Poverty, Inequality and Environmental Resources: Quantitative Analysis of Rural Households

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Abstract: Rural households have been suspected to rely heavily on goods and services freely provided by environmental resources. However, there has been no adequate quantitative analysis of this issue due to a lack of appropriate household data sets encompassing economic and environmental data. We use a purpose-collected 213 household data set from rural Zimbabwe to investigate the impact of incorporating this missing source of household welfare on quantitative analysis of the measurement and causes of rural poverty and inequality. Incorporating environmental income in the household accounts results in dramatic and significant reductions in measured poverty, 50 percent or more over income as conventionally measured. Environmental income is also strongly and significantly equalising, bringing about roughly a 30 percent reduction in measured inequality. So access to commons resources has a substantial impact on poverty and inequality. However, including the value of environmental utilisations leaves analysis of the causes of rural differentiation unchanged: these resources do not alleviate the poverty trap.

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1. Introduction

How poor are rural households? How unequal are rural societies? And what explains these phenomena? These questions have a long history and continue to engage leading economists (see for example Sen 1982, Dreze and Sen 1990, Dasgupta 1993, Deaton 1997: ch.3). At the same time, there has recently been increasing interest in the economic relationship between rural households and environmental resources - commonly termed the poverty-environment relationship. It has been suggested that rural households may depend quite heavily on freely-provided environmental goods and services to sustain their welfare, through the provision of both productive inputs and consumption goods. Since these environmental resource uses are classically omitted from household budget surveys, it has also been suggested that there is a substantial gap in our quantitative understanding of rural households (Dasgupta 1993: 273). Further, given that most rural environmental resources are held under common ownership, analytical work has pointed to major informational and coordination problems in sustaining communal resource management equilibria (eg. Ostrom 1990, Baland and Platteau 1996).

To date, there have been no adequate empirical attempts to marry together the different problems of quantification of the value of environmental resource use, and the impact these values have on the poverty and inequality of rural households. Analysis of these problems has been stymied by an absence of household data sets that systematically integrate the use and value of environmental resources alongside the more standard set of household economic activities. (A partial exception is Jodha 1986, but this study did not work with detailed household survey data and presented only highly aggregated results). We overcome this problem by using a 213 household data set, collected by the author from rural Zimbabwe, constructed with exactly this purpose in mind. In other words, this data set is derived from a household budget survey that rather uniquely collected comparable quantity and price data on both environmental resource use and all other economic activities at the household level.

As we will see below, these data show that environmental resources do indeed form a quantitatively significant (and commonly overlooked) component of rural incomes. So the purpose of this paper is to examine what difference is this fact might make to an empirical analysis of poverty and inequality. One side of this analysis concerns the measurement of poverty and inequality. Given the quantitative significance of environmental income, we will explore the impact that including environmental income has on estimates of the extent of rural poverty and inequality by contrasting two income measures: one that would be derived from a typical household budget survey versus one that includes that value of resource utilisations. Simply measuring poverty and inequality is only one task, though: there is the equally compelling question of the determinants of poverty and inequality. So we also examine whether conclusions concerning the causes of rural differentiation remain unchanged when the rural income measure is changed so dramatically. Answers to these questions can be interpreted in two ways. The first is essentially statistical. The typical rural household survey produces an estimate of income which errs considerably by ignoring freely-provided environmental goods. By contrast, our survey has derived a truer measure of income, incorporating these values. So one can think of this paper as an exploration of the extent to which this particular error in the measurement of rural incomes affects our understanding of rural inequality and poverty: in short, how much are past studies likely to have got things wrong? Is the traditional view of rural inequality and poverty seriously misleading? The second way of interpreting the results relates to the specifically environmental nature of the additional incomes that have been measured. In other words, to what degree is the existence and use of environmental resources pro- or anti-poor? To what degree is this inequality-promoting or reducing? And how does this affect the underpinnings of rural household differentiation?

The paper proceeds as follows. In the next section we demonstrate the overall quantitative significance of environmental resources and define the two income measures that will be used to compare the results of the typical household survey and our environmentally-augmented survey. Sections 3 and 4 look at the impact of environmental income on the measurement of poverty and inequality respectively, using a range of indices to measure poverty and inequality, and a range of poverty lines for poverty to ensure the robustness of our findings. We find that *the inclusion of environmental income dramatically and significantly reduces estimates of the prevalence of poverty and inequality*. This suggests that rural households' poverty and inequality are considerably overstated in conventional studies. In section 5 we further check the robustness of these findings by relaxing assumptions about the definition of income used in the comparisons and by using a relative poverty line. Although the absolute magnitudes decrease, we still find substantial and significant reductions in both poverty and inequality. Finally, in section 6 the causes of rural differentiation are explored through the decomposition of poverty and inequality indices. Conversely, here *the inclusion of environmental income made little difference to findings as to the causes of poverty and inequality*. Section 7 concludes.

2. Environmental resource use data and income definitions

There is a copious literature attesting to the potential significance of environmental resources for rural households' consumption and production (eg. Sale 1981, Jodha 1986, Falconer and Arnold 1991, Lampietti and Dixon 1994, Townson 1994). To date, though, there has been no serious empirical data with which to investigate this phenomenon. Some studies have looked at rural households' use of environmental resources, but these studies have often suffered from insecure quantification and from valuation of only a subset of resource uses or a subset of non-environmental activities. It is not possible to cite a study that has attempted to quantify and value in a consistent manner both the full set of household economic activities as well as the complete range of environmental resources that these households are found to use.

Such was the purpose of this study. The data were collected in 1993/94 from 213 randomly-sampled households from 29 villages in Shindi Ward in southern Zimbabwe. (Appendix I contains more details of the research area). We briefly outline some of the principles used in producing this unusual data set.[1] First, there is the question of the precise definition of an environmental resource. The one used in our study was that to qualify as an environmental resource, the resource as must be freely provided by natural processes ie. it can treated as "Nature's bounty." In Shindi, the vast bulk of these resources were derived from areas - such as rangelands, woodlands, aquifers, and rivers - that are held under conditions of communal ownership. However, there were some wild species that grow spontaneously on private lands: these we also included in our definition of environmental resources. With this definition, it transpired that Shindi households used an enormous range of environmental resources: these included a wide variety of foodstuffs; a number of non-food direct uses; a large number of uses

[1] A full account is given in Cavendish (1999), available from the author on request.

for wood, including for energy, construction materials and various implements; other non-wood tree uses such as leaf litter and livestock fodder and browse; the use of grasses, canes, reeds etc. for thatch, mats and baskets; soil for pottery and fertiliser; and gold. At least 100 different resource utilisations were identified, and in many cases multiple wild species were used for each resource utilisation (a full list of utilisations and species, including botanical names, is in Cavendish 1999: 35-43). A broad classification of these environmental utilisations demonstrates the range of economic functions offered by these resources (table 1). It was also clear that hardly any of these utilisations would be picked up by a standard household budget survey.

Table 1 - A Classification of Environmental Resource Utilisations by Economic Function

Consumption Goods	Inputs	Output Goods	Durables and Stocks
1. Wild fruits	1. Firewood (beer brewing)	1. Wild fruit sales	1. Furniture
2. Wild vegetables	2. Firewood (brick burning)	2. Wild vegetable sales	2. Large hh utensils (wood)
3. Large wild animals	3. Leaf litter	3. Wild animal sales	3. Firewood store
4. Small wild animals	4. Termitaria	4. Wine sales	4. Construction wood
5. Wine	5. Livestock browse & graze	5. Firewood sales	5. Fencing (wood)
6. Other wild foods	6. Thatching grass	6. Construction wood sales	
7. Firewood (cooking/heating)		7. Thatching grass sales	
8. Agricultural tools (wood)		8. Other wild good sales	
9. Small hh utensils (wood)		9. Carpentry sales	
10. Mats (reeds)		10. Woven goods sales	
11. Woven baskets		11. Pottery sales	
12. Pottery		12. Env.-based labour income	
13. Wild medicines		13. Gold sales	

The environmental resource use and non-environmental economic data were valued and aggregated using standard principles for households involved in both market and non-market activities, to produce household income accounts (see Grootaert 1982). In particular, wherever possible economic transactions - including environmental utilisations - were valued either at households' reported prices or at local market prices; value-added was calculated where relevant, including for subsistence agriculture; and where valuation of resource utilisations was difficult, methods were developed using the best price data available. The household income data were then made welfare-comparable by adjusting for inter-household differences in household attendance, household size and demographic structure: thus in this paper "income" refers to income per adjusted adult equivalent unit.

Income accounts at a high state of aggregation are presented in table 2, with income sources booked under one of four categories: cash income, net gifts/transfers, subsistence income and environmental income. This table demonstrates clearly the quantitative importance of environmental resources to rural households. In total value terms, environmental resources account for as great a quantity of income as (non-environmental) cash income, while in terms of average budget share, these resources account for 35 percent of total income, just less than that of the largest item, subsistence consumption. Given that the value of these resource utilisations does not appear in standard household studies, these data confirm that there is a substantial quantitative gap in the conventional understanding of rural households. They also lead naturally on to the concerns of this paper. With such a large source of omitted value, how confident can we be of conventional poverty and inequality estimates? How does environmental income affect these measures? And does it alter analysis of the causes of these phenomena?

Table 2 - 1993/94 Shindi Total Income by Aggregated Income Source

	Sum of Incomes Per Adj. Aeu	Income Budget Shares [1]
Crop Income	6,935	3.42
Livestock Income	3,359	1.86
Unskilled Labour Income	4,277	2.91
Skilled Labour Income (Teaching)	6,534	1.23
Crafts and Small-Scale Enterprises	6,173	3.03
Remittances	28,405	13.36
Miscellaneous Cash Income	344	0.16
Total Cash Income (Excl Env Cash Income)	**56,026**	**25.96**
Total Net Gifts/Transfers	**4,664**	**1.67**
Consumption of Own Produced Goods	50,111	30.23
Input Use of Own Produced Goods	11,143	6.94
Total Own Produced Goods	**61,254**	**37.17**
Gold Panning	12,313	7.23
Environmental Resource Utilization Cash Income	7,625	4.62
Consumption of Own Collected Wild Foods	9,557	6.29
Consumption of Own Collected Firewood	11,836	7.35
Consumption of Own Collected Wild Goods	952	0.65
Use of Environmental Goods for Housing	4,476	2.70
Use of Environmental Goods for Fertiliser	879	0.57
Livestock Browse/Graze of Environmental Resources	10,186	5.79
Total Environmental Income	**57,825**	**35.20**
Total Income	**179,769**	**100.00**
Summary Data		
Mean Income Per Adj. Aeu	844	
Median Income Per Adj. Aeu	721	

Notes
1. Average income shares are calculated as the mean of the individual household's budget shares, rather than the simpler procedure of calculating the aggregate share of the income subcomponent in total income. This reduces the impact of extreme individual household values on the average budget share value.

