369.15**	**481.46**	**198.43**	**515.98**

Variations occur within the alpha and beta classes in relation to water collection, NEWP, EWP and kitchen gardens. Water collection analysis is moderated by the willingness-to-pay (WTP) of the cohorts, household size and percentage of water gatherers reported per household. The WTP across the cohorts is approximately three orders of magnitude greater than DWAF's raw water cost (R0.02 m^3) yet contingent payment still does not exceed the estimated labour costs of collection. Calculating the elicited WTP adjusted by household size and estimated current water consumption (13.72 lcd) indicates a range of household payments from R342 pa (Female-headed) to R550 pa (Pension). The labour collection cost is a notional private cost based on local effective market rates, which is believed to be lower than a social cost that incorporates a wider range of costs to society. The social cost would increase the economic non-viability of water collection. Further, the current level of water provision favours income wealthier Migrant husband and Pension households which enjoy a higher connection rate (29% and 35% respectively), which has reduced their labour collection costs proportionately to less well-connected households, e.g. Home husbands (23%) and Female-headed (23%). Whilst the cohorts' WTP covers roughly 50% of the labour cost of collection the results indicate that water for domestic purposes has a financial value to all social cohort groups.

NEWP results indicate a non-viable economic ratio for all social cohorts. However, the many goods and services that accrues to households from fuel to poles results in only a marginally negative outcome for all cohorts. The estimated water consumption cost of fuelwood is less than R20 pa/HH at the DWAF raw water tariff. Labour collection costs are the dominant cost associated with the harvesting of NEWP though non-fuelwood collection has not been estimated due to data constraints and likely double-counting with fuelwood collection and other natural resource harvesting activities.

EWP is the most economically successful livelihood activity for the beta class and contributes positively for the alpha class also. The reduced labour cost calculated with guidance from the seasonal calendar data is an important factor in this positive economic outcome.

Kitchen garden economic analysis indicates a non-viable economic ratio for all groups. The estimates and assumptions that underpin this analysis result in significant variations in the economic outcome subject to the agricultural yield of the plot, financial value of the harvest (replacement cost) and the labour time devoted to the activity. The analysis suggests that improved yields above the 15 t/ha estimate would result in viable economic outcomes for all cohorts. This outcome is also dependent on the institutional structures and processes being in place to allow the sale and marketing of the produce at the high replacement market rates. Currently, the support and services provided to emerging and subsistent farmers in the area are thought inadequate to provide the leverage, information and support to convert the agricultural potential of the area into a viable economic enterprise. However, kitchen gardens are an almost universal activity that is not constrained by cultural, financial or institutional barriers that occur in activities such as livestock or dryland production.

Each of these livelihood activities is associated with a level of water consumption moderated by either green (rainfall) or blue (runoff) availability. Tables 22 and 23 present estimates for these activities.

Examination of the water source by activity for the alpha cohorts reveals that green water is the dominant source. This is specifically due to dryland farming crop transpiration. The second most dominant water use is by NEWP. The third highest water use is by cattle though water consumption is divided between blue (rivers, streams etc) and green (fodder). The beta class is mainly dependent on green water for NEWP. Though no estimate has been recorded for EWP, its net primary productivity value is likely to be lower than all other activities except water collection; this activity provides the highest income for the beta class.

Table 22 Annual water use by alpha social cohort

Annual water use (m^3/HH/pa)		Home husband	Migrant husband	Female-headed	Pension
Water collection	*Blue*	29.05	31.10	26.49	29.70
Livestock (own)					
1. Cattle	*Blue/Green*	309.42	315.40	112.51	208.33
2. Goat	*Blue/Green*	19.14	15.45	8.67	12.87
NEWP	*Green*	884.88	860.84	889.39	994.55
EWP	*Green*	0	0	0	0
Dryland	*Green*	3540	4320	2970	4320
Kitchen gardens	*Blue*	359.31	404.85	316.56	321.10
Sub-total	**Green**	4425 -4753	5181 -5512	3859 -3981	5315 -5536
Sub-total	**Blue**	388 -716	436 -766	343 -464	351 -572
Total		**5141.8**	**5947.64**	**4323.62**	**5886.55**

