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Estimating the demand for non-timber forest products among rural communities: a case study from the Sinharaja Rain Forest region, Sri Lanka

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Abstract

Lack of adequate knowledge on forest-people interaction is an important reason for the failure of many conservation policies. This study focuses on the behavior of peripheral communities towards non-timber forest product (NTFP) harvesting by estimating the demand functions for NTFP. The paper develops a theoretical model for deriving the shadow price for NTFP using time allocation among different economic activities. Then it tests the competitive time allocation hypothesis between NTFP extraction and tea plantations, the predominant agricultural sector in the vicinity of Sinharaja rain forest. Results provide statistical evidence for the existence of competitive time allocation between tea plantations and NTFP extraction. Own-price elasticities are consistently inelastic, except for one product. As indicated by the inelastic responses, pricing policies may not be very useful in manipulating subsistence NTFP extraction. Repeating similar studies for commercial NTFPs is encouraged.

Introduction

Conservation of tropical rain forests has been a priority issue throughout the world for the past few decades (Byron and Arnold 1999). Earlier, the conservation issue was considered as a biological and ethno-botanical issue. Many efforts undertaken to conserve forests, based on a strictly natural science orientation and command-and-control approaches, have experienced failure in several parts of the world. Among the many reasons for such failures in developing countries, disregard for the needs and aspirations of adjoining communities who have been utilizing forest resources for centuries is the foremost (McDermott et al. 1990; Ganguli 1995). The Integrated Conservation and Development Projects (ICDP) approach, which was developed to incorporate the local communities to forest conservation efforts, appeared sound for sometime. This approach relies on less destructive forest use strategies such as biodiversity prospecting, eco-tourism, and sustainable harvest of non-timber forest products (NTFPs) for augmenting rural income. However, recent empirical evidence suggests that ICDPs also have failed in many instances to achieve their target viz. protection of natural forests without great income losses to local communities[1]. This frustrating experience left no option other than continuous

[1]Simpson R.D. 1995. Why integrated conservation and development projects may achieve neither goals? Discussion paper. Resources for the Future, Washington DC, 95–120.

search for better strategies for the protection of natural forests.

This paper deals with NTFP harvesting from natural forests in the context of forest conservation. There is some evidence that NTFP harvesting by local communities has resulted in deforestation (FAO 1998). However, the general perception held by many is that NTFP harvesting can be done in an eco-friendly manner to augment rural incomes (Gunatilake 1998). Nevertheless, eco-friendly NTFP harvesting needs a well-designed forest management system that does not lead to the destruction of bio-diversity and other environmental services of the forests. One suggestion for this purpose is to separately manage production-oriented and protected forests, and allow NTFP harvesting only in the former category of forests (MFE 1995; Gunatilake 1998). Reduction of community dependency on forests may be essential in the case of protected forests (Gunatilake 1998).

Large-scale removal of forest products may bring about a reduction of biodiversity (Anderson 1990; Pearce and Brown 1994; Baer 1995). Tropical forests are the most species-rich ecosystems in the world (Hartshorn 1992). Forest conservation for biodiversity purposes cannot be economically justified by the value of collected NTFPs alone. Among the available values of NTFP, Peters et al. (1989) have estimated the value of standing NTFPs in an Amazonian forest at US $6330 per hectare. This value is higher than the returns from other less-sustainable alternative uses of forests. However, more reliable estimates made later show that the average value for different NTFPs extracted from forest is about US $50 per hectare per year (Godoy and Bawa 1993; Pearce and Moran 1994; Pearce 1998). This value is much lower than the value generated by many alternative land uses. Therefore, generalization of one figure for different places may not be acceptable. This shows the necessity for other economic criteria to justify the conservation of forests.

