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FOREST DEGRADATION IN THE HIMALAYAS: DETERMINANTS AND POLICY OPTIONS

JEAN-MARIE BALAND, PRANAB BARDHAN,
SANGHAMITRA DAS & DILIP MOOKHERJEE

FACULTÉS UNIVERSITAIRES NOTRE-DAME DE LA PAIX · NAMUR ·

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Forest Degradation in the Himalayas: Determinants and Policy Options

Jean-Marie Baland (CRED, Namur), Pranab Bardhan (University of California, Berkeley), Sanghamitra Das (ISI, Delhi) and Dilip Mookherjee (Boston University)[1]

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This paper provides an overview of a decade-long project on forest degradation in the Indian and Nepalese Himalayas. It is based on LSMS data for Nepal and field work in Indian states of Uttaranchal and Himachal Pradesh comprising sample surveys of forests, households and village communities, besides commissioned anthropological studies for select villages. The purpose was to ascertain the nature and magnitude of deforestation and degradation from ground-level forest measurements, its implications for living standards of local communities, the contribution of different factors commonly alleged such as local poverty, inequality, economic growth, demographic changes, property rights and lack of collective action by local communities. Principal findings, shortcomings and questions for future research are discussed.

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Deforestation and forest degradation in the Himalayas are a major concern for social scientists and policy makers because of the large common property externalities involved at both the global and the local levels. At the global level, the Himalayan range is one of the most unstable and fragile mountain areas in the world (Ives and Messerly, 1989). Deforestation tends to accentuate the disastrous consequences of earthquakes, and is a significant contributing factor to landslides and flooding. This has a serious impact on the equilibrium of the Ganges and Brahmaputra river basins, and heightens the frequency of flooding in Bangladesh (Metz, 1991). More generally, deforestation speeds up global warming and destruction of the ozone layer.

At a more local level, the alpine zone of the Himalayas is home to populations who rely mainly on agriculture and livestock rearing for their livelihood. Their livelihoods rely strongly on the forests adjoining their villages. Firewood, timber, fodder and leaf-litter for livestock are collected from these forests. The forests are also used for grazing livestock. Environmental degradation reduces the amount of available resource and increases the time required for their collection. A number of studies have argued that these losses adversely affect the poor in a number of ways, e.g., health, nutrition and child education (see, e.g., Kumar and Hotchkiss, 1988, Cooke, 1998, Amacher *et al*, 2001).

Our project which was initiated in the late 1990s had a number of objectives. The first was to empirically assess the extent and the nature of deforestation or forest degradation in the Himalayas, using ground-level forest ecology surveys. The second objective was to investigate the role of different underlying causes commonly alleged by different groups of academic researchers, policymakers and environmental groups. These include local poverty, inequality and its deleterious effects on local collective action, economic growth and commercialization pressures, demographic changes comprising rapid population growth, household fragmentation and migratory patterns, property rights over forests and ineffective management of state-owned forests. We also sought to measure effects on standards of living of rural communities living near the forests, identify suitable policy options and estimate their effectiveness.

The primary hypotheses concerning factors driving environmental degradation in developing countries can be roughly classified as follows. At one extreme is the Poverty-Environment Hypothesis, originally proposed by the 1987 United Nations Brundtland Commission, asserting that poverty is the root cause of environmental problems, as degradation arises owing to exploitation of common property resources particularly by the poor.[2] According to this view, solutions to environmental problems require first and foremost reduction in local poverty, either via economic growth or other state-initiated anti-poverty programs. At another extreme is the view that environmental degradation owes to economic growth which raises the demand for environmental resources in tandem with private goods (e.g., views expressed in the media, 2006 Summit Report of the World Economic Forum, or World Bank reports on deforestation in India).[3] An intermediate hypothesis referred to as the `Environmental Kuznets Curve', is that economic growth may initially aggravate environmental problems in poor countries at early stages of development, but will eventually ease them once the level of per capita income passes a threshold.[4]

Other viewpoints stress the importance of local institutions such as monitoring systems and community property rights.[5] Some argue that deforestation in the past owed primarily to poor control and monitoring systems: once local communities are assigned control they will be successful in regulating environmental pressures, implying there is not much role for external state interventions. Others argue that local collective action may be undermined by social and economic inequality within neighboring communities.

These hypotheses present different perspectives on the environmental consequences of development, and the role of policy. Yet there is remarkably little systematic micro-empirical evidence on their validity. Efforts to test these hypotheses have been cast mainly on the basis of macro cross-country regressions. There are only a handful of recent efforts to use micro evidence concerning behavior of households and

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[2] Barbier (1997), Duraiappah (1998), Jalal (1993), Lele (1991), Lopez (1998), Maler (1998)).
[3] See *Economist* magazine, `No Economic Fire Without Smoke', July 8 2004, Books and Arts section; www.weforum.org/pdf/summitreports/am2006/emergence.htm, and World Bank (2000).
[4] Barbier (1997b), Grossman and Krueger (1995), Yandle, Vijayaraghavan and Bhattarai (2002).
[5] Baland and Platteau (1996), Bardhan (2005), Bardhan and Dayton-Johnson (1997), Jodha (2001), Somanathan (1991) and Varughese (2000).

local institutions governing use of environmental resources (Chaudhuri and Pfaff (2003), Foster and Rosenzweig (2003), Somanathan, Prabhakar and Mehta (2009)).

Accordingly we started by using household-level surveys (with World Bank Living Standards Surveys) in Nepal to address these questions. These household level surveys were not designed to address detailed questions concerning deforestation. We therefore subsequently conducted surveys of forests, village communities and households in two northern Indian states in the same mid-Himalayan region between 2000-03. Anthropological surveys in six villages in the sample were also commissioned, in order to test and/or corroborate our empirical findings. Resource and time limitations necessitated our relying on a single cross-section round of surveys, with limited use of recall data to estimate historical patterns of deforestation. This imposes inevitable restrictions on the econometric analysis and the nature of reliable inferences that can be drawn.

Yet we believe the data provides useful information on a number of dimensions. This paper provides an overview of the main findings so far. We first describe in Section 1 what we learnt regarding pressure on the Indian Himalayan forests on the basis of our forest ecology surveys. As we shall see, the key problem appears to be forest degradation owing to firewood and fodder collected by neighboring households, rather than deforestation. Local collective action constraining forest use is conspicuous by its absence, implying that self-interested behaviour of households drives firewood and fodder collection. Section 2 thereafter describes our findings concerning determinants of household firewood collection activities. Section 3 focuses on community property rights, where we assess the performance of the differing regimes of property management in Uttaranchal. Section 4 concludes.

1. Degradation of the Himalayan Forests

1.1 The India survey

Our analysis is based on household, community and forest ecology surveys of a random sample of 165 villages divided equally between Himachal Pradesh and Uttaranchal, carried out by our field investigators between 2000-2003. On the basis of census data, villages were stratified on the basis of altitude, population and distance to the nearest town. Villages were then selected randomly within each stratum. A random sample of 20 households was selected in each village, on the basis of a stratification procedure combining landholding and caste-distribution in the village.

Three sets of questionnaires were used to conduct surveys in each village: (a) a household questionnaire dealt with the socio-economic structure of the household and its dependence on forests; (b) a village questionnaire was designed to secure information on a host of village level characteristics such as demographic size, access to physical and social infrastructure, the market environment, and institutions of local governance; (c) an ecology questionnaire intended to gather quantitative and qualitative evidence on the condition of the forest stock accessed by the villagers.

The forest surveys were carried out by trained ecologists who first identified local forest zones accessed by each village in the sample, which were mapped by interacting with the villagers. Random transects (100 meters in length) were laid in each forest area and measurements were recorded at three equidistant plots (of 5.63 meters radius) on the transect to record the species composition, canopy cover , basal area, heights and girths of trees above 3 meters in height as well as regeneration characteristics. Qualitative assessment of grazing, lopping, leaf-litter accumulation, timber extraction and evidence on natural calamities such as fire and snowfall damage to trees was also recorded at each plot in terms of a predetermined qualitative scale. We collected detailed information on 619 forests by taking measures in 3512 forest plots (as the number of transects varied with the size of the forest). The second part of the ecology surveys interviewed 3 to 4 members of each village with regard to their perceptions of changes in forest stock over the past quarter century and the nature of institutions governing access and use of the forest.