Table 23 Annual water use by beta social cohort

Annual water use (m^3/HH/pa)		Home husband	Migrant husband	Female-headed	Pension
Water collection	*Blue*	29.05	31.10	26.49	29.70
Livestock (own)	*Blue/Green*	0	0	0	0
1. Cattle	*Blue/Green*	0	0	0	0
2. Goat					
NEWP	*Green*	884.88	860.84	889.39	994.55
EWP	*Green*	0	0	0	0
Dryland	*Green*	0	0	0	0
Kitchen gardens	*Blue*	359.31	404.85	316.56	321.10
Sub-total	**Green**	885	861	889	995
Sub-total	**Blue**	388	436	343	351
Total		**1273.24**	**1296.79**	**1232.44**	**1345.35**

Analysis of the income quintile data provides a different perspective into the value of natural resource harvesting. Tables 24 and 25 present the net economic valuation by alpha and beta classes.

Table 24 Net economic valuation by alpha income quintiles

Net annual value (Rs/HH/pa)		Bottom	2nd	3rd	4th	Top
	Water collection	-773.73	-650.77	-755.70	-389.41	-387.51
	Livestock (own)					
	1. Cattle	1311.17	1103.52	3949.28	4054.81	5423.22
	2. Goat	-885.22	-1018.59	-815.28	-974.55	-702.72
	NEWP	-47.70	-166.85	-88.39	-264.60	-219.11
	EWP	882.61	882.61	882.61	882.61	882.61
	Dryland	-730.13	-257.76	125.24	2050.63	1172.37
	Kitchen gardens	19.49	-83.99	-81.13	-64.52	19.08
Total		**-223.51**	**-191.83**	**3216.63**	**5294.97**	**6187.94**

The results for the income quintiles reveal a more structured pattern into the distribution of natural resource benefits for the alpha class. The alpha income quintile class reports a clear and stepped increment in benefits accruing to the wealthier quintiles. The pattern suggests there is a threshold above which benefits become significantly larger. Earlier examination of the data indicates that herd size is the most significant variable in this result. The economies of scale of owning a large herd (*circa*. 10) result in the benefits outweighing the opportunity costs of labour. The same phenomenon is revealed in the dryland economic analysis.

Table 25 Net economic valuation by beta income quintiles

Net annual value (Rs/HH/pa)		Bottom	2nd	3rd	4th	Top
	Water collection	-773.73	-650.77	-755.70	-389.41	-387.51
	Livestock (own)					
	2. Cattle	177.97	177.97	177.97	177.97	177.97
	2. Goat	177.97	177.97	177.97	177.97	177.97
	NEWP	-47.70	-166.85	-88.39	-264.60	-219.11
	EWP	882.61	882.61	882.61	882.61	882.61
	Dryland	0	0	0	0	0
	Kitchen gardens	19.49	-83.99	-81.13	-64.52	19.08
Total		**436.61**	**336.94**	**313.33**	**520.02**	**651.01**

Variation within the alpha and beta groups occurs with water collection, NEWP, EWP and kitchen gardens. Water collection illustrates a falling net annual economic loss that is moderated by income wealthier groups larger household size (imputed water cost) in conjunction with greater water supply provision that reduces their labour cost for collection. The poorer quintiles are less able to pay and forced to spend more time collecting than wealthier groups.

Beta class NEWP displays little variation in the marginal non-economic viability of the activity. Of note, the top two quintiles consume less fuelwood due to access to other fuel sources (electricity) and the income to pay for this market service. As noted earlier, women are the main collectors and the opportunity cost associated with collection activities is borne by them. EWP is evenly distributed activity across the quintiles due to data limitations. EWP is the most important income source for the beta class. The kitchen garden analysis presented for the social cohorts is equally applicable for the income quintile data.

The water consumption for the income quintile classes is presented in tables 26 and 27.

