RESEARCH REPORT 69

CONSEQUENCES OF DEFORESTATION FOR WOMEN'S TIME ALLOCATION, AGRICULTURAL PRODUCTION, AND NUTRITION IN HILL AREAS OF NEPAL

Shubh K. Kumar
David Hotchkiss

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FOREWORD

In the face of growing concerns about the environment, policymakers in developing countries find themselves increasingly pressured to choose between environmental deterioration in the long run and the growing demands of poor populations in the short run. Some environmentalists point to new technology—irrigation, fertilizer, and pesticides—as the basis of ecological decay in rural areas. A number of studies have shown, instead, that expanding farm yields in less fragile areas through modern technology offers a viable alternative to stripping the land to expand crop area in marginal soils.

In the hill areas of Nepal, as in many developing countries, women's work is the key not only to the functioning of the household but also as a necessary supply of field labor. In *Consequences of Deforestation for Women's Time Allocation, Agricultural Production, and Nutrition in Hill Areas of Nepal,* Research Report 69, Shubh K. Kumar and David Hotchkiss show that the allocation of women's time, as affected by deforestation, has far-reaching effects on farm output, income, and nutrition. In countries such as Nepal, where adoption of modern agricultural technology is so low, it seems that the environment, agriculture, and the quality of life all suffer for this state of affairs.

John W. Mellor

Washington, D.C.
October 1988

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Shubh K. Kumar
David Hotchkiss

1

SUMMARY

The hill areas of Nepal are a prime example of an area in which low-productivity agriculture is surrounded by rapid environmental degradation as the result of deforestation, and the interaction of the two is promoting further deterioration in both. The following characteristics prevail in the area: low agricultural productivity; high out-migration; a high reliance on labor input in production, especially given the limited use of agricultural technology; and pressure to expand cultivated land at the cost of forest land as population grows. The literature suggests that even in densely populated hill areas, deforestation does not occur as a result of fuelwood consumption by the local population. Instead, it is the low agricultural productivity and the inability of the existing land to sustain the growing population that puts pressure on forestland. Some estimates suggest that in just over 10 years, from the late 1960s to the early 1980s, up to half of the forests in some hill regions have been cut down, with the area under forest reduced from nearly 60 percent to 30 percent of the total area.

In this report, the cost in time spent collecting fuel is used as a measure of the consequences of deforestation; its effects on time allocation, agricultural output, food consumption, and nutrition are examined. In particular, the allocation of women's time is influenced because women are engaged not only in the collection of fuelwood and other essential forest products affected by deforestation—such as leaf fodder and grass for livestock feed—but also in agricultural production.

According to the study's hypothesis, deforestation reduces agricultural output from existing cultivated land by increasing time spent in collecting essential forest products, which shifts time away from agriculture. As a result, household income from agriculture is reduced. Unless alternative sources of income increase, food consumption and eventually the nutritional status of the population will be adversely affected. Because livestock production is also an important part of household enterprise in these areas, the destruction of forests also influences this sector. A reduction in the availability of fodder used for stall feeding increases the pressure for grazing, which increases soil erosion on lands that are currently not under cultivation. Also, children who are involved in collection and livestock grazing activities may experience adverse effects on health and education, which would ultimately influence the region's prospects for raising the productivity of labor.

The study is based on results from a year-long survey of 120 households in three hill districts of the Western Development Region in Nepal, conducted in 1982/83 jointly with the Agricultural Projects Services Centre of Nepal and the Food and Agriculture Organization of the United Nations. Results indicate that when deforestation—represented by the time required to collect a standard load of firewood—increased by 1.0 percent, there was a reduction in fuelwood consumption of 0.3 percent and an increase in the total time required for its collection of 0.6 percent. Assuming a similar response for other essential forest products, the collection time for fuelwood, leaf fodder, and grass alone required an additional 1.13 hours per day by women in the high deforestation sites in the sample. This represents a 45 percent increase, assuming that all workers engaged in the activity increase their work in proportion to their earlier input. The effects of this on the amount of labor available for agriculture indicate that women's farm labor would decrease by 1.4 hours per person per day, or nearly 50 percent. This decrease is not compensated for by an increase in wage labor or by men's labor, which may also decrease.

Analysis of the production functions for cropping activities indicates that women spend the most time on the dry-season crops—wheat, maize, and mustard. But the time spent for collection of fuelwood is also greater during the dry season because that is when people collect extra amounts of wood and store it for later use. As may be expected, the marginal product of upland crops—maize and ragi—is about half that for the lowland crops—paddy, wheat, and early paddy.

Caloric availability and the ratio of kilocalories from rice compared with other cereals are positively influenced by the component of household income that comes from agriculture and time spent on food preparation and cooking. At the same time, food preparation time is positively associated with the amount of fuelwood used and negatively with the amount of total time spent in fuel collection. This suggests that in addition to the effects of deforestation on agricultural production and incomes, secondary or associated effects could be related to fuel consumption and time spent on food preparation. The main determinants of preschool child nutrition are degree of deforestation, household income, household size, and work loads of women and older children. In addition, the data indicate that the Tibeto-Burman ethnic groups have better child nutrition than the Newar-Brahmin groups, when the influences of other household characteristics are controlled for.

The results suggest that it is not enough to rely on out-migration or reforestation efforts alone to improve the economy and ecology of the region. (One out of every two households already has a permanent migrant worker.) Strategies for raising agricultural productivity need to be considered. In the long run, agricultural products that offer high value to weight, such as horticultural products, may be a feasible proposition for the region. This requires investments in research and extension, as well as an efficient marketing system suited to the primarily smallholder agriculture. At present, production is largely subsistence-oriented and not very productive; therefore, the degree of rural market development is limited. In the short run, therefore, it appears necessary to increase productivity of the traditional crops through the use of improved technologies that already exist and can be promoted, thus shifting away from subsistence production and promoting the growth of rural market infrastructure.

This could provide the base for a gradual shift into more specialized horticultural and livestock products. In order to achieve this, efforts will be needed, first, to promote improved input use, and, second, to alleviate human labor bottlenecks for both small and larger farms. Labor-saving technologies for nonfarm activities, such as food processing and water supply, should also be included. Agroforestry programs that reduce collection time for essential forest products would also complement such an agricultural intensification effort in the hills of Nepal.

2

INTRODUCTION

Agricultural strategies for areas of low or marginal potential have been receiving increased attention recently.[1] This concern has been driven by several factors. Sustainability of agricultural growth requires a constantly expanding frontier beyond the areas currently experiencing rapid growth. Also, growing regional inequity between rural areas where rapid agricultural growth is occurring and those left behind is sometimes pointed to as an undesirable feature of improved agricultural technologies.[2] Related to both is concern for deterioration of the environment, which usually stems from the effects of excessive growth in input use in intensively cropped areas, but increasingly also from rampant environmental degradation, including deforestation, in areas where growth is stagnant.[3] All of these concerns point to the need for a closer examination of production characteristics and constraints to growth in the so-called low potential areas, so as to identify the best strategy for incorporating them into the overall development picture. In Nepal the major focus for agricultural development efforts has been in the southern plains, the tarai. In the hill areas the focus has been on reforestation and soil conservation efforts, and agricultural growth incentives have been virtually nonexistent.

In analyzing the range of situations that arise in the association between labor input and agricultural output in developing countries, two main groups or types have been identified. According to John Mellor,[4] they can be classified as, first, the labor-surplus case, in which highly productive nonhuman agricultural resources initially provide food for more people than are needed to work on the land, eventually leading to a large pool of underemployed and surplus labor. In such areas, there is a good potential for widespread adoption of labor-intensive agricultural technologies and for growth in rural off-farm employment. Second is the "hardworking-peasant" case, in which output is directly a product of labor input.

The first of these two situations represents most of the high-growth agricultural areas of Asia and Latin America, while the latter is generally prevalent in African agriculture. Semi-arid and hill areas in Asia, however, may also be cast in the hardworking-peasant mold.[5] Since the marginal product of labor is higher in the latter situation, labor constraints are more likely to develop, but it is difficult to support additional labor, when aggregate productivity is low. The significance of human labor in agricultural

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[1] Consultative Group on International Agricultural Research, Technical Advisory Committee, *Sustainable Agricultural Production: Implications for International Agricultural Research* (Rome: Food and Agriculture Organization of the United Nations, TAC Secretariat, 1987).

[2] Irma Adelman, "A Poverty-Focused Approach to Development Policy," in *Development Strategies Reconsidered,* ed. John P. Lewis and Valeriana Kallab (Washington, D.C.: Overseas Development Council, 1986), pp. 49-65.

[3] World Commission on Environment and Development, *Our Common Future* (Oxford: Oxford University Press, 1987).

[4] John W. Mellor, "Determinants of Rural Poverty: The Dynamics of Production, Technology, and Price," in *Agricultural Change and Rural Poverty: Variations on a Theme by Dharm Narain,* ed. John W. Mellor and Gunvant M. Desai (New Delhi: Oxford University Press, and Baltimore: Johns Hopkins University Press for the International Food Policy Research Institute, 1986), pp. 21-40.

[5] Ibid.

production remains high. Moreover, it is precisely from such areas that there is high out-migration of labor because of the relatively low productivity of the land. As the population grows, pressure to expand cultivated area is also high. This promotes deforestation and progressively lowers agricultural productivity.

What are the development policy implications for such regions? One approach that has been favored by many is that of benign neglect or of encouraging migration from these areas. Another focuses on fostering high-value cash crop production, such as horticulture and tree crops. This approach can be viable if institutional and infrastructural developments support the production, and especially the marketing, of these products. A parallel approach that is receiving increasing attention in this context is agroforestry development. Forests contribute a wide range of products essential to household production and survival, but they also contribute to the long-term environmental and agricultural land quality of the region. Growing trees as a crop can, over the course of years, contribute to household agricultural production and income generation. In the short run, however, tree crops may compete for land on which food is grown. It is possible that this competition may be reduced by raising agricultural productivity, thereby reducing the dual pressure on existing forestland for fuelwood and for land for cultivation.

Improving agricultural performance requires choosing an appropriate mix of inputs and technologies. Hence it is expeditious to examine the characteristics of producer households and to identify their relevant constraints. This provides the basis for appropriate policies to supplement market forces in providing the impetus for change.

Significance of Human Labor in Traditional Agriculture

In general, it may be useful to consider the issues of poverty, low labor productivity, and the environmental consequences together. Environmental degradation, whether it is due to excessive livestock grazing or deforestation, is largely in response to strategies for providing for human energy needs. However, as a consequence of the destruction of environmental resources, the human cost of using these resources also increases. Where productivity is low and the reliance on human labor is high to begin with, this loss of environmental resources is likely to further reduce agricultural productivity.

Traditional agriculture is characterized by a high proportion of human labor input and low productivity of land and labor. When the total amount of energy that goes into farming is calculated, it appears that subsistence farming actually requires more energy resources per hectare, especially per ton of food output, than technologically advanced forms of agriculture. However, when the concept of "useful energy" is applied—that is, energy actually delivered or made available for the production process to occur (through land preparation, irrigation, fertilizer application, and so forth)—then the picture is reversed.[6] Increases in useful energy input via irrigation, application of manure and fertilizer, improved management practices, or improvement of plant efficiencies through breeding provide the main mechanisms for achieving higher yields.

While it may seem that these observations really just state the obvious, the useful energy concept does serve to highlight the importance of human energy input and labor constraints in subsistence agriculture, as represented by the hardworking peasant mentioned earlier. An increase in useful energy input in Third World agriculture has

[6] Arjun Makhijani, *Energy and Agriculture in the Third World: A Report to the Energy Project of the Ford Foundation* (Cambridge, Mass.: Ballinger, 1975).

also been found to increase the intensity of labor use per hectare, even as the share of human energy input in production declines.[7] These empirical observations are fully consistent with the theoretical expectations for labor input and productivity in high- and low-productive agriculture, with the theory that labor demand increases with technological change, and with the nutrition-wage hypothesis.[8]

Human labor input is required both for the production of crops and the household's provision of its nonfarm energy supply that comes primarily from forests, providing essential fuel and animal feed products. As long as both crop and noncrop energy supplies for human consumption remain heavily dependent on human labor, labor productivity remains low, yet the marginal product of labor remains relatively high.[9] Land under crop production competes with forestland. This competition is further accentuated by increasing population pressure. In an eastern hill area of Nepal, Bajracharya documented that the forest fuel supply was adequate to meet people's needs, but arable area could not meet their food needs.[10] He concludes that it is essential to increase productivity of land if farmland encroachment on forests is to be reduced and a sustainable agricultural economy attained. If this does not occur, forest resources will become increasingly scarce, further accentuating the requirement for human labor and creating a further downward pressure on the productivity of land.

Quality of human labor input may also be adversely affected if low land productivity, combined with heavy demand for human energy expenditure for both crop production and provision of noncrop energy, impairs the nutritional status of the workers. Both chronic and acute food scarcities limit human work capacity, and again it is necessary to improve agricultural and labor productivity. As noted earlier, these improvements are usually accompanied with some increase in demand for labor. For smallholders of the hardworking-peasant type, this involves an explicit cost, and unless credit is available, it may not be possible to shift labor away from other activities, such as fuel and fodder procurement and essential household maintenance activities. Further, even if expected yields are vastly improved, the inherent riskiness of input adoption in the initial stages could discourage early adoption by smallholders. In order to overcome this obstacle, the public sector initially may need to play a large role in reducing the risks involved in changing resource allocation of farm households. Consequently, investments that reduce a range of household constraints—including labor requirements for noncrop activities, cash, and animal labor constraints—may need to be incorporated. Clearly, the availability of improved agricultural technologies would provide the justification for making these public investments.

In areas where growth in agricultural productivity by smallholders has occurred, it has been found that this is followed by expansion of markets and private investments in both agricultural and supportive nonagricultural sector activities in the area.[11] This

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[7] Ibid.

[8] Uma Lele and John W. Mellor, "Technological Change, Distributive Bias, and Labor Transfer in a Two-Sector Economy," *Oxford Economic Papers* 33 (November 1981): 426-441; and John W. Mellor and Robert D. Stevens, "The Average and Marginal Product of Farm Labor in Underdeveloped Countries," *Journal of Farm Economics* 28 (August 1956): 780-91.

[9] A comparison of labor production functions for low-productive hilly, dryland areas and high-productive areas was made by Mellor and Stevens in "Average and Marginal Product of Farm Labor."

[10] Deepak Bajracharya, "Fuel, Food, or Forest? Dilemmas in a Nepali Village," *World Development* 11 (No. 12, 1983): 1057-1074.

[11] Sudhir Wanmali, *Service Provision and Rural Development: A Study of Miryalguda Taluka*, Research Report 37 (Washington, D.C.: International Food Policy Research Institute, February 1983).

not only helps to ease the pressure on land to provide income and employment growth but also produces a base from which further transformation in the agricultural sector can be more readily obtained. This could include a transition toward horticultural and other high-valued but perishable products to which the hill ecology is suited. This serves to provide an additional justification for judicious public investments to overcome the initial bottlenecks and thus raise agricultural productivity.

Objectives and Rationale

The objectives of this report are to examine the effects of labor constraints, particularly of women's labor, on output from small hill-area farms and the direct adverse consequences of deforestation on such farms. More specifically, the report examines women's time allocation in a poor agricultural area for its effects on agricultural production, food consumption, and the nutritional status of children. It looks at the possible consequences of deforestation for agricultural output, as a result of competing demands for women's labor. It uses the labor costs of fuelwood collection as a measure.

It has been argued that deforestation in hill areas can have adverse consequences for plains agriculture. Flooding and silting, traditionally the source of agricultural potential for plains agriculture, also cause the rapid blockage of irrigation canals. These consequences are quite apart from the widespread ecological and environmental consequences of deforestation. These observations have led to concerted efforts to slow down the rate of forest depletion. Though agroforestry—the incorporation of tree cultivation in household farming—is often promoted as a means of slowing deforestation, the explicit linking of this process with existing agricultural activities in crop and livestock production in these areas is seldom made.

If deforestation leads to reduced agricultural productivity of land, understanding the mechanisms involved would assist in efforts to improve agriculture as well as in the forestry efforts. When yields are too low to sustain the growing population, even with high out-migration, there is inevitably pressure to expand cropland. This is often at the cost of forests. Thus while forestland may provide a safety valve for the growing population in the short run, its depletion only promotes the cycle of declining agricultural productivity.[12] In this study it is argued that productivity of agricultural land would decline, despite new land coming into production, as a result of additional labor demands created by deforestation. The increasing distance from and hence time required to collect essential forest products competes with labor input in agriculture. Therefore, unless measures to improve agricultural productivity are undertaken simultaneously, the push for clearing new land due to population growth will continue.

The focus in this report is on the issue of labor constraints, particularly on women's labor, as an intermediary to the adverse consequences of deforestation. Low productivity agriculture is known to rely heavily on input of human labor.[13] In areas where women provide most of the labor in the collection of forest products, this labor increases with deforestation. If they also provide labor in agriculture, then the consequences for production depend on their ability to take on more work and the degree of substitution between men's and women's work in agricultural production. These are some of the questions that will be examined.

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[12] Bajracharya, "Fuel, Food, or Forest?"

[13] Mellor, "Determinants of Rural Poverty."

Since women also have the major responsibility for activities directly related to food consumption, such as food processing and preparation, deforestation and increasing work loads could also have a direct effect on this activity, with possible adverse consequences. Similarly, preparing food and feeding young children is time-intensive for women, and direct adverse effects are also possible there. These two effects would be likely to occur over and above any of the changes in food consumption and nutrition engendered by the effects on agricultural productivity.

In the analysis of all forest products used by the local population, only changes in fuelwood consumption and the associated time costs are used to represent the consequences of deforestation. However, other essential forest products, such as leaf fodder and grass and water, can be expected to be influenced in a similar way. Leaf fodder and forest grass are an important part of livestock feeding because they reduce pressure on the limited grazing lands available. With deforestation, there would be either the additional work of collection or increased grazing, with direct effects on livestock production and indirect effects on both agricultural production and food consumption. It is expected that making the explicit connection between patterns of labor allocation, deforestation, and agricultural productivity will help identify the extent to which labor constraints are a factor and hence will suggest alternative approaches for increasing productivity.

3

GENERAL CHARACTERISTICS OF STUDY AREA AND HOUSEHOLDS

This report presents results obtained from a year-long household survey in a hill area of the Western Development Region in Nepal. The survey consisted of four quarterly rounds of data collection from 120 households using a pretested, structured questionnaire. Information was obtained on agricultural production, collection of forest products, time use patterns for selected activities, expenditures, off-farm employment, migration, and remittances. Food consumption was estimated using the disappearance method for crops, livestock, and horticultural products, together with expenditure data. Anthropometric measurements on all household members were taken at the time of the survey. In order to validate the time allocation measures from the survey, a more detailed time sampling technique was used on a subsample of 12 households.

The survey was conducted by the Agricultural Projects Services Centre (APROSC) of Nepal and the Food and Agriculture Organization of the United Nations (FAO) in 1982/83 with assistance from the International Food Policy Research Institute. Its initial purpose was to help area-level agricultural planners incorporate labor, energy, and nutrition links into the agricultural production process. That exercise was completed in December 1985. This report builds substantially on the work done for that phase.[14]

Nepal is divided into three distinct ecological zones, the tarai, a band of lowland plains to the south, high mountains to the north, and the hill areas in the middle (Figure 1). The six wards from which the sample households were chosen were selected from three *panchayats* in hill districts of the Western Development Region. The objective of the sampling was to obtain as wide a representation as possible of the major social, economic, and ecological characteristics of the area. Thus, *panchayats* were selected first and then wards to cover variations in altitude, access to roads and markets, ethnic groups, and degree of deforestation.

