Empirical Regularities in the Poverty-Environment Relationship of African Rural Households

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Abstract: Analysis of rural households and environmental resources is beset by inadequate data, especially in Africa. Using purpose-collected panel data from Zimbabwe, we demonstrate seven empirical regularities in the rural poverty-environment relationship. Most importantly, environmental resources make a significant contribution to average rural incomes. Poorer households also depend heavily on these resources, which contribute c.40 percent to their incomes. However richer household use greater quantities of environmental resources in total. Finally, considerable differentiation exists in the economic characteristics of environmental goods. These results demonstrate the considerable economic significance of environmental resources to rural households. Surveys which ignore them miscalculate rural incomes and welfare. (*JEL C81, D12, O13, Q20*)

Keywords: Africa; Zimbabwe; Poverty; Rural Households; Environment; Common Property Resources

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1. Introduction

In developing countries generally, study of the relationship between rural households and environmental change is beset by inadequate physical and economic data (Dasgupta 1993, Duraiappah 1998). This problem is particularly acute in rural Africa. The received wisdom is that environmental resources in Africa are being rapidly degraded, and that poor, rural peasants are the agents of this change. However, reliable Africa-wide data on key environmental resources such as forests, fisheries, soils and water simply do not exist: published data on environmental change are often no more than rough estimates.[1] Indeed, more focused environmental research can produce surprises. Quantitative studies of Sahelian desertification (Pearce 1992), of West African forest mosaics (Fairhead and Leach 1996), and of tree resources in Kenya (English *et al* 1994, Holmgren *et al* 1994, Patel *et al* 1995) have shown the assumption of systematic environmental degradation is wrong. Indeed, a number of these studies find smallholders deliberately improving their environmental resources through investments in natural capital.

There is also evidence that rural households use environmental resources quite extensively. The breadth of goods and services that environmental resources offer African rural households is vividly apparent in Sale (1981), which charts a very substantial list of potential consumption, production input and asset formation uses for wild resources. Substantial household use of a range of wild resources has been confirmed by the reviews of Falconer (1990), Scoones *et al* (1992), Arnold *et al* (1994) and Townson (1994): these suggest that wild resources may play a very important role in the economy of rural households.[2] Two characteristics aside from their renewability make environmental resources different from other economic activities: their spontaneous occurrence, and the fact they are so often held under communal tenure. As a result, this considerable set of resources and hence economic values are effectively provided free to the household - what might be termed the "supermarket of the wild."

However, these utilizations are excluded from conventional economic surveys of households, so that little is known about their value in terms of overall rural household welfare, nor about how their use and value might vary across household types. Indeed, the absence of accurate physical and economic data on rural households and environmental resources mean there are real problems in this area. For example, how accurate is economic analysis of rural households if a significant source of economic value has been ignored? What is really known about the dynamics of environmental change if physical data are missing?[3] And what can said empirically about the poverty-environment relationship in such a context?

These questions cannot all be answered in one paper. Our purpose here is to examine the first, namely the economic contribution made by environmental resources to rural household welfare, using a purpose-collected panel data set systematically integrating African rural households' environmental resource use with accurate measures of other household economic activities. We believe these to be unique results: for first time we have a rigorous measure of the value of environmental resources, and a data set which relates these values to other household socioeconomic variables.[4]

Given the paucity of empirical work in this area, the aim here is to generate basic empirical regularities - or "stylized facts" - concerning the connection between the economics of rural households and their environmental resource use. It is these stylized facts that both theoretical and econometric analyses of the poverty-environment relation should seek to explain. So the paper is set out as follows. In the next section, we explain the choice of Zimbabwe as the research area, and as background outline the environmental utilizations of Zimbabwean rural households. In section three, given the unusual nature of our data, we present the methods used for analyzing the environmental and economic data, paying special attention to the problem of environmental valuation. Finally, in section four we present the empirical results. We

demonstrate the impressive - and previously hidden - quantitative significance of environmental resources for our sample households, and examine the relationships between household resource use and key socioeconomic variables. In particular, we show the enormous importance environmental resources have in a range of activities for the poorest of the poor.

2. Zimbabwe: A Case Study of the Problem

Zimbabwe epitomizes the problems outlined above. There is plentiful evidence that rural households in Zimbabwe use a wide range of environmental resources, but there have been no rigorous, comprehensive studies of either the value of resource utilizations to rural dwellers or the economic determinants of household resource use. As background, then, we briefly summarize the literature on Zimbabwe's rural households, looking in particular at evidence on their economic status and their resource use patterns.

Economic status

Rural households in Zimbabwe are located in the Communal Areas (CAs) - areas of poorer agricultural potential to which the native population was forcibly resettled by the former colonial government. Three quarters of CA households live in areas with rainfall less than 650 mm yr^{-1}. In consequence, CA households are generally fairly poor. According to the latest reliable national survey, the 1995/96 Income, Consumption and Expenditure Survey (ICES), mean rural annual consumption levels were Z$2,136 (US$217) per capita, with median consumption levels even lower, at Z$1,434 (US$146) per capita. A corollary of these extremely low income levels is very low asset levels. CA households rarely have substantial financial savings with either formal or informal financial intermediaries. Their main asset is livestock, and they may own a limited range of agricultural implements, such as carts, ploughs, and wheelbarrows, and consumer durables such as a bicycle (MLARR 1990).

CA households - like typical peasant households - are simultaneously production and consumption units. While they engage in a diversified portfolio of economic activities, the most important is agriculture, with remittances also providing significant additional income. According to Jackson and Collier 1991, agriculture comprises 50 percent and remittances 19 percent of average rural incomes. The agricultural technology is agropastoral where households own livestock (it is hoe-based otherwise): these livestock are fed not on purchased feed but on browse and graze in local, communal rangelands and woodlands. Many CAs are economically remote, in that the transactions costs of trading in formal goods markets (where significant income-raising trading is possible) are high. These high transactions costs are due to poor infrastructure, particularly transport, so that rural households must traverse substantial distances to trade in formal markets. The average CA household is 20 km from the nearest tarred road, and 3 km from the nearest dirt road (MLARR 1990). Such distances result in enormous energy and financial costs for households entering formal markets, placing a substantial tax on such economic activities.

Households' resource use

There is no definitive work cataloguing the full set of environmental resources used by CA households, although there is an enormous case study literature, often examining individual resource utilizations.[5] But from a review of the forestry, rangeland science, biological science, ecology and anthropology literatures, it is clear that these households use an extensive range of natural resources. An summary of household resource utilization is given in table 1, which lists the types of resources used and their economic characteristics. From the literature, a number of features stand out. The first is the wide range of different resources used by CA households. These include a considerable variety of wild foods; a number of non-food direct uses, such as wild medicines and other wild goods; a large number of uses for wood, including for timber, energy, construction materials, furniture, household utensils, agricultural implements and other uses; uses of grasses, canes, reeds etc. for thatch, mats, baskets and leaf litter; and a variety of other resource uses such as pottery, termitaria, livestock fodder and browse and water. In many of these cases, a number of different species is used, so that the total number of utilizable wild species runs into the

hundreds. Also, for each type of resource utilization, it is clear from the literature that very high percentages of CA households actually use the resource (Campbell *et al* 1991).

Second, these resources offer CA households goods with a variety of economic characteristics. A number of environmental resources are straightforward consumption goods, especially wild foods, wild medicines and wild goods. Others form inputs into a wide range of consumer durables, including both household goods and leisure goods.[6] A range of resources can be used as production inputs, for example leaf litter and termitaria as fertilizer inputs into agriculture, firewood as a general energy input, wood used to make agricultural implements and various grasses and reeds used to make baskets and mats. Environmental resources are also key inputs into the major assets of CA households, namely housing and livestock. Finally, a very substantial number of these resources can be sold to raise cash.

Third, these environmental goods come from a range of different econiches. As table 1 suggests, many resources used by CA households are derived from trees and woodlands (this includes many wild foods). However, these resources can be found in a number of different areas: at homesteads, on fields, in local montane, riverine or plains woodlands, in State Forests, or in nearly commercial farms. Other key sources of environmental goods are water-related, such as aquifers, lakes, rivers, streams and dams: these also can be found both within a particular Communal Area and in surrounding areas as well. Grasses, reeds, rushes and canes are also widely-used inputs, and these are generally harvested from field borders, grasslands, river and stream banks. So not only is a large number of different econiches used, but there is often a variety of sources of supply for a given resource input.