In the context of Nepal we utilized only the World Bank Living Standard Measurement Surveys carried out in 1995-6 and 2002-3. While these surveys contain very little information on forests and village ecology, they have detailed information at the household level, particularly relative to household consumption, income and firewood collection. We will also, when possible, compare the results for Nepal and India.

1.2 Measuring Himalayan Forest Degradation

The few quantitative studies available are based on satellite imagery and indicate substantial degradation of the Himalayan forest over the last decades. Prabhakar *et al.* (2006) estimate that 61%[6] of forests in two districts of Uttarankhand are severely deteriorated (with crown cover of under 40%). This observation suggests that the present trend differs substantially from past developments, which were characterised more by deforestation, i.e. a decline of forest area. Myers (1986) calculates for example that, in Nepal between 1947 and 1980, forest cover of national territory dropped from 57% to 23%. By contrast, Foster and Rosenzweig (2003) find that, over the whole Indian territory, the proportion of land covered by forests has increased significantly over the past three decades. This study is however based on low definition satellite imagery which does not allow for a very precise estimate of the quality of the forest. It indicates that land devoted to forests has increased, but the implications for the forest biomass are unclear.

In our own survey, we used physical measurements taken directly in the forests, rather than rely on aerial satellite images. Our view is that important dimensions of forest quality can only be assessed by ground-level ecology studies. Various measures have been devised by forest ecologists for assessing the state of a forest. The conventional forest management indicators measure the available tree stock. These include canopy cover (the amount of ground area covered by the canopy through which direct light passes),[7] which measures the density of foliage, and basal area (the total area covered by the cross-sectional area of tree trunks per hectare), which measures the density of standing trees per hectare. The latter measure depends on tree-felling for timber by villagers. Another set of measures captures, for a given stock of trees, the quality and the state of the standing trees. These measures, which include lopping (the proportion of a tree trunk that has been lopped) reflect another type of pressure on the forests coming from firewood and fodder collections. At a stationary equilibrium, these various measures should be correlated, with residual variations being explained by factors such as the type of soil, natural hazards, exposure to light or tree species. The problem however stems

[6] The 90% confidence interval is equal to 48-73%.
[7] This is, in fact, a similar measure to the *crown cover* indicator used by Prabhakar *et al.* (2006), but as seen from ground level, rather than an aerial view.

from the fact that, when fodder and firewood collections increase while timber felling remains constant, the basal area does not correctly reflect forest degradation, at least in the short run. The other measures are much more sensitive to these changes.[8]

Table 1 below shows the mean values and the correlations obtained between these variables. We have also included the firewood collection time, which measures one of the direct impacts of forest degradation on households. Here, collection time corresponds to total collection time, which includes the time it takes to walk to the forest.

	Canopy cover (%)	Basal area (m^2/ha)	Lopping (%)	Collection time (hr)
Canopy cover (%)	1.00			
Basal area (m^2/ha)	0.32	1.00		
Lopping (%)	-0.59	-0.21	1.00	
Collection time (hr)	0.06	0.13	-0.02	1.00
Median (standard errors)	37.5 (11.1)	41.3 (24.6)	67.1 (13.2)	4 (1.2)

Table 1: Correlation Coefficients Between Measures of Forest Quality in India [9]
Source: Baland *et al*., 2008b.

This table invites three comments. First, the correlation between the measures is weak, which justifies using all of them to obtain a correct evaluation. Secondly, there is little correlation between collection time and the other measures. The low correlation is partly explained by the fact that collection times are not a good measure of forest degradation within a village. Indeed, as villagers choose their collecting places on the basis of the time they expect to take, we expect collection times to show little variance between the

[8] In Baland *et al* (2008), we also measured the volume of wood per hectare (basal volume), which is another conventional measure of biomass and regeneration capacity (number of saplings above a height of 0.5 metre per hectare), which declines in the case of illegal felling or frequent grazing. Further measures of biological diversity or quality of tree species could be included. However the main issue here is more the quantity of available wood, which explains our choice of the aforementioned measures.

[9] This table is based on the sub-sample of the forests in Uttarakhand. A similar picture emerges when using the Himachal forests.

different types of forests. In the absence of particular restrictions, collection times across forests within a village should be equalized, and are therefore independent of the degree of degradation of a particular forest. The relevant comparisons should therefore be one comparing forests across different villages, or collection time within a village across time. The relationship between the degree of the forest degradation and the time spent by the villagers on firewood collection is particularly important when asking the question of the impact of degradation on the villagers' behaviour, and we return to this issue below.

Finally, the median values of canopy cover and lopping are alarmingly low, indicating that forests are severely degraded. By comparison, the natural thresholds indicating a completely non-degraded forest have been estimated around 80% for canopy cover, 40 m^2/ha for the basal area and 15% for lopping (Thadani, 1999). We illustrate the distribution observed for each of these measures in Figures 1 to 3 below. We also use a vertical broken straight line to show the level corresponding to a ”severely degraded” state of the forest (Thadani, 1999).

More than half of the forests evidence a severely degraded canopy cover (less than 40%) and the extent of lopping exceeds two-thirds of tree height. On the other hand, as shown in Figure 3, the tree biomass, measured by the basal area, shows much less deterioration. This means that most of the degradation is linked to excessive short-run exploitation, which is not yet visible in terms of a reduction in the volume of standing wood in the forest. In other words, even though the quantity of trees is satisfactory, they are in a particularly poor state: most of their branches have been lopped or torn off and their canopy density is much too low. The unhealthy quality of trees threatens their growth potential and their resistance to natural calamities (frost, drought…). It thus drastically reduces the forest's capacities for future biomass production.

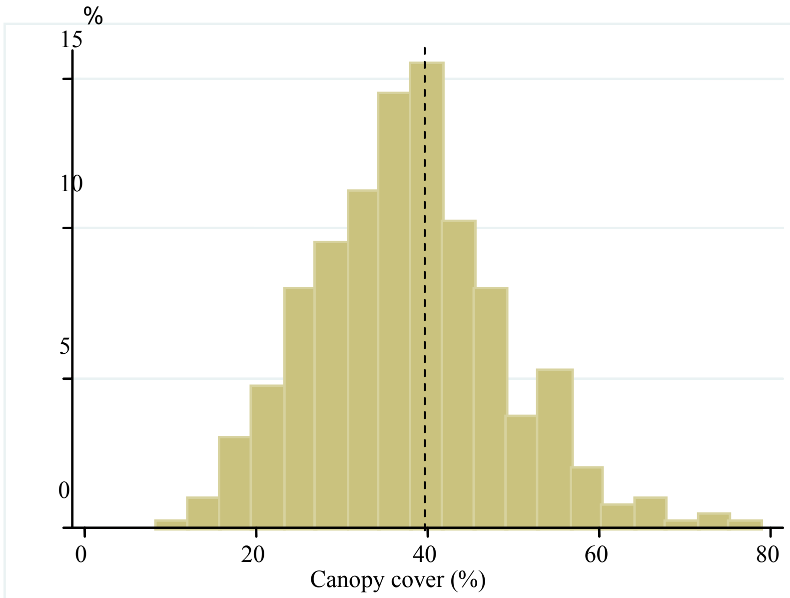

Figure 1: Percentage distribution of forests based on their canopy cover (Indian Himalayas, 2002-3)