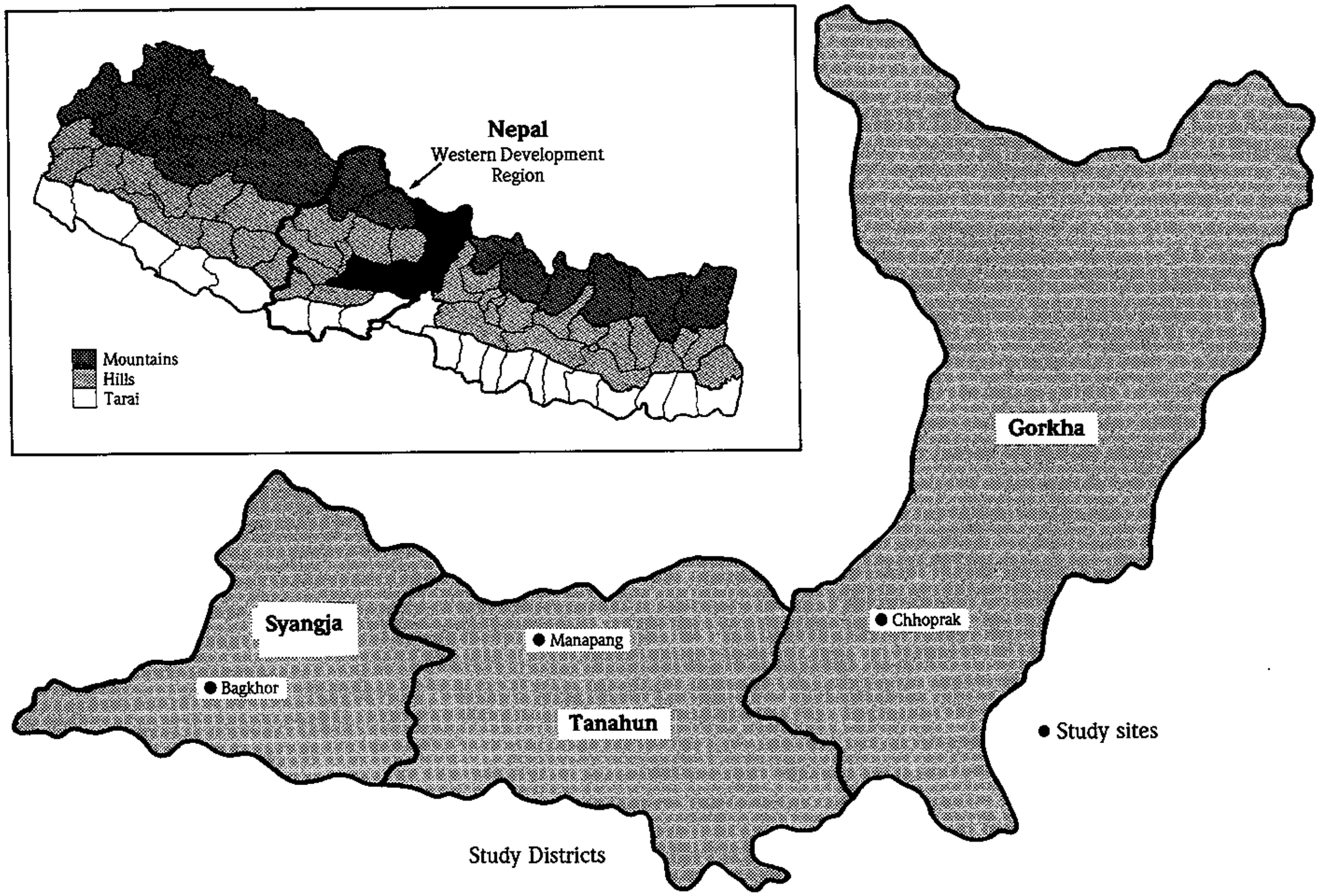
The sites selected were

District	Panchayat	Wards
Gorkha	Chhoprak	1 and 7
Tanahun	Manapang	5 and 8
Syangja	Bagkhor	2 and 8

The hill areas are, naturally, composed of hills (highlands) and valleys (lowlands). The altitudes at which farms are located range from a low of about 500 meters in Manapang to a height of about 1,500 meters in Chhoprak. Road transport and markets are easily accessible in Bagkhor, but they are a day's hike from Chhoprak. While it was not possible to obtain every possible type of situation, the distribution was a fair representation of road and market access at different altitudes. Similarly, the degree of deforestation is most severe in Chhoprak, and less severe in Manapang. In an effort

[14] Shubh K. Kumar and David Hotchkiss, "Energy and Nutrition Links to Agriculture in a Hill Region of Nepal," International Food Policy Research Institute, Washington, D.C., 1985 (mimeographed).

Figure 1—Study area and sites and ecological zones of Nepal



to obtain both lowland and highland agricultural characteristics in each of the selected *panchayats*, a somewhat higher inclusion of lowland farmers relative to what generally prevails in these districts may have resulted. Associated with this was a slightly higher proportion of Brahmin castes in the study source, as they tend to predominate in lowland farming. In the hill areas, lowland, called *khet*, may occur either in valley bottoms or on mountainsides. It is distinguished from upland, called *pakho*, by the fact that it can be irrigated at least during some part of the year. It is expected that this sampling bias may improve the analysis of production constraints for different crops, but it will not influence the results of the deforestation links to agriculture and nutrition. Within these selected wards, a random sample of 20 households (approximately 8 percent of households) was taken from each for a total of 120 households for the survey. A ward census survey was undertaken to assess the characteristics of the sample. A comparison of the basic assets of the households sampled with those in the census survey indicates a close comparability between the two groups.[15]

Size and Composition of Households and Landholdings

The average household size was between six and seven members (6.6), with one permanent migrant worker for every two households.[16] The average number of adult women per household was just slightly higher than the number of men. Children below six years of age constituted 20 percent of the total population, and those below 15 years of age were 45 percent of the population. This is consistent with the expected demographic pattern in developing countries.

The average landholding size was 1.45 hectares, of which 0.62 hectare was lowland or *khet*, on which water control is possible, and 0.83 hectare was upland or *pakho*, on which only rainfed agriculture is possible. Comparison with national surveys suggests a somewhat higher average farm size in this study sample than might be expected in the region (Table 1). This is mainly because more lowland was included in the sample, and lowland holdings are generally larger. This table suggests that the effective population density in terms of pressure on arable land may be much greater in the hill regions, even though the population density is lower than in the tarai in terms of population to total area.

Cropping Intensity and Patterns

The average cropping intensity of land is about 150 percent, indicating that half the land is cropped twice. Comparison with estimates made for Nepal as a whole until the late 1970s shows that cropping intensity in the study area is much higher than the national average. Moreover, the cropping intensity is nearly as high for the *pakho* at 142 percent as for the *khet* at 163 percent. This indicates an extremely high degree of cultivation intensity, which is partly a consequence of the effective population pressure on the arable land. A favorable rainfall distribution in the hills relative to the tarai is also likely to be a factor. The high cropping intensity for upland plots is particularly striking and could indicate that the potential for raising agricultural produc-

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[15] Food and Agriculture Organization of the United Nations, *Pilot Study on Energy Use and Nutritional Status at Farm Level in the Hills of Nepal*, Report No. 1 (Rome: FAO, 1984).

[16] A permanent migrant worker is one who is away for more than six months at a time.

Table 1—Average size of operated landholdings of sample farm households and Nepal, by region, 1982/83

Region	Operated Holdings		
	Lowland	Upland	Total
		(hectares)	
Study area			
Total sample mean	0.62	0.83	1.45
Nepal			
Hill			
Eastern	0.10	0.96	1.06
Central	0.34	0.82	1.16
Western	0.22	0.45	0.67
Midwestern	0.13	0.37	0.50
Far Western	0.22	0.16	0.38
Hill average	0.20	0.55	0.75
Tarai			
Eastern	1.28	0.74	2.02
Central	1.18	1.03	2.21
Western	0.36	1.64	2.00
Midwestern	2.42	0.58	3.00
Far Western	1.84	2.11	3.95
Tarai average	1.41	1.22	2.63

Source: Nepal, Agricultural Projects Services Center, *Foodgrain Marketing and Price Policy Study* (Kathmandu: APROSC, 1982), p.81; Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

tivity in hill areas is good. This may be even more so in the eastern half of the country where rainfall is relatively abundant.

While rice is the major lowland crop, both maize and ragi (finger millet) have a high share of cropped upland (Table 2). Among the lowland crops in the study area, early paddy production is much more prevalent than might have been expected, and in the upland plots, ragi area is higher than expected. It can be seen from the cropping calendar in Figure 2 that these crops do not displace the other major crops, and they contribute to the high cropping intensity noted earlier. In addition to these crops, small amounts of soybeans are planted along paddy ridges. Fruits and vegetables are grown mainly on homesteads and contribute only about 5 percent of household income. No farmland was reported to be sown with fodder crops.

Crop Yields

Crop yields in the study area are very similar to those for the country as a whole (Table 3). Although cropped area has increased for the country as a whole and for hill areas in particular, yields have declined over time. Between 1975/76 and 1982/83, for example, area under paddy in the hills increased by 30 percent, wheat by 50 percent, and maize by 10 percent. At the same time, yields for paddy declined from 2.6 to 2.0 tons per hectare and maize from 1.8 to 1.4 tons per hectare. Area increases and yield reductions are not so marked in the tarai. The only exception to this is wheat. For this crop, suitable high-yielding varieties (HYVs) have become readily available in the past 10-15 years, which has led to a sharp increase in cropped area for wheat—71.5

Table 2—Cropping pattern in the study area, 1982/83

Crop	Bagkhor		Chhoprak		Manapang		Total
	Ward 2	Ward 8	Ward 1	Ward 7	Ward 5	Ward 8	
				(hectares)			
Lowland crops	0.77	0.35	0.42	1.73	1.10	1.54	0.98
Early paddy	0.04	0.01	0.15	0.41	0.05	0.53	0.20
Paddy	0.33	0.28	0.27	1.11	0.82	0.53	0.55
Maize, irrigated	0.14	0.01	0.00	0.00	0.22	0.04	0.07
Wheat	0.25	0.05	0.00	0.20	0.02	0.45	0.16
Upland crops	0.83	0.83	1.69	1.47	1.36	1.07	1.21
Maize, dry	0.42	0.43	0.73	0.74	0.74	0.34	0.57
Ragi (finger millet)	0.41	0.41	0.70	0.19	0.60	0.16	0.41
Mustard	0.00	0.00	0.13	0.16	0.01	0.04	0.06
Blackgram (legume)	0.00	0.00	0.13	0.38	0.00	0.53	0.18

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

percent compared with 13.7 percent for all cereals between 1970/71 and 1980/81—as well as to increases in yields of as much as 44 percent during the same period.[17]

Livestock Ownership

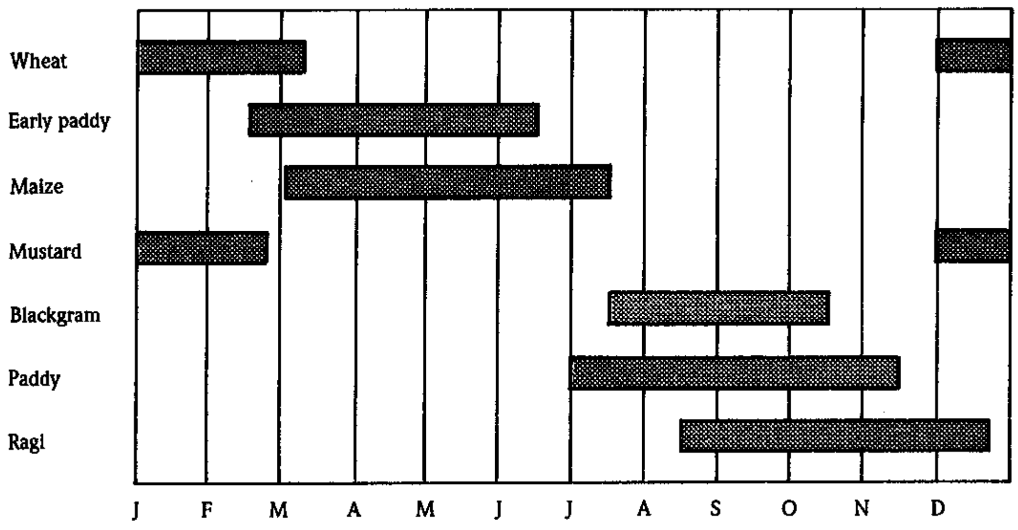
Livestock is an essential component of agricultural production in Nepal. With increasing intensification of crop production, the absolute requirement for animal labor increases, and the timely availability of livestock labor for field preparation becomes more important in maintaining or improving crop yields.

There is a wide variation in the distribution of livestock populations in Nepal. Though figures for the country as a whole are not available, a comparison of the study area with selected districts for which figures are available is given in Table 4. In Nepal as a whole, more livestock is owned in the tarai than in the hills, but livestock ownership in the study area appears to be relatively high for the hills. In addition to inputs for agriculture, livestock and livestock products contribute about 15 percent of household income in the study area.

At the same time that livestock contributes essential labor and products for agriculture, their upkeep entails the use of agricultural by-products such as rice and wheat straw, forest resources for provision of leaf fodder and grass, other feed inputs, and human labor and time. Animals are stall-fed throughout the year, supplemented with grazing in the dry months only. Another important source of animal feed is *kundo,* which consists predominantly of oilseed cake and straw cooked for extended periods of time in water. The making of *kundo* creates additional demand for firewood.

[17] Nepal, Agricultural Projects Services Centre, *Nepal: Foodgrain Marketing and Price Policy Study* (Kathmandu: APROSC, 1982).

Figure 2—Cropping calendar in the study area



Forest Resources

Though an explicit measurement of forest resources in the study area was not undertaken, an estimate for the region indicates that about 22 percent of the area is under forest cover and 50 percent under agriculture.[18] Community forests are largely used for wood and fodder. At the sites where deforestation is most severe, a higher reliance on private trees occurs. These trees are generally planted around the homestead or on the boundary of nearby fields. Although the ownership of private trees for fuel and fodder is considered a necessity by households in such areas, these trees represent only a small proportion of total fuelwood used even there. The present situation indicates that a sharp reduction in forestry resources has occurred since a survey by the Nepal Forest Resource Survey Office published in the early 1970s. In that survey, total area under forests in the hill regions was 55-60 percent, while agricultural area was about 14 percent in the far west, about 30 percent in the central and western hills, and about 36 percent in the eastern hills.

There are several mechanisms by which the gradual reduction in forest cover could have adverse consequences for agricultural productivity. Deforestation contributes to soil erosion, and marginal lands are increasingly brought under cultivation as land becomes deforested. As a result, another set of consequences becomes a factor—the additional demand on family labor to provide essential fuel, fodder, and water for humans and livestock. Usually there is an implicit assumption that there is a surplus of family labor on farms, and the higher labor demands can be easily met. This is the heart of the issue examined in this study. This constraint cannot be measured only in fuel energy or food energy: the limits imposed on time and on total human energy for productive activities as well as for essential consumption activities must also be considered. All have direct implications for human welfare.

[18] Food and Agriculture Organization of the United Nations, *Pilot Study on Energy Use and Nutritional Status.*

Table 3—Yields of principal crops in Nepal, 1975/76-1982/83, and in the study area, 1982/83

Area/Year	Paddy	Maize	Wheat	Barley	Ragi
			(metric tons/hectare)		
Nepal					
1975/76	2.07	1.65	1.18	0.93	1.14
1976/77	1.89	1.79	1.04	0.83	1.13
1977/78	1.81	1.66	1.12	0.88	1.07
1978/79	1.85	1.64	1.21	0.85	1.08
1979/80	1.64	1.28	1.20	0.90	0.97
1980/81	1.93	1.63	1.22	0.86	1.00
1981/82	1.98	1.58	1.32	0.86	1.00
1982/83	1.45	1.41	1.36	0.87	0.94
Hill area					
1982/83	1.97	1.43	1.27	0.85	0.95
Study area					
1982/83	1.80	1.20	1.00	...	0.96

Sources: Nepal, Ministry of Agriculture, Department of Food and Agricultural Marketing Services, *Agricultural Statistics of Nepal, 1985* (Kathmandu: MOA, 1985); and Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

In this study an indirect measure of forest resources was used. Since the main consideration was the increase in work load associated with reduced accessibility to forests, it was decided that a measurement of the time spent in collection would be most appropriate. The time for collecting a standard load of fuelwood (about 20 kilograms) was recorded for each household during each quarterly survey. The average time taken

Table 4—Livestock population per household in study area, 1982/83, and in selected districts of Nepal, 1977

District	Bullocks	Cows	Buffalo	Sheep, Goats, and Pigs	Livestock Units[a]
Study households	1.36	1.75	2.14	3.03	6.93
Selected districts					
Hills					
Ilam	1.65	1.85	1.74	2.41	6.59
Kavre	0.65	2.36	0.42	2.14	4.07
Dhading	0.99	2.15	2.31	2.69	7.14
Syangja	1.02	1.08	2.69	1.14	6.36
Sallyan	1.95	1.74	1.45	2.06	6.28
Kathmandu	0.23	1.69	0.14	1.08	2.35
Tarai					
Chitwan	3.56	3.17	2.67	2.04	11.14
Morang	5.00	2.27	1.00	1.73	9.46
Dhanusha	1.81	0.40	0.74	0.28	3.38
Rupandehi	2.65	0.94	0.99	0.85	5.25
Kailali	4.04	6.02	4.36	4.26	17.45

Sources: For selected districts, Ministry of Agriculture, Department of Food and Agricultural Marketing Services, *Agricultural Statistics of Nepal* (Kathmandu: MOA, 1977); and for study households, Nepal, Agricultural Projects Service Center, the Food and Agriculture Organization of the United Nations and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

[a] Buffalo are weighted at 1.5 livestock units, and sheep, goat, and pigs at 0.2.

per unit of fuelwood for each site was then computed and used to indicate the degree of deforestation encountered by the households at that site.

Only fuelwood collection time was used as the indicator for deforestation. Although leaf fodder, grass, and water were also collected, they were not included in the indicator because they are likely to be collected from specific locations. Hence their collection times per unit would be influenced more in a temporal than a cross-sectional way with deforestation. The time required for the household to collect a unit of fuelwood is used here to represent the household's effective distance from the forest area where the bulk of collection occurs. Growing of private trees is too limited to have a significant effect, although households are likely to shift to private trees as deforestation becomes more severe. At the household level, use of time per unit of fuelwood collected is likely to be a better indicator of the opportunity cost (and one that will increase as deforestation increases, given the stable patterns of habitation) than an area-specific measure of forested land.[19]

[19] These measures are also extremely difficult to collect and interpret without aerial surveys.

4

TIME ALLOCATION PATTERNS AND IMPLICATIONS OF DEFORESTATION

How much household time is allocated to production and to production support activities? Production support, or expanded economic activity,[20] includes all the activities for collection of fuel, leaf fodder, grass, and water for family and livestock, as well as food processing and cooking. These are essential activities, and a reduction in them without any increase in the productivity of these tasks would entail a real cost to households. The performance of many of the production support activities is affected by deforestation. In the following section, the implications of deforestation for the household are considered from the viewpoint of demand for time to spend on these tasks, as well as possible decreases in the quantity of forest products used. The specific case of fuelwood use is taken as an example to illustrate these changes.

Household Time Allocation

The information on time allocation in this study was obtained by setting up a series of recall instruments geared to the specific activities being measured. Since four quarterly survey rounds were conducted, it was possible to obtain some ideas about the seasonal pattern of time allocation. The main drawbacks were the use of the recall method and the limitation of the recall period to one week for most of the routine collection and food-processing activities. The data collected were then extrapolated to represent a much longer period of three months. In the case of agriculture, recall was by crop following the harvest. Because the recall period here extended over several months, the recall unit was days of work for various activities by crop. Finally, for both agriculture and off-farm employment, an assumption of an eight-hour work day, including travel time, was assumed.

