CDE
April 2005

Poverty and the Environment: Exploring the Relationship between Household Incomes, Private Assets, and Natural Assets

Urvashi Narain
Email: narain@rff.org
Resources for the Future, Washington, DC

Shreekant Gupta
Email: sgupta@econdse.org
Delhi School of Economics

Klaas van ’t Veld
Email: klaas@uwyo.edu
University of Wyoming, Laramie

Working Paper No. 134

Centre for Development Economics
Department of Economics, Delhi School of Economics

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URVASHI NARAIN
SHREEKANT GUPTA
KLAAS VAN 'T VELD

Abstract

Using purpose-collected survey data from 535 households in 60 different villages of the Jhabua district of India, this paper investigates the extent to which rural households depend on common-pool natural resources for their daily livelihood. Previous studies have found that resource dependence— defined as the fraction of total income derived from common-pool resources—strongly decreases with income. Our study uncovers a more complex relationship. Firstly, for the subsample of households that use positive amounts of resources, we find that dependence follows a U-shaped relationship with income, declining at first but then increasing. Secondly, we find that the probability of being in the subsample of common-pool resource users follows an *inverse* U-shaped relationship with income: the poorest and richest households are less likely to collect resources than those with intermediate incomes. Resource use by the rich is therefore bimodal: either very high or—for the very rich households—zero. Thirdly, we find that resource dependence increases at all income levels with an increase in the level of common-pool biomass availability. The combination of these results suggests that the quality of natural resources matters to a larger share of the rural population than had previously been believed; common-pool resources contribute a significant fraction of the income not just of the desperately poor, but also of the relatively rich.

Keywords: India, Madhya Pradesh, poverty, environment, common-pool natural resources, rural households
JEL Classification: Q2, D31, Q12, Q56, O13, I32

Acknowledgements

We are very grateful to our seven post-graduate students, Sambit Mishra, Indrani Sen, Sushil Adhikari, Manojit Saha, Hassan Imam, Supriya Singh, Piyali Mitra, and Shilpa Jain, and our five local enumerators, Karishma Gupta, Archana Kamlawat, Manish Maheswari, Om Prakash Rai, and Mukesh Upadhyay for helping us collect the data analyzed in this paper. We also gratefully acknowledge financial support from Resources for the Future, the South Asia Region Environment Sector of the World Bank, and the PREM program of the Institute for Environmental Studies at the Free University of Amsterdam.

I. Introduction

Increased recognition that rural households in developing countries depend significantly on common-pool natural resources for their livelihoods has led to a perception that common-pool resource stocks in effect serve as a public asset for poor households, substituting for the private assets (land, livestock, farm capital, human capital, financial wealth) that they lack. This, in turn, has raised the policy question of whether improved natural resource management can form the basis of poverty alleviation policies. Attempts to answer this question have given rise to a growing literature on poverty-environment interactions (for reviews, see Reardon and Vosti (1995), Duraiappah (1998), Horowitz (1998), and Barbier (2005)).

One thread of this literature (recently reviewed by Beck and Nesmith (2001), Vedeld et al. (2004), and Kuik (2005)), has tried to quantify how dependence on common-pool natural resources varies with the level of household incomes, where dependence is usually defined as the share of overall income derived from natural-resource use. The seminal paper in this literature is Jodha (1986), with important recent contributions by Reddy and Chakravarty (1999), Cavendish (2000), and Adhikari (2003)[1]. A common finding in this literature is that dependence on resources declines with income. Based on data from 502 households in 21 Indian villages, Jodha (1986) finds that poor rural households derive on average between 9% and 26% of their annual income from common-property natural resources, while (relatively) rich[2] households derive only between 1% and 4% of their annual income from the commons. Reddy and Chakravarty (1999), based on data from 232 households in 12 Himalayan villages, similarly find that dependence on resources decreases from 23% for the poor to 4% for the rich[3]. Cavendish (2000), based on data from 197 households in 29 villages in Zimbabwe, finds much higher rates of dependency, with poor households deriving as much as 40% of their incomes from natural resources and the rich deriving about 30%. On the other

[1] Other, much smaller-scale studies include Pasha (1992), Singh, Singh and Singh (1996), Nadkarni (1997), Qureshi and Kumar (1998), Beck and Ghosh (2000), and Fisher (2004).

[2] Although we refer to households with incomes at the higher end of the rural income distribution here, and elsewhere in the paper, as rich, it is important to note that these households are still poor in absolute terms.

[3] Reddy and Chakravarty only report figures on resource use and total income for rich and poor households. We have used these figures to calculate resource dependence.

hand, Adhikari (2003), based on data from 330 households in 8 “forest user groups” in Nepal, finds that dependence increases with income, from 14% for the poor to 22% for the rich[4]. All four studies also examine the relationship between income and the absolute level of resource use, but find no consistent trend: Jodha finds that use, along with dependence, decreases with income, Reddy and Chakravarty find an initial slight increase followed by a decrease, and Cavendish and Adhikari find an increase throughout.

Although these studies establish some empirical regularities about the relationship between natural resource dependence (or use) and rural-household incomes, they suffer from a number of shortcomings. One is that none of the studies examines how, if at all, the relationship changes with a change in the stock of natural resources. They therefore shed no light on the important policy issue of who might gain or lose from potential improvements in, or degradation of, the natural resource base in rural villages[5]. Another shortcoming of the studies is that they examine the relationship between natural-resource dependence and household incomes using only simple tabulations, without verifying if the reported regularities are statistically significant. Most importantly, the studies provide only conjectures—unsupported by evidence from their data—as to why the reported regularities were obtained. Reddy and Chakravarty merely note that the poor have less land and speculate that this explains their higher dependence on forest resources. Cavendish conjectures that the decline in dependence with income may in part be due to cash constraints: poorer households are less able to purchase food and are therefore forced to collect it from the commons instead. Jodha, in contrast, provides a fairly detailed discussion of why poor households may be more dependent on commons, suggesting three specific reasons: (1) common-pool resources act as a substitute for the private assets that poor households lack—instead of acquiring fuel and fodder from private lands, for example, land-poor households can collect these

[4] Cavendish (2000) and Reddy and Chakravarty (1999) categorize households as being poor or rich on the basis of the households’ total income. Jodha (1986) defines poor households as those that are either landless or own less than 2 hectares of land, and rich households as those with more than 2 hectares of land. Adhikari (2003) classifies households as either poor, middle wealth, or rich based on multiple criteria identified by villagers as important in assessing a household’s’ socio-economic position.

[5] Based on oral accounts of villagers, Jodha claims that the contribution of commons to the income of poor households increases with an increase in the stock of these resources. He does not support this claim with any data, however.

resources from common lands; (2) poor households have surplus labor that is well suited to resource extraction, an activity where labor is usually the only input; and (3) returns to extraction from the commons are often not very high, and are therefore unattractive to the rich[6].

Our study, using purpose-collected data from 535 households in 60 Indian villages, is able to examine the relationship between rural household incomes and natural resources at a greater level of detail, and address these shortcomings. By collecting data on village-level biomass availability, we are able to examine the impact of changes in biomass on resource use and dependence at different income levels. By using regression analysis, we identify inconsistencies with the results of simple tabulations; these inconsistencies highlight the limited usefulness of such tabulations. Furthermore, we are able to bring information on household characteristics to bear, in order to understand why certain trends emerge between resource use, dependence, and income. We thereby focus, in particular, on the question of how private holdings of productive assets (land, livestock, farm capital, and human capital) affect households' use of the commons, i.e., whether, as Jodha suggests, common-pool resources serve as a substitute for the private assets that poor households lack.

A more technical contribution of our paper concerns the measurement of resource dependence. In existing studies, dependence is measured as the ratio of a household's income derived from natural resources in a given year to its total income in that same year[7]. The typically high variability of household incomes, both from year to year and across households, makes this a very noisy measure of "true" resource dependence, and also fails to fully capture differences between households that are poor in terms of private assets and households that are not. We would argue that, all else being equal—

[6] Fisher's (2004) study is exceptional, in that she does report estimates of how various household characteristics affect dependence on forest income in Malawi. Her results lend support to Jodha's conjectures, in that she finds that dependence (1) decreases with goat ownership, (2) increases with the number of men in the household, and (3) decreases with the household head's education. Adhikari (2003) reports on how various household characteristics affect resource *use*, but there is no straightforward way of translating these into estimates of how the characteristics affect resource *dependence.*

[7] Jodha defines dependence on income from commons as the ratio of income from commons to income from all other sources excluding the commons. He also uses two alternative measures of dependence on the commons, namely the proportion of households of a given income class that use common property resources and the extent to which a given household is dependent on the commons for its employment. Using these other measures Jodha finds that poor households are more dependent on commons than the rich.

i.e., regardless of what happens in any given year—asset-rich households should be considered less dependent on natural resources, since their assets serve as an additional buffer to potential negative income shocks[8]. In this paper, we account for private asset holdings by calculating what we call the household's 'permanent income from various sources', defined as the flow of income that a household can expect to derive from these sources over the long run. For incomes derived from private assets (land, livestock, farm capital, financial capital), we calculate this by combining current-year returns on these assets with the assets' annualized end-of-year value; for incomes derived from natural resources, wages, home enterprises, and transfers, we simply extrapolate current-year income. Dependence on natural resources is then defined as the ratio of permanent income from natural resources to total permanent income[9].

Using these definitions of income and dependence[10] we find that, for the subsample of households that collect resources from the commons (about 75% of all households are in this subsample), dependence does not necessarily decrease with income. Instead, we find evidence of a U-shaped relationship: dependence declines with income at first but then increases.

We examine which characteristics of rich households in the subsample drive their higher dependence on resources compared to households with intermediate incomes. We find, first of all, that households in the top income quartile simply consume more fuel and construction wood. At the same time, they do not meet significantly more of their consumption through private provision (i.e., collection from trees on their own land) and only in the case of construction wood do they meet part of their higher consumption through higher market purchases.

As for the collection of fodder (dependence on which is found to monotonically increase with income) here we find evidence suggesting that the rich prefer stall-feeding

[8] Jodha (1986) makes a similar observation by noting that "...the CPRs' role as a cushion during the crisis situation...is greater for the poor households, as unlike the rich, they do not have many other adjustment mechanisms." He does not account for this difference between poor and rich in his measure of dependence, however.

[9] A different approach would be to use total household *expenditures* rather than total income in the denominator of the dependence measure, since expenditures are typically less variable, and more closely tied to expected lifetime income. We are unable to use this approach, however, because our expenditure data cover only purchases of natural resources.

[10] Hereafter, we omit the qualifier "permanent," treating it as understood.

their animals to grazing them. This, in turn, may be explained by time constraints, as we find that the rich tend to have fewer children, and derive a larger share of their income from ‘off-village’ jobs, as well as private-and public-sector jobs. Again, however, we find that private provision of fodder differs very little between the rich and the poor; the bulk of the rich group’s higher demand for fodder is met from the commons.