At the global level, the contribution of forests to GDP is considered as 3–5%, while forests produce 60% of global net biomass. Agriculture, which is about one-third of the forest area, is estimated to contribute to GDP 15 times as the forests contribute (WRI 1993). One reason for this low estimate is attributed to the lack of economic analysis of NTFP consumption and production[2]. Among the roles of NTFPs, the provision of nutritional supplements and fulfillment of seasonal or emergency shortages are crucially relevant to the poor who do not have sufficient capacity to deal with food deficiencies. Hence, analyses of the economic impacts of NTFPs on the rural economy need to emphasize rural poverty. The impact of NTFPs on income distribution is another important aspect. A study conducted in the Sinharaja area has shown slight changes in the Gini coefficient due to income from NTFPs[3].

A successful forest conservation program may need a rural development component so as to reduce the people's dependence on forest products. The declining trend in NTFP extraction by the higher-income groups provides the basis for this conclusion (Gunatilake 1998). Therefore, understanding the behavior of the people within the context of income generation from both NTFPs and other sources is crucial for policy formulation. The economic behavior governing the gathering activities is not understood properly. The purpose of this paper is to estimate the demand for subsistence NTFPs and to examine the impacts of price and income on NTFP gathering. Many subsistence NTFPs do not have a market and hence market prices are not available for them. This study further investigates the economic behavior of rural households with respect to NTFP gathering.

A household model

Assume a representative household living in the periphery of a protected forest. Members of the household are engaged in three major economic activities: agriculture, gathering forest products, and wage-earning work. Although different types of agriculture may exist, for simplicity, we assume a single agricultural activity that provides cash income. Our focus here is on forest resource extraction. Therefore, subsistence agriculture is assumed away. Also, agriculture is assumed to be confined

[2]Linde-Rahr M. 2000. Environmental Goods and Cash Constraint. Draft paper. Department of Economics, Goteborg University, Sweden.

[3]Batagoda D.M.S. 1998. Policy relevant ecosystem services valuation: Rain forest non-timber products. Unpublished manuscript. Ministry of Forestry and Environment, Colombo, Sri Lanka.

to privately-owned lands located in the village. Shifting cultivation and some of the cash crops may clear the forest lands under certain circumstances. In this analysis, however, we assume that the protected forest boundary is well defined and that the conversion of forest lands for agriculture is effectively controlled by the forest protection agency. This assumption is not unrealistic because legal measures to avoid conversion of protected forest-lands for agriculture are largely in place in many developing countries. Also, in general, forest land conversion to agriculture is visible and can be easily controlled compared to forest resource extraction.

Although conversion of forest lands for agriculture is not allowed, peripheral communities are either allowed to gather forest products or permitted to disregard the regulations that restrict extraction of forest products. Tropical rain forests provide a large variety of forest products such as fruits, vegetables, construction materials, mushrooms, ornamental plants, raw materials for cottage industries (such as rattan and bamboo), honey, meat, and fish. Local communities generally do not extract timber from protected forests and, therefore, the forest products will be designated as NTFPs. We assume that the households gather two types of NTFP: subsistence NTFPs and commercial NTFPs. The subsistence NTFPs directly enter the household consumption and never enter the market exchange process, while the commercial NTFPs provide cash income through market exchange. Commercial NTFPs are not consumed by the household. They provide cash income to buy market commodities.

The household, thus, exchanges the agricultural products and the commercial NTFPs in the market to obtain market commodities for consumption. Wages earned by the household members are also exchanged in the market for market commodities. Following the Becker (1965) approach, it is assumed that market and subsistence commodities do not enter the utility function directly. Instead, these commodities go through the household production process in which the households combine the market commodities and subsistence commodities gathered from the forest with time to produce a bundle of final commodities that provide utility. The household utility function is represented as:

$$u = u(\mathbf{z}) \tag{1}$$

where $\mathbf{z}$ is a vector of final commodities that provide utility for the members of the household. The utility function is assumed to be increasing and quasi- concave in $\mathbf{z}$. The household production function is represented by:

$$z_i = z(x_m, x_f^s, T_{ci}) \tag{2}$$

where x_m is a vector of market commodities and $x^s{}_f$ is a vector of subsistence forest commodities. T_{ci} is the time spent in producing and consuming z_i.