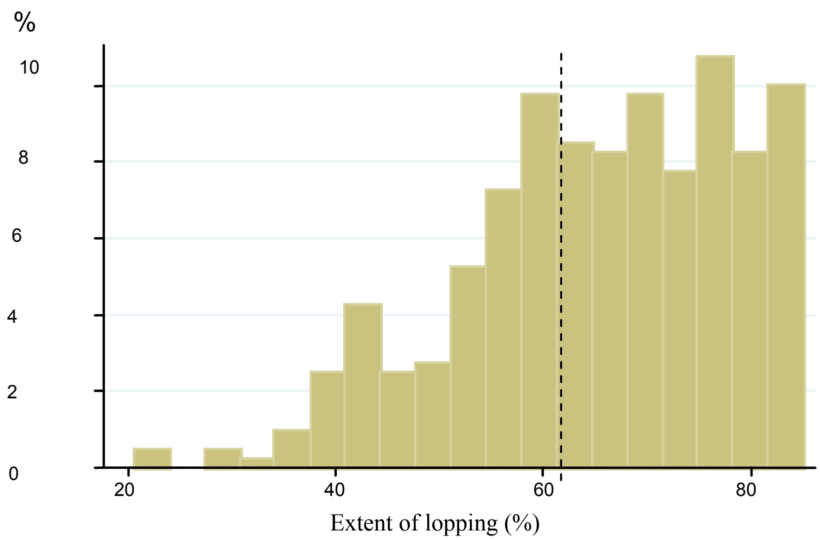

Figure 2: Percentage distribution of forests based on the extent of lopping (Indian Himalayas, 2002-3)

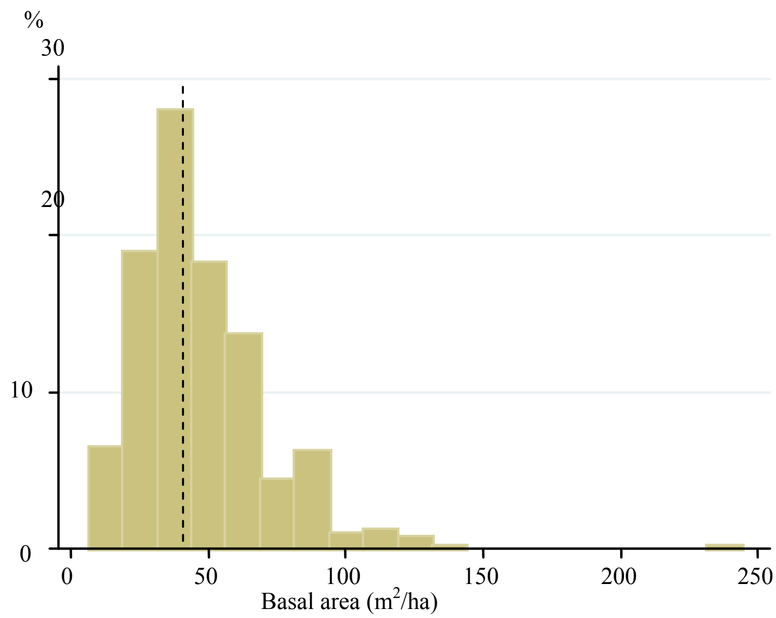

Figure 3: Percentage distribution of forests based on basal area (m^2/ha) (Indian Himalayas, 2002-3)

The household surveys conducted confirm these trends. Over the last 25 years, the average firewood collection time increased by 60% (from 2.36 to 3.84 hours per firewood bundle), whereas distance to the forest increased by only 10% (from 2.06 to 2.31 kilometres). These differing trends suggest that the cause of increased collection time is not so much the conversion of forest areas into agricultural land or pastureland as the degradation of forest quality.[10] More than 80% of the village respondents said they felt that forest quality was in decline. Forest degradation rather than deforestation thus seems to characterise current changes in the Himalayan forest.

1.3 Proximate Causes of Himalayan Forest Degradation

We thus set about examining the causes of this degradation. These can be natural, such as fire- or snowfall-related damage, or anthropogenic. Among the man-related causes, a distinction should be made between those linked to the use of firewood, fodder

[10] The household surveys show that the level of clearance for agricultural purposes is relatively negligible. Moreover, clearance mostly involves non-forested commons (60%). Clearance of forested areas only concerns 5% of cases.

collection and grazing, and those relating to tree-felling for commercial purposes or to timber removal. Table 2 illustrates the relative importance of these causes in each of the forest plots visited.[11] Although all the measures are not strictly comparable, anthropogenic pressures, particularly firewood collection, play a crucial role in this forest degradation.

	Percent of plots in each category (n = 3512)	
Type of degradation (within a plot)	Low impact %	High impact %
Grazing: low if the only sign of interference is a livestock trail	30	70
Lopping : low if lopping is less than 30%	20	80
Wood-cutting: low if less than 3 tree stumps from wood-cutting	57	43
Forest fires: low if less than 3 tree stumps from burning	62	38
Snowfall: low if less than 3 tree stumps ripped by snow	81	19

Table 2: Extent of Degradation of Forest Lots According to Each Possible Cause (India 2002-3)

It is somewhat difficult to obtain reliable data on timber removal, chiefly because this activity is strictly controlled and commercial exploitation is mostly forbidden. This said, our household surveys show one tree equivalent of timber is used by a household every five years for construction purposes. Assuming an average three-ton weight per tree, and an average of 80 households per village, this represents 48 tons of timber per year per village. This compares with a little over 450 tons of firewood per year per village. In terms of biomass, timber removal for household usage accounts for scarcely 10% of the total mass of wood removed from the forest. Lopping for fodder and particularly for firewood is thus the foremost cause of forest degradation.

[11] The size of each plot is equal to 100 m^2.

Local Collective Action Constraining Forest Use

A sample of four local inhabitants in each village was asked to provide oral histories of local forests on the basis of a structured questionnaire. A large majority of them (88%) agreed that there was a general sense in their villages that the forest stock was depleting. Yet only 45% reported that there was any alarm or concern regarding this in their communities. Only in a handful of cases did they report that concrete steps had been taken to arrest the process.[12] This was corroborated in the more detailed anthropological studies of select villages.

Could the failure to act collectively to arrest the deforestation process more widely reflect lack of knowledge of appropriate forest management practices? This appears unlikely as villagers seemed well aware of methods of ensuring sustainable forests prescribed by the forest department (collection of dry wood, rotational methods of lopping) but these were restricted to their own private tree holdings and to sacred groves. The collective failure to arrest forest degradation could neither be explained by a collective failure to organize collective action in the village. As a matter of fact, there are numerous instances of collective action in other areas relevant to current livelihoods, such as agriculture and credit, besides women's groups, youth groups, temple committees etc.

Spontaneous collective action with respect to forests therefore seems basically absent. In many villages, however, some of the village forest is managed by a formal forest committee (Van Panchayats, eco-vikas, forest management committees). These are more widespread in Uttaranchal where 45 out of 83 villages had a van panchayat. However, the actual area under the control of these formal village committees remains limited (according to Sarkar (2008), Van Panchayat forests represent 11% of the total forest area in Uttaranchal). The experience of these committees is described as mixed, with some committees functioning effectively and succeeding in protecting the part of the

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[12] In a few villages in Uttaranchal some un-demarcated state forests were reported to have been closed for regeneration. Village inhabitants of Rogi village in Kinnaur district and Gojra in Kullu district of Himachal, closed some local forest patches due to severe threat of landslides that has damaged their fields in the past.

forest under their command. We provide a more systematic analysis of this question in section 3 below.

2. Analyzing Household Demand for Firewood

2.1 Modelling Household Choices

At the beginning of this project we thought that understanding patterns of collective action would be important, and how it interacts with the state of the common property resource as well as with a number of village characteristics, such as leadership and inequality. But with the community surveys and anthropological evidence indicating virtual absence of spontaneous collective action, as well as extremely weak control over firewood use in state forests, it became evident that we needed to model household collections as resulting from self-interested household choices, unconstrained by social norms or penalties for collections. The only relevant costs of collecting firewood and fodder were the opportunity costs of the time spent in these activities. Hence our analytical efforts shifted from modelling collective action in villages to private household production-cum-consumption models where production, energy and household consumption activities are jointly determined.

The household surveys showed that firewood continues to be the main source of household energy in the Himalayas. In the zone under study, firewood is used for cooking energy in summer by 90% of households, and gas by 9%. For cooking and heating in winter, firewood is used by 99% of households (Baland *et al*., 2007a). In Nepal, according to 1995-6 LSMS, villages use firewood as the prime source of energy, when it is available: 82% of households in 1995-6 and 75% in 2002-3. The second source of energy used was gas (in 2002-3) (Baland *et al.,* 2009).