The time allocation data obtained for men, women, and children in Table 5 show that the most intense period for agricultural work is during the rainy-season quarter of July to September. During the dry-season quarter, April to June, less time is spent on agricultural work, but it is the maximum time period for work on production support activities. Fuelwood and water collection activities, in particular, peak at that time of the year. Women's total recorded work time is between 150 and 180 percent of men's recorded work time. Of this total time spent by women, between two-thirds and three-fourths is spent on production support activities. Within the production support category, half to two-thirds of their time is spent on collection tasks alone, or up to half of their total recorded work load. Men spend time equivalent to 50 to 90 percent of their total recorded field work time in agriculture on support activities such as construction, collection, and domestic work. Their maximum time in production support activities, like that of women, is in the dry-season quarter of April to June.

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[20] The term "production support" is used in the study, *The Status of Women in Nepal.* A summary report of that study is found in Meena Acharya and Lynn Bennett, *The Rural Women of Nepal: An Aggregate Analysis and Summary of Eight Village Studies,* vol. 2, part 9 (Kathmandu: Centre for Economic Development and Administration, Tribhuvan University, 1981).

Table 5—Seasonal pattern of time allocation

Activity	April-June			July-September			October-December			January-March		
	Men	Women	Children[a]	Men	Women	Children	Men	Women	Children	Men	Women	Children
	(hours/person/day)											
Agricultural work												
Field work[b]	2.2	2.1	0.1	4.1	3.4	0.0	3.8	3.4	0.0	2.3	2.1	0.1
Employment[c]	0.5	0.2	. . .	0.6	0.2	. . .	0.5	0.0	. . .	1.6	0.1	. . .
Subtotal	2.7	2.3	0.1	4.7	3.6	0.0	4.3	3.4	0.0	3.9	2.2	0.1
Support activities												
Fuelwood collection	0.4	2.0	0.2	0.0	0.9	0.2	0.0	0.8	0.1	0.1	0.9	0.0
Water collection	0.2	1.6	0.3	0.0	0.9	0.4	0.1	0.9	0.1	0.1	1.2	0.1
Grass collection	1.2	0.9	0.3	0.1	2.4	0.7	0.1	0.4	0.1	0.0	0.2	0.0
Leaf fodder collection	0.1	0.3	0.0	0.0	0.0	0.0	0.2	0.4	0.1	0.1	0.7	0.0
Grazing[d]	. . .	. . .	2.5	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	2.6
Food processing	0.2	0.7	. . .	0.2	0.7	. . .	0.2	0.7	. . .	0.2	0.7	. . .
Cooking	0.4	2.2	. . .	0.4	2.4	. . .	0.4	2.1	. . .	0.3	1.7	. . .
Subtotal	2.5	7.7	3.3	0.7	7.3	1.3	1.0	5.3	2.5	0.8	5.4	2.7
Total of all recorded activities	5.2	10.0	3.4	5.4	10.9	1.3	5.3	8.7	2.5	4.7	7.6	2.8

Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

[a] Children 6-15 years old are included.

[b] Fieldwork was recorded by crop, which cuts across individual quarters. Therefore, it is aggregated into two semiannual periods: dry-season crops were assigned the first and fourth quarters, and wet-season crops were assigned the second and third quarters.

[c] Includes seasonal migration.

[d] Since grazing of cattle was mostly performed by children and no data on individual grazing time is available, it is all assigned to that category.

Given the drawbacks in methodology for collection of time allocation information for this study, results were compared with those from the subsample of 12 households, using a more intensive direct observation and time-sampling method,[21] and with results from the in-depth study on *The Status of Women in Nepal*.[22] The methodology used in this study was identical to that used for the subsample.

The results obtained with the structured recall method and with direct observation are remarkably similar. The comparison with *The Status of Women in Nepal* study also shows similar results (Table 6). This table indicates the amount of time spent on activities not enumerated in the present study but picked up by the more comprehensive methodology. It amounts to an additional 20-25 percent of work time by men and children and just over 30 percent more for women. This suggests that the percentage of underreported time in this study due to omitted activities was similar for men, women, and children.

Given the difference in methodologies used in the two studies, the similarity of results is somewhat unexpected. This may be because the respondents in *The Status of Women in Nepal* study were asked to recall the amount of time required to perform a task rather than time allocation per se as in the structured questionnaire used in the

Table 6—Comparison of data on patterns of time allocation from two studies

Activity	Rural Women of Nepal Study[a]			Nepal Energy and Nutrition Survey		
	Men	Women	Children	Men	Women	Children
			(hours/person/day)			
Agricultural work						
Household farm	2.73	2.74	0.99	3.10	2.75	0.05
Employment	1.24	0.46	0.21	0.80	0.13	. . .
Subtotal	3.97	3.20	1.20	3.90	2.88	0.05
Support activities						
Fuelwood collection	0.24	0.38	0.20	0.13	1.15	0.13
Water collection	0.07	0.67	0.33	0.10	1.15	0.23
Grass collection				0.35	0.98	0.28
Leaf fodder collection	1.43	0.97	1.79	0.10	0.35	0.00
Grazing				(0.90)[b]	. . .	1.80 (0.90)[b]
Food processing	0.18	0.97	0.16	0.20	0.70	. . .
Cooking	0.27	2.05	0.24	0.38	2.10	. . .
Subtotal	2.19	5.04	2.72	1.26 (2.16)[b]	6.43	2.44 (1.54)[b]
Total	6.16	8.24	3.92	5.16 (6.06)[b]	9.31	2.49 (1.59)[b]
Other[c]	1.37	2.57	0.69	n.a.	n.a.	n.a.

Sources: Meena Acharya and Lynn Bennett, *The Rural Women of Nepal: An Aggregate Analysis and Summary of Eight Village Studies*, vol. 2, part 9 (Kathmandu: Tribhuvan University, 1981); and Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: The ellipses indicate a nil or negligible amount. n.a. means not available.

[a] Based on observations from five hill villages and one tarai village.

[b] The numbers in parentheses are alternate assumptions of cattle grazing time. Under the first assumption all grazing time is assigned to children.

[c] Activities recorded by Acharya and Bennett but not included in the present study are manufacturing, hunting and gathering, house construction, plastering walls, cleaning and laundry, shopping, child care, and other domestic work.

[21] The methodology is derived from Acharya and Bennett, *Rural Women of Nepal*, pp. 16-19.

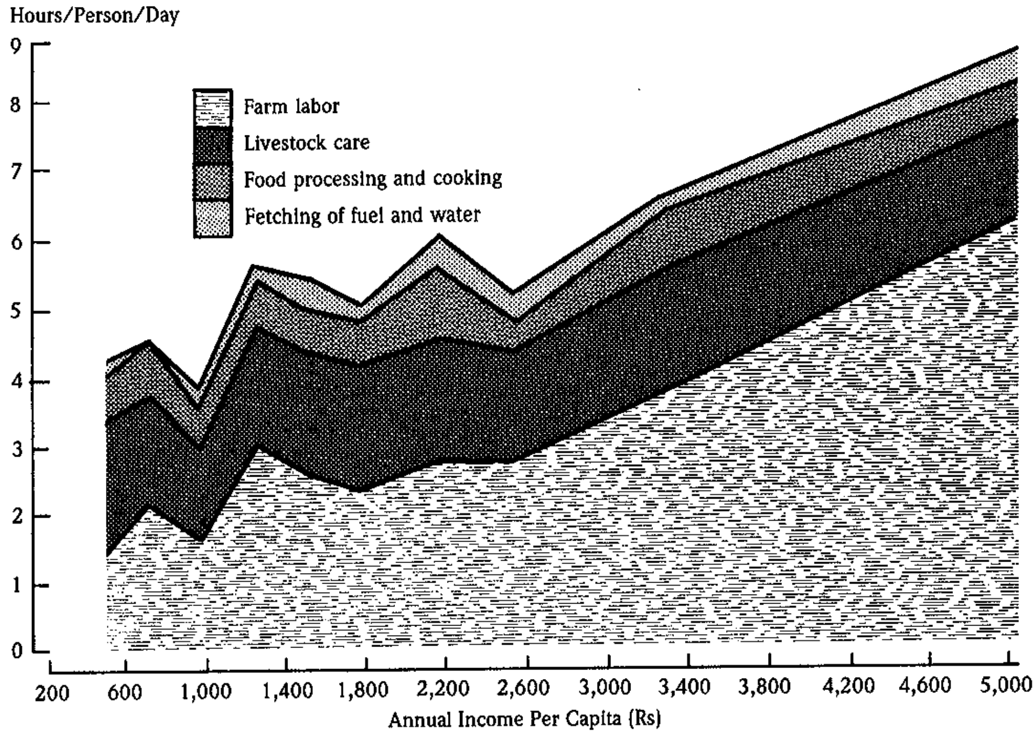
[22] Acharya and Bennett, *Rural Women of Nepal*.

present study, which requires a higher degree of knowledge about practices in the area than is usually available for designing survey instruments.

An examination of the effects of household income on men's and women's work time shows that agricultural work increases for both sexes, but especially for men, as household income increases. This may indicate some labor surplus for men at lower income levels, which may be taken up by an increase in seasonal migration. Women's labor, especially their total work load, is less variable by income. This suggests that women are already working long hours at low incomes (and lower food availability). If there is limited substitutability between men's and women's labor in agriculture, then this could curtail men's labor use until it is possible to expand hired labor use. Also, part of the increase in both men's and women's labor with higher income may be due to improved food availability and intakes. Since household income is mainly the product of agriculture and farm size, household labor use seems to increase with farm size. This is confirmed later in the analysis of household labor use.

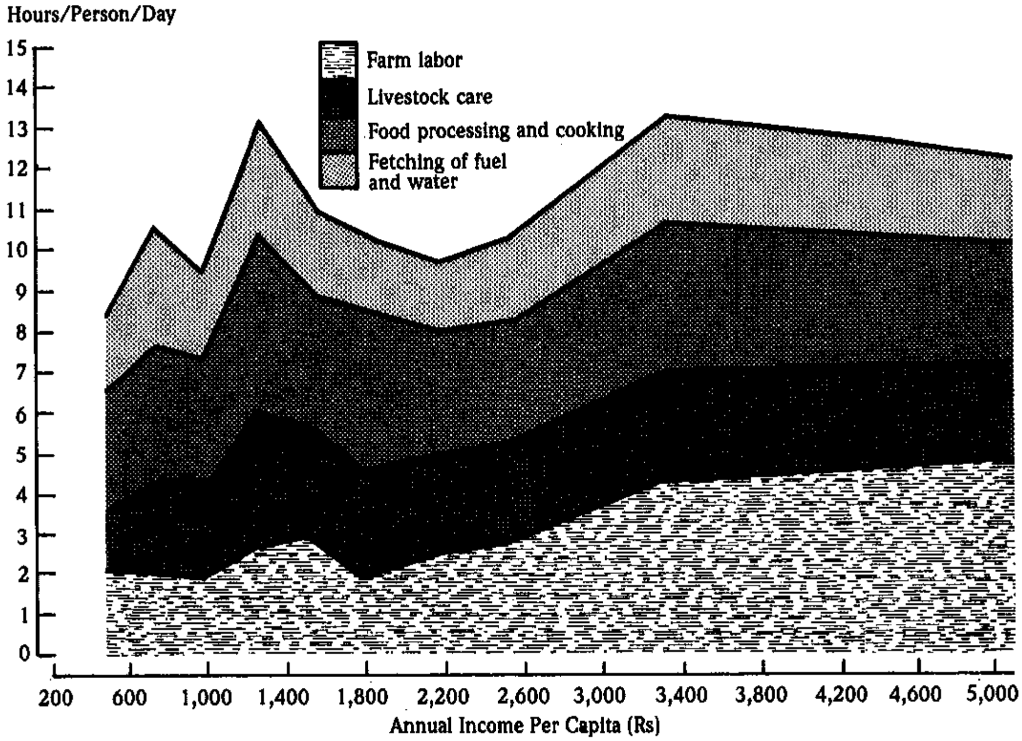
Time spent on other activities is relatively constant at all income levels for both men and women (Figures 3 and 4). This indicates that there is probably a high propensity to spend additional time on agriculture, despite an increase in wage labor use at the higher income levels. This observation, in conjunction with the high marginal product of labor in crop production, as seen later, suggests that if mechanisms were available

Figure 3—Men's time allocation by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Figure 4—Women's time allocation by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

to reduce the time spent on production support activities, more time would be spent on agriculture.

Implications of Deforestation

As deforestation proceeds, access to forest resources becomes more and more removed for the settled population. In the long run, populations have been observed to shift increasingly to other sources to substitute for these fast-depleting resources. Fuelwood is increasingly replaced by straw and dungcakes or other by-products. (At the time of this study, cow dung was used exclusively for manuring fields and not as fuel.) Leaf fodder and grass for animals are replaced by increased grazing,[23] coarse grains, and crop by-products. Also in the long run, water from forest streams becomes more scarce and is replaced by water from more distant or contaminated rivers and

[23] This is shown to have occurred in India in Subhachari Dasgupta and Asok Kumar Maiti, *The Rural Energy Crisis, Poverty, and Women's Roles in Five Indian Villages* (Geneva: International Labour Organisation, Rural Employment Policy Research Programme, 1986).

ponds. All of these changes have adverse effects on productivity and health, which can partly be alleviated by higher incomes and the ability to purchase the alternatives in the marketplace. However, if aggregate productivity of agriculture is also declining, then the possibility of higher incomes also declines.

In order to understand the wider implications of household responses, the starting point for this analysis is the behavioral response of deforestation on fuelwood consumption behavior. Fuelwood demand is expected to be influenced by both income and price factors, as well as fixed demand factors such as family size. Livestock numbers also influence fuel consumption in Nepal because livestock are fed a cooked feed preparation called *kundo* to increase the nutrient availability of miscellaneous crop by-products used in livestock feed. The larger the herd the more fuelwood is needed to cook the *kundo*. Since fuelwood is seldom purchased, the "price" is based on time required for collection of a unit of fuelwood (a standard load, a *bhari*, was measured to be approximately 20 kilograms of fuelwood). Two alternate price estimates can be made here—one in terms of time required and the other incorporating the average wage rate for agricultural labor. The information on wage rates for women in particular was relatively poor because very few women worked for wages. Consequently, this derived price is also mainly a function of time required for fetching fuelwood. Time required to fetch a load of fuelwood is determined by the distance to the source, which will increase as deforestation progresses.

The relationship of fuelwood use to price (time required to collect a *bhari* of fuelwood) and income factors is illustrated in Figures 5-7. With rising household income, fuelwood consumption generally increases through the first seven deciles, after which there appears to be a declining trend.[24] For kerosene, which is used mainly for lighting, there is a fairly steady increase in use with income growth. There is a rapid reduction in fuelwood consumption with increasing time per load. For estimating the magnitude of these changes and its implication for total time spent on fuelwood collection, two sets of equations are specified.[25] In the first,

$$FW = f(\text{Log}Y, FW_P, HS, L, MB),^{26} \quad (1)$$

where

FW = quantity of fuelwood consumed (in kilograms per capita per year),

Y = total household income (rupees per capita per year),

FW_P = fuelwood price in time per load (8-hour days),

HS = household size,

L = livestock units,[27] and

MB = maize by-products (in kilograms).

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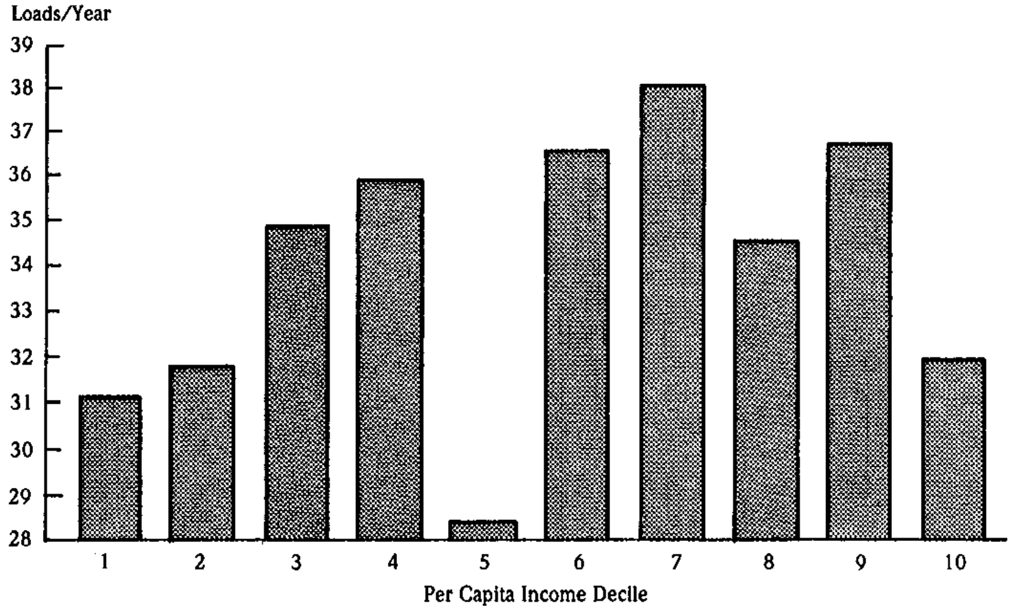
[24] The quadratic specification for the income effect on fuelwood use is, however, insignificant. This could be due to the inexplicably reduced use of fuel in the fifth decile.

[25] Although there appears to be some substitution of kerosene for fuelwood at higher income levels, deforestation is not found to be a factor in the shift.

[26] This equation was specified in both semilog and quadratic forms, but the semilog form was a better fit. The quadratic term was insignificant for both the household and per capita equations.

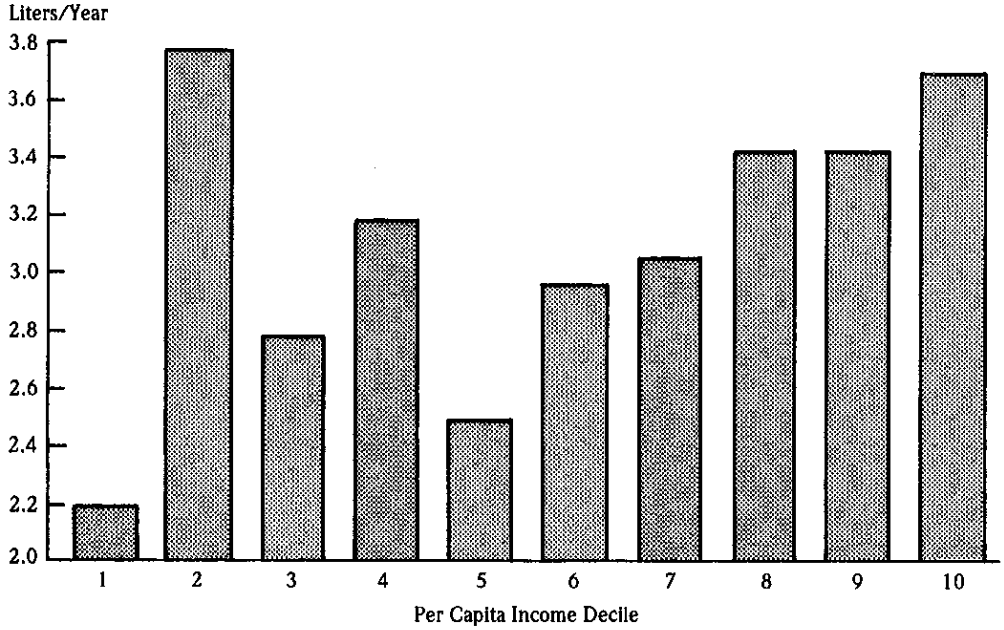
[27] Livestock were weighted as follows: buffalo, 1.5; cows and bullocks, 1.0; and sheep and goats, 0.2.