Table 26 Annual water use by alpha income quintile

Annual water use (m^3/HH/pa)		Bottom	2nd	3rd	4th	Top
Water collection	*Blue*	26.29	25.24	30.05	31.65	33.00
Livestock (own)						
1. Cattle	*Blue/Green*	124.50	114.37	253.15	258.30	325.03
2. Goat	*Blue/Green*	15.75	11.31	14.19	11.67	20.82
NEWP	*Green*	984.61	994.55	974.66	944.82	745.91
EWP	*Green*	0	0	0	0	0
Dryland	*Green*	2640	3120	3540	5490	4500
Kitchen gardens	*Blue*	331.82	339.61	343.54	327.72	391.75
Sub-total	**Green**	3624 -3765	4115 -4240	4515 -4782	6435 -6705	5246 -5592
Sub-total	**Blue**	358 -498	365 -491	374 -640	359 -629	425 -771
Total		**4122.97**	**4605.08**	**5155.59**	**7064.16**	**6016.51**

Water consumption for the alpha class is dominated by green water use explained predominantly by dryland agriculture. The second highest water consumption activity is NEWP, which is again green water. The only significant blue water use is potentially kitchen gardens. Water consumption by the alpha class exceeds beta water use by at least a factor of three in each quintile.

Table 27 Annual water use by beta income quintile

Annual water use (m^3/HH/pa)		Bottom	2nd	3rd	4th	Top
Water collection	*Blue*	26.29	25.24	30.05	31.65	33.00
Livestock (own)						
1. Cattle	*Blue/Green*	0	0	0	0	0
2. Goat	*Blue/Green*	0	0	0	0	0
NEWP	*Green*	984.61	994.55	974.66	944.82	745.91
EWP	*Green*	0	0	0	0	0
Dryland	*Green*	0	0	0	0	0
Kitchen gardens	*Blue*	331.82	339.61	343.54	327.72	391.75
Sub-total	**Green**	985	995	975	945	746
Sub-total	**Blue**	358	365	374	359	425
Total		**1342.72**	**1359.4**	**1348.25**	**1304.19**	**1170.66**

In drawing the inter-linked strands of water, poverty and livelihoods together a number of issues and implications have been revealed in this descriptive analysis:

- Green water use is the most significant water source for alpha and beta livelihood classes;
- Blue water is proportionately a minor source to water-dependent livelihood activities;
- Dryland crop production is potentially (rainfall permitting) the highest water consuming activity though access to and use of the resource is appropriated largely by income wealthier quintiles, and Migrant husband and Pension cohorts;
- NEWP is the second highest (green) water consumption activity;
- The one potentially significant blue water livelihood opportunity is kitchen garden farming though the analysis labours under the assumption of adequate provision;
- EWP is the highest net annual economic activity for beta class households.

The hypothesis of this paper is that poorer groups gain a higher percentage value from natural resource harvesting proportionately to their reported income than income wealthier groups. Figures 4 and 5 illustrate the findings from this paper in relation to the proportional contribution of the estimated natural resource harvest value to the reported household annual income (Figures 4 and 5).

Figure 4 Proportional value of natural resource harvest to annual household income for social cohorts