Definition of income measures
To answer these questions, we first define the different income measures that are to be compared. The first - total income - is drawn from the full, environmentally-augmented questionnaire implemented in Shindi. It is the broadest measure of income that can be derived from those data, and incorporates the value of all measured environmental utilizations as well as the other three income categories of table 1. The second measure we label standard income: this comprises cash income (excluding environmental cash income), net gifts and the net value of own production. This measure of income excludes by construction all environmental income sources, and is a

plausible estimate of the income measure that would be derived for the sample households if a standard Household Budget Survey (HBS) had been implemented over the same period.

This we argue for two reasons. The first is that standard HBSs exclude all the questions we included concerning the use of environmental resources, without which it is not possible to calibrate resource use values. For example, very few household surveys in developing countries have attempted to value even the household's use of firewood, yet this is the most widely recognised use of environmental resources. As for less well-known resource utilizations - such as wild foods, natural fertilisers, natural construction materials and production inputs - these are completely excluded. Of course, there are some environmental values that a standard questionnaire may pick up in passing. This may be the case especially with environmental sources of cash income, which we have excluded from standard income. Since standard HBSs do have sections on cash income generally, it may be argued that they would pick up this item. However, field experience leads one to be cautious about this assertion. It is truism that questionnaires get data only on the questions that they directly ask. General questions about "other cash sources" rarely pick up even significant cash sources, and this is particularly true of resources which are regarded locally as "small" or "inferior." Many of the data on environmental cash income were only picked up in our questionnaire because there were specific questions asking about these income sources, without which it is unlikely that these data would have been volunteered by the respondents. This goes even for categories like environmentally-derived local labour income, since the activities which comprise this item were thatching, digging termitaria, carving and roof mending. It is reasonable to assume that without questions specifically targeted at these items, they would not have been uncovered.[2]

Second, the non-environmental sections of the questionnaire were explicitly modelled on standard HBSs, such as those conducted by national statistical agencies and under Living Standards Measurement Survey of the World Bank. Indeed, the survey questions on resource use were “piggy-backed” onto standard question and categories concerning income, consumption, expenditure and assets. Income calculations from these sections of the questionnaire should therefore be very similar to income measures derived from these standard surveys. Thus the two measures "standard income" and "total income" will serve us for exploring both facets of the questions posed above, relating both to the problem of misestimation of income was well as to the specific poverty and inequality characteristics of environmental income.

3. Poverty and environmental income

Since the poor are those who are unable to command sufficient resources to meet a reasonable minimum standard of living, it follows that poverty alleviation is a pressing social imperative. However, poverty alleviation must rely on an accurate measure of poverty and accurate identification of the poor. In this section we focus on the issue of poverty measurement, deferring consideration of the causes of poverty to section 6. Specifically, we pursue the questions: how does the incorporation of environmental income alter our view of the extent of

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[2] In section 5 we define a broader measure of income derived from the typical HBS, which we term expanded income. This expanded income measure includes certain environmental income sources - such as gold panning - which a broader interpretation could ascribe to the typical household questionnaire. We then compare this income measure against total income to check that our results are not contingent on the definition of standard income adopted here.

rural poverty? Associatedly, how far wrong would we be in our assessment of the extent of rural poverty if we relied on the standard measure of income? These questions have particular pertinence in the field of poverty analysis, due to fact that both in Zimbabwe and indeed globally, poverty is overwhelmingly a rural phenomenon. For example, in Zimbabwe it is estimated that 88 percent of the poor live in rural areas, while 31 percent of rural dwellers are classed as being poor (World Bank 1996).[3] Thus any answers to these questions on the impact of environmental resources on our measurement of rural poverty have potentially wide significance.

Defining a poverty measure

In order to compare poverty prevalence under standard and total income measures, we must first define a poverty measure. However, there are many controversies in the field of poverty research when it comes to measuring poverty. The first concerns the choice of a measure of personal welfare. Arguments range about the appropriateness of welfarist as against non-welfarist indicators; about the balance between well-being as measured by the actual consumption of goods as against the potential consumption of goods; and about supplementing measures based on private goods with adjustments for public goods. For this study we have had follow standard practice and ignore many of these issues by simply choosing income as the measure of welfare. Note that although it is more common for poverty studies to choose per capita consumption as a measure of individual welfare, in our study there is little difference between income and consumption as such a high fraction of household total income is made up of the consumption of own produced goods and the consumption of own collected environmental goods, which appear in both income and consumption accounts.

A second decision needs to be made concerning the choice of the poverty line. In the literature there is disagreement whether the poverty line should be absolute, relative or subjective; if absolute, what bundle of goods should constitute "basic needs" and what the ratio should be between food and non-food consumption, plus how the costs of this bundle should be estimated; if relative, what the elasticity should be between mean incomes and the poverty line; whether one poverty line should be used, or more than one; and so on. (These issues are comprehensively discussed in Ravallion 1992 and Deaton 1997). For our purposes, though, deciding the exact position of the poverty line is not as important as comparing results for poverty measures under different assumptions about the location of the poverty line. In other words, we are concerned less with a point estimate of poverty, more with the robustness of poverty measures to different poverty lines. So we have chosen poverty lines, fixed with reference to the standard income distribution, that span a wide range of incomes in our sample. The first three poverty lines correspond to the uppermost incomes of the first three quartiles of the standard income distribution. The fourth poverty line is set at the mean of the rural poverty lines used in other household studies in Zimbabwe. This produced a poverty line of Z$1,000 per adj. aeu per annum, equivalent to the 89th percentile of the standard income distribution in Shindi.[4] We then

[3] These data are drawn from the 1990/91 Income, Consumption and Expenditure Survey conducted by the Zimbabwe Statistics Organisation. While this survey had methodological flaws, it remains the best source of information for rural households. Other estimates of poverty in Zimbabwe give higher figures than the ICES. The Poverty Assessment Study Survey of 1995 estimated overall poverty to be 62 percent of the population, while Ravallion and Chen (1996) estimated that, in 1993, 39 percent of the population were living on less than US$1 per person per day.

[4] There is no consensus within Zimbabwe on the choice of a poverty line. The 1990/91 ICES used upper and lower rural poverty lines of US$100 (Z$340) and US$61 (Z$209), while the 1995/96 PASS used much higher upper and lower rural poverty lines of US$224 (Z$1,924) and US$137 (Z$1,180). If these various US$ poverty lines were ordered and applied to

calculate poverty indices for all these different poverty lines for both income measures, so that we are then effectively conducting the experiment - if the poverty line were Z$x, how much poverty would there be using the standard income measure? How much would there be, for the same poverty lines, using the total income measure? This method therefore allows us to examine how far wrong standard household survey methods are, but in a manner that is robust to the choice of poverty line.[5]

A third problem concerns the choice of indices to be used in the measurement of poverty. We follow common practice and use three measures from the Foster-Greer-Thorbecke (P_α) class of poverty measures. The general class of P_α poverty indices is given by

$$P_\alpha = \int_0^z \left(\frac{z-x}{z} \right)^\alpha f(x)\, dx$$

where z is the poverty line, and $f(x)$ is the population density function of income. The measures that we calculate here are α = 0, 1, and 2. These measures have been extensively described in the poverty literature, so we simply summarise. In descriptive terms, P_0 is the headcount index, P_1 is the poverty gap index, and P_2 is the poverty severity index. In normative terms, all P_α terms are sub-group decomposable and homogenous of degree zero in incomes and the poverty line. However, P_0 fails the Sen monotonicity axiom, namely that any poverty measure must increase if *ceteris paribus* the income of a poor person decreases, while only P_2 meets Sen's transfer axiom, namely that a pure transfer of income from a poorer to a richer person should increase the poverty measure. Thus the headcount measure is a purely informative index, indicating the percentage of households in the sample that are poor, while P_1 and P_2 are the indices which accord more with normative perceptions concerning the measurement of poverty.

Environmental income and aggregate poverty measures

Turning to the results of the poverty calculations, in table 3 we present poverty measures for three poverty indices and four poverty lines, computed for both the standard income measure and the total income measure. The results are striking. If the poverty line is set at a lowish percentile of income, then there is an enormous difference between poverty measured by standard income versus that measured by total income. In the case of the 25th percentile poverty line, only 2 percent of households would be classified as poor by total income against 25 percent for standard income, a drop of 91 percent in the headcount measure. The poverty gap and poverty severity indices would drop by an even larger degree: a 98 percent decrease in the case of the latter measure. Now it is quite likely that a poverty line of Z$304 is an underestimate. However, as we saw the 50th and 75th percentile poverty lines accord roughly with the lower and upper rural poverty lines for the Zimbabwean ICES, and using these poverty lines there are still dramatic

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Shindi using the 1993/94 period average exchange rate (Z$7.71 per US$), they would imply poverty lines of Z$470, Z$771, Z$1,056 and Z$1,727 respectively. Since the PASS poverty lines are at the upper end of our distribution, as stated in the text we have also included a poverty line of Z$1,000, which is the average of the four measures and is roughly equal to the PASS lower rural poverty line. Note that the 50th and 75th percentile poverty lines of our distribution are also roughly equal to the ICES lower and upper rural poverty lines translated into Z$ for 1993/94.

[5] This assumes that the poverty line remains unchanged as we move between standard and total income. We justify this assumption in section 5 where we also explore the consequences for measured poverty of relaxing this assumption.

differences in the measurement of poverty using the two measures. The headcount measure alone drops 68 and 39 percent respectively: for either of these poverty lines use of the standard income measure would lead to substantial overestimates of the proportion of the population classified as poor. However, in both cases the P_1 and P_2 indices register even greater reductions in measured poverty for the total income measure. We will discover later that environmental income is an equalising income source, so one would expect these two measures to register larger decreases in poverty than the headcount measure, in that the addition of environmental income "pulls up" the incomes of the worst off more, thereby reducing the poverty gap more than the proportion of households who are poor. Nonetheless, the magnitude of the figures is impressive. Taking the poverty gap measure, for a poverty line of Z$433 the calculation of poverty using total income reduces measured poverty by 82 percent, and by 62 percent for a poverty line of Z$674. These are substantial reductions.

This point also applies for the higher, 89th percentile poverty line. Here the reduction in the headcount measure of poverty is a smaller, though at 17 percent it still remains important. But the key result is that, even for this higher poverty line, the reduction in poverty measured by the poverty gap and poverty severity measures are still sizeable. Thus comparing standard and total income poverty measures, P_1 drops by 42 percent while P_2 drops by 56 percent. In other words, for this poverty line, conventional estimates of poverty based on the standard income measure will be overestimating poverty by a factor of two.