General production functions for subsistence NTFP and marketable agricultural commodities can be represented as:

$$x_f^s = f(L_f, Z_p, F, K_f) \tag{3}$$

where, L_f is the labor allocation for extraction, Z_p is the household characteristics, F is the forest access and quality and K_f is the accumulated forest knowledge. Similarly,

$$x_a^m = f(L_a, I_a, Z_p, A_c) \tag{4}$$

where, L_a is the labor allocation for agricultural production, I_a is the variable inputs, A_c is the area under cultivation.[4]

If one uses a precise definition of T_{ci}, it is also a vector, since different times have different values. However, in this analysis, we assume away the details of differences in time during the day (morning, evening, etc.) and time in week days and weekends.

So T_{ci} is treated as a scalar. Although, in general, z, $x_a{}^m$, and $x_f{}^s$ are vectors, in the analysis that follows we treat them also as scalars for simplicity in notation. The household, thus, buys a representative market commodity in exchange for its agricultural product, commercial NTFP, and wage income. These representative market-and subsistence-forest-commodities are combined with time to produce a representative final commodity.

Household production functions can be represented as follows:

$$\begin{aligned} T_c &= \alpha z \\ T_f &= \beta_1 x_f^s + \beta_2 x_f^m \\ T_a &= \gamma x_a^m \end{aligned} \tag{5}$$

where α, β_1, β_2 and γ are the time required to produce one unit of z, $x_f{}^s$, $x_f{}^m$ and $x_a{}^m$, respectively. T_f and T_a are total time spent on agriculture

[4]In order to simplify the model, the production function for NTFP and agriculture is excluded in our analysis.

and forest gathering activities, respectively. $x_f{}^m$ and $x_a{}^m$ denote the representative forest and agricultural commodities that are exchanged in the market for the representative market commodity x_m.

In this model (non-recursive) we assume that households engage in both agricultural production and NTFP collection due to diminishing relative marginal utility. However, in the recursive model (profit-maximizing) it is assumed that households should engage in either agricultural production or NTFP collection which leads to a corner solution. The assumption about agricultural production implies land of homogeneous quality in unlimited quantities, relative to household labor.

Also the input-output relations in household production for final consumption with $x_a{}^m$ and $x_f{}^s$ are given by:

$$x_a^m = \sigma z \tag{6}$$

where σ and δ are the quantities of $x_a{}^m$ and $x_f{}^s$ required to produce one unit of z.

The household faces the following time and budget constraints:

$$T = T_c + T_a + T_f + T_w \tag{7}$$

where T is the total available time and T_w is the time spent on wage-earning work.

$$I = T_w w + P_a x_a^m + P_f x_f^m + V = P_c x_m \tag{8}$$

I denotes the cash income that has four different components, namely, income from wage-earning work, income from agriculture, income from marketable NTFP, and other incomes (V). This is not the full income specification as it does not include the value of labor used for subsistence production (agriculture and NTFP) and leisure. V can be any income derived from wealth (such as hiring buffalo draft power for agriculture or any rent from capital items) and government transfers. w is the wage rate and p_a and p_f are the prices of agricultural and marketable NTFP commodities, respectively.

Labor of adult males, adult females and children may have different productivity in agriculture and forest gathering activities. There can be different wage rates for males, females, and children. In this model, however, these differences are ignored and the same wage rate is assumed for different categories of labor. Time constraint (7) and budget constraint (8) can be combined into a single constraint by substituting T_w from (7) into (8) that takes the form:

$$Tw - w\alpha z - w(\beta_1 x_f^s + \beta_2 x_f^m) - w\gamma x_a^m + p_a x_a^m + p_f x_f^m + v = p_c x_m \tag{9}$$

Equation (9) can be interpreted as follows. The first four terms together denote the net wage income which is equal to total possible earnings (from allocating all available time for wage work) less the value of time spent on household production and consumption (valued at the wage rate) plus the value of time spent on forest gathering activities and agricultural activities. Thus, the equation shows that the total earnings from wage work, commercial NTFPs and agricultural products plus other income are spent on market commodity which is used to produce the final commodity (z), together with forest subsistence commodity ($x_f{}^s$) and time. The utility function of the household, after substituting z in (2), is represented by:

$$U = u(x_m, x_f^s, T_c), \tag{10}$$

It is assumed that household utility is non-decreasing in all three arguments.