In most villages there are no markets for firewood at the village level, though some marginal amounts are commercialized at the nearby market centres. This implies that, for a typical villager, the collection and the production of firewood cannot be separated. Going back to our initial question as to what extent income growth is related to forest degradation in this region, there are two effects at play here. The first is the direct income effect, which makes households wealthier, and increases their consumption of goods and thereof energy, at a constant cost. (The direct income effect can nonetheless be negative if firewood is considered as an inferior, less prestigious or more polluting source of energy.) The second is the substitution effect: insofar as firewood is mainly collected by households, wealthier households have a higher opportunity cost of time spent collecting it, which makes the firewood more expensive. The substitution effect is clearly negative. The net effect is ambiguous and depends on the respective strengths of the income effect and the substitution effect.

From an econometric point of view, since the economic cost of firewood cannot be separated from other household characteristics, incomes or consumption, the conventional tools of demand analysis that assume exogeneity of income, consumption and prices are inapplicable.[13] In most of the existing literature, there are no attempts to estimate wealth and substitution effects associated with increases in income (or the underlying productive assets). Given the lack of longitudinal data, we examine cross-sectional variations in household firewood collections with ownership of different assets. Our analysis addresses a number of methodological problems associated with endogeneity of income, measurement error, omitted variables and endogenous censoring.

The most important problem is endogeneity of income or consumption, the most commonly used measures of household living standards. There are many possible unobserved household traits that affect both consumption and firewood collection that could bias estimated Engel elasticities. In addition, both income and consumption are prone to significant measurement errors, especially in a rural society dominated by farming and livestock related occupations. Reliable instruments for income and consumption that do not affect firewood collections are rarely available. We proceed on the premise that endogeneity and measurement error problems are less acute for underlying household assets (land, livestock, household size, education etc.) than income or consumption. Based on a model of household decision-making concerning labor supply, fuel choice and consumption for a given composition of assets owned, we develop two estimation strategies. The first (called the semi-structural form (SS) approach) aggregates stocks of different assets into a single scalar measure of wealth

[13] As discussed further in Baland et al (2009), there are few rigorous micro-econometric studies on the determinants of fuelwood demand at the household level, with some notable exceptions (e.g., Pitt (1985), Foster and Rosenzweig (2003), Chaudhuri and Pfaff (20034)).

(called 'potential income'). For this purpose we estimate a household production function, following the approach of Jacoby (1993) to overcome problems with endogeneity of labor supply. Apart from allowing us to estimate household potential income as the measure of wealth, this yields an estimate of household shadow wages which can be used to value the opportunity cost of time spent collecting firewood. At the second step these are used as measures of household wealth and collection cost (interacted with reported firewood collection times) used to predict firewood collections.

The second estimation strategy (we call the reduced form (RF) approach) relates firewood collection directly to the entire vector of household assets, and their interaction with collection times. While the results of this approach are more complex and harder to interpret than the SS results, they are more reliable owing to avoidance of errors in estimating potential income and shadow wages. Moreover, it avoids the assumption implicit in the aggregation procedure underlying the SS approach that the wealth effects of each asset are proportional to their respective effects on household income. Wealth effects could differ from income effects in a heterogenous fashion if different assets are associated with distinct occupations, locations of work, or networks of coworkers, which affect awareness of household members concerning health effects of firewood vis-a-vis alternate fuels, or accessibility to the latter.

Other econometric issues pertain to omitted variables, functional form and endogenous censoring. Geography or climate variations may jointly affect firewood availability, asset ownership and living standards. We control for such village-specific characteristics with village fixed effects, effectively focusing on intra-village variations of firewood collections with household wealth. This also controls for factors such as inequality or social norms that have been argued to be important determinants of common property resources use. We control for various other household characteristics available in the LSMS data, such as household demographics.

Problems that we cannot address owing to the nature of the data include the following. The amount of firewood collected is measured in terms of the number of 'bharis' or headloads that the household report collecting. As the size of a headload varies across individuals, this introduces a potential bias. It is possible that richer households are better fed tend to carry larger bharis, resulting in an underestimate of the impact of living standards on actual firewood collection. Additionally, households confronted with longer walking times carry lighter or smaller headloads. The impact of collection time on the amount of firewood taken may thus be under-estimated. Collection time is also based on individual reporting by the household, and may thus vary with various characteristics. To partially address this problem, we compute the average of individual collection times at the village level, and use the latter as a more `objective' measure of collection time. The other advantage of this is that this measure can also be used for villagers that do not collect firewood. This procedure is valid as long as villages are not too dispersed so that all villagers face the same distance to the forests.

Other problems arise from our assumption that all household members are identical with regard to their skills and are thus perfect substitutes in production. In particular, it implies that all members face the same shadow wage in collecting firewood, and share collection tasks equally. This ignores the possibility of specialization of tasks within the household, with resulting disparities in shadow wages across different members.

The hypotheses discussed in the Introduction are all based on a specific assumption as to the predominance that one of the effects has over the other. For example, the environmental Kuznets curve implies that the income effect dominates the substitution effect at low levels of income. Unfortunately, rigorous studies separating out these effects are few and far between. Many studies suffer from major methodological weaknesses, discussed in more detail in Baland *et al*. (2009). These shortcomings range from questions of variables of interest (as, for example, firewood collection time, the quantity of wood consumed or the opportunity cost of time) through to questions of comparing incomparable situations (linked to biases due to omitted variables), on the basis of which it is impossible to deduce a causality relationship. For example, if a wealthier village, close to an urban centre, is compared to a poorer, isolated village surrounded by forest, a negative relationship between firewood consumption and income might be observed. Yet this negative relationship obviously does not imply that a general increase in income will reduce consumption of firewood. The opportunity of a specific economic policy measure can thus not be assessed on the basis of this simple comparison.

Among the methodologically rigorous studies, Chaudhury and Pfaff (2003) use a large sample of households in Pakistan to evidence a clear transition from traditional to modern fuels as per capita income rises. A point of interest, however, is that this transition happens mainly in urban areas, where substitutes to firewood are more readily available. Foster and Rosenzweig (2003) find a small (but statistically significant) negative effect between firewood consumption and income in a large household sample of rural households in India. However, the Himalayan village context is different, mainly due to the easy access to firewood, the higher average level of poverty and the lesser availability of substitute sources of energy.

2.2 Firewood Engel Curves

We first describe the relationship between income and firewood consumption in Nepal and the Indian Himalayas (Baland *et al.,* (2007a, 2009)[14]) using simple Engel curves. These show the relationship between the amount of firewood collected compared to the village average (in the number of standard deviations), and household income compared to the village average (in the number of standard deviations, income being measured by consumption expenditures). In this way, we actually compare the amount of firewood collected by different households within the same village (that is to say with respect to the village average) non-parametrically, at the intra-village level with no other

[14] We use collection and consumption interchangeably, given the low amounts involved in commercial exploitation.

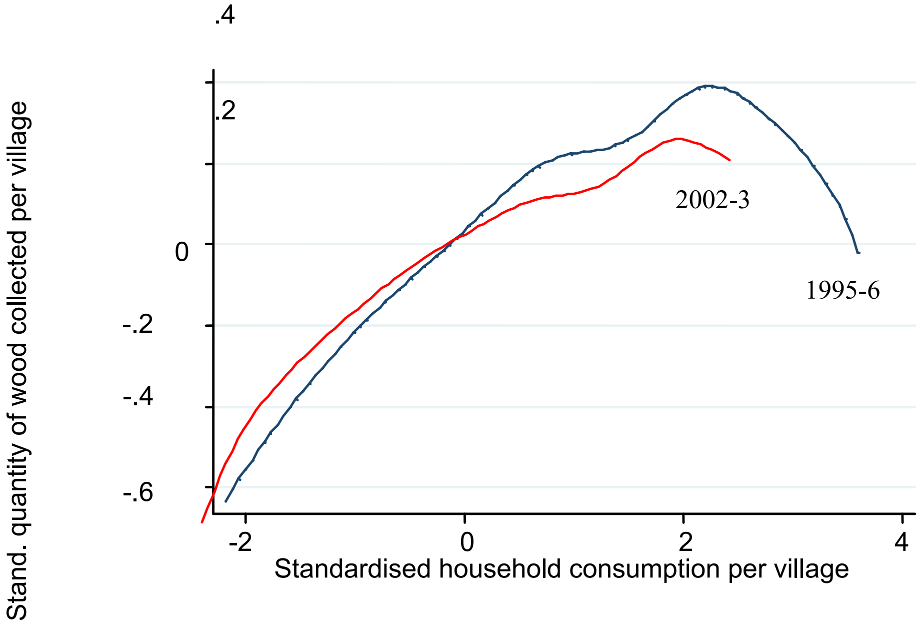

Figure 4: Engel curve for firewood collection in Nepal in 1995-6 and 2002-3

Source: Baland *et al.* (2009)