Confusingly, when we consider the probability of a household using any common-pool resources at all (i.e., of it being in the above subsample), we find that this follows an *inverse* U-shaped relationship with income: the poorest and richest households are less likely to collect resources than those with intermediate incomes. The combination of these two relationships i) the U-shaped relationship between dependence and income for the subsample of 399 collecting households and ii) the inversely U-shaped probability of being in that subsample—results in a declining relationship of dependence with income for the sample as a whole, i.e., for the 535 collecting and non-collecting households combined.

The very different relationship between i) income and dependence for collecting households and ii) between income and the probability of collecting at all, is explained by a “bifurcation” in the use of resources by rich households. Rich households tend to either collect nothing at all or to collect a lot of resources, and *both* tendencies are stronger than they are for middle-income households.

When we compare the characteristics of rich non-collecting households in our sample to those of rich collecting households, we find that non-collecting households are at the top end of the income distribution, i.e., they are among the “richest of the rich,” with on average 65% higher permanent incomes than rich collecting households. Some of the difference is accounted for by higher incomes from transfers, enterprise, and current-year income from agriculture, in part offset by the lower (by definition zero) income from resource collection. Most of the difference, however, is accounted for by significantly higher ownership of land and farm capital.

Although, as noted above, rich collecting households consume significantly more fuel and construction wood than do poorer households, consumption of both drops sharply for the very rich, non-collecting households. Although we have no data to confirm this, we conjecture that the latter households use purchased fuels (e.g., kerosene) and construction materials (e.g., bricks) as substitutes.

Both types of households were found to have similar animal holdings, but although, as noted above, rich collecting households meet no more of their fodder demand from private provision than do poorer households, such private provision increases sharply for the very rich, non-collecting households. The non-collecting rich also tend to be more educated, and (not unrelatedly) derive more income from private/public-sector jobs than the collecting rich. Lastly, they tend to have smaller families. All these observations are consistent with Jodha's conjectures about what factors drive dependence on natural resources. The fact that non-collecting rich households have fewer children suggests that they have less surplus labor to devote to resource collection. The fact that they are more educated and derive more income from agriculture, enterprise, and relatively high-skilled jobs suggests that they prefer to allocate their time to higher-return activities than extraction from the commons. And finally, the non-collecting households' higher landholdings appear to act to some extent as a substitute for the commons in terms of private fodder and fuelwood provision.

That said, we find that most rich non-collecting households do spend time grazing their animals on the village commons, and in that sense do engage in "indirect" collection. Unfortunately, because we have no reliable way of converting time spent grazing to a monetary value, we have to consider the relationship between income and this form of indirect resource dependence separately from the remainder of the analysis.

We first consider the relationship between time spent grazing and income for only the subsample of households (about 82% of the total) that spend positive amounts of time grazing. Time spent grazing is found to increase strongly and monotonically with income, but this relationship is explained entirely by the fact that animal holdings increase with income in the same way within the subsample. When we next consider the probability of being in the subsample, we find that this probability initially increases with income, but declines at the very highest income levels. This, too, is explained by a similar pattern for animal holdings in the sample as a whole: at the very high end of the income distribution, animal ownership drops somewhat.

When we examine more closely the characteristics of rich households (in our sample) that graze their animals compared to those that do not, we find that non-grazing households are somewhat richer than grazing ones, despite having lower incomes from agriculture and livestock. The difference is more than made up for by these households' much higher income from non-agricultural sources, such as home enterprise and private- or public-sector jobs. As with the non-collecting rich, the non-grazing rich tend to be more educated, and have smaller families. It appears, therefore, that non-grazing households have less surplus labor, and prefer to allocate their time to activities that have higher returns not just compared to the activity of grazing livestock, but also to agricultural activities as a whole.

Concerning the question of how changes in biomass affect the dependence relationships, we find that overall resource use and dependence increases with overall biomass availability for all households, at all levels of income. The same is also true when we consider only the resources of fuel and construction wood, and examine how dependence on these wood resources changes with forest biomass availability. For the fodder resource, the effect of changes in grass biomass availability is somewhat more complex, and—perhaps not surprisingly—mediated strongly by households' animal holdings. Overall, households with larger animal holdings (which tend to be rich) tend to rely more on grazing and less on stall-feeding fodder in areas with high grass biomass availability.

Summing up, and returning to the policy question that motivates this study, our findings suggest that, except in the case of particularly rich households, private assets do not appear to act as an important substitute for common-pool resources, and the private asset of livestock in fact complements common resources. As a result, improvements in the quality of natural resources have the potential to benefit a large share of the rural population: not just the desperately poor, but also middle-income households and the relatively rich.

The remainder of the paper is organized as follows: Section 2 describes the study site and Section 3 the data collection process. Section 4 discusses the methodology used to estimate current household incomes, while Section 5 discusses the methodology used to estimate permanent income. Both sections also provide some descriptive statistics on these income measures. Section 6 presents our results on resource dependence, Section 7, our results on grazing, and Section 8 concludes.

2. Site Description

The study site for our project is the Jhabua district in the Indian state of Madhya Pradesh. Jhabua is an upland in western Madhya Pradesh that is spread over 0.68 million hectares. According to the Human Development report published by the Madhya Pradesh government in 1998, of the total land area, 54% is classified as agricultural land, 19% as forest land, and the rest as "degraded" land[11]. Jhabua is one of the poorest districts in the state, with a Human Development Index of only 0.356, the lowest out of 45 districts in the state. Only 26.3% of men and 11.5% of women in the district are literate and the life expectancy of an average person is only 51.5 years. Moreover, 30.2% of the district's rural population and 41.6% of its urban population is classified as living below the poverty line. Agriculture is the main occupation of households, with 90.6% of the work force employed in this sector (MPHDR (1998)). Furthermore, agriculture in the district is predominantly rain-fed. Households in this region usually supplement their incomes through livestock rearing and with various products from the forests—most notably fuelwood, construction wood, tendu (*Diospyros Melonoxylon Roxb.*) leaves, and mahua (*Madhuca Indica*) flowers. These characteristics of the region—its level of poverty, its dependence on agriculture, and its dependence on natural resources (fodder, construction wood, and other forest products)—make Jhabua a suitable study site. Moreover, since high dependence on rainfed agriculture, livestock income, and supplementary resource income characterize the economies of large parts of rural semi-arid India, the results of this study can be plausibly used to generalize about areas beyond Jhabua.

3. Data Collection and Sampling Procedure

Data were collected from 550 households in 60 villages in the district of Jhabua, covering the period from June 2000 to May 2001. A random sample of households for the survey was generated through a two-stage sampling design. In the first stage, a stratified random sample of villages was generated, and in the second stage, a stratified random sample of households.

[11] Degraded land, in turn, is made up of fallow land, cultivable wasteland, and land not available for cultivation.

3.1. Sample of Villages. The village sample frame was comprised of 89 villages in the district of Jhabua where the Madhya Pradesh Groundwater Department has (since 1973) monitored the groundwater level thrice-yearly (pre-monsoon, post-monsoon, and winter). There is little reason to believe that the restricted sample frame led to sample selection bias: the 89 villages were selected in 1973 simply to ensure that each of the district's micro drainage basins would be represented[12]. Furthermore, because each of the micro drainage basins is about 100 km^2, the villages in our sample are well dispersed.

From the sample frame of 89 villages, a stratified sample of 64 villages was selected to maximize variability in the forest stock. For the latter, we used data from the Madhya Pradesh Forest Department's 1998 inventory of all forest "compartments" (the smallest forest management unit of area) in Jhabua. For each compartment, the inventory gives area and total volume of trees in cubic meters. Summing the volume over all compartments within a 5 km radius[13] from the center of a village gave us a measure of the total forest biomass available to the village as a whole, which we then divided by the number of village households. The resulting measure of per-household biomass was used as the basis for stratification. Unfortunately, political unrest in Jhabua at the time of the survey made it impossible to complete the survey in 4 of the selected villages, leaving 60 villages in all.

3.2. Sample of Households. Household sample frames were constructed for each of the sample villages from village land ownership records and from the Madhya Pradesh state government's village-level list of households living below the poverty line (BPL). A random sample of households was selected from three strata—BPL, land-poor (owning less than 3 hectares of land) and land-rich (owning more than 3 hectares of land), with over-sampling of BPL and land-rich households[14]. Table 1 shows the actual

[12] This information was obtained through personal communication with a now retired employee of the Madhya Pradesh Groundwater Department, S.C. Joshi, a geohydrologist, who was involved in the selection of these wells in 1973.
[13] By law, villages within 5 km of any given tract of forest have legal rights to its forest products; villages outside this radius do not have the same rights.
[14] Note that we used the size of land holdings for the purpose of stratification only and not to define a household's income. As discussed below, we define income comprehensively to include income in cash and kind from agriculture, livestock rearing, resource extraction, home enterprises, off-farm labor, financial and transfer transactions.

distribution—determined from the household survey—of land owned by our final sample of 535 households (15 of the initial 550 had to be dropped because of data problems). Only 7% of the sample households are literally landless, while another 19% cultivate at most 0.5 hectares. At the other extreme, 13% of the sample households cultivate more than 3 hectares, up to a sample maximum of 39 hectares.

Land Owned (ha.)	0	>0 to 0.5	>0.5 to 3	>3
No. of households	36 (7%)	104 (19%)	326 (61%)	69 (13%)

Table 1. Distribution of Land Owned by Sample Households

3.3. Remote Sensing Data. In addition to the data obtained through the household and the village survey, we relied on remote-sensing images and tree and grass biomass measures from sample plots to obtain data on forest and fodder biomass. A total of 42 plots, of mostly 0.1 hectares, were laid throughout the district in the fall of 2002[15]. Care was taken to ensure that the sample plots covered different landscape types found in Jhabua. Tree biomass and grass biomass data was collected from each of these sample plots and used to estimate the tree, grass, and total biomass in tonnes per hectares for the sample plots. At the same time two satellite images for October 26 and 29, 2002 (obtained from the Indian Remote Sensing Satellite (IRS LISS-III)) were used to construct the Normalized Difference Vegetation Index (NDVI)[16] for the sample plots. Next, the biomass and NDVI estimates were used to develop regression models that uses the NDVI as a predictor of biomass (including both tree and grass biomass) (Arroyo-Mora, Sanchez-Azofeifa, Rivard and Calvo (2001)) for three major land classifications—grass and young tree plantation, mature but leafless trees, and mature trees with leaves. Finally, these regression estimates were combined with NDVI estimates for 1995 and 2000 to estimate tree and grass biomass measures for these years. The total biomass available to a household was then estimated by summing up the volume of biomass that fell within a 5 km radius of the center of the village and

[15] 31 plots of the 42 were 0.1 hectares in size, another 5 varied between 0.08 and 1.11 hectares, and in the remaining 6 plots only canopy cover measurements were taken.

[16] The NDVI is equal to the difference in near infra-red (NIR) and red (R) light reflectance divided by the sum of these reflectances, that is, NDVI = (NIR • R)/(NIR + R) and is commonly used to assess or predict vegetation biomass from remote-sensing data.

dividing it by the number of households in the village.