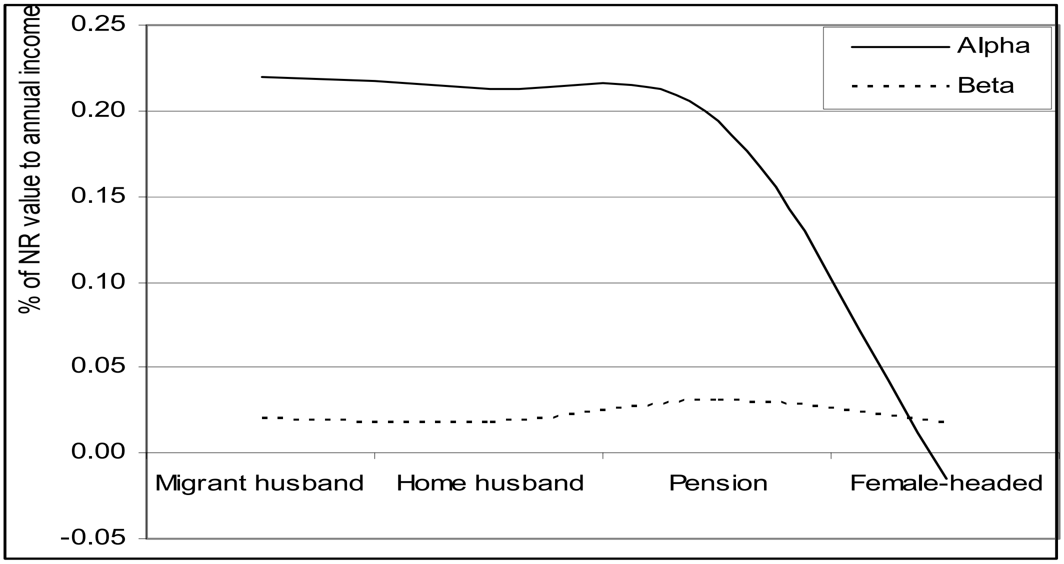
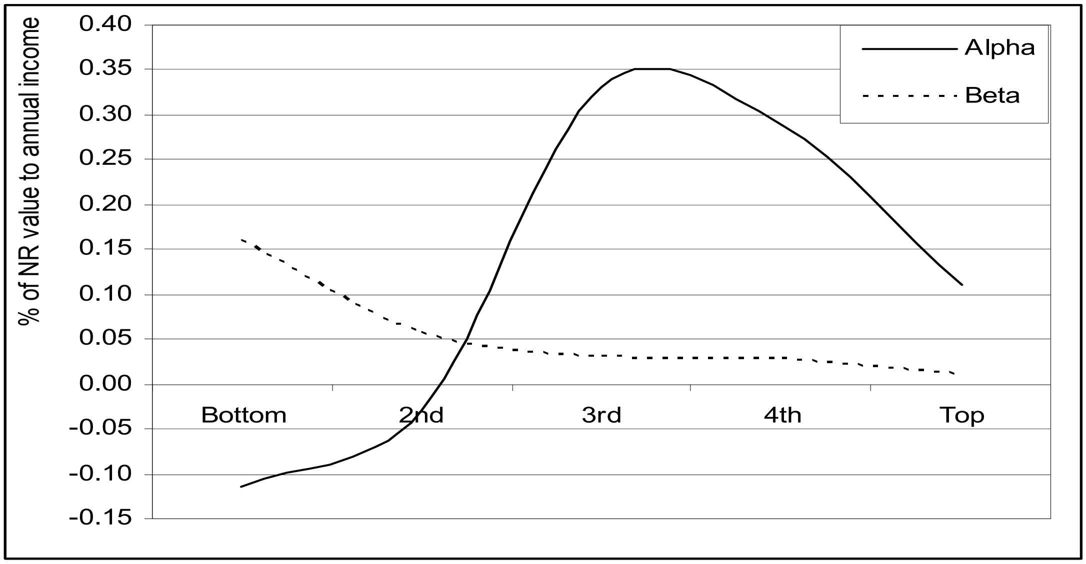


Figure 4 depicts an inverse representation of the paper's hypothesis. It may be interpreted as a situation under structural inequality where households with higher levels of assets (livestock, land, people, education etc) are able to lever the local institutional environment in their favour in terms of exploiting the 'communal' natural resource base. The Female-headed cohort, which is characterised by lower levels of assets, is poorly represented in the alpha class to the extent that the economic ratio of the more lucrative rangeland activities (cattle rearing, dryland farming) are non-viable due to low herd size and concomitant high labour costs. Whilst economic analysis suggests the economic viability may not be justified the financial returns in terms of expenditure-saving are significant within a remote rural economy suffering from national structural unemployment. The wealthier Migrant husband and Pension cohorts have the greater economies of scale (land, finance) to exploit this livelihood opportunity, which is moderated by institutional structures. The beta class benefit stream from natural resource harvesting is modest due to the economic analysis of cost and benefit returns.