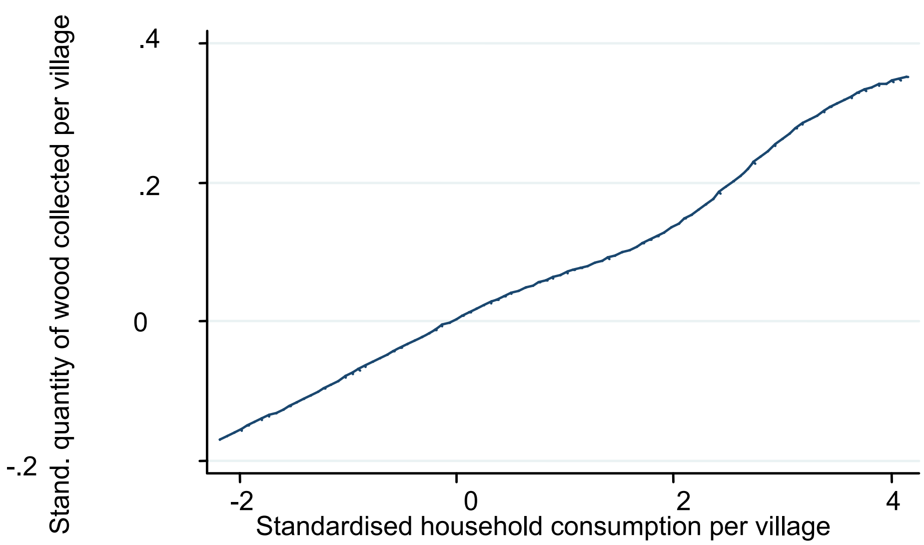

Figure 5: Engel curve for firewood collection in the Indian Himalayas (rural zone) in 2002-3

controls. Figure 4 represents the Engel curve obtained for Nepal in 1995-6 and 2002-3, Figure 5 the curve obtained for the Indian Himalayan villages. The Engel curves show an essentially increasing relationship between firewood collection and household income. In the Nepalese villages, this relationship is concave, with the wealthiest households showing a turning point in the tail of the distribution (above the 95 percentile). On average, a 10% increase in income is associated with a 4% rise in firewood collection. The income effect thus seems to be largely positive and dominates the substitution effect. The results are very similar for India. It should be noted that the concavity of the Engel curves could imply, all other things being equal, that villages in which income disparities are lower consume more wood. The concavity measure in the present instance remains relatively weak, which means that this effect is probably not of great importance. This is corroborated by lack of direct evidence of any significant effect of local land inequality on household firewood collection, in a paper which estimated village fixed effects at the first step and then examined how the estimated village effects varied with measures of inequality (Baland et al (2007b)).

2.3 Reduced Form and Semi-Structural Approaches to Estimating Household Demand for Firewood

Households maximize utility by choosing firewood, leisure and consumption expenditures subject to a time budget constraint. Productive assets, demographics and the time taken to collect firewood are taken as given. This maximization yields the household demand for firewood as a function of income (or some measure of wealth), collection cost (the product of shadow wage and collection time) and household size.[15] We thus have:

(1) $F_i = f(C_i, w_i.tc_i, n_i)$

where F_i represents the amount of firewood collected and consumed, C_i, a measure of income, tc_i, the time spent collecting one unit of firewood, w_i, the shadow wage and n_i, the labor stock in the family, or family size. We consider that tc_i, the collection time,

[15] It is relatively immediate to also include the price of the closest substitute source of energy, such as gas (see Baland et al, 2009).

depends on occupational patterns, which themselves depend on the composition of assets owned. We therefore assume:

(2) $tc_i = t(\; + \; {}_iA_i)$

where t represents collection time in the village, and A_i represent the assets operated by household i. Linearizing by a first-order Taylor approximation, we obtain:

(3) $F_i = \; {}_1C_i + \; {}_2\, w_i\, t(\; + \; {}_iA_i) + \; {}_3\, n_i$.

This expression represents the basic equation of our semi-structural (SS) approach. The coefficient ${}_1$ is a measure of the income effect while ${}_2$ is a measure of the substitution effect.

The critical problem here is the measure of income and the shadow wage, C_i and w_i. One possibility is to directly use the level of consumption expenditures of household income as a measure of income and as a proxy of the shadow wage. However, both are endogenously determined. Omitted household characteristics such as industriousness, location or illness could affect consumption, shadow wages and firewood collections, resulting in biased estimates.

To address the endogeneity issue, an alternative strategy is to measure income by the household potential income, defined as the self-employment income that the household would earn if it were to fully utilize its labor stock. We therefore also provide estimations of equation (3) by estimating in a first step a Cobb-Douglas production function in which the household productive assets and the number of labor hours worked enter as inputs. As labor choices are endogenous, we instrument labor hours by household size (the number of adults available for self-employment) (see Jakoby, 1993).[16] This instrumentation strategy arguably constitutes an improvement on an estimation directly based on labor hours, but may not completely solve the problem. Having estimated the different production elasticities, we can then, for each household, compute its potential income, W_i, by replacing the number of labour hours worked by the total amount of productive labour available in the family, n_i. We also assume that

[16] This strategy ignores the possibility that more productive households might attract relatives to join the household. Moreover, the exclusion restriction rules out the possibility that controlling for total hours employed, a larger household may be more productive, by taking better advantage of the division of labor or complementarity of skills across members.

potential income per head is a reasonable measure of w_i, the marginal productivity of labour, i.e. the shadow wage. We then estimate equation (3) using W_i and w_i.

The use of estimates of the production function parameters inevitably creates some errors of measurement in potential income and shadow wages, with attendant attenuation biases. They may also involve aggregation biases if the assumption underlying the aggregation (that the wealth effect generated by different assets should be proportional to their respective income effects) is not valid. These problems can be avoided in the reduced form approach, which relates consumption and shadow wages back to household characteristics. Consumption is a function of household assets (which includes household labor stock). The shadow wage is a function of household assets and

Dependent Variable: Firewood Collection (log of number of bharis per year)	Using Potential income		
Log Potential Income	1.961 (1.599)	___	___
Square of Log Potential income	-0.083 (0.076)	___	___
Log Consumption Expenditures	___	2.289** (1.138)	___
Square of Log Consumption Expenditures	___	-0.118** (0.056)	___
Log Actual Income	___	___	0.959* (0.482)
Square of Log Actual Income	___	___	-0.049* (0.025)
Log(Collection Time)*Log(Shadow Wage)	-0.165** (0.079)	-0.150** (0.070)	-0.134* (0.071)

Household size and triple interactions between collection time, shadow wage and productive assets are included. Village Fixed Effects are included. Standard errors are given in parentheses. *: significant at 10%, **: significant at 5%, ***: significant at 1%. The number of observations is 2190 households in 201 villages.

Table 3: Firewood Collection: Semi-Structural estimates for Nepal (1995-6 LSMS)

Source: Baland et al (2009)

collection costs. Combining these, we obtain the (RF) specification in which F is expressed as a function of household assets, household size and collection time interacted with household assets (as collection costs are the product of collection time with the shadow wage in the household).