4. Current Household Incomes

To determine the extent to which households in rural Jhabua use common-property natural resources for their livelihood, we calculate the income that each household obtained from seven major sources, namely (i) agriculture, (ii) livestock rearing, (iii) common-property resource collection, (iv) household enterprise, (v) wage employment, (vi) financial transactions, and (vii) transfers. Income from each of these sources is calculated as the difference between total revenue obtained and total input costs incurred, where these totals include both market transactions and imputed values for non-market transactions. For example, the revenue obtained from common-property resource collection includes imputed values for resources collected but not sold by the household. Similarly, the input costs incurred for livestock rearing includes imputed values for fodder collected from the commons and then fed to own livestock. For income sources (i)–(iv), no cost is imputed for a household's own labor inputs, however; in this sense, the incomes from these sources are "gross" incomes[17].

4.1. Income Definitions. *Income from Agriculture:* Income from agriculture is defined as the difference between the revenue obtained from all crops and crop-residues harvested by the household and the input costs incurred for crop production. Input costs, in turn, are defined as the sum of wages paid to hired agricultural labor; costs of fertilizers, manure, pesticides, diesel and electricity (the latter for diesel and electric water pumps, respectively); costs incurred to maintain farm capital (e.g., tractors, water pumps, bullocks); rent paid on land rented in; and rent paid for farm capital rented in. In addition, we include income obtained from bullocks, calculated as the difference between revenues from dung produced by the bullocks (which is sold or used by the household for either manure or fuel), and the cost of labor hired to graze the bullocks as well as that of the fodder fed to them. We also include income obtained by the household from trees on its private lands, equal to the revenues from fuel and construction wood, flowers, fruit, and seeds extracted. No input costs are deducted from

[17] Were we to subtract imputed own-labor costs from sources (i)–(iv), we would have to add these imputed costs to source (v), leaving total income unaffected.

these revenues, as the only significant input used is the household's own labor. Finally, we added any income from the renting out of own farm capital equipment and land.

Income from Livestock Rearing: Income from livestock rearing is calculated for the six main types of livestock found in Jhabua, namely cows, buffalo, goats, sheep, donkeys, and chickens. Revenue is defined as the sum of the value of off-springs, milk, eggs, and dung produced by the animals, while costs include the cost of labor hired to graze them and the cost of fodder fed to them. The latter cost includes the imputed value of fodder grown as a crop and not sold, residue from other crops used as fodder, fodder collected from village commons and not sold, and fodder bought from the market.

Income from Common-Property Resource Collection: An open-ended question used during the pre-testing of the household survey determined that households in Jhabua collect seven main resources from village commons: (i) fuelwood, (ii) wood for construction, (iii) fodder, (iv) mahua flowers, (v) mahua seeds, (vi) tendu leaves, and (vii) dung. For the majority of households, the income from common-property resource collection is the sum of the revenue obtained from these seven resources. The final survey also asked households to list "other" resources obtained from the village commons, but only in a few instances did income from such resources exist.

Income from Household Enterprise: Income from household enterprise is defined as income from any non-agricultural enterprise operated by the household.

Income from Wage Employment: The household survey distinguished three categories of wage employment, namely (i) in-village casual employment off the household's own farm, (ii) off-village casual employment, and (iii) regular employment in the private or public sector. Income from wage employment is defined as the sum of cash and in-kind wages received from these three categories of employment.

Income from Financial Transactions: Households in our sample own a variety of financial assets, including deposits at Banks or the Post-office, deposits with women's savings groups, and loans given to relative or friends. They also owe debt to a number of sources—women's savings groups, moneylenders, friends or relatives. During the survey year, households earned interest income on their deposits and paid out interest on their debts. Net interest income (interest income earned less interest income paid out) constitutes the household's current-year income from financial transactions.

Income from Transfers: Lastly, income from transfers is defined as the sum of cash and in-kind payments received by the household from its family, friends, the state, and any non-governmental organizations operating in the area.

After calculating these different components of total household income, we make them comparable across households by dividing the income obtained by the number of adult-equivalent units in the household. See Cavendish (1999) for a discussion of this adjustment procedure.

	Current Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
Income from Agriculture	-1325	81	418	2092
Income from Livestock Rearing	-365	-78	-1	7
Income from Resource Collection	320	338	513	1001
Fuelwood	72	141	149	484
Construction Wood	2	16	3	145
Fodder	160	114	293	253
Other Resources	86	67	67	120
Income from Household Enterprise	60	140	160	1298
Income from Wage Employment	613	1142	2063	4971
Income from Financial Transactions	-1408	-550	-456	-524
Income from Transfers	159	117	160	1454
Total Current Income	-1946	1190	2857	10300

Table 2. Current Per Capita Household Income in Rs. by Major Sources and Income Quartiles for Whole Sample

	Current Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
Amount of Land Cultivated (hectares)	0.37	0.18	0.24	0.35
Value of Land Owned (Rs.)	30797	13423	18321	35803
Value of Farm Capital (Rs.)	7437	1861	2332	4650
Value of Livestock (Rs.)	3211	2441	2587	2657
Asset Disinvestment (Rs.)	269	41	-72	-976

Table 3. Asset Holdings Per Capita by Current Income Quartiles for Whole Sample

4.2. Some Statistics on Current Income. Table 2 shows the composition of current income for the different current-income quartiles[18]. The first thing to note is the large disparity between the mean current income of households in the bottom three quartiles and that of households in the top quartile. The mean household in the lowest quartile lost Rs. 1,946 over the course of the survey year (June 2000-May 2001), while the

[18] In this table, and all tables reported hereafter, quartiles and means within each quartile are calculated after weighting the observations to account for the oversampling of forest-rich villages, and of landless and land-rich households within the villages.

mean household in the top quartile earned Rs. 10,300. The large losses in agricultural, livestock rearing, and financial income are explained by the fact that the survey year was the fifth consecutive drought year in Jhabua.

Current income from agriculture, livestock rearing, resource collection, household enterprise and wage employment increases monotonically across income quartiles: for example, households in the bottom quartile incurred a loss from agriculture, those in the second quartile made a very small profit, and those in the third and fourth quartile made larger profits. Income from transfers decreased from the first to the second quartile but increased from the second to the fourth quartile. Similarly, losses from financial transactions increased in the fourth quartile after decreasing from the first to the third quartile[19]. Surprisingly, households in the bottom quartile are not asset-poor. As shown in Table 3, these households cultivate more land than households in the other three quartiles. Per capita ownership of land of these households is considerably above that of households in the second and third income quartiles, though below that of households in the top quartile. Similarly, households in the bottom quartile have more farm capital and livestock than households in the top three quartiles. In fact, households in the bottom income quartile appear to make the largest asset disinvestments, financial as well as physical, to make up for income losses[20].

These findings on asset holdings and asset disinvestment confirm that private asset holdings significantly affect the ability of a household to cope with negative income shocks, a fact that needs to be taken into account when assessing a household's dependence on common natural resources.

5. Permanent Household Incomes

Dependence on natural resources is most commonly defined in the literature as the ratio of the income from natural resources in a given year to the household's total income in that year. This measure fails, however, to capture differences between households that are rich in private assets and households that are not. All else being

[19] Information on financial transactions was the hardest to elicit from households and is likely to be somewhat incomplete.
[20] Note that asset disinvestment is not included in a household's measure of total current income, as this transaction reflects a change in wealth and not income.

equal, households rich in private assets should be considered less dependent on natural resources, since their assets serve as an additional buffer against potential negative income shocks. As noted above, there is in fact evidence of such buffering occurring in the survey year. We therefore account for private asset holdings by calculating what we call the household's permanent income from various sources, defined as the flow of income that the household can expect to derive from these sources over the long run. For incomes derived from private assets (land, livestock, farm capital, financial assets), we do so by combining current-year returns on these assets with their annualized end-of-year value; for incomes derived from natural resources, wages, household enterprise, and transfers, we simply extrapolate current-year income. Dependence on natural resources is then defined as the ratio of permanent income from natural resources to total permanent income.

5.1. Definition of Permanent Income. To make our definitions of permanent income from private assets explicit, we first consider the simplest case of financial assets. Given an interest rate of *r*%—we use 10% throughout the paper, which is roughly the value-weighted average interest rate on bank deposits and other types of savings reported by all households in the sample—and given private financial assets worth Rs. A_t at the beginning of year *t*, we assume that the long-run flow of income that the household can expect from these assets is equal to rA_t per year. Given this formulation, one could estimate the household's permanent financial income as *r* times the value of total financial assets owned by the household at the beginning of the survey year. This, however, would not make use of information we have from the survey year on the actual return from financial assets in that year. In order to use this information, we instead define permanent financial income as follows[21]:

(1) $$q = r\left[\frac{I_t}{1+r} - \frac{\Delta A_t}{1+r} + \frac{rA_{t+1}}{(1+r)^2} + \frac{rA_{t+1}}{(1+r)^3} + ...\right],$$

where *q* is permanent income, I_t is the return on the assets during the survey year, ΔA_t is the net change in asset holdings between *t* and *t*+1, $A_{t+1}$is the value of the assets at

[21] Note that we are assuming that the household receives its income at the end of the year and therefore we discount current income as well.

the end of the year[22] (i.e., at the beginning of the following year), and $rA_{t+1}$is the long-run flow of income that the household can expect to obtain from these assets. Since

(2) $$\frac{rA}{(1+r)^2}+\frac{rA}{(1+r)^3}+......=\frac{A}{(1+r)}$$

and $\Delta A_t = A_{t+1} - A_t$, equation (1) reduces to

(3) $$q=\frac{r}{1+r}(I_t + A_t)$$

Note that if $I_t = rA_t$, i.e., if the return on assets during the survey year happens to equal the expected return, then q reduces further to simply equal that expected return, rA_t.

As for permanent income from physical assets—land, farm capital, and livestock—we have to take into account that these assets produce income only when combined with labor. Expected income from these assets over the long run is therefore equal to the sum of the expected return to the capital itself and that to the household's own labor. That is, given an economy-wide interest rate of r%, an economy-wide wage rate of Rs. w, physical capital worth Rs. K_t, and L_t units of own labor applied to capital, the long-run flow of income that the households can expect from the physical asset is equal to rK_t+wL_t. Again taking into account the returns to physical capital in the current year, and net changes in asset holdings during the year[23], the permanent income from physical capital is

(4) $$q=r\left[\frac{I_t}{1+r}-\frac{\Delta K_t}{1+r}+\frac{rK_{t+1}}{(1+r)^2}+\frac{wL_t}{(1+r)^2}+\frac{rK_{t+1}}{(1+r)^3}+\frac{wL_t}{(1+r)^3}......\right]$$

[22] Given the sensitive nature of the information, our household survey did not require the household to report the amount of jewelry it owned at the beginning of the year. The survey did ask the household for information on the net sales of jewelry during the year. Consequently, we have assumed that the value of jewelry owned by the household at the end of the year is equal to the amount bought minus the amount sold during the year.

[23] Our household survey did not elicit information on the amount of land bought or sold by the household during the survey year and therefore we assumed that the amount of land at the beginning of the year was equal to the amount at the end of the year.