The utility-maximization problem of the household can be represented as:

$$\max_{x_m, x_f^s, x_f^m, x_a^m} u = u(x_m, x_f^s, T_c), \tag{11}$$

where

$$T_c = T - (T_a + T_f + T_w)$$

$$\text{St. } I = p_c x_m$$

The first-order conditions of the utility maximization problem are:

$$\frac{\partial u}{\partial x_m} = \lambda\{(\alpha/\sigma)w + p_c\} \tag{11.1}$$

$$\frac{\partial u}{\partial x_f^s} = \lambda \beta_1 w \tag{11.2}$$

$$\frac{\partial u}{\partial x_f^m} = \beta_2 w + p_f \tag{11.3}$$

$$\frac{\partial u}{\partial x_f^m} = \gamma w + p_a \tag{11.4}$$

$$Tw - w\alpha z - w(\beta_1 x_f^s + \beta_2 x_f^m) - w\gamma x_a^m + p_a x_a^m + p_f x_f^m + v = p_c x_m \tag{11.5}$$

Equation (11.1) shows that the marginal utility obtained from the market commodity is equal to the marginal utility of money income (λ) times the price of market commodity. The price of the market commodity, however, has a direct component (p_c) and an indirect component (α/σ w). The indirect component is the opportunity cost of time spent in converting the market commodity to the final commodity (z) through the household production process and the time spent on consumption of z. The indirect component appears in the equation because the time spent on production and consumption, otherwise, would have been used to generate more cash income from agriculture, gathering NTFP, and wage-earning work. Equation (11.2) equates the marginal utility of the subsistence forest product to the marginal utility of money income times the value of time spent on gathering a unit of subsistence forest products. Equation (11.3) shows that the price of the commercial forest commodity is equal to the marginal utility of money times the value of time spent on gathering it. Equation (11.4) shows that the price of the agricultural commodity is equal to the marginal utility of money times the value of time spent on agriculture. Equation (11.5) indicates that cash income earned from wage work, agriculture, commercial NTFP and other income is spent on purchasing market commodities for consumption. In all of the above equations, time is valued at the existing wage rate. Labor market opportunities at competitive wages do exist in rural areas in Sri Lanka[5] (see Cooke 1998, for similar assumption for Nepal). Therefore the optimizing household allocates labor such that the shadow price is equal to the market wage. Note that NTFP is valued in this model based on the time spent on these activities. Gathering NTFP uses basically the time input, while other material or mechanical inputs are rarely used. Therefore, equating the price of NTFP to the opportunity cost of time makes sense.

Solution to the above first-order conditions provided the demand function for the subsistence NTFP, among other things. That demand function can be represented as

$$x_f^s = f(w, p_c, p_a, p_f, I, w_1\beta) \qquad (12)$$

Where w is the wage, p_c, p_a and p_f are the prices of other commodities, agricultural products and forest products, respectively, I is the income, and $w_1\beta$ is the shadow price.

Data

The data were obtained from the households living near the peripheral villages of the Sinharaja rain forest in Sri Lanka. Sinharaja rain forest reserve covers an area of 8,800 ha of natural and modified forests. The reserve lies in the south-west of the island at 6°21′–6°26′ N. and 80°21′–80°34′ E. The forest spreads into three administrative districts, viz. Ratnapura, Galle and Matara. A survey was conducted in 17 Gramasevaka divisions in the Sinharaja periphery. A list of all the households in the 17 Gramasevaka divisions was obtained from the village headman (Grama Seva Niladhari). A total of 1909 families were residing in the selected villages. Households not involved in NTFP collection were excluded from the list. The random number tables were then used to select 180 households among those who engage in NTFP extraction. However, due to incomplete information, only 142 surveys were used for the analysis. All the households in the sample extract products such as fuel wood, Beraliya (*Doona cordifolia*), Hal (*Vateria copallifera*), and Goraka (*Garcinia cambogia*).