Finally, the great bulk of the environmental resources in Communal Areas are owned communally. Most woodlands, rangelands, wetlands, rivers, streams and dams in CAs are not privately-owned, but rather are owned by the community through the traditional leadership. It is common for access and use rules to exist for certain species and certain resources: these rules can range from local, spirit-linked prohibitions to national laws. However, broadly-speaking CA environmental resources can be characterized as being subject either to open access or to mild common property tenure systems.[7]

Although the background literature suggests that environmental resources contribute to a wide range of household economic activities, there has been little quantitative work done on total resource use values at the household level. Certain partial valuations have been attempted. For example, Campbell *et al* (1991) valued tree-based, direct resource utilizations using consumption levels derived from the secondary literature, and local market prices to convert quantities to values. This suggested that tree products had a value of nearly Z$1,000 (US$292) hh^{-1} yr^{-1}. Campbell *et al* (1994)'s study of two villages used household interviews to assess tree-based resources use, and estimated these to be worth roughly Z$300 (US$37) hh^{-1} yr^{-1} and Z$500 (US$61) hh^{-1} yr^{-1} in the two villages concerned. While these studies both suggest that resource use values may be important, especially given the low incomes of CA households presented earlier, they examined a subset of resource utilizations only and did not collect other household income data. In consequence, we cannot answer certain basic economic questions, such as what the total value of resource use is to CA households; how this might compare to the value of the household's other economic activities; and how resource use relates to other economic parameters and to the various socio-demographic characteristics of the household.

3. Methods

To answer these basic questions, we conducted a set of household surveys that explicitly integrated quantitative environmental data with household economic data. The surveys were conducted in Shindi Ward in southern Zimbabwe, comprising full household data collection in two different years (August 1993 to September 1994; August 1996 to September 1997), and involving a random sample of 197 panel households in 29 villages.[8] In order to provide a rigorous measure of the value of environmental resources,

the surveys were based on four basic principles not found in other studies. They included as wide range of environmental goods as possible; they allowed calculation of household values on the basis of environmental resource use rather than resource availability; they collected local price data to calculate resource values; and they allowed calibration of environmental resource use values against a full accounting of the household's other economic activities.

As stated earlier, these survey data generate unique empirical results. However, they are also somewhat unusual. In this section, then, we explain various aspects of the data collection, aggregation, processing and valuation so as to provide support to the results presented in section 4.[9]

The research area, questionnaire design and data definitions

Shindi Ward was chosen as being typical of Zimbabwe's Communal Areas, in that it is poor; has predominantly sandy soils; has low but variable rainfall (mean 546 mm pa, s.d. 204 mm pa); lacks basic infrastructure such as tarred roads, piped water or electricity; has an agropastoral on hoe-based agricultural system; and relies to a degree on remittances from non-Shindi sources. It is not a resource-abundant, frontier zone, being settled for generations with substantial population growth since the 1950s from both natural increase and forced resettlement. In consequence, the environmental resource base is largely reduced to communally-held, refuge woodlands and grasslands on mountains, kopjes, riverine areas and plains. In floristic terms Shindi sits on the edge of the miombo and mopane woodland zones.

Household questionnaires of the Income, Consumption and Expenditure (ICE) type were administered in the local dialect, augmented by quantitative questions on environmental resource use and values. Questionnaires were implemented quarterly for each household for an entire agricultural year, supplemented by annual questionnaires on household durables, assets, socio-demographics and so on. Identical questions were used in 93/94 and 96/97, making the data highly comparable. Particular efforts were made to localize the questionnaire; to ensure comprehensive coverage of environmental resources; and to design best recall periods for resource uses that could be seasonal, casual and small. This was achieved by extensive preliminary PRA analysis work on household livelihoods, and rigorous questionnaire pre-testing. The quantitative data were also supplemented by widespread qualitative data collection, such as stakeholder interviews, life histories and species listings. In general, the data are of a high quality.

The unusual feature of this data set is the inclusion of a wide range of environmental utilizations as part of the household's income, consumption and expenditure. To qualify as an environmental utilization, a resource must be freely provided by natural processes ie. it is "Nature's bounty." In Shindi, the vast bulk of these resources were derived from areas - such as rangelands, woodlands, dams, and rivers - that were held under communal ownership with near-open access.[10] With this definition, it transpired that sample households used an enormous range of environmental resources: these included almost all the resources listed in table 1, with economic uses as suggested there. At least 100 different resource utilizations were identified, and often multiple wild species were used for each resource utilization (a full list of utilizations and species, including botanical names, is in Cavendish 1999c: 35-43). Note that hardly any of these utilizations would be picked up by a standard household budget survey.

Valuation of environmental resources

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 were valued either at households' reported prices or at local market prices; value-added was calculated where relevant, including for subsistence agriculture; and where economic valuation was difficult, methods were developed using the best price data available.

Thus the methodology adopted for valuing environmental resource utilizations was the same as that used for all other economic transactions, namely households' own reports of both the quantity and total value of their resource utilizations, whether these were collection, consumption, purchase or sale.[11] The potential problem with this method is that many environmental goods are not traded in formal markets - this is often why they have been excluded from household budget surveys in the past. In consequence, one might expect that households would face considerable uncertainty about the value of their resource utilizations, resulting in a substantial missing values problem and highly inaccurate valuation.

However, the fieldwork found that households were able to place direct valuations on the overwhelming majority of environmental resource utilizations. There were many resources that were traded or bartered locally: for these goods households had no difficulty in assigning resource values, and these produced a coherent local schedule of prices and quantities. For a number of environmental goods, households were able to report values despite absent or thin trading. Examples here included wild foods such as insects, honey, birds and mushrooms; leaf litter and termitaria; firewood; cattle manure; and wood inputs into construction. Finally, some environmental goods that households had difficulty valuing directly had close, locally-traded substitutes (eg. wild fruits and vegetables). In such cases we used these substitutes' prices to impute environmental resource use values.[12]

To check the plausibility of these values, we analyzed the implicit unit values of each resource use ie. total value divided by quantity used. If households' reported values are usable, aggregate unit values should look like prices. Across households, each environmental good should have a clear implicit price, and price differences within and across goods should relate systematically to differences in quantity and quality. Table 2 gives examples of basic distributional statistics for a number of environmental goods and their units of quantity. Certain features of the data stand out. First, own-reported unit values are clustered around the mean: not the pattern one would expect if individual households were answering questions in a random manner. Indeed skewness in the data is not high. Second, where an environmental good uses more than one quantity unit, the ratio of reported unit values generally matches the ratio of quantities, as prices should (eg. firewood, fruit wine and mice). Third, where similar environmental goods use the same quantity unit, the reported relative unit values made sense (eg. wild vegetables, and others not shown). Finally, where foods can be used fresh or prepared, the unit values of prepared foods are higher than those of fresh food, which is sensible given the extra labor involved (eg. wild vegetables, and *Sclerocarya birrea* nuts vs fruits). So despite sometimes thin markets, environmental goods in Shindi indeed have recognized unit values; these reported unit values appear to be usable as prices; and likewise we were confident that own-reported values could be used to value environmental goods.[13]

Income definition

As the measure of overall household welfare we have used total income, namely the sum of cash income, net gifts/transfers, subsistence income and environmental income. Total income is the broadest measure of income that can be derived from the questionnaire data. (The grouping of the income sub-components follows the standard disaggregation of rural household income, whereby market activities, non-market/subsistence activities and gifts are separated out and their magnitudes compared. The main difference here is the addition of an environmental income category, reflecting the contribution natural resources are making to rural household welfare in our data set). While consumption is often preferred to income as a welfare measure in household studies (Deaton 1980), in this study the distinction between total income and consumption is not large. This is because certain quantitatively significant economic activities, namely the consumption of own produced goods and of own-collected environmental goods, represent both income and consumption. As these two items comprise c.60 percent of average total incomes in both 93/94 and 96/97, so household income and consumption are of similar magnitude.

Adjustments were made to the household total income data to make them comparable across household types and across time. First, household incomes were made welfare-comparable by an equivalence scale

allowing for inter-household differences in household attendance, household size and demographic structure (for details see Cavendish 1999c): thus in this paper "income" refers to income per adjusted adult equivalent unit (aeu), often abbreviated to income per person. To check that differences in incomes per person across the two surveys were not simply the result of fluctuations in measured household size, and hence possibly erroneous, kernel density estimates of the number of adjusted aeus per households were compared. These demonstrated very little difference in the two distributions. Second, 96/97 data were deflated to 1993/94 Z$, using the national CPI recalculated for the exact survey months as a deflator. This is not ideal, as the weights of the consumption basket used for the national CPI are different to those of poorer rural households. However, recalculation of the CPI using weights more appropriate to rural households made little difference, and analysis of village-level price changes between 93/94 and 96/97 suggested they followed the trend of national prices reasonably closely. So although imperfect, the national CPI is the measure of the change in prices adopted.

