

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

Urvashi Narain, Shreekant Gupta,  
and Klaas van 't Veld

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Resources for the Future  
1616 P Street, NW  
Washington, D.C. 20036  
Telephone: 202-328-5000  
Fax: 202-939-3460  
Internet: <http://www.rff.org>

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### Abstract\*

Using purpose-collected survey data from 537 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 finds a more complex relationship. First, 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. Second, 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 richest households—zero. Third, 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 been previously 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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## 1. 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. The attempt to answer this question has given rise to a growing literature on poverty-environment interactions (for reviews, see Reardon and Vosti (1995), Duraiappah (1998), Horowitz (1998), and Barbier (forthcoming)).

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).<sup>1</sup> 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<sup>2</sup> households derive only between 1% and 4% of their annual income from the commons.<sup>3</sup> Reddy and Chakravarty (1999), based on data from 232 households in 12 Himalayan villages, similarly find that dependence on resources decreases from 22.78% for the poor to 4.26% for the rich.<sup>4</sup> 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 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.<sup>5</sup> All four studies also examine the relationship between income and the absolute level of resource use,

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<sup>1</sup>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).

<sup>2</sup>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.

<sup>3</sup>Note that in this paper Jodha also refers to data from a larger study, based on 82 villages, to discuss other aspects of the relationship between poverty and natural resources.

<sup>4</sup>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.

<sup>5</sup>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 who 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 multiple criteria identified by villagers as important in assessing households’ socio-economic position.

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.<sup>6</sup> 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 obtain. Reddy and Chakravarty merely note that the poor have less land and conjecture 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 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.<sup>7</sup>

Our study, using purpose-collected data from 537 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 that highlight the limited usefulness of the latter. Furthermore, we are able to bring information on household characteristics to bear to understand why certain trends emerge

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<sup>6</sup>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.

<sup>7</sup>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 estimates of 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*.

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., on 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.<sup>8</sup> The typical high variability of household incomes, both from year to year and across households, makes this a very noisy measure of "true" resource dependence, which in particular fails to fully capture differences between households that are poor in private assets and households that are not. We would argue that all else equal—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 future negative income shocks.<sup>9</sup> 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 the 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 do so 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.<sup>10</sup>

Using these definitions of income and dependence<sup>11</sup> we find that, for the subsample of households that in fact collect any 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.

When 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 construction wood. At the same

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<sup>8</sup>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, too, Jodha finds that poor households are more dependent on commons than the rich.

<sup>9</sup>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.

<sup>10</sup>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.

<sup>11</sup>Hereafter, we omit the qualifier "permanent," treating it as understood.

time, they do not meet significantly more of their consumption through private provision, i.e., collection from trees on their own land, and only part of their higher consumption through higher market purchases.

As for collection of fodder, dependence on which is found to monotonically increase in income, here we find evidence suggesting that the rich prefer stall-feeding 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 to derive a larger share of their income from off-village, as well as private- and public-sector jobs. Again, however, we find that private provision of fodder differs very little between rich and poor; the bulk of the higher demand for fodder by the rich is met from the commons.

Confusingly, when we next 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—the U-shaped relationship between dependence and income for the subsample of 401 collecting households, but 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 537 collecting and non-collecting households combined.

The very different relationship between income and dependence for collecting households and 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., 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 of course 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 construction wood than do poorer households, consumption of wood drops sharply for the very rich, non-collecting households. Although we have no data to confirm this, we conjecture that the latter households substitute away to different, purchased construction materials (e.g., bricks).

Both types of households turn out 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 tend to also be more educated, and (not unrelatedly) to derive

more income from private- or 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 resources. The fact that non-collecting rich households have fewer children suggest 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-skill 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 wood provision.

That said, we find that most of rich non-collecting households do spend time grazing their animals in 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 again consider first the relationship of time spent grazing to 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 to 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 compared to not just 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 true also 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 the 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 acts as a complement. As a result, improvements in the quality of natural resources have the potential of benefiting 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 offers conclusions.

## 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.<sup>12</sup> 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 the men and 11.5% of the women in the district are literate, the life expectancy of an average person is only 51.5 years, and 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 workforce employed in this sector (MPHDR 1998). Furthermore, agriculture in the district is predominantly rainfed. Households in this region usually supplement their incomes through livestock rearing and with various products from the forests—most notably fuel wood, construction wood, tendu (*Diospyros melonoxydon 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 semiarid India, the results of this study plausibly generalize to areas beyond Jhabua.

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<sup>12</sup>Degraded land, in turn, is made up of fallow land, cultivable wasteland, and land not available for cultivation.



### 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.

**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, and continues to monitor, the groundwater level thrice-yearly (pre-monsoon, post-monsoon, and winter). There is little reason to believe that the restricted sample frame leads 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.<sup>13</sup> Furthermore, because each of the micro drainage basins is about 100 km<sup>2</sup>, 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<sup>14</sup> 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 oversampling of BPL and land-rich households.<sup>15</sup> Table 1 shows the actual distribution—determined from the household survey—of land owned by our final sample of 537 households (13 of the initial 550 had to be dropped because of data

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<sup>13</sup>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 in 1973 involved in the selection of these wells.

<sup>14</sup>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.

<sup>15</sup>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.

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	37 (7%)	105 (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.<sup>16</sup> 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 tones per hectares for the sample plots. At the same time two satellite images for October 26 and 29, 2002, obtain from the Indian Remote Sensing Satellite (IRS LISS-III), were used to construct the Normalized Difference Vegetation Index (NDVI)<sup>17</sup> 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, tree, and grass separately (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 regressions 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 the household was then estimates by summing up the volume of biomass that fell within a 5 km radius of the center of the village and 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

<sup>16</sup>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.

<sup>17</sup>The NDVI is equal to the difference in near infrared (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.