Using equation (2) and the fact that $\Delta K_t = K_{t+1} - K_t$, equation (4) reduces to

(5)
$$q = \frac{r}{1+r}\left(I_t + K_t + \frac{wL_t}{r} \right)$$

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
Lowest 25%	0.34	0.23	0.21	0.19
25-50%	0.52	0.28	0.18	0.07
50-75%	0.13	0.38	0.34	0.14
Top 25%	0.01	0.11	0.27	0.60
	1.00	1.00	1.00	1.00

Table 4. Relationship between Current and Permanent Income Quartiles for Whole Sample

5.2. Relationship between Current and Permanent Income. Table 4 shows that the correlation between current-income and permanent-income quartiles is not very strong. For example, although 60% of households that fall into the top permanent-income quartile also fall into the top current-income quartile, 14%, 7% and 19% of these households fall into the third, second, and bottom current-income quartiles, respectively. This indicates that income in one particular year may not give an accurate picture of the household's expected long-run income. For this reason, it is important to look at dependence in terms of the latter, and not in terms of income in one particular year[24].

5.3. Descriptive Statistics on Permanent Income. As shown in Table 5, households in the lowest permanent income quartile earn Rs.2,402 per capita on average, while households in the top income quartile earn Rs.16,202. According to the Madhya Pradesh Directorate of Economics and Statistics, the average per capita income in the state—for both rural and urban households combined—was Rs.11,244 in 1999-2000. Although this figure is not directly comparable to our measures of per capita permanent income, it does suggest that our sample captures a significant amount of income variability.

[24] Cavendish (2000) addresses this issue to some extent by examining the relationship between resource dependence and household income in two separate years—1993-94 and 1996-97. He finds that the relationship does not change materially between the two data waves.

	Permanent Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
Income from Agriculture	1550	2446	3844	7815
Income from Livestock Rearing	125	184	218	179
Income from Resource Collection	187	354	490	1136
Fuelwood	100	157	198	391
Construction Wood	2	2	40	123
Fodder	24	72	184	536
Other Resource	60	123	68	87
Income from Household Enterprise	51	144	246	1216
Income from Wage Employment	597	1466	2087	4630
Income from Financial Transactions	-243	-227	-446	-131
Income from Transfers	134	148	250	1357
Total Permanent Income	2402	4515	6690	16202

Table 5. Permanent Per Capita Household Income in Rs. by Major Sources and Income Quartiles for Whole Sample

Permanent income from most sources—agriculture, resource collection, household enterprise, wage employment, and transfers—increases monotonically from the first to the fourth income quartile. Income from livestock rearing increases from the first to the third quartile and then decreases, while income from financial transactions shows no clear trend.

After income from agriculture, income from wage employment is the largest source of income for households in all four quartiles. For the first three quartiles, the wage income mostly comes from off-village casual employment. Households in these quartiles earned about 65-70% of their total wage income from such seasonal migration.

	Permanent Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
Income from In-Village Casual Labor	127	274	236	320
Income from Off-Village Casual Labor	418	1035	1398	1385
Income from Private and Public Jobs	52	157	454	2924
Total Wage Income	597	1466	2087	4630

Table 6. Permanent Per Capita Wage Income in Rs. by Income Quartiles for Whole Sample

In contrast, households in the top quartile earned the largest share of total labor income (63%) from regular jobs in the private or public sector and only about 30% from off-village labor. In absolute terms, however, households in the top quartile still earned more from in-village employment than households in any other quartile and more from off-village employment than households in the first and second income quartiles.

As shown in Table 7, the main source of transfer incomes for households in all four quartiles was the state, and almost no income was received from non-governmental organizations. Households in the top quartile received substantially higher transfer incomes than households in the bottom three quartiles. Nevertheless, these households are not as dependent on the state as households in the bottom quartile.

	Permanent Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
Transfer Income from Relatives	31	33	44	239
Transfer Income from Friends	0	3	0	263
Transfer Income from NGOs	2	0	0	27
Transfer Income from State	100	112	205	828
Total Transfer Income	134	148	250	1357

Table 7. Permanent Per Capita Transfer Income in Rs. by Income Quartiles for Whole Sample

As for income derived from common-property resource collection—the main focus of this study—Table 5 shows that the absolute level of such income increased monotonically with income. The average household in the bottom quartile earned Rs. 187 per capita from natural resources (with the majority of this income coming from fuelwood and other resource collection), while the average household in the top quartile earned Rs. 1,136 per capita (with the majority of this income coming from fodder and fuelwood collection). Consistent with the findings of Cavendish (2000), and Adhikari, Di Falco and Lovett (2004), use of all resources combined increases with income in our sample, although the same is not true of all resources considered individually.

	Permanent Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
Fuelwood	4.6	3.5	2.8	3.0
Construction Wood	0.1	0	0.5	1.0
Fodder	0.9	1.6	2.7	3.7
Other Resources	3.5	2.7	1.0	0.7
All Resources	9.0	7.8	7.1	8.4

Table 8. Dependence on Resources (%) by Income Quartile for Whole Sample

In contrast to the findings of Jodha (1986), Reddy and Chakravarty (1999) and Cavendish (2000), dependence on common resources does *not* decrease with income for our sample of households. Instead, dependence follows a U-shaped relationship with income, declining at first but then increasing. This relationship holds, regardless of whether one considers the entire sample of households (last row in Table 8) or only the subsample of households that collect positive amounts of common resources (last row in Table 9). Among collecting households (399 households in all, dispersed across all 60 villages in the sample)[25] the poorest derive about 12% of their total income from natural resources. Dependence decreases to 10% for households in the second and third income quartiles and then increases again to 13% for households in the fourth quartile.

For both the entire sample of households and just the subsample of collecting households, the U-shaped relationship is explained by a combination of trends in dependence on individual resources. While increasing use of construction wood and fodder account for the increase in dependence at higher incomes, decreasing use of other resources (mahua flowers and seeds, tendu leaves, gum and dung) accounts for the decrease in dependence at lower incomes. It is only dependence on fuelwood that itself exhibits a mild U-shaped, or L-shaped, relationship with income. At the income extremes, high resource dependence of the poorest collecting households is mostly due to their high dependence on fuelwood (5.9%) and other resources (4.5%), whereas the high resource dependence of the richest households is mostly due to their high dependence on fodder (5.9%) and again fuelwood (4.7%).

	Permanent Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
Fuelwood	5.9	4.3	4.0	4.7
Construction Wood	0.1	0.0	0.7	1.6
Fodder	1.2	1.9	3.8	5.9
Other Resources	4.5	3.3	1.5	1.1
All Resources	11.7	9.5	10.1	13.3

Table 9. Dependence on Resources (%) by Income Quartile for Collecting Households

We now turn from simple descriptive statistics to regression estimates of the relationships between dependence on resources and permanent income for our sample households.

[25] Out of our total sample of 535 households, 136 did not collect common property resources, leaving 399 that did.

6. Econometric Results

6.1. Use for Collecting Households. We begin by investigating the relationship between resource use (rather than dependence) and both income and biomass availability for the subsample of households that derive at least some income from common property resources.

lei_res_c	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	-2.289229	1.382308	-1.66	0.103	-5.059436	.4809775
lei_tot_sq_c	.1751691	.0860405	2.04	0.047	.0027401	.3475981
rs_bio_c	.180785	.0722943	2.50	0.015	.035904	.325666
_cons	11.77148	5.54238	2.12	0.038	.6642981	22.87865

Number of obs = 399
R-squared = 0.09

Table 10. Level of Resource Income as a Function of Total Income and Total Biomass for Collecting Households

6.1.1. ***All resources combined.*** Table 10 shows the results of regressing, for this subsample, the (log of) permanent income per capita from all natural resources combined (lei_res_c) on the (log of) total permanent income per capita (lei_tot_c), its square (lei_tot_sq_c), and biomass availability per capita (rs_bio_c)[26].

The negative (though not significant at 5%) coefficient on income and the positive coefficient on income squared suggest that the relationship between resource income and total income may be L-, U-, or J-shaped. A plot of the predicted relationship (shown in Figure 1) shows that the relationship is in fact J-shaped. Furthermore, the coefficient on biomass availability is positive, indicating that higher biomass availability leads to higher use. Figure 1 illustrates this by plotting the predicted relationship at two different levels of biomass availability—"low," corresponding to the 25th percentile of biomass availability in the sample, and "high," corresponding to the 75th percentile.

[26] In all regressions reported in this paper, observations have been weighted and standard errors corrected to account for our survey design, i.e., for the stratified selection of villages, the oversampling of landless and land-rich households within villages, and the fact that error terms for households within any given village are likely to be correlated.

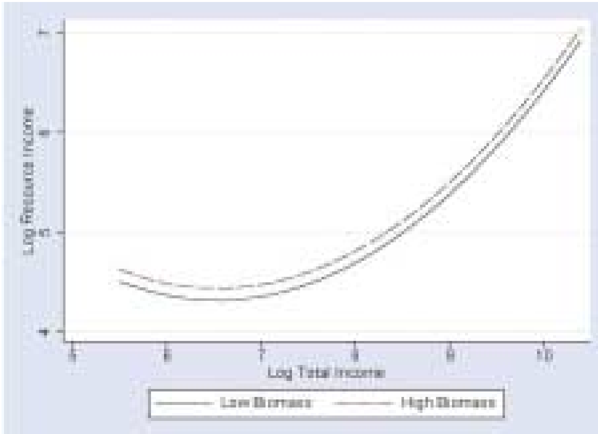

Figure 1. Relationship between Income from Resources, Total Income, and Total Biomass for Collecting Households

We find, therefore, consistent with the simple tabulation results reported in Table 5 and also with results in some of the existing literature, that resource use mostly increases with income. The poorest households are not the largest users of common resources.

6.2. Dependence for Collecting Households. We next consider the relationship between *dependence* on all natural resources and both income and biomass availability, again only for the subsample of collecting households. Because dependence, our left-hand side variable, is constrained to lie between 0 and 1, we use a two-sided Tobit regression to estimate this relationship.

d_res	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	-.6504508	.168738	-3.85	0.000	-.9886093	-.3122924
lei_tot_sq_c	.0382391	.0102258	3.74	0.000	.0177461	.0587321
rs_bio_c	.0233792	.0105962	2.21	0.032	.0021439	.0446144
_cons	2.84044	.6961727	4.08	0.000	1.445279	4.235601
/lnsigma	-1.830079	.0917664	-19.94	0.000	-2.013983	-1.646175

Number of obs = 399

Table 11. Dependence on Resource Income as a Function of Total Income and Total Biomass for Collecting Households

Table 11 shows that the coefficient on income is negative while that on income squared is positive, suggesting again that the relationship between resource dependence and income could be L-, U-, or J-shaped. Figure 2 shows that the relationship is in fact U-shaped, and higher for all income levels at higher levels of biomass availability[27].