4. Empirical Evidence on Rural Households and Environmental Resources

With these definitions and procedures in mind, we turn now to the main point of the paper, namely the presentation of empirical regularities in the relationship between poor, rural households and environmental resources. As suggested in the introduction, our purpose here is to generate "stylized facts" based on rigorous empirical data which can ground the poverty-environment literature, and provide the basis for fact-driven theoretical and econometric work.

4.1 The aggregate contribution of environmental resources

Tables 3 and 4 present aggregated data on the contribution of different income sources to total income per person. Table 3 contains absolute values (in 93/94 Z$ per person) for each income source, while table 4 presents incomes budget shares.[14] The headline result is striking: in both years environmental income makes a substantial contribution to total incomes, comprising 35.4 percent of average total income per person in 93/94 and fully 36.9 percent in 96/97. Indeed, in this latter year environmental income provided an income source that is of the same magnitude or greater than those provided by the income sources (cash and subsistence) that are measured in more conventional household surveys. Looked at another way, the inclusion of environmental income over and above the income sources normally captured by rural household surveys would have boosted measured mean incomes by as much as 47.3 percent in 93/94 and 46.0 percent in 96/97. In both cases, these are considerable figures.

This overall, aggregate contribution of environmental resources is comprised of a number of medium-sized income sources. In 93/94, the largest contributions came from gold panning and firewood use (both 7.3 percent of total income), followed by the consumption of wild foods (6.3 percent), the value of livestock browse and graze (6.0 percent) and environmental cash income (4.6 percent), with others smaller still. In 96/97, livestock browse and graze played a more important role (11.7 percent), with the value of firewood collected (8.2 percent), environmental cash income (5.4 percent) and the consumption of wild foods (4.5 percent) remaining significant. So the panel households derive environmental income from quite a wide range of small contributions by different environmental resources. However, even given this the contribution of some environmental income sub-groups is at a level equal to if not greater than income sub-groups that have received vastly more attention in the literature to date, for example cash crop production, unskilled labor income and small-scale enterprises and crafts.

4.2 Socio-economic differentiation and environmental resource use

While these aggregate figures are striking, they are of limited use in understanding the structural relationships linking households to resource use. So next we go beneath the aggregated data and examine

differentiation in natural resources by unpicking the relationship between key socio-economic factors and environmental resource use.

Resource use and income strata

An obvious starting point is to group the sample by income rank, thus the income accounts in tables 3 and 4 are stratified by total income quintiles. Salient features of these rankings are as follows. First, the aggregate results above actually understate the importance of environmental resources to panel households by hiding the fact that a majority of households depend more heavily on environmental resources than the average (mean) household: this is a consequence of skewness in the income distribution whereby the top quintile receives roughly 40 percent of total income, while the bottom quintile receives only 8 to 9 percent of total income. Thus, across the two waves the bottom 20 percent of the population generated a sizable 40 percent or more of their total income from environmental resources, while for the middle three quintiles of the sample, total environmental income generally comprised 35 percent of total income or more. It is only for the top quintile that the contribution of environmental income dropped significantly, although even here it is 29 percent, still significant.

Second, these data suggest that resource dependence varies systematically with income. In both waves the share of aggregate environmental income decreases as income rises: so the poor are definitely more resource-dependent than the rich. As far as we are aware, this is the first time such a claim has been verified with empirical rigor using panel data. This systematic relationship between environmental resource dependence and income quintile also holds for some interesting resource subgroups. In both waves, the income share of the consumption of own collected wild foods displays a secular decline as the income quintile rises. Lower income households clearly depend proportionately more on the consumption of wild foods than do higher income households, evidence perhaps that these households are unable to allocate as high a share of cash income to purchased foods as better-off households. There are similar secular declines in the income budget shares of firewood and the consumption of own collected wild goods: again for the economic services that these subgroups offer, the poor are more heavily dependent on environmental resources than the rich.

Third, while the income data tell us that poorer households are more resource dependent than the rich, the poor are not in fact the main users of environmental resources in quantity terms. Contrary to the results on income shares, absolute demands for environmental resources do not decline with income (at least over the income ranges in the surveys). Indeed, the value data of table 3 show that in both survey waves the quantity of environmental resources consumed rises systematically with total income quintile, so that the top quintile consumes three to four times the value and hence quantity of environmental resources as the lowest quintile. This pattern of rising absolute resource demands is replicated amongst many of the environmental income subgroups eg. wild foods, firewood, wild goods, fertilizer and livestock browse and graze. If one accepted the argument that it is rising quantities of resource demands and resource utilizations that cause environmental stress, then on these data one would have to accept comparative affluence rather than comparative poverty as the primary issue of concern.

However, while there are clear connections between income levels and resource use, these are not a complete explanation of resource use. This is both intuitive, and also can be seen from the fact that not all resources have declining income shares and increases in total value consumed or used as income quintile rise. Therefore we turn now to other socio-demographic variables that interact with income in determining resource use.

Sex

Collection and use of environmental resources is also strongly linked to the sex of the individual concerned. In our survey area, the great majority of environmental utilizations were associated primarily either with men or with women (table 5). For example, almost all activities associated with wood (sales of wood,

carpentry) are carried out by men. Likewise, men alone hunt and sell wild animals. However, pottery, the sale of wild vegetables, fruits and wine and the collection and/or sale of thatching grass, are activities carried out almost exclusively by women. Joint activities do exist: for example, both sexes can make or sell certain mats (rupasa and rusero), and both sexes are involved in gold panning. Traditional healers (n'anga) can be either male or female: sales of wild medicines can therefore be done by either sex (although this is not reflected in our data). But strong gender differentiation also characterizes environmental utilizations not covered in this table. For example, in Shindi the collection of firewood is largely done by women, as is the gathering of wild fruits, wild vegetables and leaf litter. On the other hand, men are overwhelmingly responsible for collecting termitaria.

There are a variety of reasons for this strong pattern of gender differentiation. One is physical: digging termite mounds, for example, is an extremely strenuous activity for which men are naturally advantaged. Another is economic: efficient gold panning requires two adults (one digger, one sifter and helper), so that in a two parent household, both sexes can be involved. Specialization in resource use is also linked to patterns of gender specialization found in the broader household economy. Gardens are generally the responsibility of women, and hence activities involving these gardens (eg. leaf litter gathering, relish production and sale) also fall in the female domain. Firewood collection and pottery production are dominated by women: these are both associated with cooking. Construction is a man's responsibility, so it is men who are thatchers and builders. In general, much of the gender specialization in the survey is due to the strongly differentiated gender roles and gender rights that exist in traditional African communities. Examples here amongst the activities of table 5 are thatching grass collection/sale and wine brewing as female activities, and sales of small wild animals, sales of fish, sales of firewood, and carpentry as male activities. More broadly, since women have no ownership rights over trees, they are significantly less likely to plant trees than men (Fortmann and Nabane 1992).

Age

Different resources are also used by different individuals and households at different ages. Although hard data are difficult to get here, fieldwork evidence showed children, and particularly poor children, depended heavily on wild foods at certain times. For example, few schoolchildren were given food to take to school or were given breakfast before their often long walk to school. So children relied heavily on the opportunistic gathering of wild foods (such as mice, small birds, insects, wild fruits) on their trips to school and during school breaks. These items formed the bulk of food intake for schoolchildren until the evening meal at home. Similarly, when herding livestock children can spend the whole day away from the homestead, during which time they are expected to forage for wild foods to feed themselves. This importance of wild foods in children's diets has also been found in other case studies of wild resource use (see Wilson 1990, McGregor 1995).

Certain foods are regarded as unfit for adult consumption. While children may eat a wide variety of insects and wild fruits, adults consume a much more restricted set of these foods.[15] However, adulthood and marriage brings a boom in construction uses. Every man must provide for his wife a kitchen hut and bedroom hut, causing a rapid surge in construction activity and associated firewood use (for brick burning), construction poles, roofing poles, thatching grass, and bark-based ropes and fibers (for binding the thatch to the roof). Likewise, the first harvest requires the construction of a granary for crop storage, the arrival of children will necessitate the building of further bedroom huts, and the acquisition of livestock will require building a kraal and, often, a stover store.

Finally, as individuals age, their resource demands alter again. Older individuals have difficulty carrying out arduous agricultural tasks, and reduce cultivated acreage and per capita food production. In response, they depend more on wild foods (and on transfers from off-spring). For similar reasons, older individuals can no longer conduct certain economic activities, such as earning remittances, hiring out plough teams, or panning for gold, all of which demand considerable effort. Instead they turn to activities where

collection of resource inputs is free of entry barriers, and which demand little physical labor, such as weaving, pottery, or collecting wild vegetables and fruit. For all these reasons, then, the character of environmental utilizations alters over the life-cycle of individuals and households.