The results of these various strategies are given in Tables 3, 4 and 5. Table 3 gives the results for Nepal in 1995-6 of the semi-structural approach, using potential income, actual income or production expenditures as measures of income and proxy for the shadow wage. The results presented in Table 3 separate the effect of rising assets into wealth and cost-of-collection effects. Estimated wealth effects are statistically insignificant at the 10% level when potential income is used as the measure of wealth. However, they are significant when consumption and income are used instead. Cost-of-collection effects do not differ much across different measures of wealth. Rising collection time itself (interacted with the shadow wage) has a significant negative effect. The computation of the elasticity of firewood consumption to collection time cannot be directly estimated, as we have to take into account the interaction terms with the household productive assets. We discuss this further below.

Percentage change in firewood collection for an average household following increase in	
Increase in Potential Income by 10%	-0.06
Increase in Land by 10 %	-0.08
Increase in Big Livestock by 10%	0.15
Increase in Small Livestock by 10%	0.01
Increase in Education by 10%	-0.19
Increase in Non-Farm Business Assets by 10%	-0.01

Table 4: Effects of 10% Asset Growth on Yearly Per-Capita Firewood Use of Average Household: Based on Semi-Structural Elasticity Estimates for India (2002-3)

Source: Baland et al (2007a)

We also estimated firewood collection in India using a similar semi-structural approach. The estimated elasticities for an average household are given in the Table 4. It shows that in the Indian sample firewood use is inelastic with respect to income growth, irrespective of whether it arises from productivity increases or asset accumulation. For the average household, firewood use per capita falls 0.06% following an increase in potential income of 10%. The elasticity with respect to growth of any asset is uniformly below 0.02 in absolute value. Compared to our estimates for Nepal, the estimates for the Indian Himalayan region using the potential income approach yields substantially smaller elasticities.

We also estimated firewood collection using the reduced form approach for Nepal in 1995-6 and 2002-3. We obtained the following results, where we distinguish between the income and the substitution (cost of collection) effect of changes in various assets.

	Income Effect Elasticity		Substitution Effect Elasticity		Total elasticity	
Productive asset	1995-6	2002-3	1995-6	2002-3	1995-6	2002-3
Land	0.22	0.36	-0.19	-0.25	0.03	0.12
Livestock	N.S.	-0.25	0.50	0.50	0.50	0.25
Education	0.57	N.S.	-0.39	-0.19	0.18	-0.19
Non-farm Business Assets	0.18	0.13	N.S.	N.S.	0.18	0.13

N.S.: not significant at the 10% level.

Table 5: Elasticity of Firewood Collection: Reduced Form estimates for Nepal, 1995-6 and 2002-3.

Source: Baland *et al*. (2009)

The reduced form elasticities are generally statistically significant, though of smaller magnitude than indicated by the estimates in Table 3 based on the semi-structural form using potential income. The improved statistical significance owes partly to reduced measurement error in asset measures compared with use of potential income as a measure of wealth in the semi-structural approach. The results also indicate substantial misspecification in the semi-structural form: e.g., disparate productive assets do not have a homogenous impact on firewood collection. For example, livestock ownership is associated with a positive substitution effect, indicating complementarity between livestock-rearing activities and firewood collection. On the other hand, land and education, and probably non-farm business assets, are associated with negative substitution effects. Even the income effects of different assets are not proportional to their effects on potential income in the first stage regression in the semi-structural approach.

The reduced form estimates are therefore more reliable. They indicate future impact of economic growth for the forest in Nepal therefore crucially depends on the type of asset underpinning this growth. Growth based on modern assets, such as education and non-farm business assets, reduces firewood collection (on the basis of 2002-3 estimates), with a total net elasticity of -0.06: if these two assets increase by 100%, the demand for firewood declines by around 6%. On the other hand, growth based exclusively on traditional farm-related assets, such as land and particularly livestock, leads to an increased demand for firewood, with a total net elasticity of 0.37.

Moreover, total elasticity, equal to the sum of the elasticities of all the assets, is relatively high: 0.89 in 1995-6 and 0.31 in 2002-3. An overall growth of all the assets, which leads to an equivalent growth in household income (economies of scale proved constant in our estimates), thus produces a significant increase in the demand for firewood. The Engel curves presented in Figure 4 already illustrated this phenomenon.

These results for Nepal indicate the need to estimate firewood demand in India using the reduced form approach rather than the semi-structural approach. This still remains to be done. Hence the estimates for Nepal appear to be more reliable.

To summarize, overall we do not find any evidence from within-village variations in support of the Poverty Environment Hypothesis. If anything, we find some evidence for the Environmental Kuznets curve in Nepal, whether one relies on the direct income effect or on its combined effect including the induced changes in the costs of collection. The impact of income on firewood collection is either negligible (as in our SS estimates for India) or essentially positive, except at the very top end of the income distribution where collections start to decrease with income.

We have seen above that our estimates of income or growth effects for India are significantly lower than those obtained for Nepal. Two reasons may account for this. First, in India, we used a semi-structural approach relying on the use of the 'potential income'. As already discussed above, this is more prone to misspecification and measurement error. The same phenomenon is observed for Nepal when the potential income approach is used (see Table 3). The estimates are therefore sensitive to the approach taken. In this respect, it is worth noting that the naïve approach using actual income or consumption expenditures as measures of income and shadow wages (see e.g. table 3) tended to produce much larger and significant estimates than the more sophisticated SS or RF approaches.

Second, the observations from India were collected in villages located in the alpine belt of the Himalayas (between 1800 and 3000 meters). Given the remoteness of those villages and the need for heat in the winter, it can be expected that their demand for firewood is relatively inelastic to changes in income and assets, once properly controlling for other determinants (such as the availability of gas). By contrast, the Nepal data are drawn from all over the country, and include in particular villages from the Terai plains which are not exposed to the same climatic and geographic conditions than high altitude villages. It should also be noted that the elasticities obtained in 2002-3 for Nepal are systematically lower than in those in 1995-6. Even if the two samples are not totally comparable, this result is to be related to the fact that the use of gas as a source of energy (especially for cooking during the summer season) seems to have developed over this period. It is also possible that the general increase in income may have taken the average household closer to the turning point on the Environmental Kuznets curve, as suggested by Figure 4 above.[17]

Finally, consider the implications of the preceding results for effects of demographic changes, consisting of population growth and changes in household size and composition. The average household size in both India and Nepal indicates that most families are nuclear already and there is little scope for further fragmentation of households. Within villages we also find little variation in household size with per capita

[17] It must also be pointed out that the Engel curve for 2002-3 shifts to the right compared with the 1995-6 curve, indicating that the decline in the demand for firewood intervenes at lower income levels.

potential income. So it is reasonable to assume that household size will remain fixed in the near future, irrespective of economic growth. This implies that population growth will consist mainly of an increase in the number of households. Unless there is substantial out-migration from villages, it is reasonable to suppose that population will grow by at least 10% in the next decade. Since our estimates pertained to demand per household, a 10% increase in the number of households in the village would give rise to a 10% rise in **total** firewood and fodder collections from the neighboring forests. Demographic changes may thus be much more important than economic growth in determining the rate of forest degradation over time. Absent significant increases in migration out of these villages, the pressure on forests may be expected to rise approximately in proportion to the rise in population.

2.4 Local Impact of Forest Degradation: Estimating the Local Externality

Continued forest degradation will impact the lives of neighboring villagers primarily by raising the time it takes them to collect firewood and fodder. If trees are more severely lopped, the villagers will take longer to collect a single bundle, either by searching longer for trees that still have branches that can be lopped, or walking further into the forest parts that have not yet been harvested. This is the principal source of the local externality: higher collections today by any single household will raise collection times for all households in surrounding villages in the future.

Precise quantification of the magnitude of this local externality requires knowledge of the rate at which future collection times will rise in response to current collection levels.[18] We have not attempted to estimate this so far. Instead we will try to provide some bounds for the magnitude of the externality by considering the effects of an increase in collection time by one hour per bundle.