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 households’ own labor inputs, however; in this sense, the incomes from these sources are “gross” incomes.<sup>18</sup>

**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 these revenues, as the only significant input used is the household’s own labor. Finally, we added any income from the rental 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 such products as offspring, 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) fuel wood, (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.

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<sup>18</sup>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.

*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 a 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	-1,336	81	437	2,099
Income from Livestock Rearing	-379	-99	20	21
Income from Resource Collection	317	363	495	991
Fuel Wood	75	135	160	474
Construction Wood	2	16	3	145
Fodder	156	148	259	253
Other Resources	83	64	73	119
Income from Household Enterprise	45	134	133	1,346
Income from Wage Employment	603	1,127	2,125	4,936
Income from Financial Transactions	-1,134	-430	-408	-236
Income from Transfers	159	123	163	1,451
Total Current Income	-1,725	1,299	2,965	10,607

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 (ha)	0.35	0.20	0.24	0.35
Value of Land Owned (Rs.)	29,423	14,064	18,276	36,263
Value of Farm Capital (Rs.)	6,981	2,075	2,395	4,755
Value of Livestock (Rs.)	3,127	2,551	2,525	2,651
Asset Disinvestment (Rs.)	68	30	137	-805

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.<sup>19</sup> 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. 1,725 over the course of the survey year (June 2000-May 2001), while the mean household in the top quartile earned Rs. 10,607. 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, wage employment and financial transactions<sup>20</sup> 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 first to the second quartile but increased from the second to the fourth quartile.

Surprisingly, households in the bottom quartile are not asset-poor. As shown in Table 3, these households cultivate as much land as households in the fourth income quartile and more than households in the second and third income 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. Finally, households in the bottom three income quartiles appear to make asset disinvestments, financial as well as physical, to make up for income losses.<sup>21</sup>

<sup>19</sup>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.

<sup>20</sup>Information on financial transactions was the hardest to elicit from households and is likely to be somewhat incomplete.

<sup>21</sup>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.

These findings on asset holdings and asset disinvestment confirm that private 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 equal, households rich in private assets should be considered less dependent on natural resources, since their assets serve as an additional buffer to potential future 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, first consider the simplest case of financial assets. Given an interest rate of  $r\%$ —we use 10% throughout the paper, which is the value-weighted average interest rate on bank deposits and other types of savings reported by all households in the sample<sup>22</sup>—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

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<sup>22</sup>Sensitivity analysis with a higher interest rate, namely 15%, did not change any of the results reported in the paper. However, a lower interest rate, 5%, while giving the same qualitative results, resulted in lower significance for some of the regression coefficients reported in the remainder of the paper. The latter result suggests that information on current income is more noisy compared to that on permanent income.

as follows:<sup>23</sup>

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

where  $q$  is permanent income,  $I_t$  is the return on the assets during the survey year,  $\Delta A_t$  is the net change in asset holdings between  $t$  and  $t+1$ ,  $A_{t+1}$  is the value of the assets at the end of the year<sup>24</sup> (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

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

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

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

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,<sup>25</sup> the permanent income from physical capital is

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

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

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

**5.2. Relationship between Current and Permanent Income.** Table 4 shows that the correlation between current- and permanent-income quartiles is not very high. For example, although

<sup>23</sup>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.

<sup>24</sup>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.

<sup>25</sup>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.

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
Lowest 25%	0.36	0.22	0.20	0.16
25–50%	0.50	0.28	0.18	0.11
50–75%	0.13	0.39	0.35	0.13
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

60% of households that fall into the top permanent-income income quartile also fall into the top current-income quartile, 13%, 11%, and 16% 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.<sup>26</sup>

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
Income from Agriculture	1,515	2,449	3,723	7,959
Income from Livestock Rearing	121	183	220	181
Income from Resource Collection	186	336	524	1,119
Fuel Wood	100	155	208	382
Construction Wood	2	2	40	123
Fodder	23	72	191	529
Other Resources	60	108	85	85
Income from Household Enterprise	51	151	222	1,233
Income from Wage Employment	627	1,473	2,111	4,580
Income from Financial Transactions	-178	-169	-295	-40
Income from Transfers	123	160	262	1,352
Total Permanent Income	2,444	4,583	6,768	16,382

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

**5.3. Descriptive Statistics on Permanent Income.** As shown in Table 5, households in the lowest permanent income quartile earn Rs. 2,444 per capita on average while households in the top income quartile earn Rs. 16,382. 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.

<sup>26</sup>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 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.

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
Income from In-Village Casual Labor	137	284	195	342
Income from Off-Village Casual Labor	436	1,023	1,476	1,306
Income from Private and Public Jobs	53	166	441	2,931
Total Wage Income	627	1,473	2,111	4,580

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

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 70% of their total wage income from such seasonal migration. In contrast, households in the top quartile earned the largest share of total labor income (64%) from regular jobs in the private or public sector and only 29% 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 household 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	21	42	44	239
Transfer Income from Friends	1	3	0	264
Transfer Income from NGOs	2	0	0	27
Transfer Income from State	99	115	217	828
Total Transfer Income	123	160	262	1,352

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. 186 per capita from natural resources (with

the majority of this income coming from fuel wood and other resource collection), while the average household in the top quartile earned Rs. 1,119 per capita (with the majority of this income coming from fodder and fuel wood collection). Consistent with 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%
Fuel Wood	4.4	3.4	2.9	2.8
Construction Wood	0.1	0	0.5	1.0
Fodder	0.9	1.6	2.7	3.6
Other Resources	3.5	2.3	1.3	0.7
All Resources	8.8	7.4	7.5	8.1

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 (401 households in all, dispersed across all 60 villages in the sample)<sup>27</sup> the poorest derive about 11% of their total income from resources. Dependence decreases to 9% for households in the second income quartile, and then increases again to 11% for the third income quartile and to 13% for households in the fourth quartile.<sup>28</sup>

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. For the whole sample fuel wood also accounts for the decrease in dependence at lower incomes, while for the sample of households that collect dependence on fuel wood 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 fuel wood (5.6%) and other resources (4.4%), whereas

<sup>27</sup>Out of our total sample of 537 households, 136 did not collect common property resources, leaving 401 that did.