Fuelwood is used mainly for cooking purposes. Hal is used for various purposes (Rajapaksha 1998). The fruit is the edible part, but it tastes bitter. Traditionally, scrapped Hal is soaked in water to remove bitterness and make food. Hal bark is used to eliminate fermentation of toddy and thus comply with the mandatory requirement for making tricle. Goraka is used as spice, especially in preparing fish curry. Fruit is the edible part in Beraliya. According to the villagers, fruit could be kept without deterioration for about 6 months, but it is vulnerable to fruit borer attack. Fruit of Beraliya is not bitter like Hal. Beraliya fruit is also used as food. All the above products are subsistence commodities in Sinharaja periphery. In addition, green leaves, canes, some wines, mushrooms, resins, bee honey, and yams are the other frequently collected products. Except for

[5]For the sake of simplicity of the model, it is assumed that households can only hire out labor (see Eq. 7). However, under the complete labor market assumption, households can also hire in labor.

green leaves, most of these products are marketable.

The household head was interviewed using a well-structured questionnaire. The questionnaire was pre-tested with a few households before conducting the survey. The information collected included socio-economic data such as age, education level of the respondent, total household income, NTFP extraction per year, and time allocation among different economic activities.

Households extract different kinds of goods from forests. They are measured in different units. Therefore, the addition of these collected goods does not provide a correct idea of quantities. Hence, a quantity index for collected goods presents an accurate picture of a common good. A quantity index for NTFP was developed by using the following formula:

$$Q_i = \Sigma_i P_i \Sigma_i X_i / \bar{P}, \quad \bar{P} = \Sigma_i \Sigma_j P_{ij} \Sigma_i \Sigma_j X_{ij} / \Sigma_i \Sigma_j X_{ij}$$

where P_i is the price for a good, X_i is the quantity extracted of a good, and $\bar{P}$ is the common price for goods. As forest gate prices are missing in the NTFP considered, the opportunity cost of time and the value of the closest substitute were used as the prices in the quantity index. As the extraction is a time-consuming activity, the opportunity cost of time makes sense in approximating the value of extracted products. Similarly, when the extraction time is difficult to count, those products were valued on the basis of the closest substitutes available in the market (see Godoy et al. 1993 for a detailed discussion of valuing NTFP).

NTFP production model

The theoretical model described above is based on the time allocation among NTFP collection, agriculture, and wage-earning work. Time allocation among different activities is, in general, considered to be competitive. Competitive time allocation means that if more time is allocated for agriculture or wage-earning work, less time will be available for NTFP gathering. Based on this assumption, support for labor-intensive agriculture is viewed to be beneficial for conservation as it reduces the forest gathering activities. However, if agriculture is seasonal, this competitive relationship may not hold. In that case, gathering activities take place when labor is not utilized for agriculture.

If there is no competitive labor allocation between agriculture and NTFP gathering, agricultural development will not be a proper strategy for forest conservation. Moreover, competitive/complementary labor allocation may vary between subsistence and commercial forest gathering activities. However, it is worth mentioning that competitive labor allocation may exist depending on other situations such as time spent on different activities (e.g. hunting at night), weather conditions, etc.

In this section, we test the hypothesis of competitive/complementary labor allocation between NTFP gathering and agriculture. We accomplish this by estimating the production function for NTFPs. The hypothesis was tested including the labor allocation in agriculture in the NTFP production function.

NTFP production is assumed to depend on two factors i.e. number of labor days required to extract NTFP and labor requirements for tea production. Note that tea is the dominant agricultural activity in the study area and time allocation data for other minor agricultural activities are not available.

In the NTFP production model, R^2 is 53.9%. The results of the analysis showed positive and significant effect on labor contribution for NTFP. The labor requirement for tea production is negatively and significantly related to NTFP production. Thus, NTFP gathering and agriculture are competing activities for labor, as assumed. These results provide supportive empirical evidence to the proposition that labor-intensive agricultural development can be used to reduce forest dependence of local communities in protected forests. Moreover, the results validate the theoretical model presented earlier that assumes competitive labor allocation between agriculture and NTFP harvesting (Table 1).