Applying Hotelling's Lemma, the effect of a small increase in collection time on household welfare can be approximated by calculating the shadow cost of additional time required to collect the same number of bundles of firewood selected by the household

[18] We thank Andy Foster for pointing out the need for this information in order to estimate the magnitude of the externality.

prior to the increase in collection time. We therefore compute the shadow wage corresponding to the rise in time required to collect the same amount of firewood over a year. In the case of Nepal in 1995-6, the cost linked to a one-hour increase in collection time can be estimated at a loss of income of around 2%.[19] In the case of India, this figure is slightly lower, standing at around 1%. The direct impact of the local externality on the villagers' welfare is thus weak, which is certainly part of the factors explaining the lack of collective action at the local level.

Finally, assessments of future degradation would require estimates of the extent to which increased collection times resulting from current degradation would induce a reduction in firewood collections. This requires an estimate of the elasticity of firewood consumption to collection time. The regression specification using village fixed effects makes this difficult, as collection times are partially absorbed by the village fixed effect. We estimated only the extent to which differences in asset ownership interact with collection time at the village level to affect firewood collections. Better data on variations in collection time across households within the same village would be needed to estimate the overall effect of increased collection time, and thus assess the extent to which current degradation patterns would generate a self-correcting tendency for household collections to decrease in the future.

3. Decentralisation, Community Management and Forest Quality

3.1 Decentralisation Movements in India and Nepal

For several years, policies have been adopted in both Nepal and India to transfer part of the rights relating to State forest management and use to local communities. This policy approach is grounded in the idea that degradation of common property resources result from an inadequate institutional framework, which does not provide rural households with suitable incentives for rational and sustainable resource management. While it is true that centralised State management, which often focuses on regulating resources, yields mitigated results in terms of environmental management (cf. Ostrom, 1990, for

[19] The data we use is an average firewood collection of 79 bundles per household per year, a median shadow wage of Rs 6.4 per hour, and median consumption expenditure of Rs 30 675.5 per year. The total time spent collecting firewood in Nepal in 1995-6 represented around 400 hours per household per year.

example), the performance of decentralisation policies concerning natural resources management by user communities has been called into question by many authors (e.g., Baland and Platteau, 1996). Whereas local user organizations are often able to develop complex mechanisms for allocating and distributing products from these resources, they often seem to be inadequate when it comes to setting up systems to protect such resources. This is particularly true when market expansion and population pressures come into play. Certain authors also criticise the idealised image of village "communities" put forward by some literature, drawing on case studies. They lay greater emphasis on the shortcomings of community participation programmes, underlining phenomena such as capture by village elites, the absence of accountability and monitoring procedures or insufficient knowledge and preparation of users (Abraham and Platteau, 2001; Mansuri and Rao, 2004). In the context of Himalayan forests, an important question thus concerns the relative effectiveness of local community management *vis*-à-vis centralised State management.

In Nepal, a large-scale programme for forest resources management was launched in 1993. The programme's objective is to transfer the management of all accessible forests to local communities, via Forest User Groups (FUGs). This includes controls on access to the forests, the right to tax forest products, hire forest guards and launch plantation programmes. Incomes generated by forest-related activities can be used by these groups to finance local projects (such as roads, schools and temples).[20] This programme expanded very swiftly and it was estimated that 38% of the population was involved in an FUG by January 2007,.

In India, local forest management structures (known as Van Panchayats) were first created in 1931, primarily in Uttaranchal by the colonial British government in order to guarantee local communities the exclusive use of demarcated forest areas. This policy was vigorously pursued after independence, and by 1998, more than one third of the region's villages had their own Van Panchayat. An estimated 10% of existing forests are now under Van Panchayat control. Currently, three types of common property management regimes co-exist in Uttaranchal. State forests (*Reserve Forest* and

[20] Certain legal restrictions are set for the use of these funds. For example, 25% of revenue must be reinvested in work aimed at developing the forest.

Demarcated Protected Forests) are forests protected and managed by the State. Access and use of these forests are subject to many restrictions, the Forest Department being responsible for their enforcement. Open access forests (*Civil Soyam*) are forest patches with unrestricted rights of access (except that tree-felling for commercial purposes remains prohibited). They correspond to open access commons. Finally, the forests managed by the Van Panchayats are clearly demarcated forest patches, the use and exploitation (including plantation programmes) of which are defined by the local Van Panchayat, sometimes with State support.

Since 2001, there has been a dramatic increase of Van Panchayats, as shown in Table 6. Under pressure from the Indian government, the number of Van Panchayats has almost doubled in five years. New rules were introduced to make it easier to create Van Panchayats (for example, approval by only 1/5 of the population is now required to create a Van Panchayat, instead of the previous 1/3). The programme includes various infrastructure and plantation projects, which are a source of employment for the villagers.

Number of Van Panchayats in Uttaranchal	
In 1947	429
In 1993	3635
In 2001	6777
In 2006	12089

Table 6: Number of Van Panchayats in Uttaranchal

Source: Sarkar (2008)

Some observers, however, have pointed to the villagers' lack of interest in these recently created community-managed forests, once the casual jobs related to the plantation and infrastructure work disappear. Some of the new Van Panchayats no longer meet and, in fact, only exist on paper (Sarkar, 2008). This situation seems to differ from that of the Van Panchayats that were set up much earlier, which involved greater mobilisation and active involvement of local communities.

3.2 The Impact of Decentralisation Policies in India and Nepal

Most existing surveys (e.g. Somanathan, 1991) that compare state-managed forests with those managed by local communities underline the relative effectiveness of the latter but also the great disparities in their functioning and performance. These studies have three major shortcomings. Firstly, they often only cover very narrow geographical areas (e.g. Ostrom, 1990; Somanathan, 1991; Gibson, McKean and Ostrom, 2000; Jodha, 2001; Varughese and Ostrom, 2001 or Shivakoti and Ostrom, 2002). Moreover, they often base their evaluations on how the management councils operate (existence of regulations, penalties, forest guards…) or how the villagers perceive the state of the forests, rather than objective indicators of forest quality. Finally, they typically do not take into account problems of selection: a Van Panchayat is formed by villagers' decisions, which gives rise to a potentially significant selection bias. For example, it is possible that villages facing a more deteriorated forest environment have more to gain by creating active Van Panchayats to protect their forests. If forest quality is compared across villages with and without Van Panchayats, a positive correlation would be observed between the existence of a Van Panchayat and forest degradation.

The studies discussed below attempt to get around these problems. In Baland *et al*. (2009), we compare different types of forest areas accessed by the same village. Somanathan *et al*. (2009) compare adjoining forests of different status. Edmonds (2002) compares villages where a community-managed forest is about to be created with villages in which this type of forest has just been created.

Edmonds (2002) followed the implementation of an FUG programme in Nepal. He uses the fact that these groups are gradually set up to compare those villages where the programme was already in place in 1995-96 with the villages where it had not yet been implemented, in a region with relatively similar ecological conditions. After controlling for a large number of household and village variables, he finds that setting up an FUG causes a 10 to 15% reduction in the amount of firewood collected by neighboring households. This estimate is robust to a set of alternative methods and controls. This suggests the programme had a moderating effect on the quantities of firewood used.[21] Tree plantation and timber sales are also a key part of the programme, but a rigorous evaluation of this component is not yet available.[22]

Somanathan *et al.* (2009) evaluate forest quality using data from satellite images in two regions of Uttaranchal. They compare crown cover of forests across three types of forest management regimes: Van Panchayat forest, open access forest (unregulated), and State forest. They show that on average the crown cover of Van Panchayat forests is significantly higher than open access forests (12% for broad-leafed forests), and similar to State-managed forests. This is all the more remarkable as the Van Panchayats do not have the same rights as the Forest Department, especially as far as timber sales are concerned. In their comparisons, the authors take important factors into account such as population density, closeness to the villages and the geographical attributes of the forests, State forests having a better aspect and being further from the villages than the other types of forest. The authors compare these results with forest management costs: the costs of State management are 13 times higher per hectare of forest than those for Van Panchayat management.[23]

In Uttaranchal we collected detailed information on different types of forest management regimes in the villages surveyed (i.e. 399 forest in 83 villages). We were thus able to study how ground-level measures of forest quality varied across different management regimes. We will report here results for three measures: canopy cover, basal area and lopping (for further details, see Baland *et al*., 2009).