<sup>28</sup>If we follow Jodha and define dependence on natural resources as the ratio of income from natural resources to income from all other sources excluding natural resources, then dependence for the rich households increases substantially, strengthening the U-shaped relationship between dependence and income.

the high resource dependence of the richest households is mostly due to their high dependence on fodder (5.9%) and again fuel wood (4.6%).

	Permanent Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
Fuel Wood	5.6	4.2	4.1	4.6
Construction Wood	0.1	0.0	0.8	1.7
Fodder	1.1	1.9	3.8	5.9
Other Resources	4.4	2.8	1.8	1.1
All Resources	11.2	9.0	10.5	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.

## 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	-2.02396	1.268615	-1.60	0.116	-4.566321 .518401
lei_tot_sq_c	.1604198	.0797864	2.01	0.049	.0005244 .3203153
rs_bio_c	.1828206	.07217	2.53	0.014	.0381887 .3274525
_cons	10.5765	5.029754	2.10	0.040	.4966496 20.65635

Number of obs = 401  
R-squared = 0.10

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`).<sup>29</sup>

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,

<sup>29</sup>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.

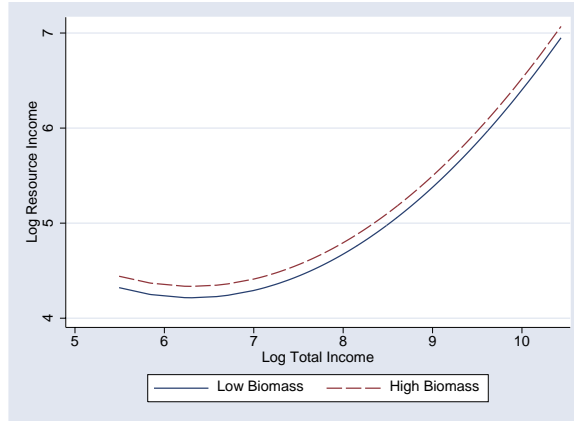


FIGURE 1. Relationship between Income from Resources, Total Income, and Total Biomass for Collecting Households

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.

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 lefthand side variable, is constrained to lie between 0 and 1, we use a two-sided Tobit regression to estimate this relationship.

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	-.5378577	.1638286	-3.28	0.002	-.8661776	-.2095379
lei_tot_sq_c	.0318358	.0099209	3.21	0.002	.0119538	.0517178
rs_bio_c	.0235811	.0106013	2.22	0.030	.0023357	.0448265
_cons	2.34655	.6767354	3.47	0.001	.9903422	3.702758
/lnsigma	-1.844132	.0905069	-20.38	0.000	-2.025512	-1.662753

Number of obs = 401

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

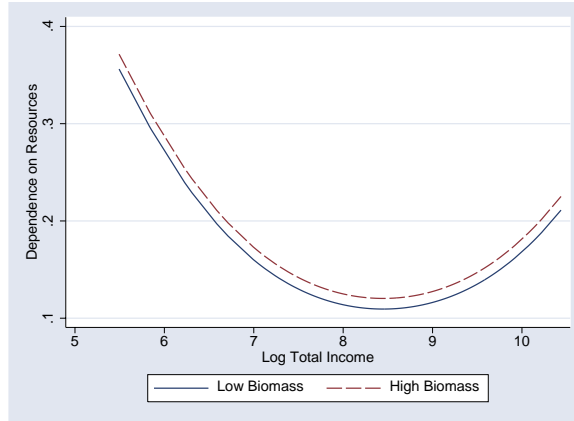


FIGURE 2. Relationship between Dependence on Resources, Total Income, and Total Biomass for Collecting Households

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.<sup>30</sup>

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 examine the relationship between income and dependence on individual resources.

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	-.3118402	.2676525	-1.17	0.249	-.8482279	.2245475
lei_tot_sq_c	.0174604	.0154571	1.13	0.264	-.0135164	.0484372
rs_for_c	.0242235	.0124373	1.95	0.057	-.0007015	.0491485
_cons	1.437912	1.155441	1.24	0.219	-.8776445	3.753468
/lnsigma	-2.22105	.0954046	-23.28	0.000	-2.412245	-2.029855
Number of obs = 265						

TABLE 12. Dependence on Fuel Wood as a Function of Total Income and Total Biomass for Collecting Households.

6.2.1. *Fuel Wood.* As reported in Table 12, in the regression of dependence on fuel wood on income and forest biomass availability per capita (`rs_for_c`), neither the coefficient on income or income square is significant. Dependence on fuel wood, therefore, is constant in income or fuel wood collection from the commons increases in proportion with income. Since, as Table 13 indicates, households meet most of their demand for fuel wood from the commons, consumption of fuel

<sup>30</sup>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.