Household headship
Resource use can also be affected by household structure. An imperfect proxy here is to stratify the income data by household headship (table 6).[16] Now it is obvious that some of the differences that appear in table 6 are largely income-based. For de facto female-headed households, remittances dominate the income accounts, comprising c.45 percent of total income. These households are "cash-rich", allowing them to purchase more and collect less food: they have a small proportion of their income derived from subsistence consumption; the lowest share of their income derived from the consumption of wild foods; the smallest amounts of cash from environmental resources; and have the lowest share of total income derived from total environmental income.

However, we can also see the effect of gender stratification on environmental utilizations, as this stratification means that households' activity portfolios will differ systematically partly due to their gender composition. Certain households' gender composition means that various resource activities are closed off to them. The headship categories demonstrating this most clearly are de jure female-headed households with no married sons, and divorced/widowed male-headed households. In the former, which lack adult male labor, restrictions on women's environmental activities show up in a distinctive pattern of environmental cash income, with shares of total income derived from sales of wine, wild fruits and thatching grass being the largest of any household headship type.[17]

The obverse are those households headed by divorced or widowed males. Generally, the defining feature of divorced/widowed male-headed households is a lack of female labor to carry out the essential tasks of fetching water and collecting firewood, which adult males are incapable of doing. This implies that such households require cash to hire in labor for these activities. To earn cash, these households turn to certain environmental resources and use them intensively. In both waves, these households generated significant income shares from gold panning and environmental cash income sub-components linked to classic male environmental activities such as carpentry, hunting, fishing and thatching. (The importance of fishing and hunting to these households is also shown by their greater dependence on the consumption of wild animals). In general, these households are highly dependent on environmental resources: these contributed more than 50 percent of total income in 96/97 and as much as 68 percent in 93/94.

4.3 Environmental resources and key rural economic activities

In the preceding sections, we looked at the economic importance of environmental resource use, and its determinants, using the total income accounts. In this section, we continue this analysis, but look instead at two critical sub-components of the household's economic activities, namely cash income generation and agricultural fertilizer use. What role do environmental resources play here?

Cash income
As table 4 shows, in both survey years there was a dramatic rise in the proportion of total income attributable to cash income, as incomes rose. Cash income is critical to the sample households for two reasons. First, as shown in a companion paper (Cavendish 1999a), access to cash income plays a critical role in determining household prosperity. Second, certain key economic transactions require cash, such as payment of school fees, purchasing of foods, purchasing of agricultural inputs, and so on.

To examine the role played by environmental resources in generating cash income, in table 7 individual cash income sources are expressed as a share of total cash income per person, rather than total income per person as before. Once again, the most striking finding is the systematic, negative relationship between

the environmental cash income share and income quintile. Although environmental cash income varies in significance quite substantially across the two waves (averages of 35 and 22 percent respectively), in both years the share of total environmental income falls monotonically as incomes quintile rises. (This is also generally true for the two sub-components of environmental income). Thus, in 93/94 the lowest quintile derived almost half its cash income from environmental sources: this proportion fell to 30 percent or more for the middle 60 percent of households, and to 25 percent for the richest 20 percent. Even in 96/97, the lowest quintile still derived 34 percent of its cash income from environmental sources: however, in this year the proportion for the top quintile fell to only 6 percent.

So the poorest households are highly dependent on environmental resources to generate the cash income that they require to conduct major economic transactions. By contrast it is clear that the process of enrichment in Shindi involves shifting into much more lucrative economic activities. The counterpart to the declining environmental cash income share is the rising share of cash derived from remittances and, less significantly, high value crops and large livestock. Entry barriers stop poorer individuals from involving themselves in such economic activities, hence their reliance more than anyone else on environmental resources to generate cash.

Agricultural fertilizers

The importance of agricultural production to rural households is well known. Less well appreciated is the importance of fertilizer inputs. Shindi soils are predominantly granite-derived sands which are dystrophic and hence nutrient-poor. Additionally, the main grain crops - maize, sorghum and millet - all impose substantial nitrogen losses on their soils, so that production of these crops requires regular additions of nitrogen-based fertilizers. Hence for the bulk of farmers in Shindi, access to and use of fertilizers is of great importance.[18] Farmers have a range of supply options for fertilizer, namely commercial fertilizers; livestock manure, whether cattle, goats or poultry; leaf litter collected from local woodlands; and termitaria from their fields.[19] These various fertilizers differ markedly both in quality and access. Given these differences, the natural expectation is that fertilizer use will vary systematically across households, field types and field uses. To explore some of this variation, data on the use of fertilizer (including gifts and purchases) were aggregated for the two survey years: these are presented in table 8.

A number of results stand out. The first is that environmental fertilizers (termitaria and leaf litter) are significant in value terms. They comprised 41 percent of all fertilizers' value in 93/94 and 24 percent in 96/97. In 93/94, these fertilizers were far more significant than livestock manures (about which much has been written), and in 96/97 they ranked higher than commercial fertilizers. Second, in general poorer households again depend more heavily on environmentally-derived fertilizers than richer households. In 93/94, the value share of environmental fertilizers fell steadily with income. Whereas the pattern is less clear in 96/97, the bottom two quintiles had higher budget shares than the top three quintiles. Third, once more there is a heavy dependence of poor households on environmental resources. In 93/94, the bottom two quintiles derived over 50 percent of their total fertilizer values from leaf litter and termitaria: in 96/97 their average share was over 40 percent. Fourth, even for richer households, environmental fertilizers have a significant value share. Thus environmental resources are an important source of fertilizer - and hence an important input into agricultural production - for all households, and especially so for the least well-off.[20]

4.4 Environmental resource use in context

A major finding of this paper is the quantitative significance of environmental resource utilizations to the sample households. Given knowledge of CA households' general production and consumption patterns, as reviewed in an earlier section, these result should be robust. Nonetheless, these data span two

agricultural year only, so that they do not offer a full picture of the dynamics of resource utilizations. And while environmental resources are clearly significant to our sample households, it is also the case the resource use magnitudes are likely to fluctuate quite substantially from year to year.

There are a number of reasons for such fluctuations, including changes in the economic parameters underpinning household choices, particularly in the adjustment era, and changes in resource availability caused by natural climatic variation. Some of these changes are evident in the survey data. For example, major differences occur in the value of gold panning and livestock browse and graze. These reflected that fact that gold resources had become nearly exhausted by 1996/97, and that cattle numbers had continued to recover in the area since the 1991/92 drought (in which 75 percent of large livestock died). This latter change was also reflected in the rise in livestock income between 93/94 and 96/97.

Perhaps the clearest evidence of natural resource variability came from comparing wild food consumption in 93/94 and during the severe 91/92 drought. During the drought, most wild fruit trees totally failed to produce fruit, while in other trees fruiting was sporadic. Wild vegetables that people consume in normal years also failed to appear. This dramatically changed wild food consumption, so that in the face of devastating food scarcity, people ended up consuming highly inferior wild foods such as *Alternanthera sessilis*, *Dicerocaryum zanguebarium*, *Senna occidentalis*, the leaves of *Adansonia digitata* and *Afzelia quanzensis*, and other weed species. In the normal rainfall year 93/94, people predominantly consumed preferred species such as *Curcurbita pepa*, *Cucumis metuliferis*, *Phaseolus vulgaris*, and *Gynandropsis gynandra*. So it is clear that consumption patterns can change radically in the event of a shock of such magnitude.[21] This rather extreme variation is mirrored by smaller, rainfall-induced changes in resource availability from year to year in foods such as mushrooms, wild leaf vegetables, certain insects and honey (McGregor 1995).[22]

5. Conclusions and Discussion

The main aim of this paper has been to generate some fundamental empirical regularities concerning the value of environmental resource use to rural households. However, we have also briefly explained the methodology we developed for integrating a set of unorthodox environmental goods into the household accounts. This included comprehensive data collection using a locally-targeted, random household questionnaire; data processing and accounting issues; and methods for making the data comparable across households and across years. Most important was the valuation of environmental resource utilizations. Here we found it possible to use respondents' own estimates of quantity and value, as these produced implicit unit values with acceptable properties. In many cases these unit values were based on local trading prices: however, even when environmental goods were not widely traded, sensible estimates of resource values usually emerged.