Table 3 - Poverty Indices for Differing Measures of Income and Differing Poverty Lines

1	2	3	4	5	6	7	8	9	10
			Income Aggregate		Percent Poverty Reduction via Income Expansion	Standard Errors (3)		t-stat. of diff. between poverty measures	
Percentile of Poverty Line (1)	Implied Poverty Line (2)	Poverty Measure	Standard income	Total income		Standard income	Total income		t-stat signif. level (4)
25th	304	Head Count	0.249	0.023	90.6	0.030	0.010	7.18	0.00
		Poverty Gap	0.063	0.003	95.7	0.009	0.002	6.26	0.00
		Poverty Severity	0.023	0.000	97.8	0.005	0.000	4.43	0.00
50th	433	Head Count	0.502	0.160	68.2	0.034	0.025	8.07	0.00
		Poverty Gap	0.154	0.027	82.3	0.014	0.005	8.33	0.00
		Poverty Severity	0.067	0.007	89.6	0.008	0.002	7.08	0.00
75th	674	Head Count	0.751	0.460	38.8	0.030	0.034	6.44	0.00
		Poverty Gap	0.331	0.126	61.8	0.018	0.012	9.55	0.00
		Poverty Severity	0.176	0.047	73.0	0.013	0.006	9.26	0.00
89th	1000	Head Count	0.887	0.737	16.9	0.022	0.030	4.05	0.00
		Poverty Gap	0.493	0.285	42.3	0.018	0.016	8.66	0.00
		Poverty Severity	0.311	0.137	55.9	0.015	0.010	9.48	0.00

Notes
1. Percentile of the distribution of the standard income measure.
2. Z$ per adjusted a.e.u. per annum.
3. Formulae for the standard errors and t-statistics are taken from Kakwani (1993).
4. One-sided t-test.

Though table 3 suggests that the impact of environmental income on measured poverty is substantial, we also wish to check whether the difference between poverty indices based on standard income as against those based on total income is statistically significant. Let $\{\hat{P}_i^1, \hat{P}_i^2\}$ be two sample estimates of a poverty measure $\hat{P}_i$ based on independent, random samples $\{n_1, n_2\}$, with standard errors of $\text{s.e.}(\hat{P}_i^1)$ and $\text{s.e.}(\hat{P}_i^2)$ respectively. We can conduct tests of the hypothesis H_0: $(\hat{P}_i^1 - \hat{P}_i^2) = 0$ using the standard test statistic

$$\theta_i^{1,2} = \frac{\hat{P}_i^1 - \hat{P}_i^2}{\sqrt{(\text{s.e.}(\hat{P}_i^1))^2 + (\text{s.e.}(\hat{P}_i^2))^2}} \sim \text{asy. N}(0,1)$$

if formulae exist for calculating the sample standard errors. (Note that the distributional results for both this test statistic is asymptotic: however, with a sample size of 213, the error in using the normal distribution as a distributional approximation will be small). These have been provided by Kakwani (1993), and in the case of the P_α indices are simply

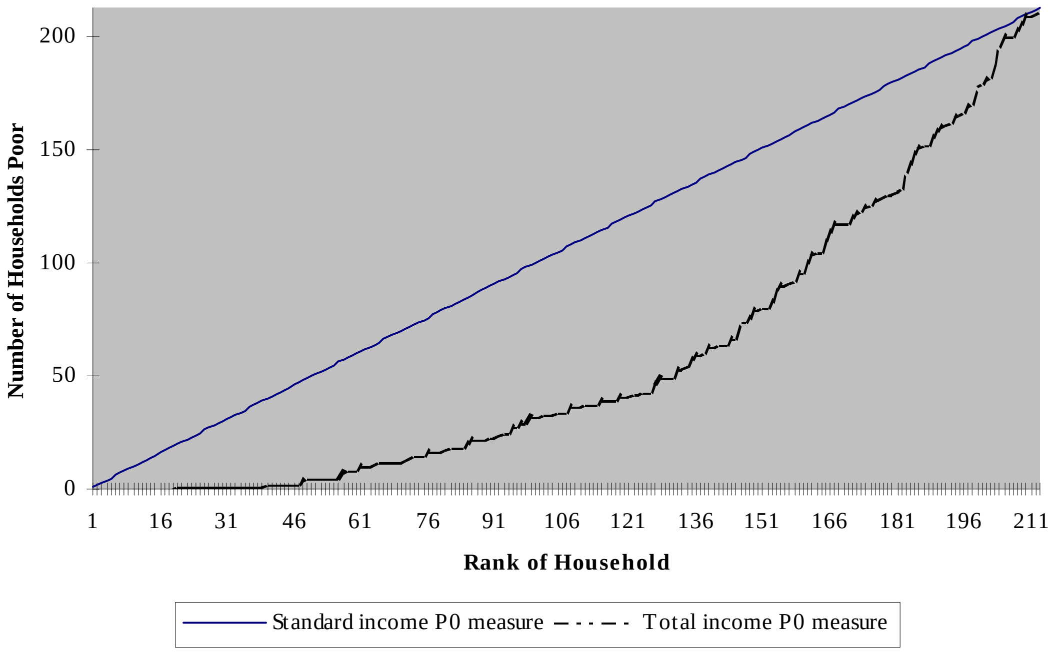
$$\text{s.e.}(\hat{P}_\alpha) = \sqrt{(\hat{P}_{2\alpha} - \hat{P}_\alpha^2)/n}$$

Table 3 contains results both for the sample standard errors of the differing poverty indices (columns 7, 8), and also for tests of significance in the differences (columns 9, 10). Given the sizes of the differences between the poverty measures estimated by the standard and total income measures, it is not surprising to find that these differences are statistically significant. As column 10 demonstrates, poverty as measured by total income is significantly lower at the 1 percent level than poverty measured by standard income for all poverty measures and poverty lines. So standard and total income not only generate enormously different measures of poverty, but these poverty measures also differ in a statistically significant way.

Table 3 demonstrates differences in poverty measures for standard and total income given discrete variations in the poverty line. We can "fill in the gaps" of this table by examining the poverty calculations of these two income measures for continuous variations in the poverty line. The most straightforward poverty index for continuous calculation is the P_0: the results are presented in figure 1. For this figure, the households' standard income vector has been ordered, and the poverty line set at successive household incomes, for all the 213 households. The P_0 index has then been calculated for standard and total income, with the figure setting the number of households classified as poor against the income rank of the household used for the poverty line. For standard income, the results are straightforward: the number of households counted as poor will equal the household rank of the poverty line, so the standard income P_0 in this figure is simply a straight line. The total income P_0 measure, by contrast, shows what the number of households genuinely in poverty might be for each rank increase in the standard income-based poverty line.

As the figure shows, the degree of error over a wide span of the household income ranking is large. At the bottom of the distribution, environmental incomes are sufficiently large compared to other income sources that their inclusion would eliminate poverty completely for a poverty line set that low. "True" poverty then rises only slowly as the household rank of the standard income poverty line rises, so that even by the 150th household, there is still a major difference between

Figure 1 - Headcount Poverty Measure With Two Different Income Measures



the proportions of poverty according to two different income measures. Only towards the very uppermost section of the standard income distribution do the two poverty measures begin to converge. This figure also helps to explain why the reductions in the P_1 measure are also so impressive. The large distances between the standard income P_0 measure and the total income P_0 measure are indicative of a much reduced poverty gap using total income for households at the lower end of the distribution. The cumulative impact of this gap is of course substantial.

4. Inequality and environmental resources

We turn now to the question of the impact of incorporating environmental income on the measurement of inequality. While alleviating inequality is an important ethical concern, a logical prior to be considered before this concern can be addressed is to quantify exactly how much inequality there is in a given social state. An immediate problem in doing this, though, lies in the question of inequality measurement. While analysis of inequality has a long history, there is no agreement on how best to measure inequality, so that a plethora of inequality measures exist, and different combinations of these are used in different studies of the issue. Now an inequality measure is simply an index number characterising a (set of) relevant feature(s) of a set of possible income distributions. In other words, define $x_i \in \mathbb{R}$ as the income of the ith person, and $\mathbf{x} = (x_1,\ldots,x_n) \in \mathbb{R}^n$ as the vector of incomes (or income distribution) of a sample of n agents. Then the set of income vectors can be written $X = \{\mathbf{x}\}$, and an inequality index can be defined as a function $I{:}X \to \mathbb{R}$. The debate in the literature on the theory of inequality measurement essentially surrounds the properties that the function I should possess.

In this paper we have adopted a catholic approach to inequality measurement, by estimating a wide range of inequality measures at each stage of the analysis. We have done this partly in response to the lack of consensus concerning the theory of inequality measurement, and partly as it allows greater comparison between the results of this study and the results of other works on inequality. But also by using a wide range of inequality indices, we augment the robustness of our findings, in that the results cannot be dismissed as an artifact of the indices chosen. The seven indices actually calculated are summarised in table 4, categorised according to whether they are positive or normative inequality indices. The positive indices all summarise some feature of statistical dispersion in the income distribution $\boldsymbol{x}$. While all fail basic ethical criteria for use as inequality indices, they are widely used in other studies, hence their use here (see Kanbur 1984 for more details).

By contrast, the normative indices are derived by imposing restrictions on $I(\boldsymbol{x})$ derived from explicitly-stated ethical beliefs underlying societies' concerns for inequality. Thus, the desire for inequality indices to be anonymous, scale invariant[6] and to meet the Dalton-Pigou criterion requires $I(\boldsymbol{x})$ to be a symmetric, convex function that is homogenous of degree zero in incomes. If we further require $I(\boldsymbol{x})$ to be additively decomposable, then the only admissable indices belong to the generalized entropy class, $GE_\alpha(\boldsymbol{x})$ (Shorrocks 1980, Cowell and Kuga 1981, Shorrocks 1984).[7] So in the analysis below, we calculate GE_α inequality measures for three values, $\alpha = \{0,1,2\}$, in order to reflect a range of social attitudes to inequality. (Given the GE_α form, the elasticity of social substitution equals $1/(1-\alpha)$).

Table 4 - Positive and Normative Inequality Indices

Positive		Normative	
Name	Function	Name	Function
Relative mean deviation, R_1	$\frac{1}{\bar{x}}\left\{\frac{1}{n}\sum_{i=1}^{n} \lvert x_i - \bar{x}\rvert\right\}$	Generalized entropy class, $GE_\alpha(\boldsymbol{x})$	$\frac{1}{\alpha(\alpha-1)}\frac{1}{n}\left[\sum_{i=1}^{n}\left(\frac{x_i}{\bar{x}}\right)^{\alpha}-1\right]$
Coefficient of variation, R_2	$\frac{1}{\bar{x}}\sqrt{\frac{1}{n}\sum_{i=1}^{n}\lvert x_i-\bar{x}\rvert^2} = \frac{1}{\bar{x}}\hat{\sigma}$	- Mean log deviation, GE_0	$\frac{1}{n}\sum_{i=1}^{n}\ln\left(\frac{\bar{x}}{x_i}\right)$
Variance of logarithms, V	$\frac{1}{n}\sum_{i=1}^{n}(\tilde{x}-\ln x_i)^2,\ \tilde{x} = \frac{1}{n}\sum_{i=1}^{n}\ln x_i$	- Theil entropy index, GE_1	$\frac{1}{n}\sum_{i=1}^{n}\left(\frac{x_i}{\bar{x}}\right)\ln\left(\frac{x_i}{\bar{x}}\right)$
Gini coefficient, G	$\frac{1}{2\bar{x}}\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}\lvert x_i - x_j\rvert$	- Generalised entropy-2, GE_2	$\frac{1}{2}\frac{1}{n}\left[\sum_{i=1}^{n}\left(\frac{x_i}{\bar{x}}\right)^2-1\right]$

Calculating inequality indices

We turn now to the actual calculation of these inequality indices. There in one minor issues concerning the transformation of the theoretical approaches above to practical empirics. As noted earlier, in order to make welfare comparisons conceptually feasible across households, we adjusted the crude household income data by an equivalence scale which made allowances for differences in individuals' needs and for economies of scale in household production. While this

6 Invariance to scale change is not universally accepted as a desirable feature of an inequality index: both Sen (1973) and Kolm (1976) have suggested that an inequality index should be "sharper" at lower mean income.