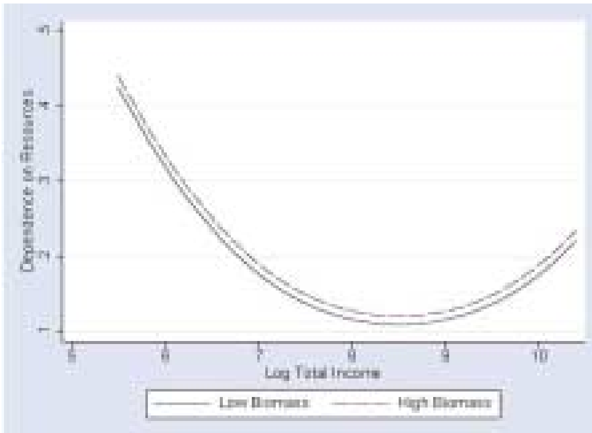

Figure 2. Relationship between Dependence on Resources, Total Income, and Total Biomass for Collecting Households

The regression establishes that the U-shaped relationship between income and dependence suggested by the simple tabulation reported in Table 9 is in fact statistically significant. Since this pattern of resource dependence differs from the common pattern found in the existing literature (namely that dependence decreases with income) the question arises as to what explains the difference. To shed light on this question, we now turn to the relationship between income and dependence on individual resources.

d_wfu	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	-.7059765	.3376614	-2.09	0.041	-1.382665	-.0292879
lei_tot_sq_c	.040035	.0194335	2.06	0.044	.0010894	.0789806
rs_for_c	.023584	.0122702	1.92	0.060	-.0010059	.048174
_cons	3.151301	1.463224	2.15	0.036	.2189345	6.083667
/lnsigma	-2.218394	.0921574	-24.07	0.000	-2.403082	-2.033707
Number of obs = 264						

Table 12. Dependence on Fuelwood as a Function of Total Income and Total Biomass for Collecting Households

[27] The figure plots predicted actual dependence rather than predicted latent dependence (which might be less than 0 or greater than 1). The same is true of all dependence plots hereafter

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
Collection from Commons	210	293	471	988
Sale from Commons	0	0	0	219
Collection from Private Sources	26	59	53	72
Sale from Private Sources	21	35	17	19
Market Purchase	31	11	28	16
Total Consumption	246	328	535	838

Table 13. Collection and Consumption of Fuelwood by Income Quartile For Collecting Households (Rs.)

6.2.1 *Fuelwood.* As with all resources combined, in the regression of dependence on fuelwood on i) income and ii) forest biomass availability per capita (rs_for_c), the coefficient on income is negative, that on income squared is positive, and that on forest biomass is positive as well (see Table 12). As Figure 3 shows, this translates into a U-shaped relationship between dependence on fuelwood and income, confirming the pattern suggested by the tabulation in Table 9. Moreover, dependence is somewhat higher at all income levels for households with higher availability of forest biomass[28].

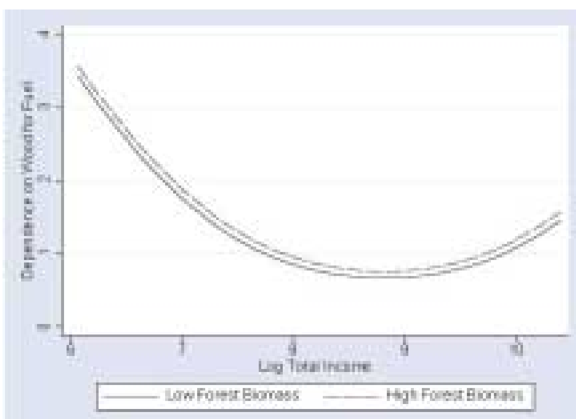

Figure 3. Relationship between Dependence on Fuelwood, Total Income, and Total Biomass for Collecting Households

We find, therefore, that dependence on fuelwood does not decrease monotonically with income. Although the poorest households are the most dependent on fuelwood, the richest households are not the least dependent. Table 13 suggests that the high dependence of the rich on fuelwood can be explained by the fact that they simply

[28] The “low” and “high” biomass levels for which predicted dependence is plotted correspond, respectively, to the 25th and 75th percentile of forest biomass availability in the sample.

consume more fuelwood: total consumption of fuelwood sharply increases between the third and the fourth income quartiles. At the same time, rich households do not meet significantly more of their consumption through private provision (i.e., collection from trees on their own land): households in all income quartiles meet their demands mostly from the commons. These facts together lead to a decrease in dependence between the first and the third income quartiles and then an increase between the third and the fourth quartiles.

Interestingly, only households in the fourth income quartile sell any fuelwood from the commons, suggesting that poorer households do not consider collecting fuelwood for the purposes of selling it a productive use of their time. Also, the fact that households in higher income brackets rely largely on the commons for fuelwood provision, despite their higher land holdings, indicates that the private asset of land in this case does not substitute to any significant extent for the public asset of the commons.

d_wco	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	1.192363	.6885918	1.73	0.089	-.1876058	2.572332
lei_tot_sq_c	-.0627425	.0374016	-1.68	0.099	-.1376969	.0122119
rs_for_c	.007984	.0075645	1.06	0.296	-.0071756	.0231435
_cons	-5.563433	3.151419	-1.77	0.083	-11.87902	.7521524
/lnsigma	-1.965065	.2518972	-7.80	0.000	-2.469878	-1.460251

Number of obs = 37

Table 14. Dependence on Construction Wood as a Function of Total Income and Total Biomass for Collecting Households

6.2.2. ***Construction Wood.*** Only 37 households in our sample collect construction wood from the commons. This likely explains, in part, the low significance of the income and biomass coefficients in the regression results for dependence on construction wood reported in Table 14. Figure 4 shows that the income coefficients (which are both significant only at the 10% level) translate into an inverse U-shaped relationship between income and dependence. This is inconsistent with the pattern suggested by the simple tabulation in Table 9. There, we found that dependence on construction wood decreases slightly between the first and the second income quartiles and then increases.

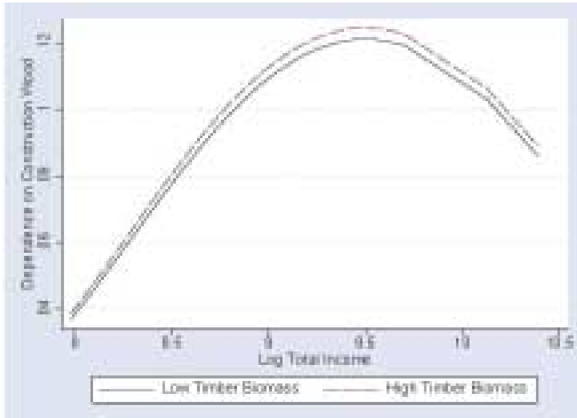

Figure 4. Relationship between Dependence on Construction Wood, Total Income, and Total Biomass for Collecting Households

	Permanent Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
Collection from commons	67	61	446	1281
Sales from Commons	0	0	0	0
Collection from Private Sources	136	1	3	1032
Sale from Private Sources	0	0	0	364
Market Purchase	0	14	23	3031
Total consumption	203	76	473	4981

Table 15. Collection and Consumption of Construction Wood by Income Quartile For Collecting Households (Rs.)

The discrepancy appears to be driven by two outliers: the two richest households in the sample of 37 collect very little construction wood. If these two sample points are dropped, the predicted relationship between income and dependence on construction wood becomes monotonically increasing in income, and therefore more consistent with the tabulation result.

Table 15 suggests that, as with fuelwood, the high dependence of the rich on construction wood is driven by their higher demand. Although much of this higher demand is met through higher market purchases, a significant fraction is met through higher collection from the commons, and only a small fraction through higher private provision.

6.2.3. *Fodder*. Only 74 households in our sample collect any fodder from the commons by hand, although, as discussed in Section 7, many more graze their animals on the commons. Table 16 reports the regression results for dependence on fodder.

d_fod	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	.1074323	.0440785	2.44	0.018	.0190969	.1957676
rs_grs_c	6.997335	3.780804	1.85	0.070	-.579565	14.57423
xxx_grs_tot	-.7538115	.4153315	-1.81	0.075	-1.586154	.0785314
_cons	-.8206422	.3863552	-2.12	0.038	-1.594915	-.0463691
/lnsigma	-1.669207	.1293915	-12.90	0.000	-1.928514	-1.409901

d_fod	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	.0899779	.0423668	2.12	0.038	.0050731	.1748828
la_ani_c	-.084253	.0740458	-1.14	0.260	-.2326441	.0641382
rs_grs_c	1.957048	4.903549	0.40	0.691	-7.869883	11.78398
xxx_grs_tot	-.1561651	.5524241	-0.28	0.778	-1.263248	.9509175
xxx_grs_ani	-.6900648	.3289601	-2.10	0.041	-1.349316	-.030814
_cons	-.6090471	.3774375	-1.61	0.112	-1.365449	.1473544
/lnsigma	-1.710365	.1471804	-11.62	0.000	-2.005321	-1.415409

Number of obs = 74

Table 16. Dependence on Fodder as a Function of Total Income and Total Biomass for Collecting Households

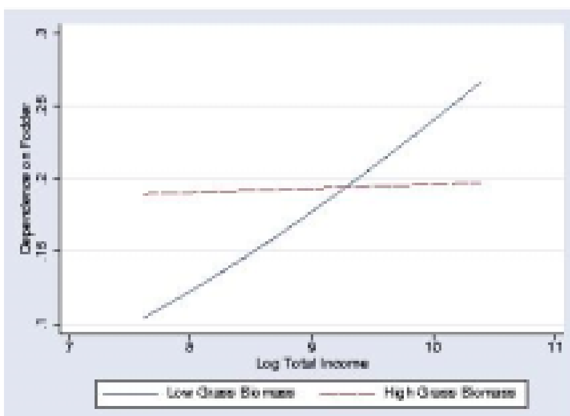

Figure 5. Relationship between Dependence on Fodder, Total Income, and Total Biomass for Collecting Households

In the first regression, the coefficients on income and total grass biomass availability per capita (rs_grs_c) are both positive, while that on the interaction term between income and grass biomass (xxx_grs_tot) is negative. Figure 5 plots the predicted relationship between dependence on fodder and income. At "low" grass biomass levels[29], dependence on fodder increases sharply with income. However, because of the

[29] Corresponding to the 25th percentile of grass biomass availability in the sample, with "high" biomass levels corresponding to the 75th percentile.

negative interaction term, dependence is almost constant in income at "high" grass biomass levels. Higher fodder collection by the rich, at least at low biomass levels, therefore appears to explain some of the upturn in overall resource dependence for the rich.

However, if the (log of) animal holdings[30] (la_ani_c) and an interaction term between that and grass biomass (xxx_grs_ani) are included in the regression (as in the second regression reported in Table 16), then the coefficients on both the grass biomass term and the interaction term between income and grass biomass become insignificant. The negative coefficient on the interaction term between animal holdings and grass biomass indicates that, regardless of income, households with larger animal holdings depend less on collected fodder in grass-rich areas. As we show in Section 7, the latter appears to be explained by the fact that such households switch from collecting fodder by hand to grazing their animals on the commons.