Turning to the data, we believe we have unique quantitative results linking rural households and environmental resources. Seven empirical regularities emerged from our data. The first is that environmental resources in aggregate contribute significantly to rural incomes. In our sample, roughly 35 percent of average total income came from freely-provided environmental goods: this overlooked income source is just as significant as others which have received extensive attention in past studies of rural households. The second is that rural households generally use a wide variety of environmental resources, and that the sizeable aggregate value of environmentally-derived income is made up of a fairly large number of smaller individual income sources. The third is that there is a negative relationship between the aggregate environmental income share and household total income, so that it is fair to claim - as many have - that the poor are more resource-dependent than the rich. By contrast, the fourth finding is that aggregate total resource demands still rise with income: better off households are, in quantitative terms, the most significant users of environmental resources.

Fifth, at a disaggregated level, environmental goods are a heterogenous rather than a homogenous bundle. Resource demands were affected differentially by income changes: there is clearly no single income elasticity for the set of resources used by our panel households. Socioeconomic variables such as sex, age and household composition also affected resource use, sometimes leading to dramatically different patterns of resource use across different households. This relatively complex pattern of differentiation in resource use confirms what other case studies of individual environmental utilizations in Zimbabwe have suggested: that different households use different resources for different reasons at different times.[23]

Sixth, environmental resources are important for key economic activities. In both cash generation and the fertilizer provision, environmental resources proved quantitatively significant *in toto*, and were of particular importance once again to poorer households. Finally, both the use and value of environmental resources are likely to vary substantially from year to year in response to both climatic variation and variation in other relevant economic parameters. While we believe that this is unlikely to contradict our finding about the aggregate significance of environmental resources to rural households, it does mean that the households' aggregate resource dependence will rarely be stable from one period to the next.

Discussion

One of the most important findings of this research has been the substantial quantitative contribution that environmental resources make to rural households. There are two obvious implications of this finding. The first is that many households - and particular poorer households - depend very heavily on communally-held natural resources. So maintenance of the commons will be of great importance to the welfare of these household. The second is that, by ignoring the contribution of resource utilizations, quantitative measurements of many rural phenomena - such as incomes, consumption, expenditure, nutrition, agricultural productivity and even growth - may have been significantly in error. Clearly, the extent of any error varies by location and by survey date, but given the results above the quantitative magnitudes are potentially large.

Of course, these empirical findings pose a whole range of further questions. Some of these have been analyzed elsewhere, such as: how does the inclusion of environmental resources as a source of economic value change our view of rural poverty and inequality (Cavendish 1999a)? How does the fact of economic differentiation in environmental goods alter our analysis of sustainability (Cavendish 1999b)? But other questions remain. Most fundamentally, why are rural households generally and poor households in particular so dependent on environmental resources? What are the dynamics of this process? How might policy encourage investment in rather than destruction of natural resources, given these rates of resource dependence and resource use? And how do CPR management systems work in the context of economically differentiated resources and economically differentiated agents, if they work at all? Thus much work remains in the theoretical and empirical analysis of the poverty-environmental relationship.

Endnotes

1. As illustration, see the notes to the tables in a widely-used source book for environmental data such as the World Resources Institute (1994).

2. African rural households are not unique in using wild resources so extensively: for reviews covering other continents see Jodha (1986), Falconer and Arnold (1991), Godoy and Bawa (1993) and Lampietti and Dixon (1994).

3. Fairhead and Leach (1998) demonstrate how misguided assessments of the causes of environmental change can be when little is known about the physical direction of change.

4. Other papers (Cavendish 1999a, 1999b) have reported briefly on the economic contribution of environmental resources to rural households using cross-section results from one survey wave of these data. This paper analyses this contribution in more detail, and uses the panel data to ensure the empirical results are not simply one-offs. The only other study which has seriously attempted to measure the economic contribution of environmental resources to rural households is the pioneering study by Jodha (1986). Using cross-section data, this found resource utilizations from the commons comprising between 9 and 26 percent of the incomes of poor households, and between 1 and 4 percent of the incomes of rich households. However, this study quantified only a subset of environmental resource utilizations.

5. The best reviews are Wilson (1990), Bradley and Dewees (1993) and Clarke *et al* (1996). However, even these studies focus primarily on woodlands and woodland products, rather than the complete list of household resource usages. For key references in the case study literature see table 1.

6. Given their very low income levels, the ownership of purchased goods by CA households is very restricted, so resource-based products often comprise the major share of consumer durables.

7. This paragraph is naturally a considerable simplification. For views on resource tenure in CAs, see Fortmann and Nhira (1992) and Matose and Wily (1996).

8. In both years, household rosters were compiled locally in conjunction with the traditional authorities. In 93/94, a 1-in-5 random sampling of the household roster generated a 213 household sample. In 96/97, 197 of these households still existed, and were resurveyed to form the panel data set. In addition, a random 1-in-5 sampling was taken of all new households, giving 21 extra households sampled for 96/97 only. Results for the 197 panel households are given in this paper, but no significant differences arise from using the full samples in each year.

9. These issues are covered in much greater detail in Cavendish (1999c), available from the author on request.

10. Some wild species that grew spontaneously on private lands: these were included in our definition.

11. No attempt was made to value indirect use environmental values such as watershed protection, windbreak uses or general aesthetic and spiritual values. Such indirect uses require specialised valuation techniques such as hedonic pricing, contingent valuation, travel costs methods, or production function approaches.

12. The most problematic valuations were for livestock fodder and for livestock inputs into agriculture. For the solutions adopted, see Cavendish (1999c).

13. There remains dispersion in the unit values of table 2, but a degree of dispersion is to be expected. Respondent error will of course be a factor. But also units of measurement are in practice not identical - there are no uniform measures for items such as mice, doves, firewood, thatch bundles or home-made clay pots. Likewise, there can be considerable quality differences in environmental goods. Though these quality differences should be captured in reported total values, they will result in varying unit resource values.

14. Note that in this table we have calculated average income shares 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 shares.

15. This has its roots both in local preferences and in the spread in rural Zimbabwe of evangelical Christian sects. These ban the consumption of wild goods such as insects, mice, fruit-based wines and wild medicines as heathen practices.

16. Table 6's five-fold classification by household headship divides households into categories that reflect the Shona social system. Male-headed households are categorised into "resident married male" and "divorced/widowed male", as the latter have very distinctive characteristics. Female-headed households are divided into de facto and de jure female-headed, with the latter sub-divided into households with married sons present and those without. This distinction was drawn as de jure female-headed households with married sons present were generally transitional households: decisions were increasingly made by the newly-married son, so that in a short time the named household head would switch to being a married male.

17. These households also generate a higher proportion of their income from beer brewing, another female activity.

18. There is a substantial literature concerning soils and agricultural production both in semi-arid savanna areas generally and Zimbabwe's Communal Areas in particular. For a geological description of soils in Zimbabwe, see Nyamapfene (1991). For an analysis of the relationship between soil moisture availability, soil nutrient status and primary production in semi-arid savannas, see Huntly (1982) and Frost *et al* (1986). These references also explore the impact of climatic variability on primary production. For a model of nitrogen flows within the typical Communal Area farming system, see Swift *et al* (1989). Finally, for a discussion of household responses to the constraints imposed on farming by the soils and climate conditions of semi-arid savannas, see Scoones (1989), Ashworth (1990), and Behnke and Scoones (1992).

19. For the economic characteristics and nutrient content of these fertilizers see Conroy (1990) on commercial fertilizers; Rodel *et al* (1980), Shumba (1984) and Scoones (1992) on livestock manures; McGregor (1995) and Campbell *et al* (1996) on leaf litter; and Watson (1976, 1977) and Nyamapfene (1986) on termitaria.

20. Significantly greater use of leaf litter by poorer households was also found by McGregor (1995).

21. For quantitative data on wild food consumption patterns in 91/92 versus 93/94 see Cavendish (1997: 106).

22. These inter-annual variations are underlain by longer-run processes of resource change. Aerial photographs for 1955 and 1985 and fieldwork interviews with village historians confirmed that substantial changes occurred in the abundance and distribution of natural resources in Shindi over the last few decades. For example, the clearance of various woodlands has reduced the per capita availability of firewood and construction poles. Likewise, the disappearance of sacred woodlands has reduced the availability of game animals, such as impala, duiker, zebra, and warthog. Similarly, the shrinkage in woodland area has reduced the availability of other wild foods: older interviewees recalled that there was never any need to cook meals for children as wild foods were abundant and nearby.

23. Harder econometric evidence on resource differentiation, and a discussion of its significance for poverty-environment analyses, is presented in Cavendish (1999b).