7 Another commonly-used ethical inequality index is the Atkinson measure. However, as this is simply an increasing transform of the GE_α measure, so the two measures will rank income distributions identically (Cowell and Kuga 1981).

makes it plausible to claim that, in our inequality measures, we are comparing welfare across households, it is only feasible to extend that claim to welfare across individuals if we assume that equivalent incomes are equally distributed within the household. While this is an implicit assumption often made in studies of inequality, it is hardly plausible especially in view of the compelling evidence that intrahousehold distributions are far from egalitarian (Alderman *et al* 1995, Behrman 1997). In other words, all our calculations for inequality will be underestimates, even if we cannot say by how much this is likely to be the case.

Table 5 - Inequality Indices for Standard and Total Measures of Income

		1	2	3	4	5	6	7	8	9
		Standard income			Total income					
Inequality measure		Inequality index	Std. error	t-stat, η_i	Inequality index	Std. error	t-stat, η_i	Percent inequality reduction, (4) vs (1)	t-test of difference between measures, $\eta_i^{1,2}$	t-stat signif. level
Relative mean deviation	R_1	0.53	n.a.	n.a.	0.42	n.a.	n.a.	20.0	n.a.	n.a.
Coefficient of variation	R_2	0.83	0.079	10.5	0.62	0.053	11.7	25.1	2.2	0.01
Log variance	V	0.44	0.056	7.9	0.28	0.032	8.6	36.8	2.5	0.01
Gini	G	0.36	0.023	15.5	0.30	0.018	16.4	18.6	2.3	0.01
Mean log deviation	GE_0	0.22	0.028	7.8	0.14	0.017	8.4	35.3	2.4	0.01
Theil entropy index	GE_1	0.24	0.035	6.8	0.15	0.021	7.3	36.9	2.2	0.02
Generalised entropy-2	GE_2	0.34	0.065	5.3	0.19	0.033	5.9	43.9	2.1	0.02
Mean income [3]	$\bar{x}$	573			844					
Standard deviation [3]	$\hat{\sigma}$	476			526					

Notes
1. All formulae for the standard errors of inequality measures and their t-statistics are taken from Kakwani (1990).
2. Column 9 presents significance levels for a one-sided t-test.
3. Income is measured in Z$ per adjusted a.e.u per annum.
4. For comparison, inequality measures for the UK for 1986 were: R_2 = 0.80, G = 0.35, GE_0 = 0.22 and GE_1 = 0.22 (Coulter *et al* 1994).

With this caution in mind, we proceed to provide sample estimates for the different inequality measures and for various different measures of income. These estimates are presented in table 5. We start by discussing the standard income measure as this by construction the income measure closest to those produced by other household surveys. It is instructive to compare inequality in this data set against measured inequality both in other countries and in other studies of rural Zimbabwe. For example, comparing Shindi with data for the UK in 1986 (table 5, note 4), what is remarkable is how similar the inequality measures are. Given that in global terms the UK is regarded as only a moderately inegalitarian society, this suggests that our rural area is likewise not wildly unequal. This is supported by comparing the Gini coefficient for Shindi against the coefficient for a range of other countries (World Bank 1997: table 5). The Gini coefficient for Zimbabwe as a whole is 0.57, while the coefficients for other African countries which are either Zimbabwe's neighbours or which have similar income levels are Côte d'Ivoire 0.37; Egypt 0.32; Ghana 0.34; Guinea 0.47; Lesotho 0.56; Mauritania 0.42; Morocco 0.39; Senegal 0.54; South Africa 0.58; and Zambia 0.46. Shindi also seems to be less unequal than other parts of Zimbabwe: one study of income distribution in 1990/91 for all Communal Areas calculated the Theil entropy index to be either 0.33 or 0.35, depending on the indicator of welfare used (Jenkins and Prinsloo 1995) while another, based on an earlier data set of 1984/85, calculated the all-Communal Areas Theil to be 0.34 (Jackson and Collier 1991).

What we wish to highlight is the comparison between inequality measured by standard income as against that measured by total income (columns 1, 4 and 7): it is this figure that tells us the degree to which standard measures of inequality are mistaken. Here the results are quite startling. We observe a sizeable reduction in measured inequality using total income, that is consistent across inequality measures. Taking the totemic Gini coefficient, this falls from 0.36 for standard income to 0.30 for total income: a reduction of c.19 percent. In fact, the Gini records the lowest reduction in inequality of all the indices used: more distributionally-sensitive measures such as the log variance and the GE family record reductions in inequality consequent on the incorporation of environmental income of 30 to 44 percent. Thus environmental income appears to have a strong equalising effect for rural households. Indeed, the degree of rural inequality revealed in the total income measure is very low indeed: not only is this only roughly half the national Gini coefficient for Zimbabwe, but it is also one of the lowest recorded in international comparisons. Likewise, the total income coefficients are lower than the comparative coefficients for the UK. So use of the total income measure changes our view of inequality in the sample area: rather than regarding the area as a moderately inegalitarian one, based on standard practice, in fact we should regard it has a fairly equal society.

Further, as for the poverty measures we wish to check that these results are the product of significant differences rather than just noise in the data. We do this using the test statistic

$$\eta_i^{1,2} = \frac{\hat{I}_i^1 - \hat{I}_i^2}{\sqrt{(\text{s.e.}(\hat{I}_i^1))^2 + (\text{s.e.}(\hat{I}_i^2))^2}} \sim \text{asy. N}(0,1)$$

where $\{\hat{I}_i^1, \hat{I}_i^2\}$ are two sample estimates of an inequality measure $\hat{I}_i$ with standard errors of $\text{s.e.}(\hat{I}_i^1)$ and $\text{s.e.}(\hat{I}_i^2)$ respectively. This can be calculated using results of Kakwani (1990), who presents formulae for the standard errors of a wide variety of inequality indices, as well as the sample estimates of these standard errors. These tests are also presented in table 5, columns 8 and 9. Here we see that, for all the indices used, inequality measured using total income is significantly lower (at the 5% level) than inequality measured by standard income. In other words, the fairly substantial percentage reductions in inequality brought about by inclusion of environmental income are not the result of sampling error, but rather reflect a genuine difference in inequality measurement between the two income measures.

Finally, we look at the relationship between environmental income, aggregate inequality and social welfare. Recall that the GE_α inequality indices were derived explicitly from underlying social welfare functions. This means that the fact that, for these indices, inequality in total income is significantly lower than inequality in standard income also implies that social welfare is significantly higher when environmental income is included in our measure of individual welfare. However, such a social welfare ranking holds only for the GE_α indices' particular functional forms and their corresponding social welfare functions. We would naturally prefer a less restrictive answer to the question, one which held for a broader class of social welfare functions than the specific ones considered above.

The original result linking social welfare and income distributions was derived in Dasgupta *et al* (1973) and in Rothschild and Stiglitz (1973). There it was shown that for any social welfare function $W(.)$ which is a symmetric and strictly quasi-concave function of individual incomes, then for two distributions ($\mathbf{x}$,$\mathbf{x}'$) with equal mean incomes but differing levels of inequality, if $\mathbf{x}$ Lorenz-dominates $\mathbf{x}'$ ($L(\boldsymbol{x}) \geq L(\boldsymbol{x}')$), then $W(\boldsymbol{x}) \geq W(\boldsymbol{x}')$. This has been extended to distributions with differing mean incomes by Shorrocks (1983) as follows. For any social welfare function $W(.)$ which is both a symmetric and strictly quasi-concave function of individual incomes (equity preference) and which is subject to scale improvement, ie. $W(k\boldsymbol{x}) \geq W(\boldsymbol{x}') \, \forall \, k \geq 1$ (higher income preference), then if both $\mu \geq \mu'$ and $L(\boldsymbol{x}) \geq L(\boldsymbol{x}')$, so $W(\boldsymbol{x}) \geq W(\boldsymbol{x}')$. With this in mind we can see how decisive a social welfare improvement is represented by the income measure that incorporates environmental income as against the standard income measure. Total income both has a higher mean than standard income, and also the total income distribution Lorenz-dominates the standard income distribution (figure 2): consequently for all symmetric, concave social welfare functions which exhibit scale improvement - a very general class - the social state represented by total income is superior to that represented by standard income.

From this examination of environmental income and inequality, we can draw three conclusions. The first is that environmental income in-and-of-itself has a significant and substantial equalizing effect on rural income distribution. Both the size of the reduction in inequality occasioned by incorporating environmental income into our household accounts, and the fact of its statistical significance are impressive. Second, access to environmental income substantially improves the social welfare of our survey area, through its impact in both increasing and equalising individual incomes. Finally, and importantly, failure to include environmental income in rural household questionnaires in fact leads us to make significant errors in our estimation of the true degree of aggregate income inequality. Inequality estimates based on standard income - the income concept closest to standard questionnaire practice - will on our evidence significantly overestimate the degree of rural inequality, probably by about 30 percent. Yet all the evidence we have on rural inequality in fact comes from these types of flawed estimates.

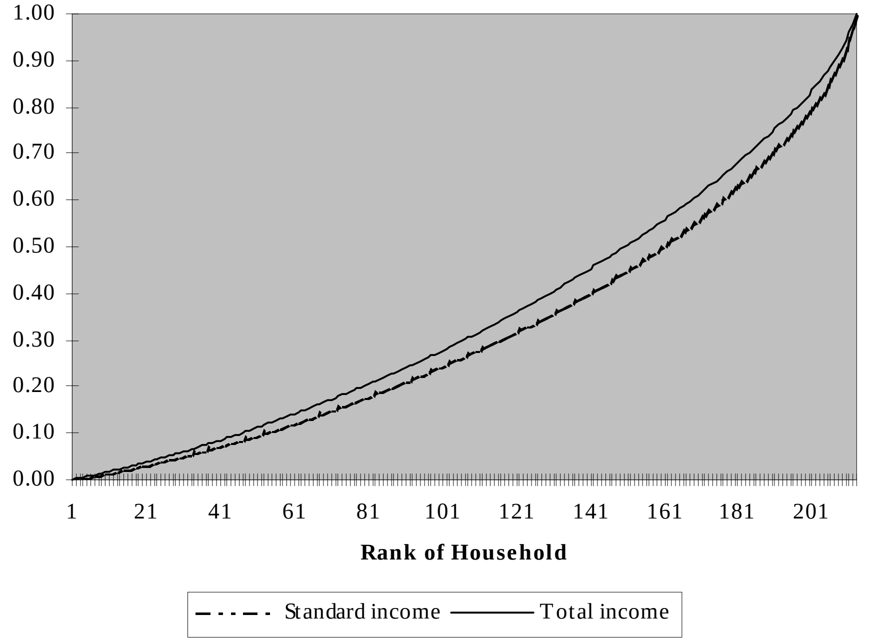
5. Robustness of the results

The income measure

Are our results simply a misleading consequence of the two income measures chosen for analysis? Although we have argued that standard income measure is close to level of household income measured by a typical household budget survey, the results we have derived may depend too heavily on a potentially contestable definition of standard income. In particular, excluding all environmental income from the standard income measure could be thought to be unnecessarily restrictive. In this section, we address this problem by calculating an alternative standard income measure, labelled "expanded" income, and by comparing results for poverty and inequality measures as before.