Figure 5—Per capita fuelwood consumption, collected by family and nonfamily members



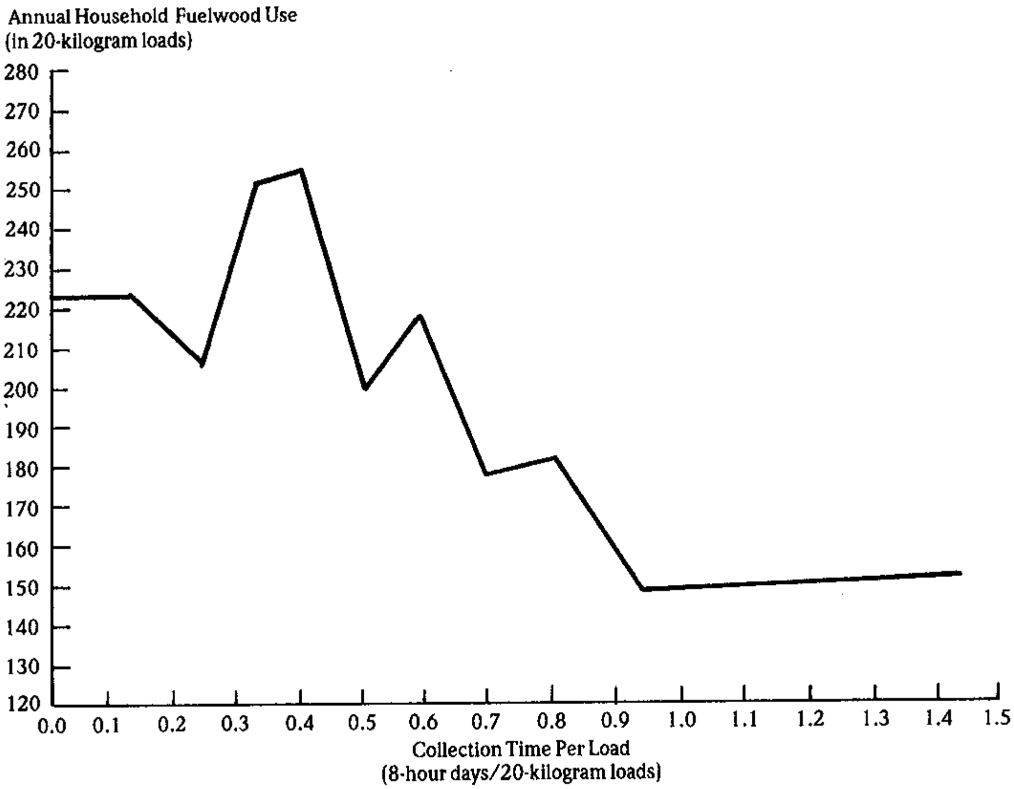
Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Figure 6—Per capita kerosene consumption



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Figure 7—Fuelwood consumption using collection time per load as an indicator of deforestation



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.
Note: Each point represents one-tenth of the sample.

Second,

$$TFW = f(\text{Log}\,Y, FW_P, HS, L, MB), \tag{2}$$

where

TFW = time spent on fuelwood collection (8-hour days per capita per year).

These equations are analogous to estimating both the consumption and expenditure consequences of price and income changes. While the second equation is not usually estimated in standard demand analysis, it is interesting given that both price and expenditure are specified in terms of time spent. Results are shown in Table 7. Calculations of elasticities for fuelwood consumption with respect to the increasing price of wood indicate that a 10 percent rise in price of wood, or the time taken for collection of one unit, will reduce its consumption by only 2-3 percent but will increase the time spent for its collection by 4-6 percent. This is consistent with a relatively inelastic response characteristic of a basic necessity. The income response best captured by a

Table 7—Factors explaining fuel collection and use, 1982/83

Explanatory Factor	Average	Fuelwood Use: Marginal Propensity to Consume	Fuelwood Use: Elasticity	Time Spent Collecting Fuelwood: Marginal Propensity to Consume	Time Spent Collecting Fuelwood: Elasticity
		(20-kilogram loads/ capita/year [x = 33.7])		(8-hour workdays/capita/ year [x = 18.3])	
Intercept	. . .	43.76**	. . .	14.25*	. . .
Log of total annual income (Rs/capita)	Rs 1,954.0	2.76† (1.72)	0.8	0.37 (0.38)	. . .
Average household size	6.6	−3.67** (−8.37)	. . .	−1.56** (−5.91)	. . .
Livestock units	7.0	0.43† (1.67)	. . .	0.19 (1.19)	. . .
Maize by-products produced per household (kilograms)	820.9	0	. . .	0	. . .
Time per load to collect[a]	0.61	−14.73** (5.44)	−0.3	16.94** (10.35)	0.6
$\bar{R}^2$ (adjusted)	. . .	0.47	. . .	0.62	. . .

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: Figures in parentheses are t-values. The size of the sample was 117.

[a] Time per load is determined using the following equation: FWP_i = (Time per load [hours]/8) × (workdays).

*Significant at the 0.05 level.

**Significant at the 0.01 level.

†Significant at the 0.10 level.

semilog functional form is small but significant. The income elasticity is found to be between 0.08 and 0.09.

Other results from this estimation indicate that, first, per capita consumption of fuelwood is lower in larger families, as is the time spent per adult in its collection; second, livestock has a small effect on raising fuel demand; and third, availability of maize by-products, often cited as a fuel source in the study area, has no effect on the total fuelwood demand.

The preceding analysis is restricted to fuelwood use. Other forest products, such as leaf fodder and grass for livestock and water from streams, would also recede with deforestation. Because, as mentioned earlier, their location in forests is more localized, the association of distance and deforestation is difficult to document in this cross-sectional study. Whereas the demand for water is likely to be as inelastic as that for fuelwood, the demand for livestock feed is influenced by changes in livestock holdings or feeding practices. If their consumption response is similar to that of fuelwood, that is, relatively inelastic, then the overall implications for demand for household and especially women's time would be correspondingly higher with increasing deforestation.

Implications of Deforestation for Time Allocation

In examining the time allocation patterns of the sample households by degree of deforestation, using simple tabular analysis, time spent on fuel-collection activities is examined separately for lowland and highland sites (Table 8). The average time per

Table 8—Pattern of time allocation and deforestation, 1982/83

Time Spent per Activity	Time Taken to Collect a Load of Fuelwood					
	Lowlands			Highlands		
	Low Deforestation	High Deforestation	Percent of Change	Low Deforestation	High Deforestation	Percent of Change
Time/load of fuelwood (minutes)	106	193	82	163	270	66
Fuel collection time (hours/day)	1.5	3.0	100	2.3	2.9*	26
All adults	1.3	2.6*	100	2.1	2.8*	33
Women	1.1	2.5*	127	1.9	2.6*	37
Children	0.2	0.4	100	0.2	0.1	−50
Per capita fuel collection time (hours/person/day)	0.3	0.4†	33	0.4	0.5	25
All adults	0.5	0.8*	45	0.7	1.0*	43
Women	1.0	1.6*	60	1.2	1.8*	50
Agricultural labor (hours/day)						
Women's field work						
Per capita	2.7	2.7	0	3.3	2.7	−17
Per hectare	2.8	1.5*	−46	2.8	1.8*	−36
Men's field work						
Per capita	1.9	4.1*	116	3.7	2.8	−23
Per hectare	2.2	2.7	23	3.1	1.7*	−42
Wage labor	0.7	0.9	29	0.3	0.5*	67
Cropped area (hectares)	1.4	3.2*	129	2.1	2.5	19

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.
*Significant at the 0.05 level.
†Significant at the 0.10 level.

trip for households in each ward is used as a proxy for the degree of deforestation in the area. In addition to the pattern of household time allocation for fuel collection, field work time by men and women is also tabulated by the degree of deforestation (or time per trip for fuelwood).

Table 8 shows that the time per trip for fuelwood increased 82 percent in the lowland wards and 66 percent in the highland wards, or an average of about 75 percent as deforestation increased. According to the earlier regression results, it would be expected that a 75-percent rise in the time per trip for fuel would increase the time spent in collection by 45 percent. The difference in increase in time spent for fuel collection between the low and high deforestation sites, in both the valley and hillside sites, is in line with the expected values from the earlier regression results. Whereas the total fuel collection time per household increased 100 percent for the lowland sites, it rose 26 percent for the highland sites. On a per capita basis, however, the average increase for lowland and highland sites combined was about 45 percent for adults and 50-60 percent for women.

Collection of fuel and other forest products, such as leaf fodder and grass, is largely done by women; women account for 72 percent of the time spent on this work (see Table 6).[28] On average, women spend 2.5 hours per day on such activities. This is

[28] This figure includes collection time for fuelwood, leaf fodder, and grass.

only slightly less than the time they spend on farm labor—about 2.8 hours per day averaged over a year. If the increase in time required for collection is borne entirely by women, and if they take all of this additional time away from farm labor, it would lead to a reduction in their farm labor input of 1.4 hours daily or a decrease of 50 percent, leading to a total reduction in farm labor of 24 percent if not substituted for by other household members or by hired labor.

To see the effect of deforestation on farm labor input, the following analysis is undertaken. First, simple tabular analysis shows that in the highland sites, where the cropped area between the two deforestation groups is similar, there is a substantial reduction in women's field labor on both a per capita and a per hectare basis. The only exception is their per capita labor input in the lowland sites. The explanation for that probably lies in the 129 percent higher amount of area cultivated, which would demand additional labor input. Despite this increase in area, women's labor per capita was no higher in the high deforestation sites. Surprisingly, men in the highland sites also showed a reduction in time spent in field labor, which was statistically significant for their hours spent per hectare. At the lowland sites with the higher amount of deforestation, there is also a significantly larger amount of area cropped. As seen earlier, household labor for both women and men increases with income (and area farmed). Consequently, the results of the tabular analysis reflect the combined effects of both deforestation and cropped area.

To some extent, there is an increase in wage labor use in the areas with higher deforestation. Even though the percentage of the increase is quite substantial, in absolute terms it does not appear to make up for the decrease in household labor input in these areas. A simple demand function for wage labor, however, does not indicate that the degree of deforestation was a statistically significant factor in influencing its use, after controlling for total cropped area and altitude.

In order to control for the main cropping characteristics in the association between deforestation and household labor input in agriculture, the following household labor input equation is estimated:

$$Lh_i = f(Lw, OffY, Tcrl, Pll, FS, Alt, Df), \qquad (3)$$

where

- Lh_i = household labor input, females and males (hours/day);
- Lw = wage labor input (hours/day);
- OffY = off-farm income, the sum of remittances and wage incomes (Rs/year);
- Tcrl = total cropped area (hectares);
- Pll = proportion of lowland in cropped area;
- FS = number of resident adults in household;
- Alt = altitude (high altitude wards = 1, others = 0); and
- Df = deforestation (wards where time per trip is high = 1, others = 0).

Total household labor input, as well as that of males and females, is expected to be a function of, first, household cropping characteristics such as total cropped area and proportion of lowland, both of which would tend to increase labor input if the income effect on labor input is greater than the substitution for leisure; second, use of wage labor and off-farm income, which may be expected to reduce household labor input; third, number of adults, which would increase total and per hectare labor input; fourth, deforestation, which would reduce household labor input; and fifth, altitude.

Results of the estimation equations are given in Table 9. They confirm the negative impact of deforestation on women's farm labor input. Even though men's farm labor also appears to be slightly reduced, this result is not statistically significant. When other household variables are controlled for, total household labor is reduced more than four hours per day, out of which three hours are accounted for by a decline in women's labor input. Also, both the increase in cropped area and the use of wage labor are accompanied by an increase in household labor use, indicating a strong income effect on household labor input. This is not unexpected given the high subsistence orientation and relatively high incidence of malnutrition among children and adults. The low levels of landlessness and hired labor use could also contribute to these results. An increase in the number of adults in the household has the expected positive effect on household labor input, and at higher altitudes, women's farm labor input is significantly higher.

The effect of deforestation on household labor input when estimated on a per person basis indicates a reduction in women's farm labor of 1.6 hours per woman and in men's farm labor of 0.8 hours per man (Table 10). Thus, while the effect for women is more pronounced, there is also some evidence that men may also cut their farm labor input. This could partly be the result of their involvement in collection activities and the higher grazing time required in the high deforestation sites. However, the limited substitutability between men's and women's activities in crop production at the household level could also play a role, especially since additional use of wage labor is limited.

The tabular analysis in Table 8 indicates a somewhat smaller reduction in labor time per person. There are, however, differences between the low-altitude and high-altitude sites. These differences can be traced to the larger areas cropped, especially in the low-altitude areas of the high deforestation sites. This correlation between deforestation and area cropped in the cross section is likely to be due to a two-way causality between the two.

Results of the regression analysis show that an increase in cropped land tends to be associated with higher household labor inputs, which partly offset the effect of deforestation alone. When Equation 3 is estimated for labor input per hectare, it is found that deforestation reduces household labor input by about 1.9 hours per hectare or by about 40 percent (Table 11). This is after controlling for the negative effect of the increasing cropped area on intensity of labor input.

Net Change in Women's Work Load with Deforestation

Results of the fuelwood equations indicate that a 1 percent increase in total collection time increases time spent collecting fuelwood by 0.6 percent and decreases the amount of fuel consumed by 0.3 percent. The time required to collect one load of fuelwood increased by about 75 percent where deforestation was high. This implies about a 45 percent increase in the time allocated for firewood collection. What is the implication of this result for the total activities surrounding collection of forest products? These

Table 9—Effects of deforestation on input of household farm labor in hours per day

Variable	Mean	Household Labor Input: Total	Females	Males
			(hours/day)	
Intercept	. . .	−2.22 (1.4)	−0.91 (1.2)	−1.29 (1.2)
Wage labor (hours/day)	1.3	1.11* (2.4)	0.74** (3.3)	0.38 (1.2)
Off-farm income (Rs/year)	2,865	-2.88^{E-05} (0.2)	4.50^{E-05} (0.7)	-7.01^{E-05} (0.8)
Total cropped area (hectares)	2.20	3.49** (6.5)	1.44** (5.6)	2.05** (5.7)
Proportion of lowland in cropped area	0.41	0.76 (0.28)	0.22 (0.2)	−1.06 (0.6)
Number of adults per household	3.4	1.36** (3.3)	0.57** (2.8)	0.78** (2.8)
Altitude (high = 1, low = 0)	0.50	1.47 (1.2)	1.54** (2.6)	−0.07 (0.1)
Time per trip for fuel (high = 1, low = 0)	0.49	−4.37** (3.1)	−3.21** (4.8)	−1.14 (1.2)
$\bar{R}^2$ (adjusted)	. . .	0.65	0.63	0.55

Notes: Means for the dependent variables are total household labor, 9.7 hours per day; female labor, 4.6 hours per day; and male labor, 5.1 hours per day. The figures in parentheses are t-ratios.
*Significant at the 0.05 level.
**Significant at the 0.01 level.

products are mainly fodder and grass for animals, but over time the availability of water would also be influenced by deforestation because the forest streams from which most household water is obtained would eventually dry up without their forest cover.

Women's time spent collecting fuelwood, fodder, and grass for the sample households was found to be 2.5 hours per person per day averaged over the year. If the response function for other forest products is assumed to be similar to that for fuelwood, one would expect that women's time spent collecting forest products would also increase by 45 percent (assuming the increased requirement is evenly distributed among all household members). That would lead to a daily increase in women's collection time for these products of 1.13 hours per day. It was estimated earlier that women's field labor decreased by 1.6 hours per day due to the effect of deforestation. However, since cropped area in the high deforestation sites tends to be higher, and this contributes to a higher demand for household labor, the actual fieldwork of women decreases by about an hour. This is reflected in the cross-sectional comparison in Table 8, which indicates a relatively small reduction in fieldwork per person with deforestation. The implications of deforestation, therefore, are two-fold: first, the work load of household members is raised, and second, labor input per hectare is reduced, with possible adverse yield effects. This reduction occurs even after controlling for cropped area, as shown in the previous section.

Table 10—Effects of deforestation on input of household farm labor in hours per person per day

Variable	Mean	Household Labor Input	
		Females	Males
		(hours/person/day)	
Intercept	. . .	2.05** (4.1)	1.79** (3.8)
Wage labor (hours/day)	1.30	0.10 (0.7)	0.10 (0.8)
Off-farm income (Rs/year)	2,918	3.43E−05 (0.8)	1.61E−05 (0.4)
Total cropped area (hectares)	2.20	0.87** (5.2)	1.07** (6.9)
Proportion of lowland in cropped area	0.41	1.12 (1.3)	0.89 (1.1)
Number of adults per household	3.4	−0.4** (3.0)	−0.47** (3.8)
Altitude (high = 1, low = 0)	0.50	0.49 (1.3)	0.37 (1.0)
Time per trip for fuel (high = 1, low = 0)	0.49	−1.57** (3.6)	−0.79* (2.0)
$\bar{R}^2$ (adjusted)	. . .	0.31	0.45

Notes: The figures in parentheses are t-ratios. Means for the dependent variables are female labor, 2.8 hours per person per day and male labor, 2.9 hours per person per day.
*Significant at the 0.05 level.
**Significant at the 0.01 level.

Table 11—Effects of deforestation on input of household farm labor per day in hours per hectare

Variable	Household Labor Input	
	Mean	Coefficient
	(hours/hectare/day)	
Intercept	. . .	3.27** (5.26)
Wage labor (hours/hectare/day)	0.57	1.08** (3.0)
Off-farm income (Rs/year)	2,865	6.19E−06 (0.1)
Total cropped area (hectares)	2.20	−0.18 (1.2)
Proportion of lowland in cropped area	0.41	0.63 (0.63)
Number of adults per household	3.4	0.41** (2.7)
Altitude (high = 1, low − 0)	0.50	0.57 (1.2)
Time per trip for fuel (high = 1, low = 0)	0.49	−1.86** (3.6)
$\bar{R}^2$ (adjusted)	. . .	0.18

Notes: The mean for the dependent variable is 4.5 hours per hectare per day. The numbers in parentheses are t-ratios.
**Significant at the 0.01 level.

5

AGRICULTURAL PRODUCTION CHARACTERISTICS

Implications of Deforestation for Production

What are the consequences for production of increasing the demand on women's time of collection activities? Not only does their total work load increase, but time spent on directly productive activities is reduced. This could have adverse consequences on income, primarily from agricultural production.

The previous section confirmed that household labor input, and especially the women's labor component of time spent in farming on a household and per-person basis, declines with a higher degree of deforestation, as reflected in the time per trip for fuel collection. At the same time, men's labor input also decreases. This could be due at least in part to lack of perfect substitutability between women's and men's labor. Detailed studies of time allocation from Nepal suggest that there are some activities for which sexual division of labor is more rigid than for others. Agricultural activities described as being almost exclusively carried out by women are seed selection, weeding, and application of organic manures.[29] If the extent to which men's labor can be substituted for women's is limited, then reduction in women's labor could also reduce men's labor if men must wait for women to complete their tasks. Other contributing factors may be more time spent by men on livestock grazing and increased seasonal migration by men.

The extent of this decline in agricultural labor is greater when controlling for cropped area in the regression analysis than in the cross-sectional comparisons. This is partly explained by the larger amount of area cropped at higher deforestation sites, and it is especially pronounced for the lowland sites. These larger land areas are consistent with the central thesis that excessive land clearing contributes to deforestation. An increase in cropped land is found to have a strong income effect on labor input. An increase of 1 hectare in cropped area increased household labor by 3.5 hours per day, women's labor by 1.4 hours per day, and men's labor by 2.1 hours per day (Table 9).