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Table 1 - Summary of Resource Utilizations by CA Households

Environmental Utilization[1] [2]	Economic Use of Environmental Good				
	Consumption	Durable	Production input	Asset formation	Sale
A. Wild Foods, Wild Goods and Minor Uses					
Wild fruits, nuts, and their produce (wine, oil, porridge, jam)	T		T		T
Wild vegetables	T				T
Wild animals	T				T
Wild fish	T				T
Insects	T				T
Other wild foods (mice, birds, honey, mushrooms, leaves, roots)	T				T
Wild medicines	T				T
Other wild goods (gum, soap, salt, tooth-sticks, oils, resins, dyes)	T		T		T
B. The Multiple Uses of Wood					
Timber (for commercial use, carvings)		T	T		T
Firewood (cooking, heat, light, beer brewing, brick burning)	T		T		T
Construction wood (huts, granaries, livestock pens, field fencing)		T	T	T	T
Agricultural implements (carts, yokes, hoes, axe handles, ploughs)		T	T		T
Furniture (wardrobes, beds, tables, chairs, stools, shelving etc.)		T		T	T
Household utensils (cook sticks, mortars, pestles, plates etc.)		T	T		T
Musical instruments (marimba, mbira, drums, guitars)		T			T
Hunting implements (knobkerries, bows, arrows, fishing rods etc.)		T	T		
Rope from bark (roofing, binding, whips, baskets, mats, nets)			T		T
C. Uses of Grass, Reeds, Rushes, Canes and Leaves					
Thatching grass		T	T		T
Woven goods (sleeping mats, crop and storage baskets, brooms, hats)	T	T	T		T
Leaf litter (as fertilizer)			T		T
D. Other Resource Utilizations					
Pottery clays (water storage, pots, cooking pots)		T	T		T
Termite mounds (as fertilizer)			T		T
Livestock fodder and browse			T	T	
Water	T		T		

Notes

1. The resource uses in this table exclude some important non-use values of natural environments to CA households. These include shade, ecological services such as watershed regulation and soil erosion protection, and various spiritual and cultural values.
2. Key references are as follows:

Environmental resource use generally: Wilson (1990), McGregor (1991), Bradley and Dewees (1993), Clarke *et al* (1996)
All wild foods: Gomez (1988), Wilson (1990), Benhura and Chitsaku (1990, 1992), Campbell *et al* (1991)
Wild fruits: Campbell (1987), Wilson (1989), Gumbo *et al* (1990), McGregor (1995)
Wild medicines: Gelfand *et al* (1985)
Firewood: du Toit *et al* (1984), MacGarry (1987), Hosier (1988), Bradley and McNamara (1990)
Construction wood: Grundy *et al* (1993)
Other wood uses: Campbell *et al* (1991), McPherson (1991)
Leaf litter and termitaria: Balderrama *et al* (1988), McGregor (1991, 1995), Campbell *et al* (1996)
Livestock fodder and browse: Sandford (1982), Scoones (1989)

Table 2 - Some Implicit Unit Values of Environmental Goods, 1993/94

Environmental Resource Use	Unit of Measure [1]	No. of Obs. [2]	Implicit Unit Value [3] Mean	Std. Dev.	Median	Mode	Min.	Max.
1. Wild Vegetables								
Phaseolus vulgaris - munyemba (fresh)	20 l bucket	93	9.92	7.73	10.00	10.00	1.00	40.00
	tswanda	71	0.85	0.27	1.00	1.00	0.50	2.00
Phaseolus vulgaris - munyemba (dried)	20 l bucket	164	22.61	7.24	24.00	20.00	6.00	40.00
Cucurbita pepa - muboora (fresh)	20 l bucket	57	8.45	3.30	10.00	10.00	1.00	20.00
	bundle	285	0.94	0.18	1.00	1.00	0.20	2.00
Cucurbita pepa - muboora (dried)	20 l bucket	29	22.00	7.32	20.00	20.00	10.00	45.00
2. Wild Fruits								
Diospyros mespiliformis - suma	plate	62	0.84	0.35	1.00	1.00	0.05	2.00
Sclerocarya birrea fruit - bvura	20 l bucket	13	1.93	0.85	2.00	1.00	1.00	4.00
Sclerocarya birrea nut - shomwe	50 kg bag	26	14.25	9.87	10.00	10.00	3.00	40.00
	20 l bucket	99	5.66	3.45	5.00	5.00	1.00	20.00
Berchemia discolor - nyii	1 kg sugar bag	33	0.68	0.34	1.00	1.00	0.10	1.00
	plate	28	1.19	0.61	1.00	1.00	0.33	2.50
3. Other Wild Foods								
Zebra - mbizi	meat bundle	12	2.00	0.00	2.00	2.00	2.00	2.00
Doves - njiva	single bird	23	0.74	0.32	1.00	1.00	0.10	1.00
Mice - mbeva	tswanda	28	8.13	6.33	5.00	5.00	2.00	25.00
	plate	49	2.87	1.80	2.00	2.00	0.15	10.00
	single mouse	104	0.25	0.21	0.20	0.10	0.05	1.00
Sclerocarya birrea wine - mukumbi	gate	33	13.42	5.60	11.67	10.00	5.00	30.00
	pfuko	68	10.54	4.58	10.00	10.00	3.00	30.00
	nyengero	20	6.23	3.28	5.00	5.00	1.33	12.50
4. Firewood								
Firewood - huni	scotch cart	236	10.42	4.28	10.00	10.00	2.00	30.00
	bundle	1,608	2.02	0.80	2.00	2.00	1.00	7.00
5. Small and Large Carpentry Items								
Cook stick - musika	one	66	1.20	0.71	1.00	1.00	0.20	5.00
Hoe handle - mupinyi	one	103	1.53	0.72	1.00	1.00	0.50	5.00
Yoke - joko	one	85	14.25	6.14	15.00	20.00	5.00	30.00
Mortar - duri	one	88	27.01	12.43	25.00	20.00	1.00	70.00
Pestle - muhwi	one	87	6.36	4.66	5.00	5.00	1.00	30.00
6. Grass and Woven Goods								
Sleeping mat - mhasa	one	217	13.50	5.07	15.00	15.00	2.00	30.00
Crop basket - tswanda	one	115	6.28	3.04	5.00	5.00	0.83	20.00
Winnowing basket - rusero	one	147	10.38	3.48	10.00	10.00	3.50	20.00
7. Pottery								
Relish cooking pot - hadyana	one	91	1.80	1.07	1.50	1.00	0.30	5.00
Beer storage pot - nyengero	one	74	5.70	3.52	5.00	5.00	1.00	20.00
8. Environmental Fertilizers								
Leaf litter - murakani	wheelbarrow	20	2.43	1.12	2.00	2.00	1.00	5.00
	20 l bucket	42	1.68	0.52	2.00	2.00	0.40	2.00
Termitaria - churo	scotch cart	43	16.43	15.76	10.00	40.00	2.00	40.00

Notes
1. Where more than one unit of measurement is shown per resource use, the units are listed in order of size.
2. This is the number of observations with meaningful value and quantity data for a given resource use and unit of measurement.
3. All data are in 1993/94 Z$.

Table 3 - Panel Households' Total Income by Quintile and by Major Income Source

1993/94 Data	93/94 Panel Household Quintile: Lowest 20%	20% to 40%	40% to 60%	60% to 80%	Top 20%	All Panel Households
Total Cash Income (Excl. Env. Cash Income)	**2,662**	**5,399**	**6,716**	**11,348**	**26,526**	**52,650**
- Crop Income	324	869	838	991	3,617	6,639
- Livestock Income	323	304	541	686	1,352	3,205
- Unskilled Labor Income	651	621	1,204	544	838	3,858
- Skilled Labor Income (Teaching)	.	520	.	.	6,015	6,534
- Crafts and Small-Scale Enterprises	246	587	679	1,516	2,462	5,491
- Remittances	1,118	2,498	3,348	7,528	12,087	26,579
- Miscellaneous Income	.	.	106	82	156	344
Total Net Gifts/Transfers	**223**	**-632**	**615**	**1,464**	**2,612**	**4,282**
Total Own Produced Goods	**6,208**	**9,609**	**10,312**	**11,672**	**18,309**	**56,109**
- Consumption of Own Produced Goods	5,048	7,542	8,578	9,967	14,727	45,861
- Input Use of Own Produced Goods	1,160	2,067	1,733	1,705	3,583	10,248
Total Environmental Income	**5,793**	**8,070**	**10,507**	**13,102**	**16,159**	**53,631**
- Gold Panning	1,215	1,273	2,080	2,556	4,310	11,434
- Natural Habitat Utilization Cash Income	665	846	1,322	2,439	1,689	6,961
- Consumption of Own Collected Wild Foods	1,250	1,662	1,779	1,967	2,201	8,858
- Consumption of Own Collected Firewood	1,316	1,913	2,065	2,232	3,325	10,851
- Consumption of Own Collected Wild Goods	149	176	186	174	194	879
- Use of Environmental Goods for Housing	521	434	1,059	932	1,109	4,055
- Use of Environmental Goods for Fertilizer	154	137	164	149	163	767
- Livestock Browse/Graze of Environmental Resources	523	1,628	1,852	2,652	3,169	9,825
Total Income	**14,886**	**22,446**	**28,150**	**37,585**	**63,607**	**166673**