The principle underlying the definition of expanded income was to include environmental income sources that might be captured by a typical household budget survey, even if there were no questions aimed at environmental income *per se*. There are two sorts of variables that meet

Figure 2 - Lorenz Curves for Standard and Total Income



this criterion. The first is environmental cash income sources which could be picked up through general questions on cash income. These were income from gold panning; cash derived from the sale of large carpentry items (such as doors, door frames, furniture, mortars, pestles, cart frames, shelving, tables and chairs); and environmentally-based local labour income (eg. thatching, roof mending and digging termitaria). The second is environmental income sources that would have appeared in the typical HBS' income measure through default. The example here is the value of all environmentally-derived fertilisers. In a typical HBS, the data on the value of these would not be collected, so that the value of these inputs would not be deducted from gross agricultural output, as has been done here. Instead, these values would remain part of (gross) agricultural income, which would be wrongly estimated but which nonetheless would contain the value of environmental inputs, albeit incorrectly. To calculate expanded income, then, we have simply taken these various environmental income sources and added them to standard income to produce a more catholic measure of income produced in a typical HBS.

We first examine the comparative results on overall poverty levels (table 6). Given the higher poverty lines associated with expanded income, the difference between poverty as measured by expanded income and that measured by total income is smaller than that between standard and total income. Even so, though, the changes in measured poverty are still very substantial. Looking at the prevalence of poverty alone, at the 50th percentile poverty line there is a 49 percent reduction in poverty using total income, at the 75th percentile poverty line the reduction is 24 percent, and at the 85th percentile the reduction is 13 percent. As before, the equalising role of environmental income sources means that there are much larger reductions in poverty gaps and poverty severities than there are in the prevalence of poverty. Thus for the 85th percentile poverty line, the 13 percent reduction in the numbers of the poor is dwarfed by a 33 percent reduction in the poverty gap and a 45 percent reduction in poverty severity. For the 50th and

75th percentile poverty lines, reductions in P_1 and P_2 are higher still: indeed, for the 50th percentile poverty line, almost three-quarters of poverty severity is removed when moving from the expanded income to the total income measure. Further, the difference between the various poverty indices as measured by expanded and total income is statistically highly significant. So our findings concerning aggregate poverty are robust: for a range of candidate poverty lines, classic measures of incomes derived from household budget surveys, whether narrowly or broadly conceived, will significantly overstate the degree of rural poverty. This overstatement is likely to be in the region of at least quarter and may be close to one half. Adding environmental income to our measure of household welfare, then, will still have substantial effects.

Table 6 - Poverty Indices For Expanded and Total Income Measures and Differing Poverty Lines

1	2	3	4	5	6	7	8	9	10
Percent-ile of Poverty Line [1]	Implied Poverty Line [2]	Poverty Measure	Income Aggregate: Expanded income	Income Aggregate: Total income	Percent Poverty Reduction via Income Expansion	Standard Errors [3]: Expanded income	Standard Errors [3]: Total income	t-stat. of diff. between poverty measures	t-stat signif. level [4]
25th	356	Head Count	0.249	0.066	73.5	0.030	0.017	5.35	0.00
		Poverty Gap	0.057	0.009	85.0	0.009	0.003	5.05	0.00
		Poverty Severity	0.020	0.002	90.8	0.005	0.001	3.87	0.00
50th	528	Head Count	0.502	0.258	48.6	0.034	0.030	5.37	0.00
		Poverty Gap	0.167	0.060	63.8	0.014	0.008	6.41	0.00
		Poverty Severity	0.071	0.019	73.3	0.008	0.003	5.88	0.00
75th	783	Head Count	0.751	0.568	24.4	0.030	0.034	4.07	0.00
		Poverty Gap	0.318	0.181	43.2	0.018	0.014	6.06	0.00
		Poverty Severity	0.168	0.075	55.2	0.012	0.008	6.42	0.00
85th	1,000	Head Count	0.845	0.737	12.8	0.025	0.030	2.77	0.00
		Poverty Gap	0.424	0.285	32.8	0.018	0.016	5.72	0.00
		Poverty Severity	0.249	0.137	44.8	0.014	0.010	6.33	0.00

Notes

1. Three poverty lines are associated with the 25th, 50th and 75th percentiles of the expanded income distribution. Since expanded incomes are generally higher than standard incomes, the fourth, Z$1,000 poverty line occurs at a lower percentile of the distribution, namely the 85th.
2. Z$ per adjusted a.e.u. per annum.
3. Formulae for the standard errors and t-statistics are taken from Kakwani (1993).
4. One-sided t-test.

We turn next to the results for inequality. Table 7 presents various inequality indices for expanded and total income measures, and tests the significance of the difference between them. We see first that inequality measured by expanded income is less than that measured by standard income. Thus, the expanded income Gini is 0.34 as against 0.36 for standard income; likewise for GE_0 the two figures are 0.19 and 0.22, while for GE_2 the two figures are 0.27 and 0.34. As a consequence, the percentage differences in inequality as measured by expanded income and total income is smaller than the differences between standard income and total income: whereas the latter ranged between 19 and 44 percent, the former ranges only between 13 and 28 percent. Nonetheless this still remains a reasonably large reduction in measured inequality, so that even with a broader conception of standard income, incorporating environmental income still matters in percentage terms. Tests of statistical significance are less clear than before. The t-test values in table 7 are lower than those in table 5, so that the difference between expanded and total income inequality measures is less statistically significant than we found earlier. However, for the six inequality measures for which we have conducted tests, all six are significant at the 10 percent level, while two are significant at the 5 percent level. So it would appear again that our general conclusions are robust. These are that, even when compared with a generous interpretation of the abilities of an HBS to measure income, incorporation of environmental income has a considerable equalising effect; that rural communities are hence likely to be more equal than currently suspected; and that conventional surveys significantly overestimate rural inequality.

Table 7 - Inequality Indices for Expanded and Total Measures of Income

		1	2	3	4	5	6	7	8	9
		Expanded income			Total income					
Inequality measure		Inequality index	Std. error	t-stat, η_i	Inequality index	Std. error	t-stat, η_i	Percent inequality reduction, (4) v (1)	t-test of difference between measures, $\eta_i^{1,2}$	t-stat signif. level
Relative mean deviation	R_1	0.49	n.a.	n.a.	0.42	n.a.	n.a.	13.5	n.a.	n.a.
Coefficient of variation	R_2	0.73	0.067	10.9	0.62	0.053	11.7	15.3	1.3	0.09
Log variance	V	0.39	0.050	7.8	0.28	0.032	8.6	28.4	1.9	0.03
Gini	G	0.34	0.021	16.5	0.30	0.018	16.4	12.7	1.6	0.06
Mean log deviation	GE_0	0.19	0.023	8.2	0.14	0.017	8.4	25.4	1.7	0.05
Theil entropy index	GE_1	0.20	0.028	7.2	0.15	0.021	7.3	24.7	1.4	0.08
Generalised entropy-2	GE_2	0.27	0.049	5.5	0.19	0.033	5.9	28.3	1.3	0.10
Mean Income	$\bar{x}$	652			844					
Standard Deviation	$\hat{\sigma}$	480			526					

Notes
1. All formulae for the standard errors of inequality measures and their t-statistics are taken from Kakwani (1990).
2. Column 9 presents significance levels for a one-sided t-test.

The poverty line

Another key assumption underlying the results on poverty was the use of a fixed or absolute poverty line. It could be argued that as the definition of income changes, so the poverty line should change as well. The decision here rests on the method by which the poverty line has been derived. There are two basic practices, which can be termed the “output” and “input” methods of deriving poverty lines. In the former case, a poverty line is calculated with reference to certain characteristics (or “outputs”) deemed relevant to the classification of individuals as poor or non-poor. These characteristics can be a mix of physical indicators such as weight-for-height or general health status, and economic indicators such as asset ownership, housing or human capital. Having defined a set of such characteristics, the poverty line is set at the income or consumption level - derived from an HBS - which marks the transition between the poor and non-poor. In this case, any change in the definition of income or consumption between HBSs requires a change in the poverty line, as there will be a different income "mark" associated with the poor/non-poor distinction for each different HBS. The relationship between income and welfare has simply been mismeasured.

Conversely, the poverty line can be calculated with reference to the set of "inputs" thought necessary for an individual to attain the level of welfare defined by the output characteristics above. These inputs are expenditures on necessities or basic goods, such as food, water, clothing, heating, health, education and so on, with the assumption being that consumption of these goods is sufficient to generate a given level of welfare. In general, though, this assumption is not cross-checked with "output" data. The poverty line is then defined by the cost of the basket of goods that comprises the input requirement, and whether an individual is poor or not is judged by whether its income or consumption is greater or lesser than this cost. In this case, changing the definition of income does not require a change in the poverty line, since there has been no change in the cost of a basket of basic goods. Rather, the ability of the household to afford or acquire this basket of essential goods has been mismeasured.

As we noted, by happenstance our poverty lines were similar to those used in other household surveys of rural Zimbabwe. However, these were all derived using the input method, so that correct practice would be to leave the poverty line unchanged as our income definition changes. Nonetheless, we briefly explore the impact of varying the poverty line on the results concerning poverty under the two different income measures of standard and total income. To do this in a systematic manner, we assume that the poverty line has been established using the "output" method. This suggests two methods of varying the poverty line. The first is to assume that if an "output"-based poverty line has been set at the *n*th percentile of the standard income distribution, then it should also be set at the *n*th percentile of the total income distribution. This generates three poverty comparisons for the first three quartiles of each distribution, as before, but restricts differences in poverty measures to be due solely to differences in the shape of the each distribution. The second is to use the mean of each distribution for comparison, as this represents the average difference in incomes across the two measures: this allows poverty measures to vary both due to absolute income changes as well as differences in the shape of the respective income distributions.