In sum, high deforestation sites have greater demand for labor both for collection activities and for agricultural labor. This is reflected in a significantly larger household size and a lower number of permanent and seasonal migrants from these sites. The possible long-term demographic implication of this kind of response to deforestation, while not possible to explore in this report, should be examined further. Labor input per hectare is significantly lower in the high deforestation sites, and both female and male labor are reduced when cropped area and proportion of lowland cropped are controlled for.

What are the implications for agricultural production? The production response to these reductions in labor input is indicated by the factor shares and the marginal

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[29] Bina Pradhan, *The Newar Women of Bulu*, vol. 2, part 6 of *The Status of Women in Nepal* (Kathmandu: Centre for Economic Development and Administration, Tribhuvan University, 1981); and Sidney Schuler, *The Women of Baragaon*, vol. 2, part 5 of *The Status of Women in Nepal* (Kathmandu: Centre for Economic Development and Administration, Tribhuvan University, 1981).

product of labor. Women's labor is primarily influenced by deforestation, but the degree of substitutability between men's and women's labor influences the reduction in men's labor. These issues are examined in the next section.

Significance of Labor to Agricultural Production

The main crops grown in the study area are wheat, early paddy, and paddy for lowland plots, and maize and ragi (finger millet) for upland plots. A small proportion of maize is planted on lowland plots. Mustard and blackgram are also grown, and both provide essential dietary ingredients. Production data recorded for each crop were area; labor input in days, by household and by wage labor of men, women, and children; days of animal labor used in crop production; purchased fertilizer use; and output. Aggregate observations for each crop are given in Table 12. Levels of labor input and yields for cereals are within the range expected for hill regions.[30] The yields for both mustard and blackgram are on average substantially lower than expected, and the variation in their yields is also very high. This would indicate either extreme riskiness in production of these crops or some underlying problem in reporting. The ratio of output to total labor days, indicating the average product of labor, is highest for early paddy at 7.7 kilograms and lowest for blackgram at 1.2 kilograms.

In order to estimate the marginal product of land, human labor, and animal labor in the production of each crop, translog or specific production functions are used. In the first equation, an interaction term for aggregate labor input and area is included to test whether the effects of each are influenced by the level of the other. This is used later to determine the factor shares and marginal products for small and large farms. The equation is

$$\text{LogP} = f(\text{LogA}, \text{LogL}_t, \text{LogLv}, \text{LogALogL}_t), \quad (4)$$

where

P = crop output (in kilograms),

A = crop area,

L_t = total human labor input (in days of family and hired labor), and

Lv = animal days used.

Next, the marginal product of men's and women's labor input in crop production is tested. This is considered important for two reasons. First, there is reason to expect, given the nature of sexual division of labor in Nepal, that there may not be perfect substitutability between men's and women's labor. Second, it has been documented that women carry nearly the entire work load for fuel, fodder, grass, and water collection as well as food processing and cooking. So if "women's tasks" in crop production are not easily assumable by men, then it would indicate that, in order to increase agricultural productivity, an improvement in productivity of women's tasks in nonagricultural activities may also be essential to increase agricultural production.

To test the homogeneity between men's labor and women's labor, the production function is tested to see if it is separable into these subaggregates. Separability implies

[30] Nepal, Agricultural Projects Services Centre, *Nepal: Foodgrain Marketing and Price Policy Study.*

Table 12—Basic crop production data, 1982/83

Crop	Number of Cultivating Households	Area	Yields	Labor Use: Household Labor Men	Labor Use: Household Labor Women	Labor Use: Wage Labor Men	Labor Use: Wage Labor Women	Total Labor	Ox-days	Fertilizer Used	Average Production/ Labor Day
	(N = 118)	(hectares)	(kilogram/ hectare)	(days/hectare)					(days/ hectare)	(kilogram/ hectare)	(kilogram/ labor day)
Wheat	46	0.40	1,008	78	82	12	5	177	9	112.4	5.7
Maize	113	0.66	1,183	77	82	17	10	186	28	...	6.4
Early paddy	54	0.40	1,751	108	103	8	9	228	23	...	7.7
Paddy	97	0.67	1,863	165	105	37	11	318	67	...	5.9
Ragi	92	0.50	955	111	162	7	8	288	27	...	3.3
Mustard	38	0.18	263	46	59	15	10	130	74	...	2.0
Blackgram	53	0.40	210	54	71	23	26	174	53	...	1.2

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Note: The ellipses indicate a nil or negligible amount.

that marginal rates of substitution between pairs of factors in the separated group are independent of the levels of factors outside that group.[31] In this case, the subaggregates are men's (L_m) and women's (L_f) labor, and area is used as the factor outside the group. If the true production function is weakly separable into L_m and L_f, and the separable form of a translog function is interpreted as an exact production function used as a Cobb-Douglas function of translog subaggregates, then

$$LnP = f[LnL_t(LnL_m, LnL_f), LnA \ldots], \tag{5}$$

where L_t is the aggregate labor input. For $f(LnL_t, LnA)$ to be linear in LnL_t and LnA only, then it has to be shown that LnL_t is quadratic in LnL_m and LnL_f. For the argument of separability, that is, the homogeneity of men's and women's labor, to hold, the constraints to apply are

$$LnL_m \cdot LnA = LnL_f \cdot LnA = 0. \tag{6}$$

It is assumed that production is a linear function of both land and labor, with a declining marginal product for both. The coefficients for the squared terms are therefore set equal to 0. The equation estimated is

$$LnP = f(LnA, LnL_m, LnL_f, LnL_m \cdot LnA, LnL_f \cdot LnA, LnL_v), \tag{7}$$

where L_m is men's labor input for the crop (in days of family and hired labor), and L_f is women's labor input for the crop.

Results from these three equations are used to calculate the marginal products and factor shares for each input at its mean value in use. These are shown in Tables 13, 14, and 15. The main observations from these tables are as follows:

1. The production response of labor is consistently significant, and its factor share is higher than that for land for all crops except early paddy. Also, the marginal product value for most crops is equal to or greater than the prevailing wage rates, indicating that despite the small size of average holdings, hill agriculture does not represent a labor surplus situation, and labor is a significant constraint in the production of most crops grown.

2. Wheat and paddy have the highest marginal products with increasing labor input. These are predominantly lowland crops. The upland crops, maize and ragi, have a lower marginal productivity of labor. A comparison with local wage rates—Rs 8.00 per day for men and Rs 5.00 for women—suggests that wages are comparable to the marginal product of labor for maize and ragi, but are lower than those for wheat and paddy if rice is priced at Rs 5.00 per kilogram and wheat, ragi, and maize at Rs 3.00 per kilogram.

3. The marginal product of men's and women's labor is found to be independently significant for all crops except early paddy, often with different marginal products. The separability test indicates that except for the dry-season crops, wheat and mustard, men's and women's labor are weakly separable, that is, they have different marginal rates of substitution with land. This suggests that, at least for some crops, there is little justification for aggregating men's and women's labor.

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[31] Michael Denny and Melvyn Fuss, "The Use of Approximation Analysis to Test for Separability and the Existence of Consistent Aggregates," *American Economic Review* 67 (June 1977): 404-418.

Table 13—Production functions by crop, 1982/83

Crop	Intercept	LArea	LLabor Total	LLabor Men's	LLabor Women's	LArea × LLabor Total	LArea × LLabor Men's	LArea × LLabor Women's	LAnimal Labor	N	R^2 (Adjusted)
Wheat											
Equation (4)	3.834	0.525	0.521*	...	...	−0.081	...	...	−0.033	46	0.59
		(1.44)	(2.82)			(−0.86)			(0.62)		
Equation (7)	4.632	0.78*	...	0.37*	−0.014	...	0.116*	−0.326*	−0.002	46	0.64
		(2.99)		(2.13)	(−0.14)		(2.03)	(−3.72)	(−0.04)		
Early paddy											
Equation (4)	5.284	0.800	0.515	...	...	−0.018	...	...	0.028	54	0.56
		(1.49)	(1.60)			(−0.13)			(0.30)		
Equation (7)	5.369	0.708	...	0.454	−0.053	...	0.020	−0.027	0.026	54	0.56
		(1.42)		(1.43)	(−0.35)		(0.11)	(−0.18)	(0.26)		
Maize											
Equation (4)	3.699	−0.026	0.393*	...	...	0.047	...	...	0.326*	112	0.62
		(−0.08)	(2.53)			(0.63)			(2.54)		
Equation (7)	4.453	0.153	...	0.031	0.193*	...	0.049	−0.024	0.421*	112	0.65
		(0.73)		(0.20)	(2.25)		(0.51)	(−0.25)	(3.33)		
Ragi											
Equation (4)	2.802	0.796*	0.617*	...	...	−0.171*	...	...	0.001†	92	0.67
		(2.71)	(5.62)			(−2.71)			(1.97)		
Equation (7)	3.536	0.723*	...	0.409*	0.151	...	0.000	−0.167	0.057†	92	0.66
		(2.57)		(2.00)	(0.77)		(0.0)	(−1.10)	(1.79)		
Paddy											
Equation (4)	3.640	0.340	0.638*	...	...	0.1010	...	...	0.095	97	0.79
		(1.40)	(4.63)			(0.19)			(0.47)		
Equation (7)	4.039	0.353†	...	0.455*	0.175	...	−0.119	0.147	0.055	97	0.79
		(1.68)		(3.15)	(1.09)		(−1.01)	(1.11)	(0.57)		
Blackgram											
Equation (4)	−1.733	−0.49	1.02*	...	...	−0.01	...	...	0.28	52	0.47
		(−1.27)	(2.15)			(−0.15)			(0.70)		
Equation (7)	−0.855	−0.46	...	0.10	0.83	...	−0.25	0.23	0.33	52	0.46
		(−1.28)		(0.10)	(0.93)		(−0.49)	(0.46)	(0.77)		
Mustard											
Equation (4)	1.364	0.23	0.43	...	...	−0.002	...	...	0.51*	37	0.62
		(0.73)	(1.21)			(−0.02)			(2.04)		
Equation (7)	2.210	0.32	...	1.35*	−1.14*	...	0.58*	−0.57*	0.53*	36	0.74
		(1.49)		(3.62)	(−2.55)		(3.37)	(−3.41)	(2.27)		

Notes: Equation (4) is $LogP = f(LogA, LogL_t, LogLv, LogALogL_t)$, where P is crop output, A is crop area, L_t is total human labor input, and Lv is animal days used. Equation (7) is $LnP = f(LnA, LnL_m, LnL_f, LnL_m \cdot LnA, LnL_f \cdot LnA, LnL_v)$, where L_m is men's labor input for the crop and L_f is women's labor input for the crop.

*Significant at the 0.05 level. †Significant at the 0.10 level.

Table 14—Marginal products in kilograms of primary factors for total sample, 1982/83

Crop	Area	Total Days of Labor			Days of Animal Labor
		Men's	Women's	Both	
	(hectares)				
Wheat					
Equation (4)	242.2[a]	. . .	. . .	4.5	−2.6[a]
Equation (7)	242.2	2.5	7.4	. . .	0.0[a]
Early paddy					
Equation (4)	1,259.1[a]	. . .	. . .	3.7[a]	2.4[a]
Equation (7)	1,311.6[a]	7.3[a]	1.7[a]	. . .	2.4[a]
Paddy					
Equation (4)	719.5[a]	. . .	. . .	3.8	1.5[a]
Equation (7)	738.0	20.6	0.9[a]	. . .	1.8[a]
Blackgram					
Equation (4)	−634.9	. . .	. . .	0.9	1.0
Equation (7)	−57.3	0.9	0.8	. . .	1.2
Maize					
Equation (4)	220.7[a]	. . .	. . .	2.1	12.4
Equation (7)	302.0[a]	−0.7[a]	2.4	. . .	15.7
Ragi					
Equation (4)	52.8	. . .	. . .	2.5	2.0
Equation (7)	79.2	3.0	1.9[a]	. . .	2.0
Mustard					
Equation (4)	30.8	. . .	. . .	0.8	2.1
Equation (7)	44.2	0.2	0.5	. . .	2.1

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: Equation (4) is $LogP = f(LogA, LogL_t, LogLv, LogALogL_t)$, where P is crop output, A is crop area, L_t is total human labor input, and Lv is animal days used. Equation (7) is $LnP = f(LnA, LnL_m, LnL_f, LnL_m \cdot LnA, LnL_f \cdot LnA, LnL_v)$, where L_m is men's labor input for the crop and L_f is women's labor input for the crop. The ellipses indicate a nil or negligible amount.

[a] These figures are marginal; they are not based on any significant coefficients.

4. The marginal product of women's labor is found to be substantially higher than that of men's labor for wheat, maize, and mustard. It should be noted that these are all dry-season crops—a time when there could also be increased competition from fuel and other collection activities, all of which are performed mainly by women.

5. For the paddy crop, men's labor input is the main constraint. For ragi, the other main wet-season crop, men's and women's labor is equally important. For wet-season crops, it is possible that women's labor may be more readily available because the burden of collection activities is reduced.

6. Among the cereal crops, animal labor is a significant constraint only in maize production. Incremental use of animal labor is also indicated as beneficial for production of both mustard and blackgram. This finding, however, cannot be seen as conclusive and needs to be investigated further.

High factor shares for labor and the significantly positive marginal product for labor found in the above analysis point to labor input as a constraint in agricultural production. This is despite the low levels of improved technological inputs used and the widespread perception of hill agriculture in Nepal as being labor surplus. Factor shares and marginal

Table 15—Factor shares of land, labor, and livestock in crop production, total sample, 1982/83

Crop	Area	Total Days of Labor			Days of Animal Labor
		Men's	Women's	Both	
	(hectares)				
Wheat					
Equation (4)	0.24[a]	...	...	0.63	−0.03[a]
Equation (7)	0.24	0.20	0.45	...	0.00[a]
Early paddy					
Equation (4)	0.72[a]	...	...	0.41[a]	0.03[a]
Equation (7)	0.75	0.42[a]	−0.09	...	0.03[a]
Paddy					
Equation (4)	0.39[a]	...	...	0.63	0.05[a]
Equation (7)	0.40	0.55	0.05[a]	...	0.06[a]
Blackgram					
Equation (4)	−0.52	...	...	1.04	0.28
Equation (7)	−0.50	0.45	0.48	...	0.33
Maize					
Equation (4)	0.19[a]	...	...	0.36	0.33
Equation (7)	0.26[a]	−0.06[a]	0.20	...	0.42
Ragi					
Equation (4)	0.06	...	...	0.80	0.06
Equation (7)	0.09	0.41	0.34[a]	...	0.06
Mustard					
Equation (4)	0.23	...	...	0.43	0.51
Equation (7)	0.33	0.05	0.14	...	0.53

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: Equation (4) is $LogP = f(LogA, LogL_t, LogLv, LogALogL_t)$, where P is crop output, A is crop area, L_t is total human labor input, and Lv is animal days used. Equation (7) is $LnP = f(LnA, LnL_m, LnL_f, LnL_m \cdot LnA, LnL_f \cdot LnA, LnL_v)$, where L_m is men's labor input for the crop and L_f is women's labor input for the crop.

[a] These factor shares are not based on any significant coefficients.

products were also calculated for small and large farms and were found to be similar in the present specification (Table 16). Sample sizes were too small for separate estimations.

The results of this analysis in conjunction with the earlier results on the reallocation of household labor with deforestation provide evidence of a labor constraint and of a declining aggregate productivity in agriculture resulting from reductions in labor input. This is further confirmed in this study by the significantly lower yield for the dry-season crops in the high deforestation sites (Table 17). The results also suggest that, first, adverse effects of deforestation on agricultural productivity will be relatively more pronounced on the smaller farms; second, introduction of improved agricultural technologies that require higher labor input may be problematic on smaller farms unless improvements in labor productivity are accessible for other essential tasks being performed by household members; and third, if improvements in agricultural labor productivity are possible, there is less likely to be a push for expanding area under cultivation than there would be in a labor-surplus situation.

Table 16—Characteristics of crop production on large and small farms, by cropped area, 1982/83

Crop	Number of Households Cultivating	Area	Yield	Labor Use: Household Labor Men	Labor Use: Household Labor Women	Labor Use: Wage Labor Men	Labor Use: Wage Labor Women	Total Labor	Animal Labor	Fertilizer	Marginal Factor Share: Land	Marginal Factor Share: Labor	Marginal Product: Land	Marginal Product: Labor
		(hectares)	(kilograms/hectare)	(days/hectare)				(days/hectare)	(kilograms/hectare)	(kilograms/hectare)	(kilograms/day)		(Kg/hectare)	(Kg/day)
Smaller farms														
Wheat	25	0.18	1,209	94	110	11	5	226	4	152	0.26	0.69	244	3.26
Maize	56	0.39	1,169	72	91	21	9	193	25	...	0.16	0.34	138	1.86
Early paddy	16	0.24	1,679	86	101	6	6	199	20	...	0.74	0.54	997	4.19
Ragi	52	0.28	856	115	169	9	11	304	19	...	0.12	0.87	74	2.28
Paddy	41	0.28	2,024	170	109	38	12	328	62	...	0.38	0.62	637	3.48
Larger farms														
Wheat	28	0.52	831	65	67	18	6	156	12	82	0.22	0.61	145	3.14
Maize	57	0.92	1,198	92	83	13	13	201	32	...	0.20	0.38	174	2.02
Early paddy	38	0.46	1,782	117	104	9	10	239	24	...	0.73	0.54	857	3.55
Ragi	52	0.66	1,071	124	165	5	4	299	35	...	0.01	0.77	67	2.30
Paddy	56	0.96	1,745	161	103	37	11	311	70	...	0.39	0.64	602	3.66

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.
Notes: Total cropped area for smaller farms is less than 1.10 hectares. The ellipses indicate a nil or negligible amount.

Table 17—Crop yields by degree of deforestation, for lowland and highland sites combined, 1982/83

Crop	Low Deforestation	High Deforestation
	(kilograms/hectare)	
Paddy	1,802	1,909
Ragi	1,009	907
Wheat	1,255	754*
Maize	1,365	998†

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.
*Significant at the 0.05 level.
†Significant at the 0.10 level.

6

HOUSEHOLD FOOD CONSUMPTION AND NUTRITION

Relationship Between Income and Food Consumption

In addition to a general description of patterns of consumption and associated characteristics of income and expenditure in the study area, two aspects of food consumption are examined. First, levels of calorie intake[32] are analyzed as a function of income, agricultural production, time allocation patterns for women, and quantity of fuelwood used. Then cereal composition of the diet and the possible implications of deforestation on it are analyzed, using a two-step approach. First, the effect of quantity of fuelwood used on cooking time is examined. (There was no variation in the type of stove used in the sample, and cooking time includes all time spent in food preparation.) Second, cooking time is incorporated into an equation to explain the ratio of rice to total calories in the diet.

Rice and maize are the chief dietary staples, with rice consumption expenditure rising rapidly with income (Figure 8).[33] Ragi has a smaller though relatively constant place in the diet. Wheat is consumed in negligible amounts and is largely produced for sale or for wage payments. Expenditures on other foods also increase with income, but not as rapidly as those for rice.

Home-produced items contribute greatly to the household's food basket. Surprisingly, the reported value of purchased foods does not appear to increase much as per capita income rises, but home-produced consumption does. Milk, milk products, and eggs constitute the major part of noncereal food expenditures in home-produced consumption. Total cereal consumption and home-produced cereal consumption are virtually identical.

Allocation of total income to food shows the expected pattern of gradually declining proportions, commonly referred to as Engel's Law (Figure 9). An inflection point occurs at the second income decile, which is a phenomenon that has been observed in other low-income countries.[34] This is shown by a rising proportion of income spent on food at very low income levels, before it starts to decline as expected. This occurs only in a seriously deprived population, in which practically *all* income increments are spent on food. It is hypothesized that there are essential nonfood fixed costs that must be incurred even at the lowest income levels, and these prevent a higher proportion of income being spent on food. The proportion of income spent on food rises from about 72 percent in the first income decile to more than 90 percent in the second income decile, before declining to about 40 percent for the highest income decile.