	Poor Households	Rich Households
Collection from Commons (Rs.)	907	3358***
Collection from Private Sources (Rs.)	1340	1294
Market Purchase (Rs.)	492	1239**
Time Spent Grazing (Days)	95	70

Table17. Fodder Collection Pattern for Rich and Poor Households that Collect Fodder

	Poor Households	Rich Households
Income from In-Village Casual Labor (Rs.)	168	220
Income from Off-Village Casual Labor (Rs.)	810	1609*
Income from Private and Public Jobs (Rs.)	4	1589**
Whether Head Attended School	0.2	0.5***
Years of Schooling	4.8	5.8
Adult Equivalent Units Per Animal	2.4	1.7*

Table18. Income and Asset Characteristics of Rich and Poor Households that Collect Fodder

More puzzling is the still positive (though smaller in magnitude and less significant) coefficient on income in this second regression, which suggests that the higher dependence of the rich on fodder is only partially explained by their higher animal holdings. To search for a fuller explanation, we examine other characteristics that might

[30] Total animal holdings are defined as the (unweighted) sum of bullocks, cows, buffalo, donkeys, goats, and sheep owned by the household.

distinguish rich and poor households that collect fodder. In Tables 17 and 18, poor households are defined as those that fall in the first or second income quartiles for the whole survey sample (i.e., below the median income level), while rich households fall in the third or fourth income quartiles. Out of the 74 households that collect fodder, 45 are rich by this definition, and the remaining 29 are poor. Table 17 confirms, first of all, that rich households collect significantly[31] more fodder than poor households, even on a per-animal basis: the value of collection per animal is about Rs. 3,358 for the rich compared to Rs. 907 for the poor. However, it also shows that poor households spend more time grazing each animal on village commons than do rich households: on average 95 days per animal, per capita, per year, compared to 70 days for the rich[32]. It appears, therefore, that rich households prefer to stall-feed their animals as opposed to grazing them on open pastures. This preference may be explained, in part, by time constraints, as these rich households have smaller families (see Table 18) as well as higher labor income from off-village casual employment and from private-sector and public-sector jobs.

6.2.4. *Other resources.* Resources other than wood and fodder are collected by 301 households in our sample. The regression results reported in Table 19 and illustrated in Figure 6 indicates that dependence on income from these other resources does not vary significantly with overall (wood plus grass) biomass availability per capita. This is reasonable in light of the fact that dung availability is at best indirectly related to grass biomass, and the remaining resources (mahua flowers and seeds, tendu leaves, and gum) are derived from very specific trees, which may purposely be left standing when other trees are cut down. The results also show that dependence on other resources decreases monotonically with income, indicating perhaps that collecting these resources is a relatively low-return activity.

[31] In this table, and all tables hereafter that report comparisons of means, superscripts *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. The underlying tests for equality of means are corrected for the survey design.

[32] The survey elicited total grazing hours, which for ease of interpretation we divide by eight to obtain grazing days. In reality, of course, hours grazed per day vary.

d_ors	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	-.4961931	.1416145	-3.50	0.001	-.779995	-.2123912
lei_tot_sq_c	.0276067	.0081583	3.38	0.001	.0112571	.0439564
rs_bio_c	.001499	.0024208	0.62	0.538	-.0033523	.0063503
_cons	2.243534	.6126462	3.66	0.001	1.015763	3.471304
/lnsigma	-2.746475	.1344301	-20.43	0.000	-3.015879	-2.477071

Number of obs = 301

Table 19. Dependence on Other Resources as a Function of Total Income and Total Biomass for Collecting Households

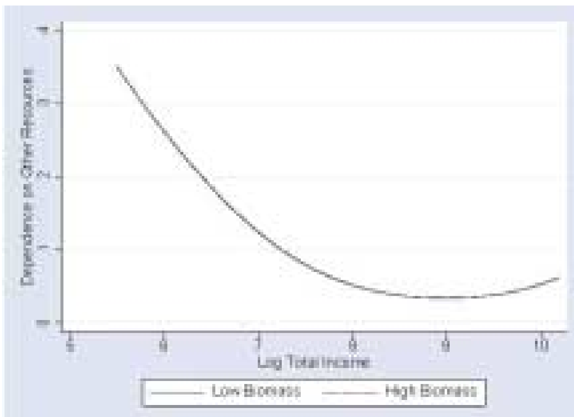

Figure 6. Relationship between Dependence on Other Resources, Total Income, and Total Biomass for Collecting Households

To summarize, although the poorest and the richest households are the most dependent on all resources combined (as indicated by the U-shaped relationship between overall resource dependence and income), they are not dependent on the same resources. The poorest households are particularly dependent on fuelwood and other resources, whereas the richest households are particularly dependent on fuelwood, construction wood and fodder. Factors that appear to underlie this situation are differences in i) consumption (the rich consume much more fuel and construction wood), ii) asset holdings (the rich have more animals), and iii) time constraints (the rich prefer stall-feeding their animals to grazing them, and do not bother to collect other resources).

6.3. Resource Dependence for All Households. After examining the relationship between resource dependence and income for only the subsample of households that collect natural resources, we now examine this relationship for our whole sample. Since

26% of the households in our sample do *not* collect any resources, our data are censored. We therefore use Tobit regressions throughout, and begin again by examining resource use rather than dependence.

lei_res_c	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	6.796619	3.074556	2.21	0.031	.6350714	12.95817
lei_tot_sq_c	-.4151841	.1815623	-2.29	0.026	-.779043	-.0513252
rs_bio_c	.3325485	.13216	2.52	0.015	.0676939	.5974032
_cons	-24.44736	13.14673	-1.86	0.068	-50.79399	1.89927
/lnsigma	1.272794	.0511069	24.90	0.000	1.170374	1.375215

Number of obs = 535
Number of uncensored obs = 399

Table 20. Use of Resources as a Function of Total Income and Total Biomass for Whole Sample

6.3.1. *All resources combined.* Table 20 shows the results for use of all resources combined, for all households in the sample. In contrast to the results of the analogous regression for those households that collect natural resources (reported in Table 10), the coefficient on income is positive while that on income squared is negative. This suggests that the relationship between resource income and total income may be inversely U-shaped.

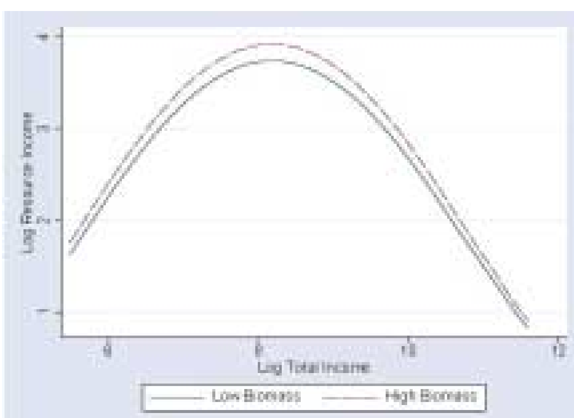

Figure 7. Relationship between Use, Biomass, and Total Income for Whole Sample

Figure 7 confirms that this is in fact the case: in contrast to the generally increasing relationship between use and income for collecting households alone (shown in Figure 1), there is a significant drop in overall resource use at higher income levels when we include non-collecting households in our sample[33]. Resource use does still increase for all income levels with biomass availability, and in fact does so more strongly when we consider the sample as a whole.

d_res	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	-.0323666	.0162639	-1.99	0.052	-.0649601	.000227
rs_bio_c	.0261446	.0092525	2.83	0.007	.0076021	.0446871
_cons	.3051527	.1398513	2.18	0.033	.0248845	.5854209
/lnsigma	-1.696314	.092597	-18.32	0.000	-1.881883	-1.510746

Number of obs = 535
Number of uncensored obs = 399

Table 21. Dependence on Resources as a Function of Total Income and Total Biomass for the Whole Sample

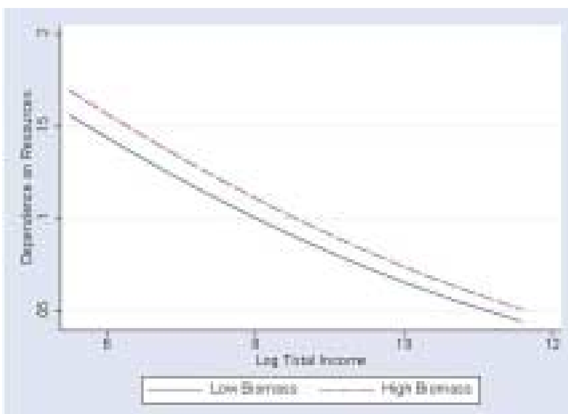

Figure 8. Relationship between Dependence, Biomass, and Total Income for the Whole Sample

Table 21 shows the results for dependence on all resources combined. Note that we omit the usual income squared term from this regression, because the coefficients on both income and income squared are found to be insignificant when we include the income squared term. If only income is included, the coefficient on it is negative and significant. This indicates that, whereas the relationship between dependence and income was U-shaped for the subsample of collecting households, it is monotonically decreasing for the sample of households as a whole. Figure 8 shows the predicted

[33] As with all plots of dependence, the figure plots predicted actual use rather than latent use (which might be less than 0).

relationship for both low and high levels of biomass. Note that the predicted relationship not only differs from that of the subsample, but also from what was suggested by the simple tabulation reported in Table 8. The tabulation suggested that, even for the sample as a whole, the relationship was U-shaped.

```
------------------------------------------------------------------------------
     collect |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   lei_tot_c |   2.268158   .8997071     2.52   0.015     .4651045    4.071211
lei_tot_sq_c |  -.1483188   .0512512    -2.89   0.005    -.2510286    -.045609
       _cons |  -7.815103   3.974718    -1.97   0.054    -15.78062      .15041
------------------------------------------------------------------------------
Number of obs = 535
------------------------------------------------------------------------------
```

Table 22. Probability of Collection as a Function of Total Income for the Whole Sample

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
% Collecting	78	83	73	64

Table 23. Collecting Resources by Income Quartiles for the Whole Sample

6.4. Probability of Collection and Income. To understand the reasons behind both these disparities, we estimate the relationship between income and a binary variable for whether or not a household chooses to collect any common-pool resources at all, using a Probit regression. As shown in Table 22, the probability of collection is found to increase with income but decrease with income squared.

Figure 9. Relationship between Probability of Collection and Total Income for the Whole Sample

Figure 9 shows that the relationship is inversely U-shaped with total income, consistent with the results of a simple tabulation of the proportion of households that collect resources in each income quartile (see Table 23). More specifically, poor households are found to be somewhat less likely to collect resources than middle-income households, but rich households are much less likely to collect resources than either group.

Resource use by rich households therefore appears to be bimodal: they tend to either collect nothing at all or collect a lot of resources, and *both* tendencies are stronger than they are for middle-income households. As a result, if we consider only households that collect resources, then the fact that the richer of these households collect more resources than those with intermediate incomes makes the relationship between use and income increasing, and that between dependence and income U-shaped. If, however, we add in households that do not collect resources, then the fact that the richer of these are less likely to collect resources pulls both the use and dependence curves down at high levels of income. This leads to an inversely U-shaped relationship between use and income, and a monotonically decreasing relationship between dependence and income.