Demand models for NTFP

The demand for subsistence NTFP is a function of many variables such as the price of agricultural commodities, the price of market commodities, the wage rate, the price of marketed forest products, and the income from other sources (Eq. 12). Among these variables, the wage rate, the price of market commodities, the price of marketed forest

Table 1. Labor allocation between NTFP collection and agriculture in Sinharaja Rain Forest periphery, Sri Lanka.

Variable	Coefficient	Std. error	*t*-ratio	*p*-value
Labor days for NTFP	3428.4	203.8	16.83	0.000*
Labor days for tea	−0.24024E + 07	0.1430E + 06	−16.800	0.000*
Intercept	956.28	81.73	11.70	0.000*
Sample size	$(n) = 142$			

*Significant at 0.05 level.

products, and the price of agricultural products do not show adequate variation in a cross-sectional study. That makes the estimation of demand functions impossible with cross-sectional data. Therefore, the derived demand function described above was modified to suit it for a cross-sectional study including own-price, shadow wage, and income. Own-price was calculated as the value of time spent per unit of NTFP. If Q quantity of a particular NTFP is collected by spending N number of labor days and the opportunity cost of a labor day is w, the price of that good, P, was to be calculated as $P = wN/Q$. Note that this formulation of own-price is in agreement with the first-order condition (11.2).

The shadow wage was calculated as the opportunity cost of time in the tea sector following the same approach. The shadow wage of labor based on tea production is the returns per labor unit in tea production. This was calculated by dividing the total revenue less cost of all other inputs (such as fertilizer, chemicals, and machinery) divided by the number of labor units (see Gittinger 1982 for alternative methods of calculating shadow wage in agriculture). Based on this calculation, the average daily shadow wage is 141.12 rupees. The reported daily market wage in smallholder tea sector in the study area is about 150 rupees. According to various studies, agricultural labor is paid a wage above its opportunity cost (McDiarmid 1977; Barnum and Squire 1979). Demand for five items, namely, aggregated NTFP, fuel wood, Beraliya (*Doona cordifolia*), Hal (*Veteria copalifera*), and Goraka (*Garcinia cambogia*) was estimated. These NTFPs were selected based on the high frequency of collecting them. Respectively, 142, 132, 124, 102 and 123 households reported that they collect NTFP, fuel wood, Beraliya, Hal, and Goraka. The income variable was measured as the sum of available annual income from agriculture and other sources. Data for demand models were obtained from the same basic sample.

Results

The demand models were first estimated using the OLS method for diagnosis of heteroscedasticity and multicollinearity. The coefficient of determination was below 0.2 for all the models. An examination of the covariance matrix indicates no severe multicollinearity in the data for all the demand models. However, heteroscedasticity was present in all the models[6]. The low R^2 shown in the OLS models may be due to the presence of heteroscedasticity. A heteroscedastic model was estimated as the final model. Table 2 presents the results of the estimated demand models. The heteroscedastic model does not provide the R^2 values.

The demand model for the aggregated NTFP shows the negative relationship with both price and income with statistical significance. In this model, the quantity index of NTFP was used as the dependent variable. The result indicates that NTFP is an inferior commodity, as income increases the demand for NTFP declines. Shadow price shows a statistically significant positive impact on NTFP demand. This is quite opposite to expectation. When the opportunity cost of time allocated to NTFP (i.e. the returns to time allocated for agriculture) increases, people should extract a smaller quantity of NTFP. This may be true for income-earning NTFP. However, since the majority of the NTFP has subsistence uses, the expected results may not be observed. Earlier studies have shown both positive and negative effects on substitution. In their studies in Nepal and Ethiopia, respectively, neither Cooke (1998) nor Mekonnen (1995) found statistical evidence of substitution between forage and fodder as animal food or between fuel wood and dung for cooking.