Looking at the three percentile poverty lines first (table 8), by construction there is no difference at all in headcount measures. As expected, differences in the poverty gap and poverty severity measures are all much lower than those using a fixed poverty line. For the 25th and 50th percentiles, the poverty gap index shows only small, statistically insignificant, reductions in poverty. The poverty severity index registers larger poverty decreases - at least 10 percent - but these are also statistically insignificant. However, as noted earlier these poverty lines are low by reference to other studies. The 75th percentile and mean poverty lines are more realistic. For all the various indices, these register more significant decreases in measured poverty between standard and total income. Thus at the 75th percentile poverty lines, the poverty gap falls by 13 percent while poverty severity falls by 20 percent, both significant at the 5 percent level. At the mean poverty lines, even the headcount index falls by 10 percent, while the poverty gap and poverty severity decrease significantly by 20 percent and 28.5 percent respectively. So with a plausible but relative poverty line, using total income as a measure of an individuals's welfare generates significantly lower estimates of poverty - roughly 10 to 20 percent - than the standard income measure. Conversely, even with a relative poverty line, conventional estimates of poverty are still likely to be significantly overstated.

Table 8 - Poverty Indices For Relative Poverty Lines

1	2	3	4	5	6	7	8	9	10	11
	Poverty Lines [1] [2]			Income Aggregate		Percent Poverty Reduction via Income Expansion	Std. Errors [3]		t-stat. of diff. between poverty meas.	t-stat signif. level [4]
%ile	Standard income	Total income	Poverty Measure	Standard income	Total income		Standard income	Total income		
25th	304	525	Head Count	0.250	0.250	0.0	0.030	0.030	0.00	0.50
			Poverty Gap	0.063	0.059	5.7	0.009	0.008	0.28	0.39
			Poverty Severity	0.023	0.018	19.6	0.005	0.003	0.74	0.23
50th	433	721	Head Count	0.500	0.500	0.0	0.034	0.034	0.00	0.50
			Poverty Gap	0.154	0.150	2.5	0.014	0.013	0.20	0.42
			Poverty Severity	0.067	0.059	11.2	0.008	0.007	0.70	0.24
75th	674	1,009	Head Count	0.750	0.750	0.0	0.030	0.030	0.00	0.50
			Poverty Gap	0.331	0.289	12.7	0.018	0.016	1.75	0.04
			Poverty Severity	0.176	0.140	20.4	0.013	0.010	2.20	0.01
Mean	573	844	Head Count	0.681	0.610	10.3	0.032	0.033	1.52	0.06
			Poverty Gap	0.263	0.210	20.0	0.017	0.015	2.33	0.01
			Poverty Severity	0.129	0.092	28.5	0.011	0.009	2.63	0.00

Notes
1. In this table, the percentile figure refers to the percentile of each different distribution.
2. The poverty lines are measured in Z$ per adjusted a.e.u. per annum.
3. Formulae for the standard errors and t-statistics are taken from Kakwani (1993).
4. One-sided t-test.

6. Decomposition and the causes of poverty and inequality

Inclusion of environmental incomes reduces considerably measured poverty and has a substantial equalising effect on measures of aggregate inequality: and these findings are robust to the use of a range of indices, to changes in the definition of the standard income measure and to the use of a relative poverty line. For both poverty and inequality, though, we wish to go further than simple measurement, and examine the causes of these phenomena. This is a natural concern in studies of this kind, as uncovering the causes of poverty and inequality highlights potential policy interventions for alleviating these problems. However, there is also an additional concern here. We have seen that accounting for natural resource use has a dramatic impact on measures of poverty and inequality: will it have a similarly substantial impact on the causes of these?

Environmental income and the causes of poverty

We can analyse the causes of poverty by constructing a poverty profile, implemented through the subgroup decomposition of the aggregate poverty measures. (One attractive property of the P_α indices is that they are all additively decomposable). There are a number of ways in which such decompositions can be implemented: we use an intuitive one, namely sub-group poverty probabilities derived from the headcount measure. Let the sample be exhaustively partitioned into $j = (1,......,J)$ mutually exclusive subgroups, with each subgroup having n_j members. The headcount poverty measure for the jth subgroup, $P_{0,j}$, is then equal to q_j/n_j, where q_j is the number of households in the jth subgroup with incomes $x_i \leq z$, so that $P_0 = \sum_{j=1}^{J} P_{0,j} n_j/n$. Then the sub-group poverty probability is the sub-group headcount measure normalised on the aggregate headcount poverty measure, ie $P_{0,j}/P_0 = (P_{0,j} - P_0)/P_0 + 1$. This means that if the jth subgroup's poverty probability is greater (less) than one, this subgroup is more (less) likely to be poor than the sample as a whole. So we compare the intensity of poverty across sub-groups by calculating these sub-group poverty probabilities for different poverty lines and for the two different income measures. (To keep the analysis manageable, we have just reported results for the 50th and 75th percentile poverty lines - however the other poverty lines merely replicate these results).

As to choice of the stratifying variables underpinning the sub-group decompositions, we have focussed on the set of exogenous factors which emerged from the fieldwork as being of potential significance in explaining differentiation within the research area. These were the distribution of productive assets such as livestock, land and human capital; certain household demographic factors such as the type of household head and the size of the household; and the household's economic connections, namely whether individuals connected to the household had been able to enter formal labour market on either a full-time or part-time basis. As well as being key factors identified in the fieldwork, these are close to the sets of variables that are identified as correlates of poverty in other studies of rural households.

Table 9 presents the calculated subgroup poverty probabilities. (They are also graphed in figure 3). Looking at the standard income results, certain stratifying variables appear to have a clear relationship with the poverty probabilities. In particular, variations in land distribution and formal labour market access seem to have a substantial impact on the chances of someone being poor. For both poverty lines, individuals living in households with small land holdings have a higher than average probability of being poor, and this probability declines monotonically as land size increases. Likewise, individuals living in households with no one in formal wage employment are more likely to be poor than the average person, but this likelihood falls systematically as household members are increasingly involved in formal labour markets. Indeed, as soon as the household has anyone at all in formal wage employment, the poverty probability falls to half the average or less.

Moderate relationships exist between other subgroup decompositions and poverty probabilities. As one might expect, there appears to be a negative relationship between poverty and the education level of the household head. For households where the head has a very low level of education (the most common category), poverty levels are a little above background rates for both poverty lines. These fall as the household head acquires more education, especially after seven years of education. Poverty probabilities also fall as the value of large livestock per person, though this only is marked at values of Z$1,000 per person. Perhaps more surprising is the positive relationship between poverty and household size.[8] Individuals in small households

[8] A positive relationship between poverty and household size has frequently been found in studies of poverty. But this is often argued to be an artificial artefact of the equivalence scale used to transform household income or consumption data, for example by using per capita adjustments which overweight children, or by ignoring economies of scale in household

have much lower poverty probabilities, while those in households with 4 or more adj. aeus have poverty probabilities at or above the average. Finally, there is a relationship between some household headship types and poverty. Individuals in de jure female headed households, with married sons in the household, have a greater than average chance of being poor, while those in de facto female headed households have a poverty risk that is consistently lower than the background rate. This undoubtedly reflects the fact that these households receive remittances from husbands who are away working in formal labour markets: their lower poverty rates are therefore connected to the results linking poverty to labour market access.

Thus, if a conclusion were to be drawn on the profile of the poor from standard income alone, it would be that the poor tend to be in households with older heads; where the head is less well-educated; where the household is larger; but most crucially in households which have little cultivable land per person and which have restricted access to formal wage employment.[9] How far does this profile change if we use analyse poverty using the total income variable instead? The surprising answer is how similar the results are for the two different income measures. In fact, the difference between the poverty probabilities of two income measures appears to be more one of emphasis than one of direction, as figure 3 shows.

Thus, if we examine the two most important correlates of poverty, namely land distribution and the employment status of the household, the figures show that incorporation of environmental income reinforces rather than overturns the results of the standard income measure. For land distribution (and for both poverty lines), incorporating environmental income increases the poverty probability of individuals in households with small amounts of land, and reduces the poverty probability for those with larger land areas. Likewise, for analysis by employment status of the household, use of the total income measure either leaves the poverty probabilities untouched (75th percentile poverty line) or increases the importance of access to the formal labour market in explaining poverty (50th percentile poverty line). A similar story holds for most of the other indicators. Environmental income lowers the poverty probability of households with young heads and increases that for households with older heads; it lowers the poverty probability of small households and increases that of large households; and it also increases the poverty probability of households with a poorly-educated head and decreases that of households with a more educated head. So, by making the distribution of the poverty probabilities more stark, the use of the total income measure would seem generally to intensify the relationship between the sources of stratification we have analysed and household poverty, rather than altering this relationship.

This conclusion is reinforced when we look at statistical tests of significance in the correlates of poverty (table 9). Once again, the most striking feature is how similar the results are for the different income measures and poverty lines. There are no sign reversals for any of the variables found to be significant: in other words there is no variable which is associated with significantly higher poverty for one income measure and poverty line which is found to be associated with

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production (for a discussion of these points see Lanjouw and Ravallion 1995). However, in our study we have adjusted household income data by using weights for different household members, and we have also included an economies of scale adjustment in our equivalence scale, so these effects should not undermine the result.

[9] These conclusions are very similar to those of Grootaert *et al* (1996), who found higher per capita welfare associated with being in small households with younger heads, larger farms and a non-farm source of income.

Table 9 - Subgroup Headcount Poverty Probabilities and Significance Tests [(1)]

Source of Stratification [(2)]	No. of hhs in sub-group	50th Percentile: Standard Income	50th Percentile: Total Income	75th Percentile: Standard Income	75th Percentile: Total Income
All Households	213	0.50	0.16	0.75	0.46
A. Type of Household Head					
Married Male, Resident	131	1.15 ++	1.24	1.15 +++	1.14 +
De Facto Female	43	0.32 --	0.00 ---	0.56 ---	0.51 ---
De Jure Female, No Married Sons	22	1.00	0.57	0.79 -	0.89
De Jure Female, Married Sons	12	1.49 +	3.13 +++	1.22	1.81
Divorced/Widowed Male	5	1.59	0.00	1.33	0.00 --
B. Age of Household Head					
0 to 30	34	0.53 ---	0.00 --	0.74 ---	0.32 ---
31 to 40	64	0.87	0.59 -	1.02	0.78 -
41 to 50	46	1.13	1.63 ++	1.13 +	1.46 +++
51 to 60	36	1.27 +	1.39	1.00	1.21
61 and over	33	1.27 +	1.52	1.05	1.25
C. Education Level of Household Head					
0 to 3 years	137	1.21 +++	1.42 ++	1.08 +++	1.19 ++
4 to 6 years	31	0.83	0.20 --	1.07	0.98
Primary School Leavers	28	0.50 ---	0.45	0.76 --	0.39 ---
JCE or more	17	0.47 --	0.00 --	0.63 --	0.64 --
D. Household Size					
0 to 2 Adj. Aeus	28	0.36 ---	0.00 --	0.57 ---	0.16 ---
2 to 4 Adj. Aeus	66	0.81 -	0.28 ---	0.93	0.53 ---
4 to 6 Adj. Aeus	82	1.26 ++	1.38 +	1.17 +++	1.40 +++
6 to 8 Adj. Aeus	24	1.16	1.57	1.11	1.63 +++
8 or more	13	1.38	3.37 +++	1.02	1.50 +
E. Value of Large Livestock Per Adj. Aeu					
Z$0	125	1.08	1.20	1.03	1.10
Z$0 to Z$500	44	0.95	1.42	1.00	1.09
Z$500 to Z$1,000	29	0.96	0.00 --	1.06	0.75
Z$1,000 or more	15	0.53 --	0.00 -	0.62 --	0.43 --
F. Cultivable Land Area Per Adj. Aeu					
0.0 to 1.0 acres	55	1.63 +++	2.39 +++	1.28 +++	1.74 +++
1.0 to 1.5 acres	85	0.94	0.81	1.02	0.89
1.5 to 2.0 acres	34	0.64 --	0.37 -	0.90	0.70 -
2.0 to 3.0 acres	28	0.64 --	0.00 --	0.76 --	0.62 --
3.0 plus acres	11	0.36 --	0.00	0.36 ---	0.00 ---
G. Employment Status of the Household					
No one in Formal Wage N	93	1.39 +++	1.62 +++	1.19 +++	1.15
1 or More in Part-Time Wage N	73	0.87	0.86	1.04	1.01
1 or More in Full-Time Wage N	38	0.52 ---	0.00 ---	0.60 ---	0.80
Full-Time and Part-Time Wage N	9	0.00 ---	0.00	0.44 ---	0.24 --

Notes

1. Binomial distribution test of the null hypothesis that the subgroup headcount measure equals the overall headcount measure. The binomial distribution test is preferred to a standard t-test due to the small sample size of some of the subgroups. As the subgroup sample size increases, the tests converge.