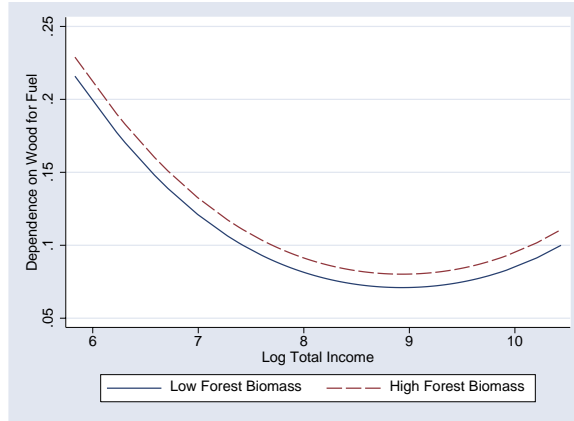


FIGURE 3. Relationship between Dependence on Fuel Wood, Total Income, and Total Biomass for Collecting Households

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
Collection from Commons	206	291	490	977
Sale from Commons	0	0	0	222
Collection from Private Sources	26	59	53	72
Sale from Private Sources	20	35	29	6
Market Purchase	30	11	33	10
Total Consumption	242	326	548	830

TABLE 13. Collection and Consumption of Fuel Wood by Income Quartile For Collecting Households.

wood also appears to increase in proportion with income. Fuel wood for our sample of collecting households is therefore a normal good. These results also indicate that dependence on fuel wood does not explain the high dependence on resources for poor and rich households which in turn results in the U-shaped relationship between income and resource dependence. In the regression the coefficient on timber availability is significant and positive. Dependence is therefore higher at all income levels for households with higher availability of forest biomass.<sup>31</sup>

Interestingly, only households in the fourth income quartile sell any fuel wood from the commons, suggesting that poorer households do not consider collecting fuel wood 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 fuel wood 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.

<sup>31</sup>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.

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	1.182598	.6726578	1.76	0.084	-.1654383	2.530634
lei_tot_sq_c	-.0622374	.0364469	-1.71	0.093	-.1352786	.0108039
rs_for_c	.0079155	.0075306	1.05	0.298	-.0071763	.0230072
_cons	-5.516836	3.084665	-1.79	0.079	-11.69864	.664971
/lnsigma	-1.964365	.2520816	-7.79	0.000	-2.469548	-1.459182

Number of obs = 37

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

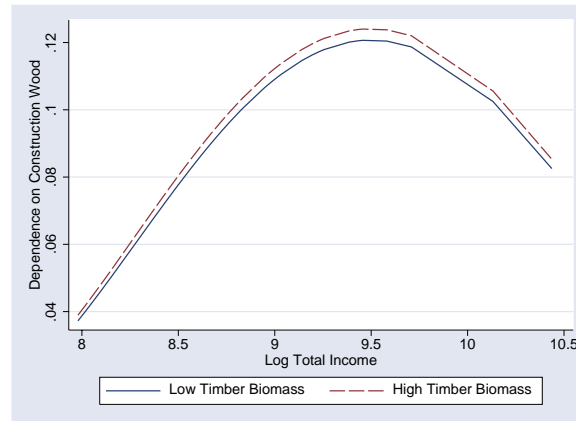


FIGURE 4. Relationship between Dependence on Construction Wood, Total Income, and Total Biomass for Collecting Households

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
Collection from Commons	67	61	406	1420
Sale from Commons	0	0	0	0
Collection from Private Sources	136	1	428	655
Sale from Private Sources	0	0	0	404
Market Purchase	0	14	24	3364
Total Consumption	203	76	858	5035

TABLE 15. Collection and Consumption of Construction Wood by Income Quartile 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. The discrepancy appears to be driven by two outliers: the two richest households in the sample of 37

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	.1066338	.043105	2.47	0.016	.0202494	.1930181
rs_grs_c	6.831779	3.687696	1.85	0.069	-.5585287	14.22209
xxx_grs_tot	-.7357267	.4049162	-1.82	0.075	-1.547197	.0757436
_cons	-.8144824	.3783037	-2.15	0.036	-1.57262	-.056345
/lnsigma	-1.679109	.1296953	-12.95	0.000	-1.939024	-1.419194
-----						
	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	.0840245	.0415964	2.02	0.048	.0006635	.1673854
la_ani_c	-.0789854	.0723033	-1.09	0.279	-.2238844	.0659136
rs_grs_c	1.176499	5.171452	0.23	0.821	-9.187323	11.54032
xxx_grs_tot	-.0682914	.5832452	-0.12	0.907	-1.237141	1.100558
xxx_grs_ani	-.7256408	.3252903	-2.23	0.030	-1.377537	-.0737444
_cons	-.5591435	.3723844	-1.50	0.139	-1.305419	.1871315
/lnsigma	-1.720507	.1479463	-11.63	0.000	-2.016998	-1.424016
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Number of obs = 74						

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

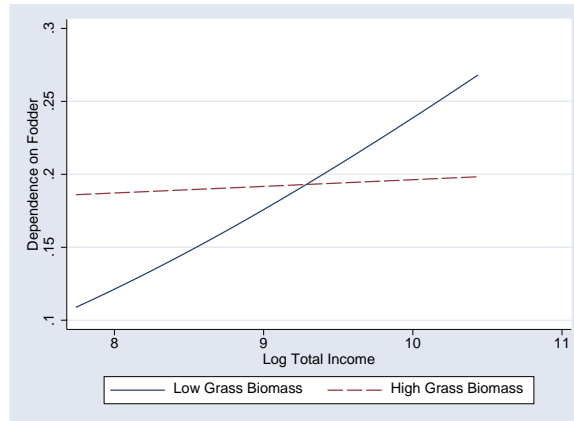


FIGURE 5. Relationship between Dependence on Fodder, Total Income, and Total Biomass for Collecting Households

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 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 as well 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. 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,<sup>32</sup> dependence on fodder increases sharply with income. However, because of the 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.

If the (log of) animal holdings<sup>33</sup> (`la_ani_c`) and an interaction term between it and grass biomass (`xxx_grs_ani`) are included in the regression, however, 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 in the commons.