Figure 5 presents the same analysis for the income quintiles. The alpha curve reflects the inverse to the hypothesis in that the income poorer quintiles are constrained by limited assets but face the same cost profile as the wealthier quintiles. The economies of scale in harvesting activities occur beyond the bottom 40% of income earners with the 3^{rd} income quintile reaping the greatest proportional benefit with the higher incomes of the 4^{th} and top quintiles reducing the proportional impact though not the economic benefit, which continues to increase. The beta curve is the best representation of the initial hypothesis. The modest benefit that accrues to the bottom quintile is partly explained by its low fuelwood purchase cost and its proportionately lower income to the other quintiles.

Figure 5 Proportional value of natural resource value to household income for income quintiles



Findings from this paper have several implications to the water, poverty and livelihoods nexus within the 'water scarcity' narrative. First, green water is the most significant water source for all livelihood groups, which underlines the dependency on the rainfall regime and issues of land access plus other input factors (labour, finance, seeds, traction etc) in order to exploit this opportunity. This finding suggests that the greatest leverage in reducing the constraints to poverty are likely to centre on the risk and vulnerability context of locally-determined agro-climatic conditions, the livelihood diversity profile in relation to the opportunity or constraint to substitute one activity for another in situations of stress (drought, flood), and the local social institutional structures that moderate access to and use of land. Further, the incremental difference to actual evapotranspiration by changing rangeland to dryland agricultural land use needs to be weighed in light of both the hydrological impact and the socio-economic impacts of who wins and loses from such a change. The findings here suggest that within both the social cohorts and income quintiles it is the wealthier who possess the greatest opportunity to further exploit the communal rangeland resource base if land use change favours conversion to dryland agriculture with the associated losses to the natural resources harvested (EWP and NEWP), upon which the poorer depend.

Second, cattle-rearing is highlighted as the most economically profitable activity given sufficient herd size. The annualized income stream that accrues to the Home husband and Migrant husband cohorts and the top 60% of income quintiles indicate the substantial gains that are made from this livelihood strategy. It however does not adequately address the 'carrying capacity' of the land nor the associated costs borne by those households unable to finance a herd. A poorer family (or individual), who cannot afford to gain a dryland plot, in principle leaves that land vacant for a wealthier cattle-owner on which to graze freely. Though secondary by-products do accrue to non-owning households they pale in comparison to the benefits derived by owner households.

Third, the working hypothesis posited in section 2 has been rejected following the analysis. This raises a number of important issues that link water and poverty. Natural resource harvesting does present one of the most viable strategies for the poor to mitigate their precarious situation. However, the institutional context of land access mediated through the Tribal Authority system appears inequitable particularly in relation to Female-headed households. Poverty reduction interventions within the water domain that are not cognisance of the dependency of the poor on the natural resource base are likely to be marginal in reducing poverty in a locally-defined and meaningful way. Focus on 'blue' water provision (as in reticulated supply) is fraught with problems in a remote rural context yet is shown here to have little leverage in reducing the constraints that the livelihoods of the rich and poor face. Health benefits do, of course, matter but reticulated supplies are not the only option, i.e. groundwater.

'Water scarcity' is the new mantra at the global policy table but the rural poor face more nuanced understandings of both poverty and water resource use than these headline titles acknowledge. Policy that fails to adequately incorporate the green water dimension of rural livelihoods will significantly reduce its poverty reduction impact. Presenting water and poverty narratives in a format that only includes the blue water and reticulated context is misleading and likely to make impacts only in the narrow but important health sector. Developing world capacity to achieve the posited gains in irrigated kitchen garden farming is unlikely in the short to medium term (3-5 years). Whilst no one disputes the value and importance of good health from clean water the resources expended in promoting and implementing such a strategy seriously compromise a more holistic water-poverty analysis that can channel funds into local solutions (e.g. sustainable use of groundwater resources) but also allow other water-dependent livelihood activities to be sustainably and equitably assessed, negotiated, developed and managed at the local level.