+++ (---) Subgroup P_0 index significantly higher (lower) than the overall P_0 index, 1 percent significance level.
++ (--) Subgroup P_0 index significantly higher (lower) than the overall P_0 index, 5 percent significance level.
+ (-) Subgroup P_0 index significantly higher (lower) than the overall P_0 index, 10 percent significance level.

2. Some of the sub-groups for the sources of stratification are self-evident or are described in the text. Otherwise:

A. "Education level of the household head" refers to the highest level of education completed by the household head. Primary School Leavers is a qualification obtained after 7 years schooling and the Junior School Certificate is obtained after 9 years of schooling.
B. By "large livestock" is meant cattle and donkeys. Values are Z$ end-period local market prices.
C. "Cultivable land area" comprises the total land area in hectares which the household either used, owned or rented in 1993/94, excluding land that was described as "rock," which overwhelmingly meant homestead sites. This was weighted by the number of adj. aeus in the household.
D. Under "employment status of the household," wage employment refers to a job, whether full-time or part-time, which pays primarily in cash and which was located outside Shindi. This therefore includes work on local commercial farms as well as jobs elsewhere in Zimbabwe.

significantly lower poverty for any other combination of income and poverty line. Further, there are certain variables which are statistically significant correlates of poverty for at least three if not all four of the measures used. Examination of these variables tends to confirm the picture of poverty that we have derived from the simple headcount and poverty probability data above. Thus, individuals are found to have significantly higher poverty rates if they are in households with little education; which are large; which have middle-aged heads; which have little land; and which have little contact with formal labour markets. Conversely, individuals are found to have significantly lower poverty rates if they are in households which are de facto female-headed; which have a young head; which are better educated; which are small; which own more than Z$1,000 of large livestock per adj. aeu; which have larger land holdings; and which have entered formal labour markets. The fact that these variables have a significant impact on poverty rates for two different income measures and two different poverty lines strengthens the robustness of these findings on the causes of poverty. However, the fundamental point remains that these significance tests serve to reinforce the similarity of findings on the correlates of poverty for the two different income measures. Thus, although measuring rural incomes inclusive of environmental income results in very much lower estimates of rural poverty, it does not change our analysis of why that poverty exists.

The origins of inequality: environmental income and inequality decompositions
The next stage is to explore the causes of the inequality observed in the sample. Again, we look at this for two reasons. First, if we can discover the causes of inequality, rather than just proving its existence, then we may be in a position to devise policies to improve the distribution of income. Second, we have found out that standard income provides a biased estimate of aggregate inequality: does it also, as would seem likely, provide a biased estimate of the causes of inequality?

As for the poverty analysis, we use decomposition techniques to pursue these questions.[10] To do this, a decomposition formula for some relevant inequality index or indices is required. We can restrict the choice of inequality indices using the result presented earlier, namely that the Generalised Entropy class of inequality measures is the only one that is symmetric, scale invariant, convex and additively decomposable. This still leaves us a wide range of indices to use, however, and a consequent plethora of calculations. So in order to simplify further, we have used only the measure GE_2 for our inequality decompositions. This choice is motivated by practical concerns: use of GE_2 avoids log transforms, so that it can cope with zero observations, while computation of GE_2 itself can be done simply from group or subgroup means and variances. (This is follows from the fact that

$$GE_2 = \frac{1}{2}\frac{1}{n}\left[\sum_{i=1}^{n}\left(\frac{x_i}{\bar{x}}\right)^2 - 1\right] = \frac{1}{2n\bar{x}^2}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2 = \frac{1}{2\bar{x}^2}\hat{\sigma}^2.$$

This ease of calculation is especially useful when dealing with a large number of decompositions. The formula also shows that $GE_2 = 1/2\,(R_2)^2$ ie. equals half the squared coefficient of variation).

[10] Jenkins (1995) presents an outstanding analysis of inequality trends for the UK using decomposition analysis. The material presented in this section of the paper owes a great debt to the methods developed in his work.

Specifically, we decompose inequality by income source. Decomposition by income source is aimed at uncovering the particular income sources that have a high inequality "loading": ie. it highlights the specific economic activities which are associated with rural inequality. This is a particularly attractive procedure for the purposes of this study. Decomposition can be carried out as follows.[11] Let income be partitioned into F sub-groups, with the fth income source having the sample mean $\bar{x}_f$ and sample variance $\hat{\sigma}_f^2$. Define s_f as the contribution of the fth income source to total inequality, so that $\hat{I}_i = \sum s_f$. Then we need to generate suitable values of these s_f's using appropriate decomposition rules. It can be shown that:

$$s_f = \rho_f \chi_f \sqrt{GE_2 \, GE_{2,f}}$$

where: ρ_f = the correlation coefficient for the fth income source and total income.

$\chi_f = \bar{x}_f / \bar{x}$ = the fth income source's factor share.

$GE_{2,f}$ = the GE_2 index for the fth group = $\frac{1}{2\bar{x}_f^2} \hat{\sigma}_f^2$.

Note that the degree to which an income source can be said to promote inequality depends on the size of the share variable s_f / GE_2: if this equals zero or is low, then the income source has a negligible impact on overall inequality (or alternatively has an “equality-promoting” role), conversely if this share variable is high then the income source is playing a strong "inequality-promoting" role.

Decomposition calculations by disaggregated income source are presented in table 10. The central results are clear: inequality in the sample is overwhelmingly accounted for by variation in cash income from formal wage employment, and this preponderance occurs whichever income measure is used. Thus, for the standard (total) income measure, variation in formal wage employment contributes 61 (47) percent to overall inequality, as against a contribution to mean income of only 29 (19) percent. So this variable's contribution to aggregate inequality is far higher than its contribution to overall income, and far greater also than the contribution to inequality of any other single income source. Unequal receipts of cash from formal sector employment clearly drive inequality and differentiation in the research area.

Other results are as follows. First, agriculture - in particular variations in the value of own consumption - is the second most important source of aggregate inequality. For both standard and total income, variations in the consumption of own crops accounted for 12 percent of aggregate inequality. (Note that the primacy of wage employment and agriculture in explaining inequality replicates the results of the poverty analysis). Second, variations in livestock income have only a moderate role to play in aggregate inequality. Finally, environmental income variables play a very small role in explaining aggregate total income inequality. Despite reasonably sizeable subgroup mean incomes, the consumption of wild foods, firewood use, gold panning and environmental cash income account for 1, 3, 2 and 2 percent respectively of overall inequality: looking at it another way, these four income sources together comprise, on average, 23 percent of aggregate total income while at the same time comprising only 8 percent of

[11] Decomposition by income source is a difficult procedure, following Shorrocks (1982a, b) which showed that the choice of decomposition rule is totally independent of the choice of inequality index, so that an infinite number of candidate decompositions are compatible with any given inequality measure.

aggregate total income inequality. So once again we observe the important role of environmental resources as an equality-promoting income source.

Table 10 - Inequality Decomposition by Detailed Income Sources and Standard and Total Income

	1	2	3	4	5	6
			GE_2 - Standard Income		GE_2 - Total Income	
Income Source [1]	Subgroup Mean Income [2]	Subgroup Inequality Index	Absolute Contribution	Share of Agg. Inequality	Absolute Contribution	Share of Agg. Inequality
A. Agriculture				**0.17**		**0.17**
Cash crop sales (net)	10	29.50	0.011	0.03	0.006	0.03
Trad. crop sales (net)	23	1.39	0.006	0.02	0.003	0.02
Consumption of own crops	208	0.15	0.041	0.12	0.024	0.12
B. Livestock				**0.07**		**0.10**
Livestock cash income	16	3.45	0.010	0.03	0.005	0.02
Cons^n of own livestock	27	0.69	0.014	0.04	0.007	0.04
Livestock fodder & browse	48	1.14	n.a.		0.007	0.04
C. Labour Income				**0.61**		**0.47**
Unskilled labour income	20	1.07	0.000	0.00	0.001	0.00
Formal wage employment	164	2.57	0.209	0.61	0.092	0.47
D. Other Productive Enterprise				**0.06**		**0.10**
Crafts and SSEs	29	4.62	0.012	0.03	0.006	0.03
Misc. cash income	2	29.30	0.001	0.00	0.000	0.00
Input use of own production	52	0.62	0.009	0.03	0.006	0.03
Gold panning	58	1.40	n.a.		0.004	0.02
Env. cash income	36	1.58	n.a.		0.003	0.02
E. Gifts				**0.08**		**0.09**
Private gifts (net)	10	115.73	0.029	0.08	0.017	0.09
Government gifts (net)	12	2.62	0.001	0.00	0.001	0.00
F. Environmental Collection and Consumption						**0.07**
Cons^n of wild foods	45	0.22	n.a.		0.002	0.01
Firewood use	56	0.20	n.a.		0.006	0.03
Use of wild goods	5	0.49	n.a.		0.000	0.00
Env. housing inputs	21	2.12	n.a.		0.002	0.01
Environmental. fertilisers	4	2.31	n.a.		0.000	0.00
Total	**844**		**0.344**	**1.00**	**0.193**	**1.00**

Notes
1. This table uses the same basic income categories as table 1, but regroups them by functional classification of income ie. by agriculture; livestock; labour income; other productive enterprise; gifts; and environmental collection and consumption
2. Income is measured in Z$ per adj. aeu per annum.

Discussion: environmental income, barriers to entry and the poverty trap

The analysis of this section has produced a puzzle. On the one hand, the inclusion of environmental income in the measure of household welfare substantially reduces measured inequality and poverty in our sample area. On the other hand, this has very little effect on analysis of the causes of inequality and poverty. Whichever income measure is used, differences in access to formal labour markets and inequalities in land distribution emerged as the main causes of rural inequality in the research area. Similarly, in the poverty profile it was variations in wage employment and land ownership that were the two most significant determinants of poverty probabilities, for both standard and total income. So the types of conclusions that would be drawn on these issues from more conventional data sets were found to be very similar to those drawn from the "better" measure of household welfare used in this study. These results seem paradoxical. Given environmental income has such a dramatic impact on measures of inequality and poverty, one might expect it should also have a dramatic impact on measures of the origins of inequality and poverty as well.