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 by 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 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, 44 are rich by this definition, and the remaining 30 are poor. Table 17 confirms, first of all, that rich households collect significantly<sup>34</sup> more fodder than poor households, even on a per-animal basis: the value of collection per animal is about Rs. 3,449 for the rich compared to Rs. 861 for the poor. It shows also, however, that poor households spend more time grazing each animal in village commons than do the rich households: on average 91 days per animal, per capita, per year, compared to 70 for the rich.<sup>35</sup> It appears, therefore, that rich households prefer to stall-feed their animals as opposed to grazing them in open pastures. This preference may be explained in part by time constraints,

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<sup>32</sup>Corresponding to the 25th percentile of grass biomass availability in the sample, with high biomass levels corresponding to the 75th percentile.

<sup>33</sup>Total animal holdings are defined as the (unweighted) sum of bullocks, cows, buffalo, donkeys, goats, and sheep owned by the household.

<sup>34</sup>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.

<sup>35</sup>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.

as these rich households have smaller families (see Table 18) as well as higher labor income from off-village casual employment and from private- and public-sector jobs.

	Poor Households	Rich Households
Collection from Commons	861	3449***
Collection from Private Sources	1323	1302
Market Purchase	524	1243**
Days Spent Grazing	91	70

TABLE 17. Fodder Collection Pattern for Rich and Poor Households that Collect Fodder.

	Poor Household	Rich Household
Income from In-Village Casual Labor	281	159
Income from Off-Village Casual Labor	772	1651**
Income from Private and Public Jobs	4	1631**
Whether Head Attended School	0.2	0.5***
Years of Schooling	4.8	5.8
Adult Equivalent Units Per Animal	2.3	1.8

TABLE 18. Income and Asset Characteristics of Rich and Poor Households that Collect Fodder.

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
lei_tot_c	-.423811	.1518375	-2.79	0.007	-.7281001 -.1195219
lei_tot_sq_c	.0234625	.0087537	2.68	0.010	.0059197 .0410053
rs_bio_c	.0017675	.0023925	0.74	0.463	-.0030271 .0065621
_cons	1.928634	.6559906	2.94	0.005	.6139996 3.243269
/lnsigma	-2.757584	.1244031	-22.17	0.000	-3.006894 -2.508275

Number of obs = 303

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

6.2.4. *Other resources.* Resources other than wood and fodder are collected by 303 households in our sample. The regression results reported in Table 19 and illustrated in Figure 6 indicate 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. The results show also that dependence on other resources decreases monotonically with income, indicating perhaps that collecting them is a relatively low-return activity.

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

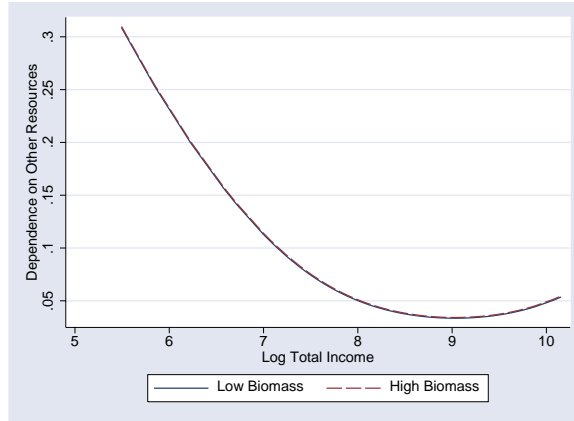


FIGURE 6. Relationship between Dependence on Other Resources, Total Income, and Total Biomass for Collecting Households

and income, they are not dependent on the same resources. The poorest households are particularly dependent on fuel wood and other resources, whereas the richest households are particularly dependent on construction wood and fodder. Factors that appear to underlie this are differences in consumption (the rich consume much more construction wood), asset holdings (the rich have more animals), and 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 turn to examining 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.

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
lei_tot_c	5.579068	2.714163	2.06	0.045	.1397637 11.01837
lei_tot_sq_c	-.3470002	.1648761	-2.10	0.040	-.6774193 -.0165812
rs_bio_c	.3285117	.131142	2.51	0.015	.0656972 .5913262
_cons	-19.04403	11.27612	-1.69	0.097	-41.64188 3.55381
/lnsigma	1.270362	.0513204	24.75	0.000	1.167513 1.37321

Number of obs = 537  
Number of uncensored obs = 401

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 only households that collect (reported in Table 10), the coefficient on income is positive while that on income

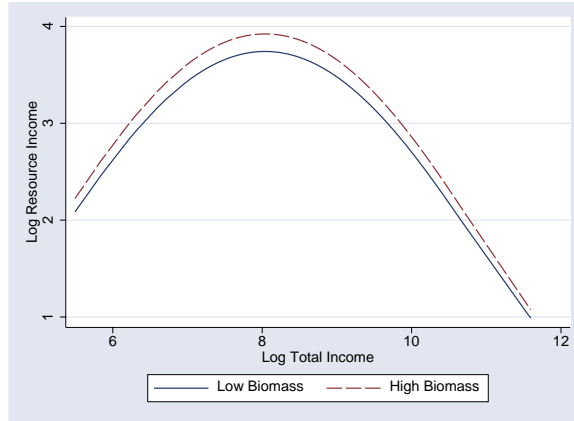


FIGURE 7. Relationship between Use, Biomass, and Total Income for Whole Sample

squared is negative. This suggests that the relationship between resource income and total income may be inversely U-shaped. 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.<sup>36</sup> Resource use does still increase for all income levels in biomass availability when we consider the sample as a whole.

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	-.0321676	.0149504	-2.15	0.036	-.062129	-.0022063
rs_bio_c	.0257892	.0091966	2.80	0.007	.0073587	.0442197
_cons	.3036225	.1283573	2.37	0.022	.0463888	.5608562
/lnsigma	-1.715643	.0925065	-18.55	0.000	-1.90103	-1.530256

Number of obs = 537  
Number of uncensored obs = 401

TABLE 21. Dependence on Resources as a Function of Total Income and Total Biomass 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, indicating 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 relationship, as usual for both low and high levels of biomass. Note that the predicted relationship not only differs from that for the subsample, but also from that suggested by the simple tabulation

<sup>36</sup>As with all plots of dependence, the figure plots predicted actual use rather than predicted latent use (which might be less than 0).