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References

Aliber, M. (1999) Study of the incidence and nature of chronic poverty and development policy in South Africa: an overview. Chronic Poverty Research Centre, Background Paper 3. IDPM: Manchester.

Arntzen, J. (1998) Economic valuation of Communal Rangelands in Botswana: A Case Study. CREED working paper No. 17. IIED: London.

Benhke, R. and Abel, N. (1996) Sustainability and stocking rate of African rangelands. *World Animal Review* **87**: 17-27.

Biswas, A.K. (2002) From Mar del Plata to Kyoto: A Review of Global Water Policy Dialogues. Key-note lecture. International symposium on water for human survival. New Delhi, India. 27-30 November, 2002.

Bojo, J. (1991) Economics and Land Degradation. *Ambio,* 20 (2): 75-79.

Budlender, D. and Brathaug, A.L. (2002) Calculating the value of unpaid labour: a discussion document. Statistics South Africa: Pretoria.

Carney, D. (1998) Implementing the Sustainable Rural Livelihoods Approach. In D. Carney (ed.) Sustainable Rural Livelihoods, What contribution can we make? Papers presented at the Department of International Development's Natural Resource Adviser's Conference, London, July 1998. DFID: London.

Carter, M. R. and May, J. (1999). "Poverty, Livelihood and Class in Rural South Africa." World Development **27**(1): 1-20.

Casley, D.J. & Kumar, K. (1988) The Collection, Analysis, and Use of Monitoring and Evaluation Data. John Hopkins University Press.

Chen, S. and Ravallion, M. (2000) How did the World's Poorest Fare in the 1990s? Policy Research Working Paper: 2409. Poverty and Human Resources, Development Research Group. World Bank: Washington, D.C.

Convery, F. (1995) Applying Environmental Economics in Africa. World Bank Technical Paper No. 277. The World Bank: Washington, D.C.

Crookes, D., Ireland, C., de Wit, M., Geach, B., Kgame, W., and Netshiluvhi, T. (2000) Benefits and costs of natural resource use in Sekhukhuneland, Northern Province: case study evidence from Manganeng and Makua. CSIR Report: ENV-P-I-2000-013. CSIR: Pretoria.

de Haan, C., Steinfeld, H., and Blackburn, H. (1997) Livestock and the Environment: finding a balance. FAO/USAID/World Bank.

Duraiappah, A.K. and Perkins, J.S. (1999) Sustainable Livestock Management in the Kalahari: an Optimal Livestock Rangeland Model (OLR). International Institute for Environmental Development (IIED)/Institute for Environmental Studies (IVM). CREED Working Paper No. 23. IIED: London.

DWAF (2003) A new charge for raw water introduced by the Department of Water Affairs and Forestry. Short news release, 2003. DWAF: Pretoria.

Ellis, F. (2000) Rural livelihoods and Diversity in Developing Countries. Oxford University Press: Oxford.

Falkenmark, M., 1995. Coping with water scarcity under rapid population growth. Conference of SADC Ministers, Pretoria 23-24 November 1995. SADC: Pretoria.

FAO (1986) Water for Animals. Food and Agricultural Organization. Report: AGL/MISC/4/85. FAO: Rome.

FAO (1998) Crop evapotranspiration: guidelines for computing crop water estimates. Irrigation and Drainage Paper No. 56. FAO: Rome.

Gleick, P.H. (1996) Basic water requirements for human activities: Meeting basic needs. *Water International,* Vol. 21: 83-92.

Gleick, P.H. (2003) The World's Water: The Biennial Report on Freshwater Resources, 2002-3. Pacific Institute for Studies in Development, Environment, and Security. Island Press: Washington, D.C.

Gordon, H.S. (1954) The economic theory of a common-property resource: the fishery. *Journal of Political Economy* **62:** 124-142.

Gowing, J.W. (2003) Food security for sub-Saharan Africa: does water scarcity limit the options? *Land Use and Water Research* **3** (2003) 2.1-2.7 (Available at: http://www.luwrr.com)

High, C. and Shackleton, C.M. (2000) The comparative value of wild and domestic plants in home gardens of a South African rural village. *Agroforestry* **48**: 141-156.