Income (Rs.)	No Collection	Collection
Current Income from Agriculture	3308	-5*
Income from Agriculture	11179	5842*
Income from Livestock	210	161
Income from Resources	0	1802***
Income from Enterprise	2769	305*
Income from Labor	4750	4560
Income from Financial Transactions	-148	-121
Income from Transfer	2066	942
Total Income	20825	13490**

Table 24. Income Characteristics of Rich Households that Do and Do Not Collect Resources

Asset Value (Rs.)	No Collection	Collection
Value of Land Owned	88950	39883*
Value of Farm Capital	13308	4459*
Value of Animals Owned	3643	3184
Value of Bullocks	1252	1634
Value of Buffalo	1225	654*
Value of Cows	613	516

Table 25. Physical Asset Characteristics of Rich Households that Do and Do Not Collect Resources

	No Collection	Collection
Adult Equivalent Units	5.1	5.5
Number of Male Members	2	1.9
Number of Female Members	2.1	2.1
Number of Children	1	1.6**

Table 26. Household Characteristics of Rich Households that Do and Do Not Collect Resources

6.5. Differences between Rich Collectors and Non-Collectors. To better understand why some rich households choose to collect from the commons and why others do not, we examine a range of household characteristics that might plausibly drive this decision. Tables 24 to 30 compare the means of such characteristics between collecting and non-collecting households in the top income quartile only. Out of 134 of these households, living in 41 different villages in our sample, 86 collect resources and 48 do not.

Tables 24 and 25 show how income composition and asset holdings differ between collecting and non-collecting rich households. Rich non-collecting households are found to be at the top end of the income distribution, i.e., to be among the "richest of the rich," with on average 65% higher permanent incomes than rich collecting households. Some of this difference is accounted for by higher incomes from transfers, enterprise, and current-year income from agriculture, in part offset by the lower (by definition zero) income from resource collection. Most of the difference, however, is accounted for by significantly higher ownership of land and farm capital by rich non-collectors. Table 25 shows that the value of land owned by rich non-collectors is more than twice as high as that of rich collectors, and the value of farm capital owned is more than three times as high.

	No Collection	Collection
Collection from commons	0	620***
Sale from Commons	0	138
Collection from Private Sources	337	104
Sale from Private Sources	73	12
Market Purchase	45	15
Total consumption	309	589

Table 27. Collection and Consumption of Fuelwood For Rich Households that Do and Do Not Collect Resources (Rs.)

	No Collection	Collection
Collection from Commons	0	195*
Sale from Commons	0	0
Collection from Private Sources	40	260**
Sale from Private Sources	0	55
Market Purchase	478	498
Total consumption	518	898

Table 28. Collection and Consumption of Construction Wood For Rich Households that Do and Do Not Collect Resources (Rs.)

Although, as noted above, rich collecting households consume significantly more fuel and construction wood than do poorer households, Tables 27 and 28 show that consumption of both drops sharply for the very rich, non-collecting households. Although we have no data to confirm this, we conjecture that the latter households use purchased fuels (e.g., kerosene) and construction materials (e.g., bricks) as substitutes. There is also some evidence that non-collecting households substitute privately provided fuelwood for wood from common-property forests, although private provision of construction wood is in fact lower for non-collectors.

	No Collection	Collection
Collection from Commons (Rs.)	0	850***
Collection from Private Sources (Rs.)	2937	1508
Market Purchase (Rs.)	748	627
Time Spent Grazing (Days)	33	41

Table 29. Fodder Consumption Characteristics of Rich Households that Do and Do Not Collect Resources

Table 25 shows that both groups of households have similar animal holdings. However, although it was noted above that rich collecting households meet no more of their fodder demand from private provision than do poorer households, Table 29 shows that such private provision increases sharply for the very rich, non-collecting households.

	No Collection	Collection
Income from In-Village Casual Labor (Rs.)	99	450
Income from Off-Village Casual Labor (Rs.)	1049	1583
Migration (days)	46	62
Income from Private and Public Jobs (Rs.)	3602	2527
Whether Head Attended School	0.64	0.56
Years of Schooling	9.3	7.7

Table 30. Labor Income and Schooling Characteristics of Rich Households that Do and Do Not Collect Resources

Finally, although Table 24 shows that total labor earnings are more or less the same between collecting and non-collecting households, Table 30 indicates some differences in the sources of these labor earnings. Rich collecting households derive more of their labor earnings from in-village and off-village casual employment (which tends to be relatively low-skilled) while rich non-collecting households derive a greater proportion of their earnings from regular jobs in the private and the public sector (which tend to be relatively high-skilled). Heads of non-collecting households are also more likely to have attended school and, conditional on attendance, to have completed more grades.

All these observations are consistent with Jodha's conjectures about what factors drive dependence on resources. The fact that non-collecting rich households have fewer children suggests that they have less surplus labor to devote to resource collection. The fact that they are more educated and derive more income from agriculture, enterprise, and relatively high-skilled jobs suggests that they prefer to allocate their time to higher-return activities than to resource extraction from the commons. And finally, the non-collecting households' higher landholdings appear to act, to some extent, as a substitute for the commons in terms of private fodder and fuel-wood provision.

7. Grazing

Thus far, we have considered only common resources that are collected "directly" by the household, i.e., by hand. Households also gather one resource, fodder, "indirectly," by letting their animals graze on common grazing lands. Unfortunately, we have no reliable way of converting time spent grazing to a monetary value. We therefore have to consider the relationship between income and this form of indirect resource dependence separately from the remainder of the analysis.

qa_lbr_lvs_c	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lei_tot_c	6.327754	2.744904	2.31	0.025	.8268441	11.82866
rs_grs_c	102.2917	24.61553	4.16	0.000	52.96108	151.6223
_cons	-17.4754	23.74671	-0.74	0.465	-65.06488	30.11408

R-squared = 0.14

qa_lbr_lvs_c	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lei_tot_c	-.2287665	3.78143	-0.06	0.952	-7.806922	7.349389
la_ani_c	21.2217	5.079281	4.18	0.000	11.04259	31.4008
rs_grs_c	-202.1219	253.8881	-0.80	0.429	-710.925	306.6812
xxx_grs_tot	25.52679	29.75249	0.86	0.395	-34.09854	85.15212
xxx_grs_ani	75.08664	26.47702	2.84	0.006	22.02551	128.1478
_cons	30.43337	32.0373	0.95	0.346	-33.77082	94.63756

Number of obs = 438
R-squared = 0.25

Table 31. Time spent Grazing as a Function of Total Income, Animal Holdings, and Biomass for Grazing Households

7.1. Households that Graze their Animals. Table 31 shows the results of two regression estimates of the relationship between time spent grazing animals (qa_lbr_lvs_c) and i) income, ii) animal holdings and iii) grass biomass availability, for only those households that choose to graze their animals (438 out of 535 households in our sample). In the first regression, time spent grazing animals is regressed on income and grass biomass availability alone. The coefficients on both are found to be significantly positive, resulting in the predicted relationship shown in Figure 10.

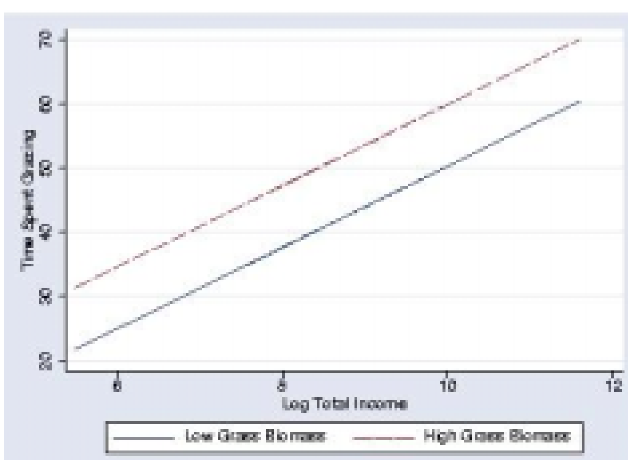

Figure 10. Relationship between Time Spent Grazing, total Income, and Grass Biomass for Grazing Households

The second regression adds animal holdings (la_ani_c), and two interaction terms between income and grass biomass (xxx_grs_tot) and between animal holdings and grass biomass (xxx_grs_ani). In this regression, the coefficient on income is no longer significant, indicating that income in the first regression merely proxies for animal holdings. The coefficient on grass biomass is no longer significant either, but that on the interaction term between animal holdings and grass biomass is positive and highly significant. This indicates, as one would expect, that grass biomass availability affects time spent grazing only if a household has positive animal holdings, and then more so, the more animals the household has. Figure 11 shows the predicted relationship between time spent grazing animals and the household's total animal holdings, for two different levels of grass biomass availability.

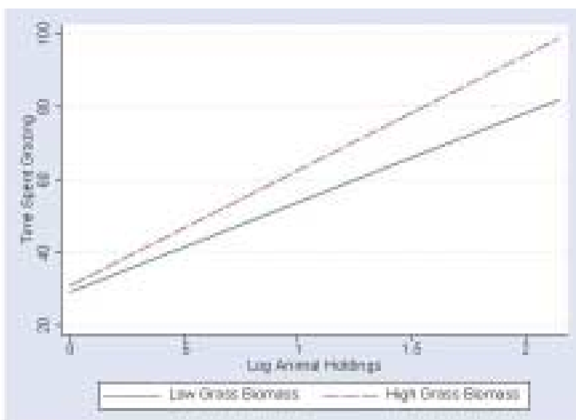

FIGURE 11. Relationship between Time Spent Grazing, Animal Holdings, and Grass Biomass for Grazing Households.

It is reasonable to assume that the amount of fodder gathered indirectly through open grazing increases with the time the household spends on this activity. If so, then this second regression establishes that the amount of fodder gathered in this way increases with the number of animals for a given level of grass biomass. This contrasts with the second regression of Table 16, which established that the amount of fodder collected *directly* by the household *decreases* with the number of animals for a given level of grass biomass. The combination of these results implies that, as grass becomes more abundant, households with larger animal holdings switch from fodder collection to grazing.

7.2. All Households. We now examine time spent grazing for the entire sample of households, rather than just the subsample of households for which this time is strictly positive.

Table 32 and Figures 12 and 13 show that the relationships between time spent grazing animals, household income, animal holdings, and fodder biomass are largely unchanged when the entire sample of households is considered. The one notable difference is that in the first regression of Table 32: the coefficient on grass biomass availability is no longer significant.

qa_lbr_lvs_c	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	5.910437	3.175544	1.86	0.068	-.4534946	12.27437
rs_grs_c	4.938886	30.76425	0.16	0.873	-56.71404	66.59181
_cons	-17.04274	27.65121	-0.62	0.540	-72.45701	38.37153
/lnsigma	3.676099	.0592996	61.99	0.000	3.55726	3.794939

qa_lbr_lvs_c	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	-1.573458	3.053436	-0.52	0.608	-7.69268	4.545765
la_ani_c	44.63472	6.759383	6.60	0.000	31.08862	58.18083
rs_grs_c	-145.6695	129.0204	-1.13	0.264	-404.2322	112.8932
xxx_grs_tot	9.301322	14.124	0.66	0.513	-19.0038	37.60644
xxx_grs_ani	131.9558	31.94725	4.13	0.000	67.93204	195.9795
_cons	25.7815	25.18956	1.02	0.311	-24.69951	76.26252
/lnsigma	3.447111	.0486131	70.91	0.000	3.349688	3.544534

Number of obs = 535

Table 32. Time spent grazing as a function of Total Income, Animal Holdings, and Biomass for Whole Sample

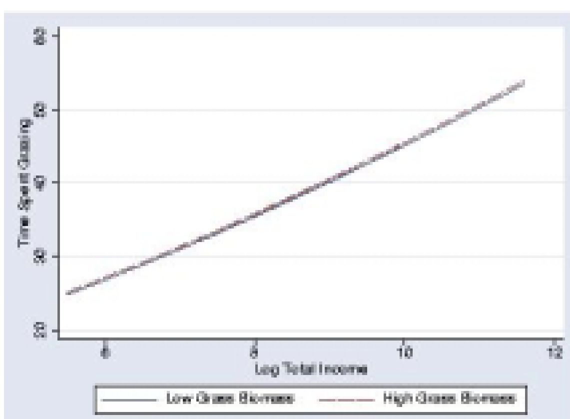

Figure 12. Relationship between Time Spent Grazing, Total Income, and Grass Biomass for Whole Sample

Comparison of Figures 10 and 12 suggests that there is a parallel shift downwards in the time spent grazing animals in high-biomass areas relative to low-biomass areas when non-grazing households are added to the sample. Underlying this is a puzzling tendency (confirmed by a tabulation not reported here) for non-grazing households to live disproportionately in high-biomass areas.