We are not able to solve this puzzle definitively here. Rather, we sketch an answer to the problem: this will provide the basis for formal modelling and empirical testing in future work. We start by asking - if entry into formal labour markets and improved agricultural production can raise household incomes substantially, why do some households do this? The answer is that both these paths out of poverty are conditional on a pre-existing level of capital accumulation. In the case of remittances, the crucial condition is to have a sufficient level of education to allow entry into the formal labour market. But this education level presupposes that a child's school fees have been paid for a number of years beforehand: in other words many years of investment are required before a household can expect to receive some return in the form of remittances. Further, since school fees cannot be paid in kind, investment in education presupposes not a just a steady flow of surplus, but in practice a steady flow of cash income to the household. In a similar fashion, sustained improvements in agricultural yields requires sustained fertilisation of the local area's sandy soils, and this means either a regular flow of cash (to purchase fertiliser), or sufficient accumulation at some time in the past to have purchased livestock.

Thus, entry into income-raising activities involves significant up-front costs which have to be met via cash payment. In other words, substantial entry barriers exist to these two enrichment activities. The existence of these entry barriers has two effects. First, they present a powerful obstacle to poorer, asset-constrained households from entry into income-raising activities. Second, they imply that economic returns will vary systematically with the existence of these entry barriers. For activities with zero entry cost, all rent will be competed away. The only activities which will start to generate a reasonable surplus are those into which entry is restricted. This creates is a poverty trap. Those households which already have sufficient assets to lever themselves into higher-return activities can go on to earn some surplus, and this may allow them to continue further the path of accumulation by alleviating the many production constraints that affect both rural agriculture and rural enterprise development. By contrast, those which start poor will have very restricted earning opportunities: these households have to work hard even to keep still, and they often exist in a "vicious cycle" of poverty characterised by low nutritional status, low labour returns and low crop production. (For models linking asset constraints, entry barriers and rural class formation, see Eswaran and Kotwal 1986 and Dasgupta 1993).

This emphasis on entry barriers as the cause of rural differentiation provides an answer to the conundrum posed earlier, namely the reason why environmental income has such a marked impact on inequality and poverty measures, but not on the correlates of household differentiation. Since so many environmental collection activities are free entry, so they are activities which are disproportionately undertaken by worse off households. The effect of omitting these activities from the income measure would therefore systematically overstate inequality and poverty measures, as indeed we saw. However, because environmental income sources are free entry, they are also low return and therefore will play little role in enabling households to overcome the accumulation constraints which bar the household from raising its income significantly. Hence incorporation of environmental resources into the rural income measure will make little difference to the analysis of the underpinnings of rural inequality and poverty. It is for this reason that our earlier decomposition analyses produced such similar results for standard and total income.

7. Conclusions and discussion

In this paper we have been concerned to examine the impact of environmental income on both the measurement and the causes of rural poverty and inequality. We analysed the impact of environmental income on the measurement of aggregate poverty and inequality indices by comparing our measure of rural incomes, total income, with that which would be derived from the typical household budget survey, labelled standard income, which excludes by definition all environmental income sources. Dramatic results ensued. For poverty, the inclusion of environmental income was found to reduce poverty rates by 50 percent or more, while for inequality the total income measure produced estimates of inequality which were 20 to 30 percent below that of the standard income measure. In both cases, these results were found to be robust to a range of indices; and for poverty to a variety of poverty lines. This reduction in measured poverty and inequality was also found to be statistically significant for all indices and measures used. The quantitative magnitude of the results was reduced somewhat when working with a broader definition of the typical HBS income measure, but the differences in poverty and inequality estimation were still substantial and statistically significant. In every case, these are notable results.

There are a number of important corollaries that follow from these findings. The first is that measures of aggregate poverty and inequality based on typical household budget surveys are likely to be quite substantially overestimated (dramatically so if conducted amongst households more resource-dependent than ours). But these are exactly the type of surveys on which most estimates of rural poverty and inequality are based. Our results suggest that it is reasonable to be cautious in assessing such estimates where attention has not been paid to the bundle of free goods that natural resources offer rural agents. The second, conversely, is that environmental income *per se* is a quantitatively large and significantly equity-promoting and poverty-alleviating income source. Given that the vast bulk of these resources are located in the commons, particularly communal woodlands and rangelands, then the importance of the preservation of the commons (and conversely the equity and poverty impacts of commons degradation or resource privatization) is obvious.

Third, there is a counterpart to this static estimation error in incomes, inequality and poverty, and that is a potentially significant dynamic estimation error of rural income growth. This is due to the fact that typical surveys only measure a subset of total income, so that while measured household incomes may be increasing at a certain rate over time, household (true) total incomes may be increasing at a greater or lesser rate, remaining static or even declining. Likewise, measured inequality (poverty) may be improving based on the standard income measure while at the same time true inequality (poverty) is worsening. So given the results of this chapter, measurement from other studies of both the statics and the dynamics of rural incomes and welfare may be in question.

Finally, the underestimation of rural welfare using standard questionnaires is often mirrored by an overestimation of urban welfare using these same questionnaires due to the omission of welfare-reducing environmental externalities such as pollution, poor water and sanitation and low-quality housing adversely affecting human health. It is a truism of national income or consumption surveys that they find rural poverty to be far more extensive than urban poverty. It remains an open question as to whether, if these environmental externalities were all valued appropriately - as we have done for rural agents - findings suggesting the comparative affluence of urban versus rural areas would remain robust.

Finally, we also examined the causes of inequality and poverty through decomposition analysis. Here it was found that, by contrast, the inclusion of environmental income made very little difference to decomposition results, in that the same variables were found to be significant correlates of rural inequality and poverty whether standard or total income measures were used. Variation in households' access to non-environmental cash income was found to be the most significant source of rural inequality, arising overwhelmingly from differences in households' entry into formal labour markets. However, agriculture was found also to be a significant secondary source of rural differentiation. We hypothesised that the origins of these results lay in the presence of entry barriers for these economic activities. We suggested that the existence of these entry barriers simultaneously explained the importance of formal wage employment in underpinning rural inequality and poverty, the greater dependence of poorer households on free-entry environmental income sources, and the lack of impact on decomposition analysis from including the value of environmental utilizations in the measure of household income. Powerful economic constraints appear to exist to rural accumulation: these constraints are not alleviated in our research area by the presence of environmental resources and the potential for their utilisation.

Appendix I - A Description of the Research Area and of Data Collection Procedures

The data underlying this study were collected by the author during a 13 month period of fieldwork (August 1993 to September 1994) in Shindi Ward, Chivi Communal Area, Zimbabwe. Shindi Ward is located in the South East of Zimbabwe in NR IV, and is an area of some 200 km^2 comprised of 30 villages under the chieftainship of Chief Shindi. To the north and west, Shindi is border by Gororo and Madzivire Wards, also in Chivi CA. To the east, Shindi is bordered by a well-wooded resettlement area: though acquisition of environmental resources is illegal from the resettlement area, breaches of this ban are common. Shindi has an irredentist land claim over this area. The southern border of Shindi follows the Runde River, a major watercourse which serves as a source of gold and fish, though once again both these activities are illegal. Directly south of the Runde is a set of large, commercial, white-owned farms, on which some Shindi people are legally employed and on which some Shindi people illegally hunt game animals.

In terms of its economic status, Shindi is typical of Zimbabwe’s Communal Areas: that is to say, it is poor, lacks basic infrastructure (no tarred roads, water supply or electricity), its agricultural system is agro-pastoral (or hoe-based where people have no large livestock), and remittances from non-Shindi sources play an important role in supporting the local economy. In terms of its physical and resource characteristics, it is important to stress given the concerns of this study that Shindi is not an untouched, resource-abundant area. Rather, it has been settled for a long period of time and since the 1950s there has been substantial growth in the settled population both from natural increase and due to the resettlement in Shindi of whole villages from other parts of Zimbabwe. In consequence, the environmental resource base has been much reduced in the last 40 years: for example, although some plains woodlands exist, the bulk of remaining woodlands are refuge woodlands on mountains, on kopjes and along riverine areas. In floristic terms, Shindi is in the miombo zone, so that the dominant species in natural woodlands are *Brachystegia spiciformis*, *B. glaucescens* and *Julbernadia globiflora*: however, it is on the edge of this zone, and hence mopane woodland species such as *Colophospermum mopane* and *Adansonia digitata* are also found. In terms of its soils, Shindi is characterised by predominantly sandy soils, but these are interlaced with smaller patches of more fertile black soils and red soils: soil patterning occurs at the scale of the individual field.

The quantitative data were collected using household-based questionnaires, administered in chiKaranga (the local variant of Shona) by a team of six local enumerators trained and supervised by the author. In the absence of an official census, in order to generate a sample of households a household roster was compiled by asking each village headman to name all the household heads under their authority: this information was rechecked and updated at the end of the fieldwork period. 1,092 households were listed by this procedure under 29 villages, and a 1-in-5 random selection was made of these to generate a 218 household sample. Of these 218 households, a mere 5 dropped out over the course of the year, all due to household dissolution or migration, leaving 213 households for which a full set of data is available. The questionnaire used was of the Income, Consumption and Expenditure (ICE) type: however, a number of modifications were made to fit the particular requirements of this research. First, income, expenditure and agricultural categories were matched directly to the restricted set of possibilities available to Shindi households elicited by a pre-questionnaire local listing of these items. Second, the four quarterly surveys were augmented by beginning- and end-of-period surveys on demographics and household assets, including livestock. Third, the standard ICE framework was expanded to include special sections on the quantitative use of environmental resources. Fourth, best recall periods for each questionnaire item were investigated locally, and the questionnaires designed accordingly. Fifth, a range of special questionnaire modules were added focussing on specific environmental utilizations, for example firewood collection and storage, housing and construction, tree planting, fields and environmental improvements, fencing, agricultural risk etc. Thus, in all eight questionnaire rounds were completed during the fieldwork period.

Comprehensive cross-checking was built into the research programme. Within-questionnaire cross-checks were included to show up respondent inconsistency and enumerator error, whether in questioning or recording the data. Across-questionnaire cross-checks were included again to reduce respondent inconsistency and also to control for the inability to interview the same household member at each visit. Random follow-ups were undertaken in each questionnaire round to check the translation of questions into the vernacular and to monitor the enumerators. Perhaps most valuably, an extensive range of qualitative information was collected as a supplement to the questionnaires. This took the form of interviews with groups of resource users, with local authorities, whether traditional (chiefs and headmen) or modern, and with local historians and elders; life history work; collection of aerial photographs; resource walks; work in the National Archives in Harare; and a species listing and species questionnaire sheet on ecology, use and distribution for roughly 200 different local trees and grasses.

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