Hope, R.A., Dixon, P-J and von Maltitz, G. (in press) The role of kitchen gardens in livelihoods and poverty reduction in Limpopo province, South Africa. In, Butterworth, J., Moriarty, P. and van Koppen, B. (eds) Beyond Domestic: cases studies on poverty and productive uses of water at the household level. IWMI/NRI/IRC: Delft, Holland.

Hussein, K. (2002) Livelihoods Approaches Compared: A Multi-agency Review of Current Practice. ODI-DFID: London.

IIED (1997) Valuing the Hidden Harvest: Methodological Approaches for Local-Level Economic Analysis of Wild Resources. Sustainable Agricultural Research Series Volume 3, Number 4. Sustainable Agricultural Programme, IIED: London.

Ironmonger, D. (1993) 'Why measure and value unpaid work?' Revised version of a paper presented to the International Conference on the Measurement and Valuation of Unpaid Work, Ottawa, Canada.

Kamara, A., van Koppen, B. and Magingxa, L. (2001) Economic viability of small-holder irrigation systems in the context of state withdrawal: the Arabie Scheme in the Northern Province of South Africa. 2nd WARFSA/WaterNet Symposium: Integrated Water Resource Management: Theory, Practice and Cases; Cape Town, 30-31 October 2001.

KAWAD (2001). A Fine Balance: Managing Karnataka's Scarce Water Resources. Bangalore, India, Karnataka Watershed Development Society (KAWAD): 18.

Kirsten, J.F., Sartorius von Bach, H.J. and van Zyl, J. (1995a) The Farmer Support Programme in KaNgwane. In, (eds) Singini, R. and van Rooyen, J. (1995) Serving small-scale farmers: An evaluation of the DBSA's farmer support programmes. Development Bank of Southern Africa, Development Paper 44. DBSA: South Africa.

Kirsten, J.F., Sartorius von Bach, H.J. and van Zyl, J. (1995b) The Farmer Support Programme in Venda. In, (eds) Singini, R. and van Rooyen, J. (1995) Serving small-scale farmers: An evaluation of the DBSA's farmer support programmes. Development Bank of Southern Africa, Development Paper 44. DBSA: South Africa.

Lange, G-M., Barnes, J. I. and Motinga, D. J. (1997) Cattle Numbers, Biomass, Productivity, and Land Degradation in the Commercial Farming Sector of Namibia, 1915-1995. DEA Research Discussion Paper No. 17. Windhoek: Namibia.

Meach, M. and Learns, R. (1996) The Lie of the Land. Heinemann. James Currey: UK.

Pazvakawambwa, G.T. and van der Zaag, P. (2000) The value of irrigation water in Nyanyadzi smallholder irrigation scheme, Zimbabwe. 1st WARFSA/WaterNet Symposium: Sustainable Use of Water Resources, Maputo, 1-2 November 2000.

Perez de Mendiguren, J.C. and Mabelane, M. (2001) Economics of productive uses of domestic water in rural areas: a case study from Bushbuckridge, South Africa. AWARD Research Report, Acornhoek, South Africa: 137.

Perman, R., Ma, Y., McGilvray, J. and Common, M. (1999) Natural Resource and Environmental Economics. Second Edition. Longman: Essex.

Perret, S. (2002) Water policies and small-holding irrigation schemes in South Africa: a history and new institutional challenges. *Water Policy* **4** (3): 283-300.

Poate, C.D. & Daplyn, P.F. (1993) *Data for Agrarian Development*. Cambridge University Press.

Quan, J., Barton, D. and Conroy, D. (1994) A Preliminary Assessment of the Economic Impact of Desertification in Namibia. DEA Research Discussion Paper No. 3. DEA: Namibia.

Rosegrant, M.W., Cai, X. and Cline, S.A. (2003) World Water and Food to 2025: Dealing with Scarcity. International Food Policy Research Institute (IFPRI): Washington, D.C.