1996/97 Data	96/97 Panel Household Quintile: Lowest 20%	20% to 40%	40% to 60%	60% to 80%	Top 20%	All Panel Households
Total Cash Income (Excl. Env. Cash Income)	**3,176**	**5,869**	**9,456**	**15,158**	**47,599**	**81258**
- Crop Income	374	602	1,229	1,879	6,145	10,230
- Livestock Income	701	1,041	917	2,399	7,668	12,726
- Unskilled Labor Income	411	365	436	527	196	1,935
- Skilled Labor Income (Teaching)	.	.	.	.	12,835	12,835
- Crafts and Small-Scale Enterprises	366	667	1,266	2,067	1,379	5,745
- Remittances	1,324	3,195	5,607	8,286	19,376	37,787
Total Net Gifts/Transfers	**440**	**410**	**949**	**2,177**	**1,571**	**5,547**
Total Own Produced Goods	**3,644**	**5,900**	**6,750**	**9,851**	**16,256**	**42,401**
- Consumption of Own Produced Goods	3,150	4,883	5,705	8,334	13,883	35,955
- Input Use of Own Produced Goods	494	1,017	1,045	1,517	2,373	6,445
Total Environmental Income	**5,694**	**8,943**	**9,390**	**13,217**	**21,468**	**58,712**
- Gold Panning	601	1,342	693	706	1,072	4,414
- Natural Habitat Utilization Cash Income	1,138	1,688	962	2,018	1,172	6,977
- Consumption of Own Collected Wild Foods	832	1,155	1,047	1,378	1,904	6,316
- Consumption of Own Collected Firewood	1,503	1,957	2,210	2,629	3,554	11,853
- Consumption of Own Collected Wild Goods	199	182	177	200	481	1,240
- Use of Environmental Goods for Housing	531	656	833	674	807	3,500
- Use of Environmental Goods for Fertilizer	73	228	72	125	220	718
- Livestock Browse/Graze of Environmental Resources	817	1,735	3,397	5,486	12,259	23,693
Total Income	**12,954**	**21,123**	**26,545**	**40,402**	**86,894**	**187,918**

Table 4 - Panel Households' Total Income Shares by Quintile and by Major Income Source

1993/94 Data	93/94 Panel Household Quintile: Lowest 20%	20% to 40%	40% to 60%	60% to 80%	Top 20%	All Panel Households
Total Cash Income (Excl. Env. Cash Income)	**16.99**	**23.78**	**23.71**	**30.27**	**36.66**	**26.29**
- Crop Income	2.17	3.97	2.94	2.69	5.81	3.52
- Livestock Income	2.24	1.34	1.88	1.89	1.91	1.85
- Unskilled Labour Income	4.34	2.77	4.29	1.46	1.50	2.87
- Skilled Labour Income (Teaching)	0.00	2.13	0.00	0.00	4.51	1.32
- Crafts and Small-Scale Enterprises	1.47	2.61	2.37	4.14	4.22	2.97
- Remittances	6.76	10.97	11.86	19.88	18.44	13.60
- Miscellaneous Income	0.00	0.00	0.37	0.20	0.28	0.17
Total Net Gifts/Transfers	**1.45**	**-2.88**	**2.23**	**3.69**	**2.93**	**1.48**
Total Own Produced Goods	**42.02**	**42.95**	**36.87**	**31.06**	**31.33**	**36.85**
- Consumption of Own Produced Goods	33.99	33.55	30.67	26.47	24.94	29.93
- Input Use of Own Produced Goods	8.03	9.40	6.19	4.59	6.39	6.92
Total Environmental Income	**39.53**	**36.14**	**37.19**	**34.97**	**29.07**	**35.38**
- Gold Panning	7.87	5.81	7.29	7.03	8.52	7.30
- Natural Habitat Utilization Cash Income	5.05	3.79	4.66	6.48	3.05	4.61
- Consumption of Own Collected Wild Foods	8.57	7.37	6.35	5.26	3.85	6.28
- Consumption of Own Collected Firewood	8.90	8.54	7.33	5.97	5.58	7.26
- Consumption of Own Collected Wild Goods	1.02	0.79	0.66	0.47	0.33	0.65
- Use of Environmental Goods for Housing	3.60	1.87	3.74	2.52	1.94	2.73
- Use of Environmental Goods for Fertilizer	0.93	0.60	0.59	0.40	0.28	0.56
- Livestock Browse/Graze of Environmental Resources	3.59	7.37	6.57	6.84	5.52	5.99
Total Income	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

1996/97 Data	96/97 Panel Household Quintile: Lowest 20%	20% to 40%	40% to 60%	60% to 80%	Top 20%	All Panel Households
Total Cash Income (Excl. Env. Cash Income)	**23.59**	**27.86**	**35.28**	**37.36**	**47.37**	**34.27**
- Crop Income	2.73	2.88	4.57	4.84	6.71	4.34
- Livestock Income	5.33	4.90	3.49	5.50	7.70	5.38
- Unskilled Labour Income	3.48	1.74	1.68	1.16	0.28	1.67
- Skilled Labour Income (Teaching)	0.00	0.00	0.00	0.00	3.95	0.78
- Crafts and Small-Scale Enterprises	2.60	3.09	4.70	5.42	1.86	3.54
- Remittances	9.46	15.24	20.83	20.44	26.87	18.56
Total Net Gifts/Transfers	**4.04**	**2.00**	**3.59**	**5.32**	**1.92**	**3.38**
Total Own Produced Goods	**28.53**	**28.18**	**25.55**	**24.38**	**20.72**	**25.48**
- Consumption of Own Produced Goods	24.60	23.24	21.55	20.61	17.45	21.50
- Input Use of Own Produced Goods	3.94	4.94	4.00	3.77	3.27	3.99
Total Environmental Income	**43.83**	**41.96**	**35.59**	**32.93**	**29.99**	**36.87**
- Gold Panning	3.88	5.89	2.58	1.88	1.74	3.20
- Natural Habitat Utilization Cash Income	8.85	8.13	3.72	4.78	1.60	5.43
- Consumption of Own Collected Wild Foods	6.83	5.48	4.01	3.44	2.66	4.48
- Consumption of Own Collected Firewood	12.00	9.27	8.37	6.58	4.66	8.17
- Consumption of Own Collected Wild Goods	1.49	0.87	0.66	0.48	0.57	0.81
- Use of Environmental Goods for Housing	4.06	3.11	3.10	1.53	1.13	2.59
- Use of Environmental Goods for Fertilizer	0.64	1.01	0.26	0.28	0.39	0.52
- Livestock Browse/Graze of Environmental Resources	6.09	8.18	12.88	13.96	17.24	11.66
Total Income	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 5 - All Households' Environmental Resource Utilizations By Sex, 93/94 and 96/97

	1993/94			1996/97		
	Number Of Cases	Percent Male	Female	Number Of Cases	Percent Male	Female
A. Utilizations for Cash Income						
1. Sales of Wild Vegetables/Fruits	50	2	98	31	0	100
2. Sales of Small Wild Animals	45	97.8	2.2	31	71	29
3. Sales of Large Wild Animals	16	87.5	12.5	6	50	50
4. Sales of Wood	10	90	10	26	96.2	3.8
6. Sales of Wine	71	2.8	97.2	24	20.8	79.2
7. Gold Panning	147	66.7	33.3	48	87.5	12.5
B. Utilizations for Cash Income and Own Use						
8. Thatching Grass	100	9	91	168	18.5	81.5
9. Large Carpentry Items	46	100	0	47	100	0
10. Small Carpentry Items	180	100	0	187	99.5	0.5
11. Pottery Goods	77	1.3	98.7	41	26.8	73.2
12. Woven Goods	75	30.7	69.3	108	19.4	80.6