As was true for the subsample of households that graze their animals, the coefficient on income is no longer significant in the second regression of Table 31, suggesting again that income in the first regression merely proxies for animal holdings. As in Figure 11, the positive coefficient on the interaction term between animal holdings and grass biomass in the second regression causes the curve between time spent grazing and animal holdings to become steeper at the high biomass level.

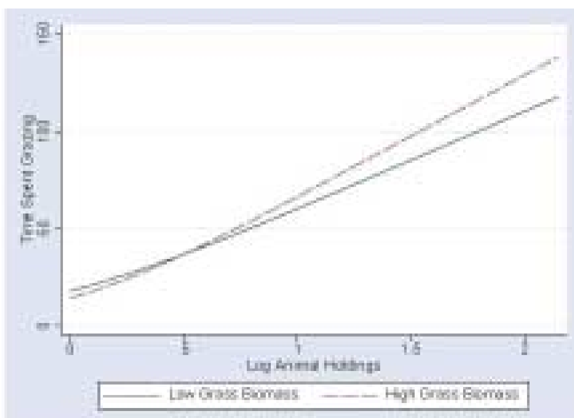

FIGURE 13. Relationship between Time Spent Grazing, Animal Holdings, and Grass Biomass for Whole Sample.

However, because non-grazing households live disproportionately in high-biomass areas, in Figure 13 the high-biomass curve is also shifted downwards relative to the low-biomass curve when compared to Figure 11.

7.3. Probability of Grazing. We finally consider the relationship between income and a binary variable for whether or not a household grazes its animals at all. Obviously, only households that own animals in the first place face a choice in this matter. Moreover, it turns out that only 6% of such households—30 out of 465—in fact choose not to graze their animals at all (i.e., to rely entirely on stall-feeding). Therefore, the binary variable in effect mostly captures whether or not a household owns any animals at all.

The first regression in Table 33 reports the results of a Probit regression of this binary variable on income and income squared. As shown in Figure 14, the estimated coefficients on both imply an inversely U-shaped relationship between the probability of grazing and income. This is also consistent with the tabulations reported in Table 34.

The second regression in Table 33 adds animal holdings and an interaction term between animal holdings and grass biomass. Income once again becomes insignificant, suggesting again that it merely serves as a proxy for animal holdings in the first regression. This in turn implies, however, that underlying the sharp decline in the probability of grazing at high income levels must be a similar drop in animal holdings, although other factors not included in the regressions may also come into play.

graze	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	3.092843	1.309848	2.36	0.022	.4678496	5.717836
lei_tot_sq_c	-.1764307	.0765604	-2.30	0.025	-.3298612	-.0230002
_cons	-12.55025	5.549006	-2.26	0.028	-23.6707	-1.429788

graze	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lei_tot_c	.9925055	1.329563	0.75	0.459	-1.671998	3.657009
lei_tot_sq_c	-.0615588	.0794264	-0.78	0.442	-.2207329	.0976153
la_ani_c	6.121277	.5742403	10.66	0.000	4.970474	7.27208
la_ani_sq_c	-2.331091	.360853	-6.46	0.000	-3.054257	-1.607925
_cons	-4.765572	5.467129	-0.87	0.387	-15.72194	6.190799

Number of obs = 535

Table 33. Probability of Grazing as a Function of Total Income and Animal Holdings for Whole Sample

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
% Grazing	73	86	88	81
Time spent Grazing	30	41	45	38

Table 34. Percentage of Households Grazing Animals and Time Spent Grazing by Income Quartiles for Whole Sample

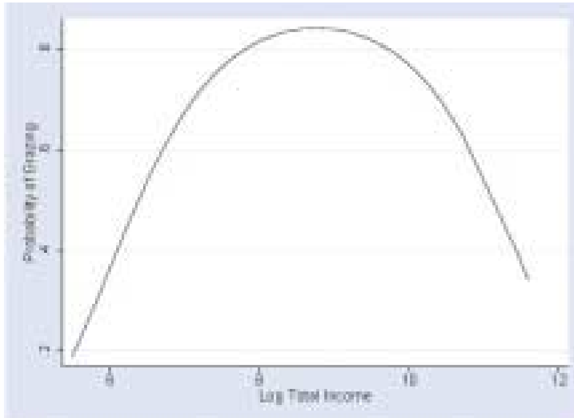

FIGURE 14. Probability of Grazing as a Function of Total Income for Whole Sample.

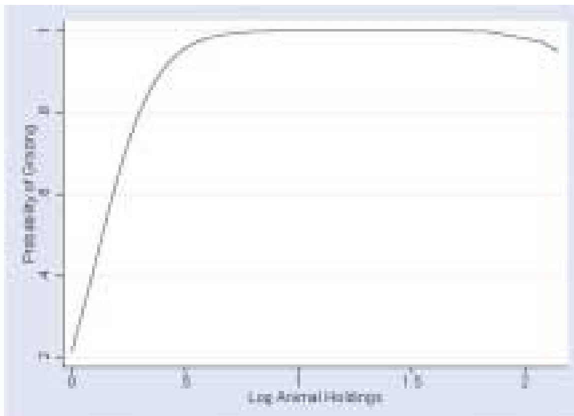

FIGURE 15. Probability of Grazing as a Function of Animal Holdings for Whole Sample.

7.4. Differences between Rich Grazers and Non-Grazers. Just as Tables 24 to 30 compared rich collecting and non-collecting households according to various dimensions, Tables 35 to 38 do so for rich grazing and non-grazing households. Out of 134 households in the top income quartile, 108 graze their animals and 26 do not.

As was true of rich non-collecting households compared to collecting ones, rich non-grazing households are richer than grazing ones (Table 35), again due mainly to higher incomes from high-skilled labor activities (especially enterprise, but also income from private and public sector jobs (Table 38)) and higher transfer incomes. However, the difference in total income is much less stark, in part because—as expected—rich non-grazing households own significantly less livestock (Table 36) and earn correspondingly less livestock income. The same fact also explains why they demand significantly less fodder from all sources (Table 37). More surprising is that non-grazing households also own significantly less land, and earn correspondingly less agricultural income. Lastly, as with the non-collecting rich, the non-grazing rich tend to be more educated and to have smaller families (see Table 38).

Income (Rs.)	No Grazing	Grazing
Income from Agriculture	4014	8983***
Income from Livestock	27	226***
Income from Resources	859	1221
Income from Enterprise	4081	335*
Income from Labor	5787	4274
Income from Financial Transactions	101	-202
Income from Transfers	3800	606*
Total Income	18668	15444

Table 35. Income Characteristics of Rich Households that Do and Do Not Graze Animals

Overall, therefore, non-grazing households appear to have less surplus labor, and prefer to allocate their time to activities that have higher returns compared to not just the activity of grazing livestock, but also to agricultural activities as a whole.

Rich non-grazing households own a lot fewer animals (see Table 36) and obtain fodder from either their own lands or from the market. That is, these households neither graze nor collect fodder from common grazing lands (see Table 37). The fact that they have smaller families suggests that these households choose not to get involved in labor-intensive activities such as livestock rearing.

Asset Value (Rs.)	No Grazing	Grazing
Value of Land Owned	27486	67410**
Value of Farm Capital Owned	3716	8964**
Value of Animals Owned	711	4166***

Table 36. Asset Characteristics of Rich Households that Do and Do Not Graze Animals

	No Grazing	Grazing
Collection from Commons (Rs.)	0	700***
Collection from Private Sources (Rs.)	425	2532***
Market Purchase (Rs.)	222	810***
Time Spent Grazing (Days)	0	49***

Table 37. Fodder Consumption Characteristics of Rich Households that Do and Do Not Graze Animals

	No Grazing	Grazing
Income from In-Village Casual Labor (Rs.)	856	156
Income from Off-Village Casual Labor (Rs.)	768	1575
Income from Private and Public Jobs (Rs.)	4164	2543
Whether Head Attended School	0.55	0.60
Years of Schooling	11.4	7.5***
Adult Equivalent Units	3.5	5.9***

Table 38. Labor Income and Schooling Characteristics of Rich Households that Do and Do Not Graze Animals

8. Conclusions

With the goal of better understanding the relationship between poverty and the common-pool stocks of natural assets, this paper investigates the extent to which rural households depend on common-pool natural resources for their daily livelihood. Previous studies have found that resource dependence—defined as the fraction of total income derived from common-pool resources—strongly decreases with income. Our study finds a more complex relationship.

Firstly, for the subsample of households that use positive amounts of resources, we find that dependence follows a U-shaped relationship with income, declining at first but then increasing. (Relatively) rich households collect much more fuel and construction wood than poor households, and collect much more fodder, even on a per-animal basis. This is true despite the higher land holdings of the rich; provision of these resources from private land is, for most households, evidently not an important substitute for provision from the commons. In fact, in the case of livestock, private assets are complementary instead[34].

Secondly, we find that the probability of being in the subsample of common-pool resource users follows an *inverse* U-shaped relationship with income: the poorest and richest households are less likely to collect resources than those with intermediate incomes. Resource use by the rich is therefore bimodal: either very high or zero. Comparing households in either group, we find that households with zero use tend to be the very richest ones. Moreover, consistent with Jodha's (1986) suggestions as to what factors might influence resource dependence (e.g., availability of surplus labor, access

[34] Largely due to difficulties with pricing water, we have been unable to consider how dependence on water changes with household incomes. Given that one of the main uses of water is irrigation, however, we would expect land to act as a complement to common water resources, which would tend to increase the overall resource dependence of the rich.

to higher-return activities, and access to substitute private assets), rich non-collecting households are found to have relatively smaller families, higher education, more income from public-sector and private-sector jobs, and higher provision of resources from private land holdings.

Thirdly, we find that resource dependence increases at all income levels with an increase in the level of common-pool biomass availability.

Taken together, these results suggest that the quality of natural resources matters to a larger share of the rural population than had previously been believed; common-pool resources contribute a significant fraction of the income not just of the desperately poor, but also of the relatively rich.

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