Rosen, S. and Vincent, J. R. (1999). Household Water Resources and Rural Productivity in Sub-Saharan Africa: A Review of the Evidence, Harvard Institute for International Development: Harvard University: 90.

RSA (1998) National Water Act. Act 36 of 1998. Government of Republic of South Africa: Pretoria.

Savenije, H.H.G., 1998. How do we feed a growing world population in a situation of water scarcity?, Key note paper presented at the 8th Stockholm Symposium, 10-13 August, 1998, Published in Water-The Key to Socio-economic Development and Quality of Life (pp.49-58). SIWI: Stockholm.

Sen, A. (1981) Poverty and Famines: An Essay on Entitlement and Deprivation. Oxford University Press: Oxford.

Singini, R. and van Rooyen, J. (1995) Serving small-scale farmers: An evaluation of the DBSA's farmer support programmes. Development Bank of Southern Africa, Development Paper 44. DBSA: South Africa.

Scholes, R.J. (1997) NPP Grassland: Nylsvley, South Africa, 1974-1989. Data set. Available at: http://www.daac.ornl.gov from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennesse, U.S.A.

Scoones, I. (1998) 'Sustainable Rural Livelihoods: A Framework for Analysis', IDS Working Paper 72.

Scoones, I., Melynk, M. and Pretty, J.N. (1992) The Hidden Harvest: Wild Foods and Agricultural Systems. A Literature Review and Annotated Bibliography. Sustainable Agricultural Programme, IIED: London.

Seckler, D. (1999) World Water Scarcity and the Challenge of increasing Water Use Efficiency and Productivity. In, Sustainable Agricultural Solutions, The Novello Press Ltd: London.

Shackleton, C.M., Netshiluvhi, T.R., Shackleton, S.E., Geach, B.S., Ballance, A. and Fairbanks, D.F.K. (1999a) Direct use values of woodland resources from three rural villages. CSIR report: ENV-P-I 98210. CSIR: Pretoria.

Shackleton, C.M., Shackleton, S.E. and Cousins, B. (2001) The role of land-based strategies in rural livelihoods: the contribution of arable production, animal husbandry and natural resource harvesting in communal areas of South Africa. *Development Southern Africa*, Vol. 18, No. 5, December 2001.

Shackleton, C.M., Shackleton, S.E., Netshiluvhi, T.R., Mathabela, F.R. and Phiri, C. (1999) The direct use value of goods and services attributed to cattle and goats in the Sand River catchment, Bushbuckridge. CSIR report: ENV-P-C 99003. CSIR: Pretoria.

Singini, R. and van Rooyen, J. (1995) Serving small-scale farmers: An evaluation of the DBSA's farmer support programmes. Development Paper 44. DBSA: South Africa.

StatsSA (1999) Rural survey, 1997. Statistical release: P0360. StatsSA: Pretoria.

StatsSA (1998) Living in Northern Province. Selected findings of the 1995 October household survey. StatsSA: Pretoria.

StatsSA (2001) A Survey of Time Use. How South African Women and Men Spend their Time. StatsSA: Pretoria.

Sullivan, C. (2001) Calculating a Water Poverty Index. *World Development* Vol.30, No. 7:1195-1210.

Thompson, J., Porra, I. T., Tumwine, J. K., Mujwahuzi, M. R., Katui-Katua, M., Johnstone, N. and Wood, L. (2001). Drawers of Water II: Domestic Water Use in East Africa. International Institute for Environment and Development (IIED). IIED: London.

van Kooten, C.G. and Bulte, E. (2000) The Economics of Nature: Managing Biological Assets. Blackwell: Oxford, UK.

Waughray, D.K., Lovell, C.J. and Mazhangara, E. (1998) Developing Basement Aquifers to Generate Economic Benefits: A Case Study from Southeast Zimbabwe. *World Development* Vol. 26, No. 10: 1903-1912.

WWAP (2003) Water for People, Water for Life. United Nations World Water Assessment Programme. UNESCO: Paris.