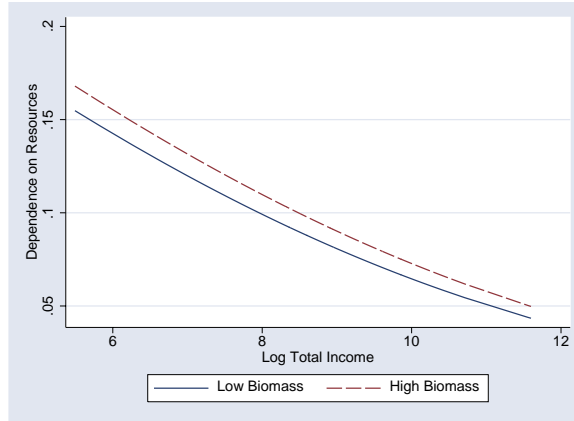


FIGURE 8. Relationship between Dependence, Biomass, and Total Income for the Whole Sample

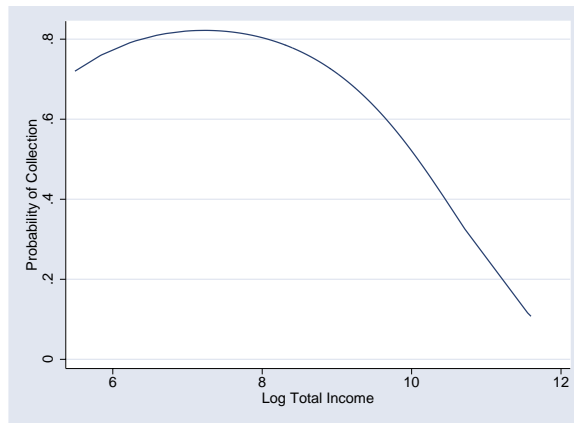


FIGURE 9. Relationship between Probability of Collection and Total Income for the Whole Sample.

reported in Table 8. The tabulation suggested that, even for the sample as a whole, the relationship is U-shaped.

collect	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	1.635368	.7677746	2.13	0.038	.0967132	3.174023
lei_tot_sq_c	-.1131493	.044779	-2.53	0.014	-.2028884	-.0234103
_cons	-4.986098	3.323998	-1.50	0.139	-11.64754	1.675343

Number of obs = 537

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

**6.4. Probability of Collection and Income.** To understand the reason for both 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,

	Permanent Income Quartiles			
	Lowest 25%	25-50%	50-75%	Top 25%
% Collecting	78	84	74	62

TABLE 23. Percentage Collecting Resources by Income Quartiles for the Whole Sample.

the probability of collection is found to increase in income but decrease in income squared. Figure 9 shows that the relationship is inversely U-shaped in 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 than middle-income households, but rich households are much less likely to collect than either.

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, 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, then the fact that the richer of these are less likely to collect pulls both the use and dependence curves down at high levels of income, leading to a 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	3174	100*
Income from Agriculture	11117	5949*
Income from Livestock	212	160
Income from Resources	0	1831***
Income from Enterprise	2676	315**
Income from Labor	4525	4614
Income from Financial Transactions	13	-74
Income from Transfers	1968	959
Total Income	20510	13755**

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

Asset Value (Rs.)	No Collection	Collection
Value of Land Owned	87,432	40,738*
Value of Farm Capital Owned	14,185	5,081*
Value of Animals Owned	3,654	3,211
Value of Bullocks	1,260	1,633
Value of Buffalo	1,241	713
Value of Cows	628	516

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

	No Collection	Collection
Adult Equivalent Units	5.1	5.3
Number of Male Members	2.1	1.8
Number of Female Members	2.1	2.1
Number of Children	0.99	1.5**

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

**6.5. Difference 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 through 30 compare the means of various such characteristics between collecting and non-collecting households in the top income quartile only. Out of 134 such households, living in 40 different villages in our sample, 83 collect resources and 51 do not.

Tables 24 and 25 show how respectively 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 of course 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 and farm capital owned by rich non-collectors is more than twice as high as that of rich collectors.

	No Collection	Collection
Collection from Commons	0	626***
Sale from Commons	0	142
Collection from Private Sources	497	106*
Sale from Private Sources	70	4*
Market Purchase	43	9*
Total Consumption	471	594

TABLE 27. Collection and Consumption of Fuel Wood For Rich Households that Do and Do Not Collect Resources.

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 substitute away to different, purchased fuels (e.g., kerosene) and construction materials (e.g., bricks). There is also some evidence that non-collecting households substitute privately provided fuel wood 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	0	201*
Sale from Commons	0	0
Collection from Private Sources	38	204*
Sale from Private Sources	0	57
Market Purchase	455	509
Total Consumption	493	856

TABLE 28. Collection and Consumption of Construction Wood For Rich Households that Do and Do Not Collect Resources.