Cash expenditures for food are a much larger share of income at lower income levels, and the share is reduced as incomes rise. However, nonmarket value of consump-

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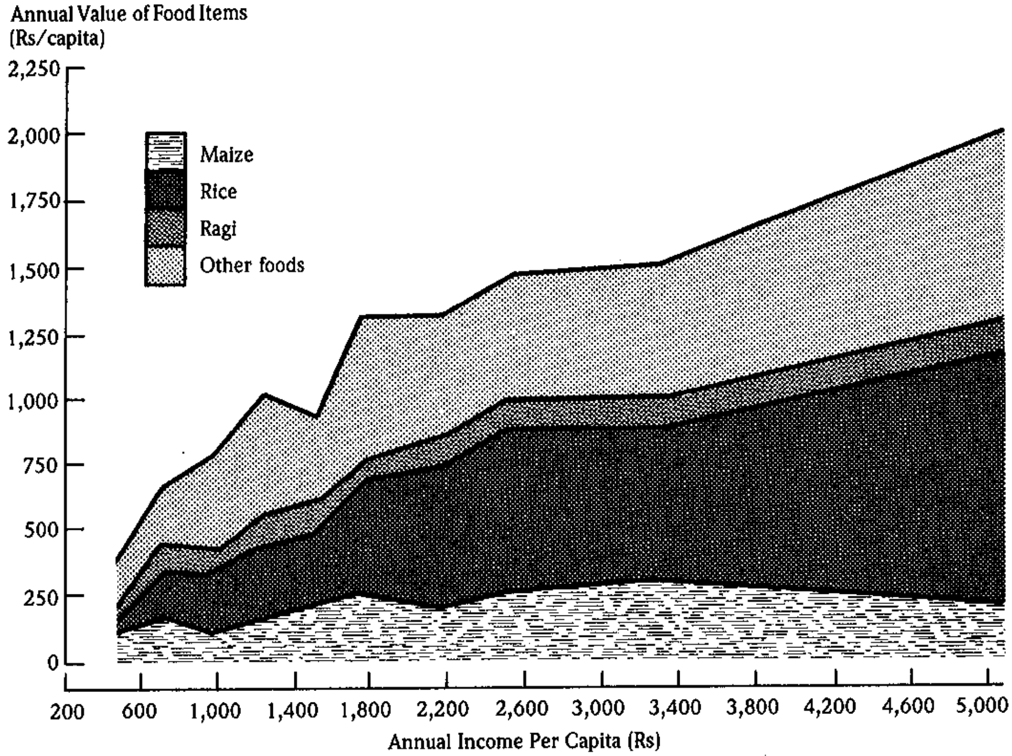
[32] All calories referred to in this report are kilocalories.

[33] Rice consumption expenditure refers to the total value of food in the diet, purchased and home-produced.

[34] Neville Edirisinghe and R. M. K. Ratnayake, "A Preliminary Analysis of the Determinants of Nutritional Welfare in Sri Lanka," International Food Policy Research Institute, Washington, D.C., January 1984 (mimeographed).

Figure 8—Value of major food items in the diet by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

tion in relation to total income roughly follows the same pattern as did total food expenditures.

Nonfood expenditures show an interesting pattern in which wage payments clearly become the major increasing expenditure item in this category (Figure 10). This reflects the relatively small amount of other nonfood expenditures incurred, given the limited use of wage labor on aggregate. This observation again emphasizes the labor constraint faced by these households, where an increase in household labor in production is paralleled by an increase in hired labor use.

Consumption reported for individual food items is converted to dietary calories.[35] The annual average daily per capita consumption is estimated at 2,137 calories. The distribution by income of caloric consumption is shown in Figure 11.

Finally, the contribution of the main income sources, farm production and remittances, is examined (Figure 12). Though the absolute values of both remittances and farm production rise with income, the ratio of farm production to total income is

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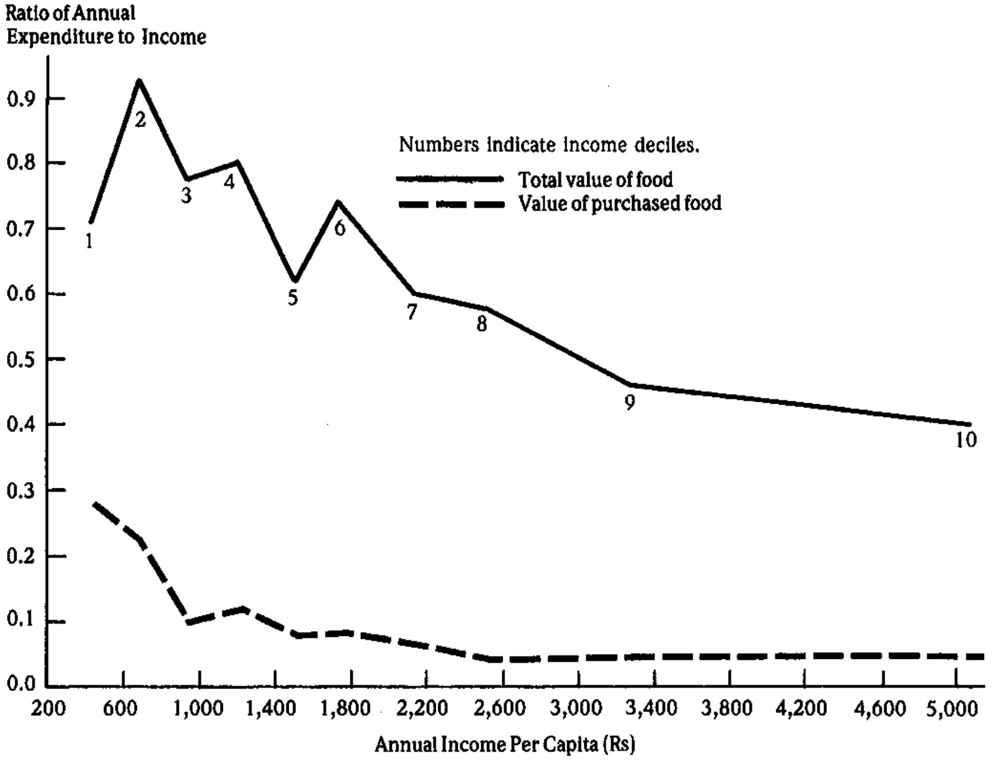
[35] The estimate of food consumption is based on amounts reportedly kept for home consumption for all field crops, livestock, horticultural produce, food purchases, and foods received as wage payments or gifts. A major disadvantage of this method is that seasonal fluctuations in food consumption cannot be identified.

Figure 9—Proportion of income spent on food by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

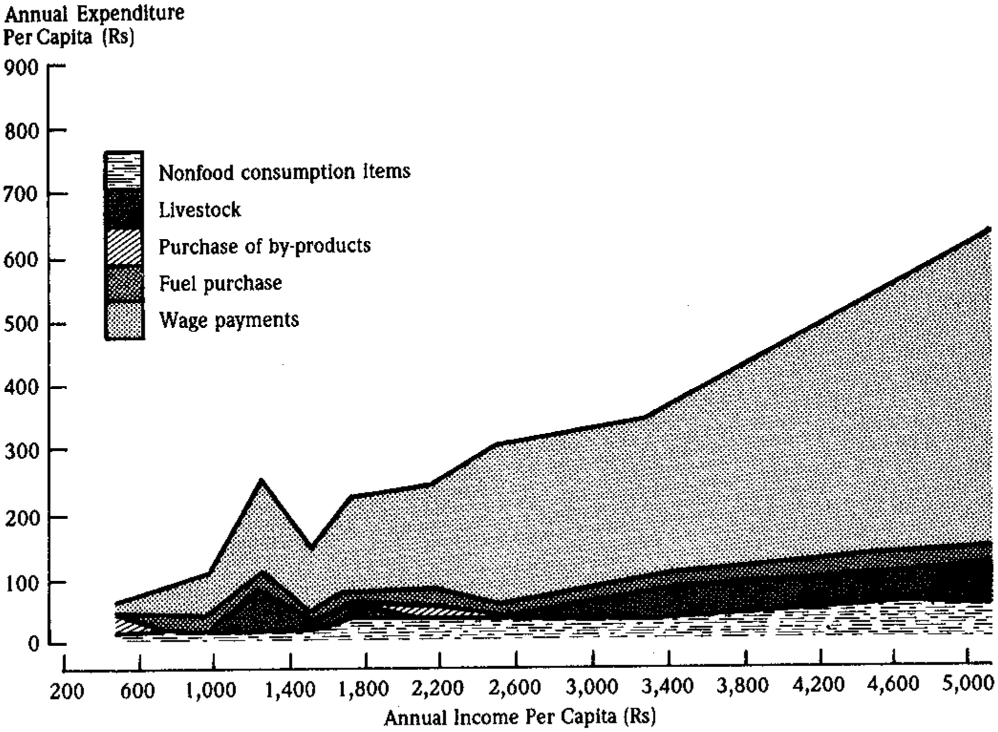
calculated to be about 60 percent for different income levels, and the proportion of remittances varies from about 20 percent of income at the lower income levels to about 10 percent for the middle income group and 16 percent for the highest income group, with no perceptible trend.

Links Between Deforestation, Diet Composition, and Intake

The effects of deforestation on collection time for fuelwood and, by inference, other essential forest products, and the possible effects on agricultural production via a substitution of production time for collection time have already been examined. Here, these effects of deforestation are extended to see if they also affect household food consumption and its composition. Figure 13 shows the pathways by which such effects might occur.

There are several simultaneously occurring mechanisms by which deforestation can be expected to have a direct effect on dietary intake and composition (the indicator of dietary composition used here is the ratio of rice calories to total cereal calories in the diet).

Figure 10—Nonfood expenditures by annual income per capita

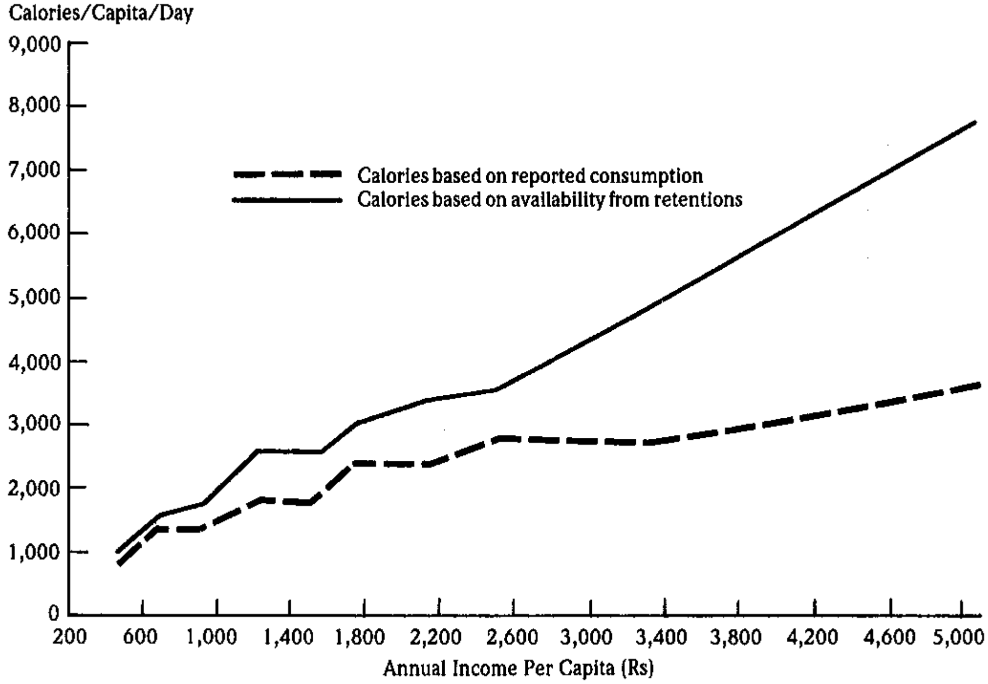


Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

As shown earlier, households use less fuelwood as their time costs rise. The higher collection time may reduce the time available to spend on food preparation and cooking, which in turn may influence both the amount of food consumed and diet composition.[36] While higher fuelwood consumption is likely to be associated with higher cooking time, higher collection times may reduce cooking time. The net effect of deforestation would then be to reduce cooking time, because deforestation both reduces fuelwood use and increases time spent in collection activities. To the extent that diets are influenced by the time spent in the kitchen, both qualitative and quantitative aspects of the diet would be relevant in the analysis. If fuelwood shortage affects the composition of the diet, it would be mediated by differences in cooking time for different products or commodities, given no change in the cooking technologies available. Also, if additional time for collection activities with deforestation reduces time available for cooking, the amount of food being consumed may also be reduced.

[36] This has been shown for Mexico in Margaret Evans, "Change in Domestic Fuel Consumption in Central Mexico and Its Relation to Employment and Nutrition," working paper prepared for World Employment Research Programme, International Labour Organisation, Geneva, 1986; and Elizabeth Cecelski, "The Rural Energy Crisis, Women's Work, and Family Welfare: Perspectives and Approaches to Action," working paper prepared for World Employment Research Programme, International Labour Organisation, Geneva, 1984.

Figure 11—Estimated calories available by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

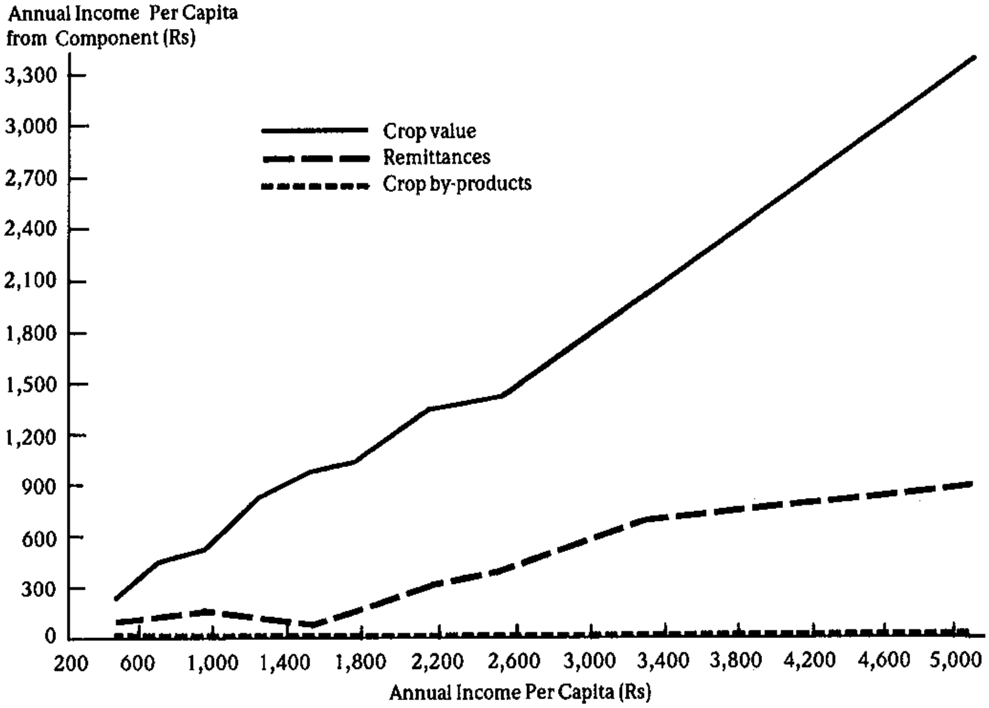
Also, with deforestation, the increased time spent in collecting fuelwood and other forest products, such as fodder and grass, may reduce the time spent on agricultural production, thereby reducing income from agriculture. This would have a direct adverse effect on food consumption.

Cereal Composition in the Diet

Although maize and rice are the two main sources of calories in this region, the households in the study have an overwhelming preference for rice. More than any other food, rice consumption value increases rapidly with income. Rice preparation, however, requires longer cooking time than other cereals. If advancing deforestation means that more time must be allocated to collecting fuelwood, it is hypothesized that cooking time will decrease and, as a result, the amount of rice consumed will be reduced relative to other cereals.

The multivariate analysis consists of two models: a cooking time function that includes independent variables relating to deforestation—amount of fuelwood used and total time spent in its collection, plus household characteristics—and a diet composition function that includes the independent variable, total cooking time. The functional form of the first model is

Figure 12—Sources of income by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

$$C = f(L, T, H, A, AR, DP, WR), \tag{8}$$

where

C = total cooking and food preparation time per day,

L = total 20-kilogram loads of fuelwood consumed per year,

T = total number of eight-hour days spent on fuelwood collection per capita per year,

H = household size,

A = livestock units,

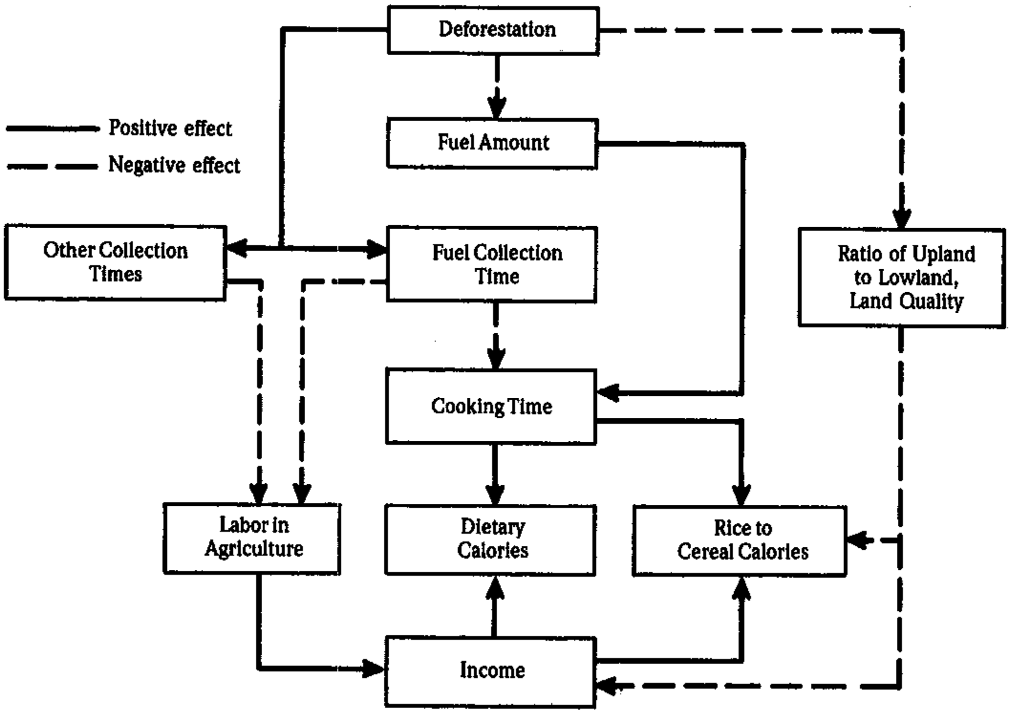
AR = farm size dummy (farm in larger half of farms = 1),

DP = ratio of children to adults, and

WR = ratio of women's farm labor time to total farm labor time.

The results in Table 18 indicate that cooking time is positively associated with fuelwood consumption and negatively associated with fuelwood collection time per

Figure 13—Links between deforestation and dietary intake



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

capita. The coefficients of both these independent variables are significant. The results indicate that the additional time necessary for the collection of fuelwood has a negative effect on time for cooking, after controlling for the other variables in the equation. It is also likely that cooking time may be negatively affected by time spent on other activities, such as fuel, fodder, and water collection, that increase with deforestation and place additional burdens on women's time.