Table 6 - Panel Households' Total Income Shares by Type of Household Head

	Resident Married Male	De Facto Female	De Jure Female, No Married Sons	De Jure Female, Married Sons	Divorced/ Widowed Male	All Panel Households
1. 1993/94						
Total Cash Income (Excl. Env. Cash Income)	**20.87**	**49.13**	**18.2**	**25.67**	**2.38**	**26.29**
- Crop Income	4.61	1.72	2.12	1.13	0.14	3.52
- Livestock Income	2.14	0.92	2.03	2.18	0	1.85
- Unskilled Labour Income	3.61	0.99	3.12	1.36	0.68	2.87
- Skilled Labour Income (Teaching)	1.43	0	0	8.5	0	1.32
- Crafts and Small-Scale Enterprises	3.4	1.85	4.9	2.47	-0.46	3.14
- Remittances	5.69	43.64	6.05	10.04	2.03	13.60
Total Net Gifts/Transfers	**1.65**	**-0.79**	**5.18**	**0.2**	**2.94**	**1.48**
Total Own Produced Goods	**38.86**	**27.32**	**41.97**	**42.47**	**26.88**	**36.85**
Total Environmental Income	**38.62**	**24.34**	**34.65**	**31.66**	**67.8**	**35.38**
- Gold Panning	8.88	2.86	5.19	4.68	25.24	7.30
- Natural Habitat Utilization Cash Income	5.65	1.23	2.96	1.74	27.99	4.61
- Consumption of Own Collected Wild Foods	6.11	5.71	7.84	6.52	9.39	6.28
- Consumption of Own Collected Firewood	7.23	5.32	11.16	8.18	4.26	7.26
- Consumption of Own Collected Wild Goods	0.67	0.48	0.83	0.78	0.7	0.65
- Use of Environmental Goods for Housing	2.5	2.87	4.17	2.72	0.18	2.73
- Use of Environmental Goods for Fertilizer	0.73	0.25	0.44	0.18	0.04	0.56
- Livestock Browse/Graze of Environmental Resources	6.86	5.61	2.05	6.86	0	5.99
Number of Households in Category	123	40	21	10	3	197
Mean Total Income Per Category (93/94 Z$ per person)	759	1065	1058	537	1058	846
2. 1996/97						
Total Cash Income (Excl. Env. Cash Income)	**29.62**	**53.1**	**24.15**	**27.74**	**28.03**	**34.27**
- Crop Income	5.2	2.36	4.62	3.96	4.08	4.34
- Livestock Income	6.26	2.43	5.52	4.64	13.81	5.38
- Unskilled Labour Income	2.5	0.39	1.05	0.92	0.99	1.67
- Skilled Labour Income (Teaching)	1.44	0.00	0.00	0.00	3.95	0.78
- Crafts and Small-Scale Enterprises	4.1	2.64	3.61	3.55	0.28	3.54
- Remittances	10.14	45.28	9.35	14.66	8.87	18.56
Total Net Gifts/Transfers	**2.78**	**-0.63**	**12.29**	**7.18**	**1.12**	**3.38**
Total Own Produced Goods	**25.78**	**22.4**	**30.33**	**28.3**	**18.23**	**25.48**
Total Environmental Income	**41.82**	**25.14**	**33.23**	**36.79**	**52.61**	**36.87**
- Gold Panning	4.55	0.28	1.5	1.33	12.77	3.20
- Natural Habitat Utilization Cash Income	6.83	1.02	6.39	3.49	15.35	5.43
- Consumption of Own Collected Wild Foods	4.45	2.91	5.15	6.59	9.32	4.48
- Consumption of Own Collected Firewood	8.24	5.9	11.11	10.22	8.04	8.17
- Consumption of Own Collected Wild Goods	0.89	0.37	0.99	1.4	0.66	0.81
- Use of Environmental Goods for Housing	3.31	1.47	2.27	1.95	1.01	2.59
- Use of Environmental Goods for Fertilizer	0.65	0.24	0.09	1.28	0	0.52
- Livestock Browse/Graze of Environmental Resources	12.9	12.95	5.72	10.53	5.47	11.66
Number of Households in Category	107	46	23	15	6	197
Mean Total Income Per Category (93/94 Z$ per person)	889	1176	994	605	1117	954

Definitions

1. Resident Married Male - Married man named as the household head who was away from the household for less than 6 months.
2. De Facto Female -Married man named as the household head who was away from the household for 6 months or more.
3. De Jure Female, No Married Sons - Divorced or widowed female named as the household head with no married sons at the homestead.
4. De Jure Female, Married Sons - Divorced or widowed female named as the household head with married sons at the homestead.
5. Divorced/Widowed Male - Divorced or widower male named as the household head.

Table 7 - Panel Households' Cash Income Shares By Quintile and Income Source

1993/94 data	93/94 Panel Household Quintile: Lowest 20%	20% to 40%	40% to 60%	60% to 80%	Top 20%	All Panel Households
Crop Income	9.55	15.45	9.12	6.10	13.53	10.75
Sales of High Value Crops (net)	*0.00*	*1.41*	*0.00*	*0.55*	*5.02*	*1.41*
Sales of Low Value Crops (net)	*7.09*	*8.24*	*6.42*	*3.91*	*5.02*	*6.13*
Livestock Income	9.48	8.68	7.07	4.49	4.44	6.83
Sales of Small Livestock	*8.47*	*8.11*	*5.00*	*1.86*	*3.51*	*5.39*
Unskilled Labour Income	17.09	9.64	13.18	3.88	4.87	9.70
Skilled Labour Income (Teaching)	0.00	3.45	0.00	0.00	4.79	1.65
Crafts and Small-Scale Enterprises	-0.77	6.27	8.06	8.76	6.72	5.42
Remittances	19.40	28.94	25.84	39.20	35.93	29.90
Net Cash Gifts	-9.10	-8.71	4.09	5.62	3.03	-1.02
Gold Panning	30.30	21.75	18.32	16.92	17.58	20.96
Environmental Resource Utilization Cash Income	18.92	14.52	14.33	15.03	9.09	14.38
Total Cash Income	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Total Environmental Cash Income Share	49.22	36.28	32.65	31.94	26.68	35.34
Mean Cash Income (93/94 Z$ per person)	115	183	267	438	849	370

1996/97 data	96/97 Panel Household Quintile: Lowest 20%	20% to 40%	40% to 60%	60% to 80%	Top 20%	All Panel Households
Crop Income	7.90	7.79	12.36	12.16	14.28	10.89
Sales of High Value Crops (net)	*0.00*	*0.00*	*0.00*	*1.01*	*5.26*	*1.25*
Sales of Low Value Crops (net)	*6.00*	*4.93*	*8.66*	*9.47*	*7.18*	*7.25*
Livestock Income	16.59	13.77	13.67	13.24	15.30	14.50
Sales of Small Livestock	*14.44*	*10.37*	*9.74*	*7.28*	*5.59*	*9.48*
Unskilled Labour Income	10.26	4.69	4.58	2.59	0.72	4.56
Skilled Labour Income (Teaching)	0.00	0.00	0.00	0.00	4.45	0.88
Crafts and Small-Scale Enterprises	7.60	7.69	13.30	10.18	4.06	8.57
Remittances	18.95	28.96	33.00	37.96	51.88	34.14
Net Cash Gifts	4.42	4.35	4.72	7.99	2.99	4.91
Gold Panning	10.33	11.82	7.71	4.37	2.87	7.43
Environmental Resource Utilization Cash Income	23.94	20.93	10.66	11.52	3.44	14.12
Total Cash Income	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Total Environmental Cash Income Share	34.27	32.75	18.37	15.89	6.32	21.55
Mean Cash Income (93/94 Z$ per person)	131	230	293	479	1312	488

Table 8 - Fertilizer Value Shares by Household Quintile, 93/94 and 96/97

	Panel Household Quintiles [1]					
	Lowest 20%	20% to 40%	40% to 60%	60% to 80%	Top 20%	All Households
1. 1993/94 Data						
Commercial Fertilizer	0.24	0.31	0.29	0.53	0.58	0.43
Livestock Manures	0.20	0.17	0.26	0.07	0.13	0.16
Environmental Fertilizers	0.56	0.52	0.45	0.40	0.29	0.41
Total Value of All Fertilizers Used [2]	300	321	425	381	798	2,225
2. 1996/97 Data						
Commercial Fertilizer	0.00	0.20	0.20	0.30	0.23	0.21
Livestock Manures	0.72	0.23	0.71	0.50	0.58	0.55
Environmental Fertilizers	0.28	0.57	0.09	0.19	0.19	0.24
Total Value of All Fertilizers Used [2]	291	444	548	640	1,137	3,059

Notes
1. Panel household quintiles for 93/94 and 96/97 respectively.
2. Measured in 1993/94 Z$ per adjusted aeu.

Analysis of rural households and environmental resources is beset by inadequate data, especially in Africa. Using purpose-collected panel data from Zimbabwe, we demonstrate seven empirical regularities in the rural poverty-environment relationship. Most important, environmental resources make a significant contribution to average rural incomes. Poorer households also depend heavily on these resources, which contribute c.40% to their incomes. Richer households, however, use greater quantities of environmental resources in total. Finally, considerable differentiation exists in the economic chara