	No Collection	Collection
Collection from Commons	0	866***
Collection from Private Sources	2,971	1,541
Market Purchase	844	653
Days Spent Grazing	33	40

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	94	500
Income from Off-Village Casual Labor	999	1,502
Migration (days)	45	59
Income from Private and Public Jobs	3,432	2,612
Whether Head Attended School	0.66	0.58
Years of Schooling	9.2	7.4

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 indicate 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-skill, while rich non-collecting households derive a greater proportion of their earning from regular jobs in the private and the public sector, which tend to relatively high-skill. Heads of non-collecting households are also more likely to have attended school and, conditional on attending, 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 suggest that they have less surplus labor to devote to resource collection. The fact that they are more educated



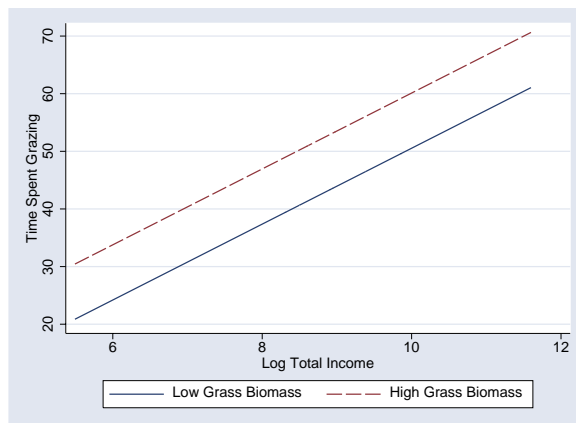


FIGURE 10. Relationship between Time Spent Grazing, Total Income, and Grass Biomass for Grazing Households.

and derive more income from agriculture, enterprise, and relatively high-skill 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 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 in 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	6.583845	2.822632	2.33	0.023	.9271644	12.24053
rs_grs_c	102.4405	24.54518	4.17	0.000	53.25087	151.6302
_cons	-19.8036	24.44799	-0.81	0.421	-68.79848	29.19128
-----						
R-squared	= 0.14					
qa_lbr_lvs_c	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	-.3459569	3.861818	-0.09	0.929	-8.085214	7.3933
la_ani_c	21.13953	5.083437	4.16	0.000	10.95209	31.32696
rs_grs_c	-222.5988	251.3519	-0.89	0.380	-726.3193	281.1217
xxx_grs_tot	27.91214	29.50999	0.95	0.348	-31.2272	87.05149
xxx_grs_ani	74.69409	26.60561	2.81	0.007	21.37526	128.0129
_cons	31.4914	32.71772	0.96	0.340	-34.07637	97.05918
-----						
Number of obs = 439						
R-squared = 0.25						
-----						

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

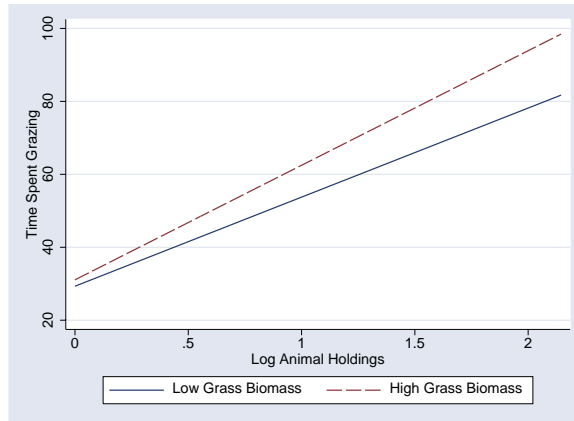


FIGURE 11. Relationship between Time Spent Grazing, Animal Holdings, and Grass Biomass for Grazing Households.

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 income, animal holdings, and grass biomass availability, for only those households that choose to graze their animals (439 out of 537 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. 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 matters to 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.

It is reasonable to assume that the amount of fodder gathered indirectly through open grazing increases in 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 in the number of animals for a given level of grass biomass. This contrast with the second regression of Table 16, which established that the amount of fodder collected *directly* by the household *decreases* in 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 large animal holdings switch from fodder collection to grazing.

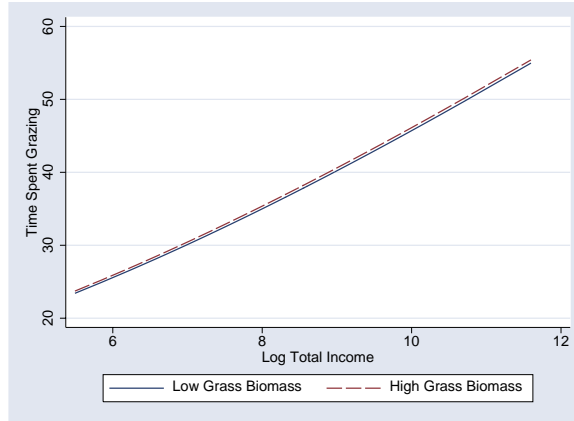


FIGURE 12. Relationship between Time Spent Grazing, Total Income, and Grass Biomass for Whole Sample.

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

	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	6.527703	3.17291	2.06	0.044	.1690482	12.88636
rs_grs_c	5.129211	30.79534	0.17	0.868	-56.58603	66.84445
_cons	-22.56429	27.62036	-0.82	0.417	-77.91672	32.78814
/lnsigma	3.67528	.0597752	61.48	0.000	3.555488	3.795073
	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	-1.165728	3.148497	-0.37	0.713	-7.475458	5.144001
la_ani_c	44.70391	6.820076	6.55	0.000	31.03617	58.37165
rs_grs_c	-140.622	132.935	-1.06	0.295	-407.0297	125.7856
xxx_grs_tot	8.729299	14.54083	0.60	0.551	-20.41118	37.86978
xxx_grs_ani	131.7797	31.984	4.12	0.000	67.68235	195.8771
_cons	22.20892	26.08812	0.85	0.398	-30.07285	74.49069
/lnsigma	3.446486	.0490694	70.24	0.000	3.348149	3.544824

Number of obs = 537

TABLE 32. Time spent Grazing as a Function of Total Income, Animal Holdings, and Biomass for Whole Sample.

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. 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.