Assuming that increasing levels of deforestation decrease time allocated to cooking, a diet composition function is estimated to determine the effect of cooking time on composition of cereal consumption. The functional form of this model is

$$RRICE = f(C, DP, Y, RAR, WR, H), \quad (9)$$

where

RRICE = ratio of calories from rice to calories from other cereals,

Y = total income per capita, and

RAR = ratio of lowland area to total area.

Table 18—Effects of fuelwood use on cooking time

Variable	Cooking Time (Model 1)	Cooking Time (Model 2)
	(minutes/day)	
Intercept	211.11	222.85
Total loads of fuelwood per year (20-kilogram loads)	0.13* (2.10)	0.13* (2.12)
Time spent on fuelwood collection	−0.09 (−1.18)	. . .
Time spent per capita on fuelwood collection	. . .	−0.69† (−1.71)
Household size	3.68* (2.15)	2.35 (1.24)
Livestock units	1.82† (1.73)	1.72† (1.68)
Dummy for farm size	−4.53 (−0.50)	−5.04 (−0.56)
Age dependency (children/adults)	−4.52 (−0.43)	−5.04 (−0.49)
Ratio of women's farm labor to total farm labor	−27.81 (−0.84)	−25.04 (−0.76)
$\bar{R}^2$ (adjusted)	0.27	0.28

Notes: Cooking time includes all time spent in food preparation. Figures in parentheses are t-values. Ellipses indicate variables that are not included in the equation.
*Significant at the 0.05 level.
†Significant at the 0.10 level.

The results of the regression procedure show that additional amounts of cooking time across income groups significantly increase the ratio of rice calories to other calories (Table 19). In addition, the variables of child dependency, income per capita, and the ratio of lowland area to total area have significantly positive associations with the dependent variable, while the ratio of women's farm time to total farm time has a significantly negative relationship.

Taken together, the results of the two models above indicate that there is an indirect relationship between deforestation and diet composition.

Dietary Calories

Food consumption behavior in terms of total intake of calories is analyzed in this study to see if it is affected by changes in household income, its composition, adult literacy, and cooking time. Even though caloric intake is made up of a variety of foods, the demand for which can be altered by a change in income, the net effect is reflected in caloric or protein levels. Energy is a basic dietary requirement, a deficiency of which is felt as hunger. Therefore, to some extent, it may be said that people do purchase food for its calories, more perhaps than for any food component other than "taste," which is largely undefinable.[37]

[37] Howarth Bouis, "An Agricultural Sector Model for the Philippines Identifying Localized Shortfalls in Household Food Security and Evaluating Policy Options Using Data from Ongoing Quarterly Surveys," a paper presented at a workshop of the International Food Policy Research Institute-Food Studies Group, Oxford, England, July 7-9, 1987.

Table 19—Effects of cooking time on cereal composition of the diet

Variable	Ratio of Rice Calories to Cereal Calories
Intercept	0.034
Cooking time	0.0003†
	(1.80)
Age dependency	0.09†
	(1.70)
Income per capita	0.00005*
	(3.37)
Ratio of lowland area to total area	0.55*
	(5.58)
Ratio of women's farm labor to total farm labor	−0.54*
	(−3.18)
Household size	0.01
	(1.34)
$\bar{R}^2$ (adjusted)	0.48

Notes: Cooking time includes all time spent in food preparation. Figures in parentheses are t-values.
*Significant at the 0.05 level.
†Significant at the 0.10 level.

There has been much debate in the literature on the size of the caloric response to income.[38] It has been observed that lower-income households and those with generally calorie-deficient diets have a higher income elasticity for caloric intake than the rest of the population. Nevertheless, income elasticities for more expensive foods are higher than those for calories, even for these households. In other words, people are likely to spend incremental income on more expensive food than on larger quantities of high-calorie but less appealing foods. Rural households, which generally expend more energy and therefore have higher requirements than urban households do, also have a higher level of caloric intake and a higher income elasticity for calories at all levels of intake and incomes than their urban counterparts. These findings suggest that, while households with inadequate consumption have a high propensity to consume additional calories, they are also buying taste. There have been some attempts to quantify the extent to which households buy taste rather than calories at different income levels, and the implications of this for diet quality, but there is still little known about this component of food demand.

Caloric consumption functions are estimated as follows:

$$LCAL = f(LY, FY/Y, ADLIT, CPC), \quad (10)$$

where

LCAL = log of calories per capita per day,

LY = log of total annual per capita household income,

[38] For a review of the debate on methods and results obtained for individual foods, overall food expenditures, and energy intakes, see Harold Alderman, *The Effect of Food Price and Income Changes on the Acquisition of Food by Low-Income Households* (Washington, D.C.: International Food Policy Research Institute, May 1986).

FY/Y = ratio of farm income to total income,

ADLIT = percent of literate adults in the households, and

CPC = women's cooking time divided by the number of household members.

The equation is estimated, first, for the total sample; second, for households for which preschool nutritional status is low for the year as a whole (average weight-for-age for four rounds of quarterly measurements is less than 80 percent of the standard); and third, for households for which preschool nutritional status is in the normal range, that is, more than 80 percent of the standard weight-for-age. This indicator combines both short- and long-term effects of malnutrition.

The results are shown in Table 20. The income elasticity for calories is 0.51 for the total sample, 0.57 for households with malnourished children, and 0.44 for the others. More than half the households had undernourished children, using the weight-for-age indicator. These households had a 20 percent lower per capita caloric availability than the rest of the households. The difference in terms of calories per adult equivalent was 12 percent. The relatively small difference in dietary calories between the two groups is consistent with the generally poor association between household food availability and child nutrition found in other studies.[39] The coefficient or farm income ratio is significant and similar for the three equations, as is the mean value for the ratio itself. Cooking time per capita is significant for the sample as a whole and in the subsample without malnourished children. Adult literacy in the present specification is not significant, but it has a positive sign in the total sample and in the sample with malnourished children.

These findings on the size of the income elasticity of dietary calories are consistent with those from other rural areas.[40] The differences in dietary calorie elasticities between those households with malnourished children and those without are noteworthy. As mentioned earlier, similar differences are found when households are grouped by low and high levels of caloric intake. They indicate a significantly higher propensity to increase dietary calories among households where less food is available. Finally, on the income effect, the farm income component appears to be responsible for most of the income effect on consumption. This is a reflection of the strong orientation to subsistence agriculture of households in which own-production contributes the major part of the diet. The relationship between household dietary intake and child nutrition will be analyzed in the next section.

Time spent on cooking by women, weighted by the number of household members, is a significant factor in the level of dietary intake only for those households with higher income, higher calorie intake, and higher nutritional levels, suggesting that at lower

[39] See, for example, Eileen T. Kennedy and Bruce Cogill, *Income and Nutritional Effects of the Commercialization of Agriculture in Southwestern Kenya,* Research Report 63 (Washington, D.C.: International Food Policy Research Institute, 1987); Howarth Bouis and Lawrence Haddad, "A Case Study of the Commercialization of Agriculture in the Southern Philippines: The Income, Consumption, and Nutritional Effects of a Switch from Corn to Sugar Production," International Food Policy Research Institute, Washington, D.C., 1988 (mimeographed); and Joachim von Braun, David Hotchkiss, and Maarten Immink, "Nontraditional Export Crops in Traditional Smallholder Agriculture: Effects on Production, Consumption, and Nutrition in Guatemala," International Food Policy Research Institute, Washington, D.C., 1988 (mimeographed).

[40] Ibid.

Table 20—Factors influencing dietary calories

Independent Variable	Sample Mean	Total Sample	Sample Mean	Households with Malnourished Children	Sample Mean	Households Without Malnourished Children
Intercept	. . .	2.77	. . .	2.36	. . .	3.29
Log of total household income (annual Rs/capita)	1,970	0.51** (10.29)	1,684	0.57** (7.12)	2,287	0.44** (6.82)
Farm income ratio	0.75	1.02** (7.83)	0.74	0.99** (5.20)	0.76	1.03** (5.75)
Cooking time	0.62	0.33** (2.88)	0.59	0.13 (0.65)	0.64	0.41** (2.97)
Adult literacy (percent of literate adults)	42.4	1.25^{-03} (1.07)	42.2	1.91^{-03} (1.18)	42.6	−5.06 (0.3)
$\bar{R}^2$ (adjusted)	. . .	0.66	. . .	0.67	. . .	0.63

Notes: Households with malnourished children are those with average weight-for-age of preschool children less than 80 percent of the standard over four quarterly measurements. The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutritional Impact* (Geneva: WHO, 1979). Figures in parentheses are t-values. Ellipses indicate a nil or negligible amount.
**Significant at the 0.01 level.

income levels, where the bulk of the nutrition problems are likely to be, it is the time spent on production activities that appears to be the primary limiting factor. It was shown earlier that even though the marginal product of labor for the small farm households is as high as that for larger farms, their time spent on production is lower than that on larger size farms. Could it be that the poorer level of nutrition of the working population is a contributing factor in the time allocation pattern of the smaller farm households? This question is outside the scope of this report. The implication here is that for all households, food consumption is adversely affected by deforestation because additional collection time detracts from food production activities. This is especially pronounced for the low-income households with smaller farms. For the rest of the households, production time is a less significant factor, but time spent in other essential consumption-related activities, such as cooking, becomes increasingly important.

Effects on Nutritional Status

Nutritional status of all household members is assessed using heights and weights measured quarterly over the survey year. For children up to 18 years, the World Health Organization (WHO) growth standards for international use are used to determine those who are below the expected growth curve distributions.[41] This section examines the nutrition situation of children in the study area and some of the main determinants that are of relevance in the present study.

Anthropometric measurements for two age groups, children less than 6 years, designated as preschoolers, and those 6-18 years old, are shown in Tables 21 and 22. For children less than 6 years old, results are compared with those of the 1975 Nepal Nutrition Survey. Both low weight- and height-for-age are more prevalent in the present

[41] World Health Organization, *Measurements of Nutritional Impact* (Geneva: WHO, 1979).

Table 21—Anthropometric measurements for preschool children in 1975, Western Region, and in 1982/83 in study area

Measurement	1975 Survey	Total of Sample Obser-vations	Syangja District, Bagkhor Panchayat		Tanahun District, Manapang Panchayat		Gorkha District, Chhoprak Panchayat	
			Ward 2	Ward 8	Ward 5	Ward 8	Ward 1	Ward 7
					(percent)			
Weight-for-age								
More than 75 percent of standard	51.4	48.9	33.0	50.8	64.8	30.4	72.4	41.2
60-75 percent	44.8	39.8	51.0	40.0	25.0	53.9	25.0	44.1
Less than 60 percent	3.8	11.3	16.0	9.2	10.2	15.7	2.6	14.7
Height-for-age								
More than 90 percent of standard	44.9	33.6	28.0	40.0	56.7	19.1	31.9	30.7
85-90 percent	36.8	35.1	36.0	23.1	22.8	41.6	44.8	35.7
Less than 85 percent	18.4	31.3	36.0	36.9	20.5	39.3	23.3	33.6
Weight-for-height								
More than 90 percent of standard	60.5	69.1	61.0	67.7	75.0	61.8	88.0	60.8
80-90 percent	34.1	22.6	26.0	24.6	15.9	28.1	10.3	30.1
Less than 80 percent	5.4	8.3	13.0	7.7	9.1	10.1	1.7	9.1
Less than 85 percent of height-for-age with less than 80 percent of weight-for-height	3.7	6.2	9.0	6.2	5.7	6.7	1.7	7.7

Sources: 1975 results for the Western Region are taken from U.S. Agency for International Development, Office of Nutrition Development Support Bureau, *Nepal Nutrition Status Survey, January-May 1975* (Washington, D.C.: USAID, 1975); those for the sample observations for this study are from Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: Preschool children includes children from 6 months to 6 years of age. The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutrition Impact* (Geneva: WHO, 1979).

Table 22—Anthropometric measurements for children 6-18 years old, 1982/83, study area only

Measurement	Total of Sample Obser-vations	Syangja District, Bagkhor Panchayat		Tanahun District, Manapang Panchayat		Gorkha District, Chhoprak Panchayat	
		Ward 2	Ward 8	Ward 5	Ward 8	Ward 1	Ward 7
				(percent)			
Weight-for-age							
More than 75 percent of standard	17.4	3.3	26.2	25.8	9.1	22.7	11.4
60-75 percent	46.3	37.4	47.5	46.8	53.0	53.9	37.7
Less than 60 percent	36.3	59.3	26.3	27.4	37.9	23.4	50.9
Height-for-age							
More than 90 percent of standard	22.3	6.6	28.7	66.1	21.2	26.9	14.0
85-90 percent	36.0	41.8	31.3	29.0	31.8	43.3	40.4
Less than 85 percent	41.7	51.6	40.0	4.9	47.0	29.8	45.6
Weight-for-height							
More than 90 percent of standard	75.6	48.3	86.2	85.5	81.8	83.7	60.6
80-90 percent	21.2	45.1	10.0	13.7	15.9	14.9	33.3
Less than 80 percent	3.2	6.6	3.8	0.8	2.3	1.4	6.1
Less than 85 percent of height-for-age with less than 80 percent of weight-for-height	2.0	5.5	2.5	0.0	2.3	0.0	3.5

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Note: The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutrition Impact* (Geneva: WHO, 1979).

study than in the earlier one. About 11 percent are severely underweight for age and more than 8 percent are severely underweight for height. This compares with about 4 and 5 percent respectively for the 1975 survey. Low height-for-age is found in 31 percent of the children observed in this study compared with 18 percent in the earlier one. These figures suggest a somewhat higher level of malnutrition than in the earlier period. Though similar standards were used in both surveys, it is not clear whether the differences are due to sampling differences, or if there has been a decline in nutritional status since the time of the earlier survey. Assuming that no major measurement problems were involved in either of the surveys and that the sample from the national survey was representative of the area, the evidence could lend support to the secular decline hypothesis. This conclusion is also supported by a somewhat larger average landholding size reported for this sample than the average figures for the area. No comparable figures from the earlier period for the older children are available. Although wasting (low weight-for-height) is less prevalent in the older group, weight-for-age and height-for-age indicators suggest that there is continued slow growth and no evidence of catch-up growth.

In order to examine the factors associated with child malnutrition, two probit models are estimated for the age group below six years.[42] The two dependent variables are low height-for-age—an indicator of longer-term malnutrition—and low weight-for-height—an indicator of short-run malnutrition. The dependent variable is equal to 1 if the child's nutrition is in the normal range and 0 if malnourished. The cutoff points used are 90 percent of the WHO reference height-for-age and 95 percent of the reference weight-for-height.

Explanatory variables for child nutrition are based on household income, agricultural characteristics, household size, ethnic characteristics, relative work load of women in agriculture, the amount that older children work in collection and agricultural activities, and deforestation. These characteristics are expected to influence the direct determinants of nutritional status such as the household's and children's diets and time available for child care. The ethnic variable is introduced to capture differences, if any, between the Tibeto-Burman and the Newar-Brahmin groups. Two of the six sites were exclusively of Tibeto-Burman extraction, while the rest were from the Newar-Brahmin groups. The deforestation variable is expected to capture the combined effects via the time allocation and agricultural productivity effects that have been found to be associated with it. The variable on children's work load is included because if older children are extensively engaged in work, less child care may be available for the younger children. A similar interpretation may be made for the share of women's work load in agriculture. Household income and landholding are expected to influence nutritional status via their impact on diets, quality of housing, health, water supply, and sanitation. These indicators may also be expected to be associated with the level of education of household members.

The equation estimated is

$$NS = F(Df, HS, Y, Tcrl, ETHNIC, WR, ChL), \tag{11}$$

where

NS = height-for-age more than 90 percent of the reference and weight-for-height more than 95 percent of the reference are 1; others are 0;

[42] In this model the dependent variable represents the probability of overcoming low nutritional status.

Df	= deforestation (wards where time per trip is high are 2, others are 1);
HS	= household size;
Y	= household income (in annual rupees per capita);
Tcrl	= total cropped area (in hectares);
ETHNIC	= ethnic group (Tibeto-Burman groups are 1, others are 0);
WR	= women's share of household labor in agriculture; and
ChL	= time spent by older children in collection activities, grazing of cattle, and agricultural production (in hours per day).

The results indicate that for preschool children, the longer-term nutrition indicator, height-for-age, is positively influenced by increasing per capita income in the household, even though the size of the coefficient is small and is negatively influenced by increasing household size (Table 23). Deforestation has a significantly negative influence on this nutritional status indicator. The more time spent by children working in collection activities, livestock grazing, and field work, the lower the level of nutrition of their preschool-age siblings.

Another indicator of nutritional status uncovered in the study is the ethnic background of the children. The ethnic groups classified as Tibeto-Burman in the sample appear to be taller than would be expected for people of their group using the height-for-age indicator after controlling for household income and other characteristics.[43] The others, which are largely from the Newar and Brahmin groups, would normally be taller, but they clearly rated below the Tibeto-Burman groups on this indicator. The reasons for the anomaly are unclear, but a future study might examine the effects of cultural differences in the area on nutritional status.

Poor nutritional status of preschoolers in the short term, as reflected in their weight-for-height, is also found to be significantly associated with deforestation, with high deforestation areas showing reduced weight-for-height. The ethnic group variable showed a similar result as the height-for-age equation, with the Tibeto-Burman groups having better child nutrition. Overall, the degree of predictability of weight-for-height is relatively lower than that of height-for-age. The time allocation variables—relative women's work load and degree of work involvement by older children—are found to be negatively associated with preschoolers' weight-for-height.

The results point to five main observations: first, high deforestation areas have poorer child nutrition when controlling for other household characteristics; second, household income is positively associated with good long-term nutrition indicators for preschool children; third, household size has a significantly negative effect on the longer-term nutrition indicator, height-for-age, but is insignificant for short-term nutritional status; fourth, the ethnic groups classified as Tibeto-Burman have better child nutrition than other groups; and fifth, the degree of involvement of older children in collection, grazing, and agricultural activities is negatively associated with child nutrition, and so, less significantly, is the relative workload of women in agricultural production.

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[43] The Tibeto-Burman groups in the sample were Gurungs and Magars. These ethnic groups usually reside at higher altitudes in the hill and mountain regions of Nepal and are usually shorter than the Newar and Brahmin groups.

Table 23—Determinants of preschool children's nutritional status (probit model)

Variable	Height-for-Age	Weight-for-Height
Intercept	1.92 (1.53)	2.14* (2.01)
Household size	−0.25** (2.77)	. . .
Household income (Rs/person/year)	0.0005** (2.83)	. . .
Total cropped area (hectares)	0.27 (1.63)	0.15 (1.25)
Ethnic group (Tibeto-Burman = 1, other = 0)	1.34** (3.34)	0.76* (2.33)
Deforestation (high = 2, low = 1)	−0.92* (2.43)	−0.68* (2.09)
Ratio of women's agricultural work	. . .	−2.22 (1.59)
Children's work (hours/day)	−0.29* (2.08)	−0.17 (1.46)
Significance of chi^2	0.89^{E-06}	0.39^{E-01}

Notes: Figures in parentheses are t-ratios. The ellipses indicate t-ratios less than 1. Preschool children include those from 6 months to 6 years old. Cutoff points for probit analysis for preschool children are 90 percent of the standard height-for-age and 95 percent of the standard weight-for-height. The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutrition Impact* (Geneva: WHO, 1979).

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Implications for Area-Level Programs

The results of this analysis indicate that overall there are strong possibilities that a labor constraint, especially of women's labor, is limiting the production and consumption potential in the area and that deforestation further aggravates this problem. In terms of policies and programs to alleviate the problems, this suggests that the payoff from labor-saving technologies for women, in conjunction with production technologies that raise labor productivity, could be high. Labor-saving technologies would be especially relevant if desired agricultural improvements require an expansion of labor input in production and postharvest processing. Labor-saving technologies for women would also benefit the nutrition of preschool children.