Table 7 reports the results of the various regressions measuring the impact of the management regime on these three measures of forest quality. These regressions, similar to those of Somanathan *et al.* (2009), use a large number of control variables (in particular, aspect, distance from the village or altitude), as well as village fixed effects.

[21] This is the case, even though the observations were made only three years after the formation of the FUGs. It is therefore likely that the long-run effects are greater.
[22] According to a recent estimate, sale of wood could represent on average two-thirds of overall revenue generated by the FUGs in Nepal (Pokharel, 2008).
[23] In 2002-3, management costs per hectare were equal to Rs 862 for a State-managed forest, as opposed to Rs 65 for a Van Panchayat-managed forest (Somanathan *et al*., 2009).

What we compare are thus the differences observed between forests patches managed by different regimes but adjoining the same village.

Difference between:	Canopy cover (%)	Basal area (m^2/ha)	Lopping (%)
Van Panchayat and State forest	5.27	-4.14	-13.18***
Van Panchayat and Open access forest	2.06	-5.20	-4.01
Old Van Panchayat and State forest	9.35**	2.47	-18.26***
New Van Panchayat and State forest	0.06	-12.56**	-6.70**

Note: **: significant at 5%, ***: significant at 1%.

Table 7: Impact of Management Regime on Forest Quality

Source: Baland *et al*., 2008

While the results show absence of significant differences between open access forests and State forests, the forests managed by Van Panchayats displayed significantly lower rates of lopping. The collection of firewood and leaf-litter for fodder is less pronounced when the forest is managed by a Van Panchayat.[24]

This more rational use of forests mainly typifies the older Van Panchayats created before 1980. They are also characterised by a higher biomass, measured by canopy cover. On the other hand, the more recently formed Van Panchayats have a smaller basal area. This latter result may indicate that Van Panchayats tend to form when the concerned forests have a poorer quality to start with.[25] The high performance of the older Van Panchayats possibly reflects superior management, being grounded in effective community participation. Reduced rates of lopping over long periods of time also are likely to explain why older Van Panchayat forests achieve superior biomass than state forest.

These findings thus reinforce similar results of Somanathan *et al.* (2009) based on aerial satellite images. Moreover, they indicate a connection between measures of

[24] It should also be noted that we did not observe any effect of increased firewood or fodder collection in neighbouring forests.
[25] As in Somanathan *et al*. (2009), everything seems to indicate that the more degraded forests are more likely to be converted into a Van Panchayat forest.

biomass in the long run and rates of lopping. It is also consistent with the results of Edmonds (2002) for Nepal that creation of an FUG reduces household firewood collection. In our study of firewood collection in India (Baland *et al*., 2007a) based on household surveys we also observed a significant decline in firewood collection in villages with a larger fraction of neighboring forests under Van Panchayat management. These estimates indicate that firewood collection levels would decline by an order of 20% if all village forests were converted from state into Van Panchayats forests.

Although setting up a formal community management structure therefore appears effective in terms of improving forest quality, it also has important effects with respect to redistribution, as it changes the rules for using and sharing forest produce. In Nepal, some studies suggest that the local elite often dominate the FUG executive committee and sway its decisions to their own benefit. More particularly, the substantial funds generated by timber sales are invested chiefly in projects that are advantageous to this elite.[26] (Banjade *et al*. 2006; Malla *et al*., 2003; Pokharel, 2008; Timsina, 2003). This is reminiscent of the results obtained by Banerjee *et al*. (2001) in the sugar cooperatives of Maharashtra, in which the richest members secure rents for themselves by manipulating producer prices and using cooperative's profits for their personal benefit.

In the same vein, in a study of some twenty villages in Gujarat, Agarwal (2007) shows how the creation of a forest management council (similar to the Van Panchayats) have excluded women—who are traditionally users of the forest—from participatory and decision-making structures and deprived them of their access rights to the forest. The women express their feeling of expropriation and exclusion as follows: *"If you were to attend meetings, the men will say, oh you haven't cooked my meal on time. What happened to my tea?...(…) The meetings are considered for men only. (…) No one ever listened to my suggestions. (…) People don't like it when we speak, they think women are becoming very smart."* (quoted by Agarwal, 2007: 288-9) Agarwal concludes that women bear a large share of the costs linked to community forest management, whereas they only benefit very indirectly from the related advantages. *"How will we cook if we*

[26] Pokharel (2008) estimates that around ¾ of the available funds are allocated to projects that benefit wealthier households.

don't get wood from the forest? What do they expect us to do?" (quoted by Agarwal, 2007: 291).

4. Conclusions and Policy Implications

Without some kind of effective government intervention, the future of Himalayan forests appear somewhat bleak. Forest degradation in this region is related to the unregulated extraction of firewood and fodder, which has led to an alarming decline in the quality and resistance of trees in the the region. The pressures on the Himalayan forests are increasing due to population growth: over the last 25 years, the average number of households per village has doubled. In addition, the demand for firewood has risen owing to rising standards of living and reduced levels of poverty, though this tends to be moderated if growth is associated with rising education and increasing incidence of non-agricultural activities.

However, it is unclear that local inhabitants perceive this degradation as an important problem, or that they are acting on it to self-regulate local collection activities. Part of the reason may be the negligible magnitude of the associated local externality. The relevant externality is essentially non-local in nature, with forest degradation in the Himalayas contributing to landslides, siltation and floods, and possibly also to global climate change. These necessitate some kind of external state interventions.

Two types of policy interventions can be considered. The first involves encouraging the development of community-based methods of forest management. The experience of Uttaranchal shows that local community management helps to ensure a better quality of forest than that obtained through the most protected State forests. The measures for setting up these community management mechanisms nonetheless have a crucial impact on the extent of their success, and it is not clear how state or central governments can encourage genuine grass-roots mobilization and involvement in forest management groups. Moreover, it may take a long time for such groups to become effective in improving the condition of the forest.

The second policy intervention could be a subsidy on gas, which is the main source of alternative energy. We studied this question in the case of India in Baland *et al.* (2007a).[27] The most commonly found substitute fuel is gas in cylinders (LPG). In the villages where this is available, the elasticity of firewood collection with respect to the price of gas is fairly high. Given an average price of Rs 300 per cylinder, the estimated impact of a Rs 100 subsidy on household firewood collection is reported in Table 8. As might be expected, the reduction in firewood consumption is larger during the summer than in winter (27% and 19% respectively), averaging to a 22% decrease in annual consumption. The effects are substantial at all income levels: even amongst the poorest households (in the first quartile of the income distribution), demand for firewood drops by 19%. Our estimates imply a Rs 200 subsidy would reduce firewood consumption by 40%.

Season	Income level	% change in the amount of wood collected
All year	Mean	-22%
	First quartile	-19%
	Second quartile	-22%
	Third quartile	-22%
	Fourth quartile	-26%
Summer	Mean	-27%
Winter	Mean	-19%

Table 8: Estimated Effect of a Rs 100 Decrease in the Price of an LPG Cylinder

Source: Baland *et al*. (2007)

Our household level estimates also enable us to estimate the fiscal cost of subsidies. As we show in Baland *et al.* (2007a), this subsidy encourages 37% of the households to use an average 1.07 cylinders per person, which represents a subsidy of Rs 107 per using household. With an average per capita consumption expenditure of Rs 8646 per year, this corresponds to around 1.2% of their total consumption

[27] It was more difficult to design a similar approach for Nepal where the use of gas in 1995-6 was much less common. The 2002-3 data has yet to be analysed.

expenditure. For the overall consumption expenditures of all the villagers, this subsidy corresponds to an annual tax of 0.4%. At a relatively low cost, this policy can thus lead to a significant decrease in firewood consumption, particularly during the summer months.

Many important questions need to be addressed in future research. We need to re-estimate household demand equations in the Indian context using the reduced form approach, and re-assess our findings concerning growth projections and elasticities with respect to alternate energy costs. The availability of longitudinal studies of forests and collection behaviour of neighboring communities would represent a big step forward, in allowing for more refined controls and accurate projections for the future. Even using the data in hand, there is scope for assessing future sustainability of the Himalayan forests using simulations of a dynamic model of interaction between forest quality and firewood collection patterns, calibrated to fit the observed patterns in the data.

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