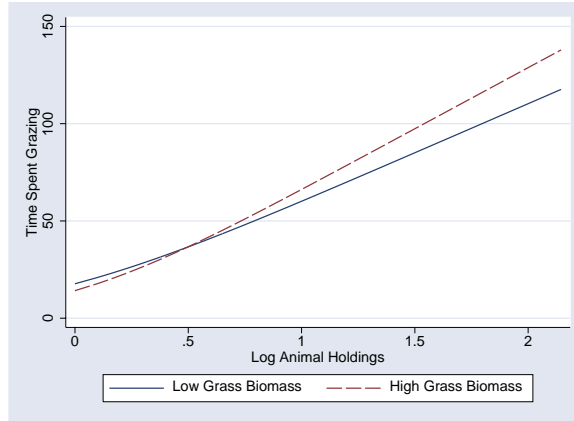


FIGURE 13. Relationship between Time Spent Grazing, Animal Holdings, and Grass Biomass for Whole Sample.

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

graze	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	3.416272	1.322227	2.58	0.012	.7664695	6.066074
lei_tot_sq_c	-.1937691	.0772857	-2.51	0.015	-.3486531	-.0388852
_cons	-14.04421	5.597639	-2.51	0.015	-25.26213	-2.826292
graze	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
lei_tot_c	1.171939	1.338588	0.88	0.385	-1.510651	3.854529
lei_tot_sq_c	-.0717602	.079784	-0.90	0.372	-.231651	.0881305
la_ani_c	6.122887	.5774282	10.60	0.000	4.965695	7.280079
la_ani_sq_c	-2.321883	.3643577	-6.37	0.000	-3.052072	-1.591693
_cons	-5.548326	5.516917	-1.01	0.319	-16.60447	5.507822

Number of obs = 537

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

**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. It should be noted that, 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 466—in fact choose not to graze their animals at

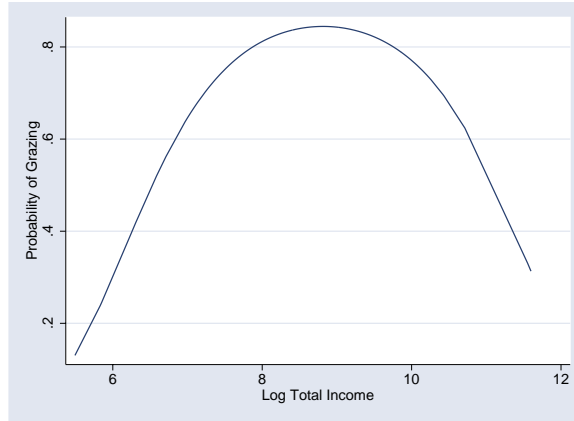


FIGURE 14. Probability of Grazing as a Function of Total Income for Whole Sample.

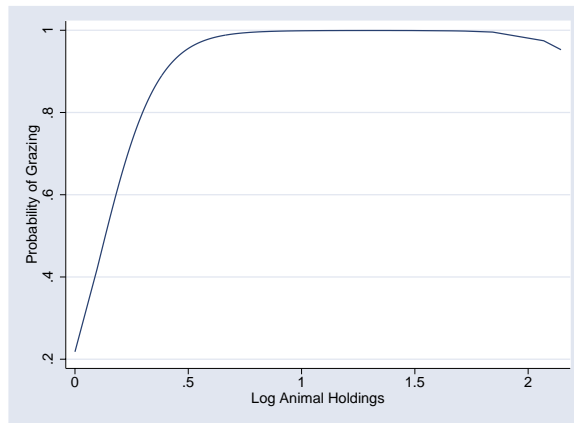


FIGURE 15. Probability of Grazing as a Function of Animal Holdings for Whole Sample.

	Permanent Income Quartiles			
	Lowest 25%	25–50%	50–75%	Top 25%
% Grazing	72	87	89	79
Days Spent Grazing	29	41	46	38

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

all (i.e., to rely entirely on stall-feeding). The binary variable therefore 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 consistent also with the simple tabulation 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 similarly sharp drop in animal holdings, although other factors (not included in the regressions) may also come into play.

**7.4. Difference between Rich Grazers and Non-Grazers.** Just as Tables 24 through 30 compared rich collecting and non-collecting households along various dimensions, Tables 35 through 38 do so for rich grazing and non-grazing households. Out 134 households in the top income quartile, 106 graze their animals and 28 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-skill labor activities—especially enterprise, but also income from private and public jobs (Table 38)—and higher transfer incomes. The difference in total income is much less stark, however, in part because—as expected—rich non-grazing households own significantly less livestock (Table 36) and earn correspondingly less livestock income. The same fact explains also 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).

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.

Income (Rs.)	No Grazing	Grazing
Income from Agriculture	4,056	9,224***
Income from Livestock	30	229***
Income from Resources	833	1,212
Income from Enterprise	3,988	340*
Income from Labor	5,625	4,241
Income from Financial Transactions	388	-179
Income from Transfers	3,659	604*
Total Income	18,579	15,670

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

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). Their having 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	27,585	69,052**
Value of Farm Capital Owned	3,888	10,157**
Value of Animals Owned	714	4,249***

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

	No Grazing	Grazing
Collection from Commons	0	700***
Collection from Private Sources	518	2,609***
Market Purchase	237	887***
Days Spent Grazing	0	50***

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

	No Grazing	Grazing
Income from In-Village Casual Labor	878	168
Income from Off-Village Casual Labor	739	1,490
Income from Private and Public Jobs	4,008	2,582
Whether Head Attended School	0.57	0.63
Years of Schooling	10.8	7.4***
Adult Equivalent Units	3.6	5.8***

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.

First, for the subsample of households using 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 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 act as a complement instead.<sup>37</sup>

<sup>37</sup>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 for 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.

Second, 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 (1996) suggestions as to what factors might influence resource dependence—availability of surplus labor, access 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- and private-sector jobs, and higher provision of resources from private land holdings.

Third, 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 suggests that the quality of natural resources matters to a larger share of the rural population than had been previously 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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