However, within an area, there is the potential for several alternative types of constraints to be present for different households. Where there is a significant labor constraint, there are also likely to be a number of farmers who face a land constraint and who would benefit from an increase in off-farm activities or from the opportunity to increase productivity from their land. Therefore, characteristics in the study area were examined to identify areas and households with different types of constraints to assist area planners in deriving an appropriate development package for different localities. Whereas for most areas inputs for increasing crop yields are desirable, it is also necessary to consider labor-saving technologies for labor bottlenecks, including those created by essential activities such as collection of fuel, fodder, or water, or food processing.

Another aspect of area-level programming is the issue of targeting publicly subsidized inputs and services. It has been widely acknowledged that, unless agricultural technology and input delivery institutions explicitly consider the needs of small farmers, benefits are likely to reach only a few well-off farmers in the initial stages of adoption of new technology or when there is a scarcity of these inputs and services.[44]

In keeping with the previous arguments, it is considered desirable to examine the characteristics of nutritionally at-risk households to facilitate the targeting of alternative program components to them. In order to identify these households, several alternative criteria could be used. It is generally accepted that preschool-aged children form the most vulnerable segment of the population. However, older children represent a considerable opportunity for catch-up growth, and nutrition of the working-age population has direct productivity implications with indirect consequences for other household members. Thus, nutrition of all household members is relevant in its own way. In order to test which single indicator is positively correlated with various nutritional status indicators for all other groups, a simple test is conducted using all three (height-for-age, weight-for-age, and weight-for-height) for children below 6 years old and children 6-18 years old and the weight-for-height measure for adult men.[45] The results, shown in Table 24, indicate that adult men's weight-for-height is positively correlated consistently with all indicators of the younger age groups. Whereas preschool children's nutritional status is positively correlated with men's weight-for-height, it is not correlated with the nutritional status of older children. Based on these results, and also because about 30 percent of households did not have any preschool-aged children, men's weight-for-height is used as the criterion for selecting at-risk households.

Table 24—t-values for differences in anthropometric measures for alternative nutritional indexes

Anthropometric Measure	Nutritional Index NSTAT 1	NSTAT 2	NSTAT 3
Children less than 6 years old			
Height-for-age	3.8	−0.8	1.6
Weight-for-age	8.0	0.6	1.7
Weight-for-height	5.8	2.4	1.7
Children 6-18 years old			
Height-for-age	−0.4	−0.6	1.4
Weight-for-age	1.5	4.3	3.1
Weight-for-height	0.1	3.8	1.4
Adult			
Weight-for-height (males)	1.8	0.5	12.3

Notes: Anthropometric measures are given as a percentage of the standards recommended in World Health Organization, *Measurements of Nutrition Impact* (Geneva: WHO, 1979). NSTAT 1 is households with children 6 months to 6 years old who are less than 80 percent of weight-for-height and 85 percent of height-for-age. NSTAT 2 is households with children 6-18 years old who are less than 80 percent of weight-for-height and 85 percent of height-for-age. NSTAT 3 is households with adult males who are less than 80 percent of weight-for-height.

[44] See G. Goodell, "Bugs, Bunds, Banks, and Bottlenecks: Organizational Contradictions in the New Rice Technology," *Economic Development and Cultural Change* 33 (October 1984); and Peter B. R. Hazell and C. Ramasamy, *Green Revolution Reconsidered: The Impact of High-Yielding Rice Varieties in South India* (Baltimore: Johns Hopkins University Press for the International Food Policy Research Institute, forthcoming).

[45] The measure for adult women could not be used because records of their physiological status were inadequate.

Within the at-risk group thus selected, three main subgroups are identified using principal components analysis.[46] These are land deficit, labor deficit, and excess livestock. Based on these earlier results, cut off points for these indicators are defined as less than 0.2 hectare (4 *ropani*) of land per capita, household size-to-worker ratio greater than 1.3, and less than 0.25 hectare per livestock unit kept by a household.[47] Generalizing from these results to the entire population, it is possible to identify a total of eight groups with various combinations of constraints. These are indicated in Table 25. From the prevalence of different constraints, the three district samples in the study, as represented by the *panchayats* of Bagkhor, Manapang, and Chhoprak, show a differing pattern of constraints. In Bagkhor, there is predominantly a land constraint, with smaller degrees of excess livestock and labor constraints. In Chhoprak, there is mainly a labor constraint, again with smaller degrees of excess livestock and land constraints. In Manapang, there is predominantly an excess of livestock, with no land constraint and some labor constraint. In this case, a secondary labor constraint may arise from the need for additional labor for grazing of livestock or for fodder and grass collection.

In predominantly land-constrained areas, deforestation is likely to be more severe in that area-expansion possibilities are probably minimal. Whereas intensification of input use to raise agricultural productivity in such areas is clearly indicated, indirect labor bottlenecks may also exist because the labor demand for collection activities is high. In the Bagkhor area, however, collection time was relatively low because the planting of private trees for fuel and fodder was expanded. Agroforestry efforts are most likely to succeed in such areas. Other areas, where landholdings are more adequate but labor is constrained, are likely to face ongoing deforestation. In these cases, input use should be intensified to stem further area expansion, especially on steeper slopes. Here tackling labor bottlenecks and intensifying input use in agriculture should both be integral parts of a program to improve production and consumption potentials of households.

Finally, some of the production characteristics of different household types and locations are examined in order to determine where improvements may best be made and the kinds of programs that may be adopted. In order to simplify the tabulation of all observations, the eight original household types are regrouped into four. In this process, livestock numbers in excess of cultivated land capacity are assumed to add to the labor requirement. If there is no existing labor constraint, then this type of constraint is not dropped from consideration. The new types are N1, which has both land and labor constraints (former types 1 and 3); N2, which has a land constraint only (former types 2 and 4); N3, which has a labor constraint only (former types 5 and 7); and N4, which has neither land nor labor constraints (former types 6 and 8).

The crop production characteristics of each of these four groups are shown in Tables 26 and 27. Overall, N2 households—those with only a land constraint—achieve the best production picture. They have the lowest amount of land under each crop but the highest yields and the largest amounts of household and wage labor inputs, fertilizer, and animal labor. Nevertheless, their annual per capita incomes are low. It is N3 households—those with a labor constraint—that have the lowest average production performance in terms of yields, labor, and fertilizer inputs. But because they have the largest amount of land under cultivation, they achieve the highest level of farm produc-

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[46] Food and Agriculture Organization of the United Nations/Nepal, Agricultural Projects Services Center, *District Planning Manual for Nepal* (Kathmandu: APROSC, 1984).
[47] Food and Agriculture Organization of the United Nations/Nepal, Agricultural Projects Services Center, *District Planning Manual for Nepal.*

Table 25—Types of household constraints possible

Type of Constraint	Landholding Less Than 0.2 Hectares Per Capita	Household Size-to-Worker Ratio More Than 1.3	Landholding Less Than 0.25 Hectares Per Livestock Unit
1	X	X	X
2	X	...	X
3	X	X	...
4	X	...	...
5	...	X	X
6	...	...	X
7	...	X	...
8	...	...	...

tion and household per capita income. The N1 households—those with both land and labor constraints—have an average-to-low production picture and are not able to achieve the productivity levels of N2 households, which also have a land constraint but no labor constraint. Both types of land-constrained households have more migrant workers and income from remittances.

Table 26—Agricultural production by type of constraint, by major crops, 1982/83

Constraint Type/Crop	Number of Households	Area	Yield	Total Family Labor	Total Wage Labor	Total Labor
		(hectares)	(kilograms/ hectare)	(days/hectare)		
Type N1[a]						
Wheat	14	0.37	987	155	18	173
Maize	32	0.49	1,078	146	15	161
Ragi	31	0.33	781	259	15	274
Paddy	26	0.35	1,857	266	49	315
Type N2[b]						
Wheat	13	0.13	1,322	234	16	250
Maize	24	0.42	1,169	196	35	231
Ragi	23	0.30	987	353	13	366
Paddy	19	0.32	2,058	285	49	334
Type N3[c]						
Wheat	16	0.47	825	137	31	168
Maize	31	0.74	1,082	147	33	180
Ragi	25	0.54	956	234	17	251
Paddy	28	1.05	1,951	254	54	308
Type N4[d]						
Wheat	10	0.47	929	141	12	153
Maize	26	0.99	1,447	200	32	232
Ragi	25	0.72	1,176	314	14	328
Paddy	24	0.86	1,612	282	40	322

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

[a] Type N1 has both land and labor constraints (N = 33).
[b] Type N2 has a land constraint only (N = 26).
[c] Type N3 has a labor constraint only (N = 31).
[d] Type N4 has no land or labor constraint (N = 28).

Table 27—Household characteristics by type of constraint, 1982/83

Household Characteristic/ Unit of Measure	Type of Constraint: Land and Labor (N1)	Land Only (N2)	Labor Only (N3)	No Land or Labor Constraint (N4)
Household size (average number)	6.9	5.7	6.6	7.1
Adults (working age)	2.8	3.4	2.8	4.7
Children (up to 15 years)	3.8	2.1	3.5	2.2
Migrant workers (number)	0.6	0.6	0.4	0.4
Land cultivated (hectares)				
Upland area	0.5	0.4	1.1	1.3
Lowland area	0.3	0.3	1.0	0.9
Cropping intensity (percent)				
Upland intensity	159	169	141	143
Lowland intensity	170	156	167	157
Livestock units	4.9	5.7	8.1	9.3
Annual total income (Rs/capita)	1,421	1,427	2,573	2,394
Farm production	715	654	1,813	1,765
Employment	171	133	85	72
Remittances	382	442	138	323
Farm by-products	166	215	403	257
Food consumption				
Calories (per capita/day)	1,431	1,758	2,926	2,449
Protein (grams/capita/day)	41.8	50.4	78.7	68.5
Anthropometry (percent of children)				
Children less than 6 years				
Less than 85 percent height-for-age and less than 80 percent weight-for-height[a]	8.6	5.8	4.6	4.2
Children 6-18 years				
Less than 85 percent height-for-age and less than 80 percent weight-for-height[a]	4.8	1.0	0.0	1.0

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Note: The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutritional Impact* (Geneva: WHO, 1979).

[a] This measurement combines stunting and wasting to indicate both long- and short-term malnutrition.

Though their overall income levels are comparable, both food consumption and child nutrition levels are significantly lower for N1 households, which may be attributed to the higher work load of adults. In addition, the nutrition of the 6-18 year olds is the worst in this group, perhaps because their work load may also be high. This age group does best in N2 households, which may also be linked to their relative work loads. Also, preschool nutritional status for N2 households is closer to that of the higher-income N3 and N4 households.

Thus, it is N1 and N3 households that need improvement, both in production and nutrition. These are essentially labor-constrained households, either with or without a land constraint. Deforestation would further exacerbate the situation for the groups that are worst off.

7

CONCLUSIONS AND POLICY IMPLICATIONS

The area described in this report is typical of the hill areas of Nepal, which are characterized by low levels of agricultural productivity, limited adoption of new technology, and a high rate of natural resource degradation, particularly deforestation. The study area is typical of many rural areas that have been bypassed by improvements in agricultural technologies and related benefits during the past two decades. However, in one respect it may be quite different. The pace of deforestation here has direct repercussions on the vast foodgrain belt of the plains. The evolution of a sustainable and stable agriculture in the hill areas may be, therefore, necessary for the welfare of more than these areas alone.

A policy prescription for such areas is simply to leave things alone, using them as a reservoir for out-migrating labor and letting remittances into the area provide the means to an effective demand for the inflow of food and other products needed to maintain their standard of living. Despite high out-migration—an average of one migrant worker for every two households—remittances have so far been small and have not contributed to raising food consumption of the households. This may change when the workers return, either with accumulated savings or retirement pensions. Alternatively, efforts in recent years have focused primarily on reforestation and other measures designed to preserve the natural resource base.

These approaches alone, however, are inadequate. Bajracharya has argued persuasively that it is initially the low productivity of agriculture in these areas that promotes deforestation.[48] According to his analysis, the inability to provide for food needs from the returns to agriculture provides an incentive for increasing land under cultivation. The results confirm that agriculture in the area is highly dependent on labor, and there is increasing competition between productive and other uses for labor, possibly contributing to inefficient methods of collection of forest products, primarily fuelwood. (For example, concentrating collection efforts on the most accessible forest, rather than spreading out the collection efforts, can promote rapid deforestation, despite the overall adequacy of forest resources in the region as a whole.)

In other words, the low agricultural productivity derived from a high dependence on human labor contributes to the relatively higher population pressure on arable land and to the erosion of the natural resources that are essential for maintaining the production base.[49] Clearly, a vital question in this context is whether the introduction of improved agricultural technologies in this area will reduce or increase the pressure on land and the encroachment on forest lands. Most likely the answers will differ depending on the crops and type of technologies promoted, the institutional setup used to make them available to smallholders, the pace of infrastructure development in the region that can help to channel resources to the off-farm sector, and the presence of forestry and related efforts.

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[48] Bajracharya, "Fuel, Food, or Forest?"

[49] Consultative Group on International Agricultural Research, Technical Advisory Committee, *Sustainable Agricultural Production.*

Results of this study suggest that deforestation has adverse effects on agricultural production, food consumption, and nutrition that occur as a result of the additional work loads entailed in the collection of essential forest products on which the households depend, primarily fuelwood, fodder, and grass. In the longer run, water availability for both household and irrigation purposes could also be affected. The adverse effects on irrigation potential will of course be far-reaching geographically.

Women, in particular, have a high and increasing work load as deforestation expands, and this burden reduces labor in agriculture. Limited availability of labor and low substitutability between women's and men's labor can lead to a much larger overall decline in labor input in agriculture with deforestation. This is a seldom acknowledged factor in the decreasing agricultural productivity of hill agriculture, where the high rate of out-migration has usually been interpreted as a sign of an underutilized work force, when instead it is the low returns to labor in agriculture that encourages out-migration. The evidence indicates that deforestation is directly and indirectly linked with levels of food consumption and nutrition for the households.

The following observations have emerged from this study:

- Deforestation, which represents a 1 percent increase in time spent for collection of a unit of fuelwood, leads to a reduction in fuel consumption of 0.3 percent but an increase in the total time required for collection of 0.6 percent.[50]

- The sites in the study sample where deforestation is extensive require 75 percent more time spent for collection per load of fuelwood, which suggests a 45 percent increase in total collection time. With a similar response for other forest products that are collected on a regular basis, such as fodder and grass for animals, and assuming that men, women, and children increase their time in proportion to their existing time allocation, women would need an additional 1.13 hours per day to collect these products. This estimate is consistent with the increases in actual time spent by women.

- Estimation of the change in household labor supply to agriculture, given the above magnitude of deforestation, shows a reduction in women's field labor of about 1.5 hours per person per day. Further, this reduction is accompanied by a reduction in men's agricultural labor of about 0.8 hours per person per day. As a result, household labor per hectare decreases by about 40 percent in high deforestation areas. The small increase in wage labor that occurs does not compensate for the reduction in household labor input.

- Estimates of physical production functions show the significance of labor input in crop output. Women's labor has the highest marginal product for dry-season crops. On a seasonally adjusted basis, the dry season is also when more time has to be spent on collection of forest products. This suggests that there are losses in agricultural productivity and real income with time allocation patterns that accompany deforestation. This is likely to be only partly offset by higher seasonal out-migration and income from such employment.

- Food consumption, in terms of caloric consumption and the ratio of rice calories to cereal calories, is a significantly positive function of household income (the

[50] All figures are based on quarterly surveys, which have been aggregated to represent time allocation on an annual basis.

farm income component is the only statistically significant component) and food preparation time. Food preparation time, however, is a positive function of fuelwood used and a negative function of the total collection time, suggesting these factors may also influence food consumption via less time spent on cooking and food preparation. This is in addition to the effect of deforestation on agricultural production and hence on household farm income.

- Preschool child nutrition is improved by raising household income, and it is lower in areas with higher levels of deforestation. An increase in household size and in children's work is also associated with inadequate nutrition of preschool children. Controlling for other household characteristics, the Tibeto-Burman ethnic groups have better child nutrition than other groups.
- An examination of the characteristics of the nutritionally at-risk households confirms that these are more likely to be labor constrained than land constrained, and they have lower levels of agricultural productivity.

The results clearly show that under current productivity, households continually need to expand cultivated area. To the extent that this contributes to deforestation, this expansion reduces household income, food consumption, and nutritional status. Under these circumstances, relying only on out-migration in these areas is unlikely to improve living conditions or stem the environmental degradation through deforestation. It is also questionable whether reforestation efforts by themselves will suffice, though this would be a useful question to examine empirically. In the past, settlement schemes in the tarai have drawn a fair share of settlers from the hill areas. But if deforestation continues at the present scale, en masse movement of population from the hills may occur at some future point in time. It seems evident that there is a need to increase agricultural productivity, preferably on soils that are better endowed. This would contribute to improvements in household welfare and reduce deforestation.

Another policy option that has frequently been proposed for the development of these hill areas is the growth of horticulture production.[51] The rationale stems from both the agroclimatic characteristics of the hill regions of Nepal and the poor road transport facilities that prevail. Products with high value to weight are consequently appealing. An IFAD study recommends the following steps be taken: a comprehensive ecological classification of areas for production of specific horticultural products, a survey of national and international markets, a research program focused on selected species, human and physical capital development to support the extension effort, research on desirable processing technologies, and support of commercial enterprises for setting these up.[52]

For smallholders' horticultural production to be successful would require not just an outlet where the products would be competitive with existing suppliers, but also an extremely efficient marketing system in the hills that would be readily accessible to the scattered smallholders and would avoid the high perishability inherent in marketing of horticultural products. Given the largely subsistence orientation of agricultural production at present in these areas, the degree of rural market development is too severely limited to be able to handle a large outflow of horticultural produce. Public marketing is probably not a good idea, as the degree of investment required and the

[51] International Fund for Agricultural Development, *Report of the Special Programming Mission to Nepal* (Rome: IFAD, 1979), p.38.
[52] Ibid.

relative inefficiency of this sector will likely lead to monopolistic tendencies that will be unproductive in the long run.

The issue of the need for efficient rural markets to handle the horticultural products is also related to the need to be competitive with the existing suppliers to the major metropolitan centers of the subcontinent, such as Kathmandu, New Delhi, Calcutta, Islamabad, and others. These centers already have a well-established network of suppliers, so that products from the Nepal hills would have to be produced very cheaply, or they would have to aim for the high price end of the horticultural products market. The latter option is probably preferable but will require many years of research on commodity and market development. Such an effort clearly needs to begin.

In the meantime, efforts for increasing productivity of traditional crops in hill regions need to continue. This is important not only for maintaining consumption without substantial area expansion, but also for promoting an expansion away from largely subsistence production. Production for the market should promote the growth of rural markets in the hill areas, providing the basis for the growth of a privately financed rural services infrastructure. The growth of such a base will facilitate the gradual shift into more specialized production of horticultural and livestock products.

The results of the study suggest that in order to increase agricultural productivity, a combination of efforts for increasing input use and reducing labor bottlenecks is necessary. These findings are consistent with the IFAD recommendation promoting the use of selected labor-saving technologies such as power tillers as an alternative to oxen for easing labor bottlenecks and for spreading employment on small farms more evenly.[53] These tillers are relatively inexpensive and simple to operate and maintain. They could also reduce demand for work oxen, thus reducing human labor needed for feed collection and grazing, and alleviating pressure on the environment. Other labor-saving technologies for improvement in operations such as food processing or water supply should also be explored, as well as agroforestry efforts that reduce collection time for forest products such as fuel and fodder.

[53] Ibid.

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