[6] Yhat and Yhat** tests were highly significant for fuel wood, Beraliya and Hal. Harvey test was significant for NTFP, Beraliya, Hal and Goraka. Glejser test was significant for all products.

Table 2. Estimation of Demand for NTFP in Sinharaja Rain Forest, Sri Lanka.

Product	Variable	Coefficient (std. error)	*t*-ratio	*p*-value
NTFP (142)[a]	Own price	−787.35 (44.90)	−17.53	0.000*
	Income	−0.78300E − 02 (0.5367E-03)	−14.59	0.000*
	Shadow wage	4.8799 (0.3640)	13.41	0.000*
	Intercept	7604.0 (430.1)	17.68	0.000*
Fuelwood (132)[a]	Own price	−5060.0 (364.6)	−13.88	0.000*
	Income	0.52661E − 02 (0.1941E-02)	2.713	0.007*
	Shadow wage	2.1391 (0.5550)	3.855	0.000*
	Intercept	7128.4 (591.5)	12.05	0.000*
Beraliya (*Doona cordifolia*) (124)[a]	Own price	−0.44256 (0.2837E − 01)	−15.60	0.000*
	Income	−0.58356E − 05 (0.3489E − 05)	−1.673	0.094**
	Shadow wage	−0.62170E − 02 (0.5703E − 03)	−10.90	0.000*
	Intercept	30.184 (1.969)	15.33	0.000*
Hal (*Veteria copalifera*)(102)[a]	Own price	−1.9228 (0.1736)	−11.07	0.000*
	Income	−0.64162E − 04 (0.1478E-04)	−4.340	0.000*
	Shadow wage	0.86038E − 03 (0.3085E-02)	0.2789	0.780
	Intercept	56.501 (4.827)	11.71	0.000*
Goraka (*Garcinia cambogia*)(123)[a]	Own price	−0.56117 (0.5051E − 01)	−11.11	0.000*
	Income	0.16763E − 04 (0.9875E − 05)	1.697	0.090**
	Shadow wage	−0.13475E − 01 (0.3040E − 02)	−4.432	0.000*
	Intercept	45.837 (4.143)	11.06	0.000*

*Significant at 0.05.
**Significant at 0.1.
[a]Number of observations.

However, Amacher et al. (1998) have found evidence of substitution between fuel wood and agricultural residues for low-income households. The NTFPs fulfill diverse needs of the local community and this may be the reason for observing the positive relationship.

In the case of fuel wood, price is negatively related to the quantity demanded, as expected. Amacher et al. (1998) also highlighted that when fuel wood prices rise, some households far from the market deviate from fuel wood purchase to fuel wood collection. The other two variables are positively significant in the model. Higher income allows more food purchases and consequently requires more firewood. This may be the reason for the positive relationship between income and demand for firewood. The positive impact of shadow wages can be explained using the same logic. The rest of the products consistently show the negative own-price effect. Beraliya and Hal are directly consumed by the households. These two products are inferior products since they have negative coefficients for the income variables. Goraka is a spice and its demand shows a positive relationship with income. This is used in preparing fish curries and higher income allows more fish consumption resulting in a positive relationship.

Shadow wages were calculated as the returns to labor in agriculture. When this variable increases, the opportunity cost of NTFP extraction also increases. As a result, NTFP extraction should decrease. However, this negative relationship was observed only for some products. The two products directly consumed have shown this relationship, while other products which go as inputs for the final product show a positive relationship. This may be due to some omitted variables (i.e. wage could be correlated with some components of wealth, fixed production assets that also increase demand for NTFPs).

Estimated own-price and income elasticities at the mean of NTFP are given in Table 3. The price elasticity for Beraliya is elastic while all other products show inelastic response to price changes. The studies of Amacher et al. (1998) and Kohlin (1998)[7] show the price elasticity for fuel wood as −1 to 0 and −1.47, respectively. Our price

[7]Kohlin G. 1998. The Value of Social Forestry in Orissa, India. Unpublished Ph.D dissertation, Goteborg University, Sweden.

Table 3. Price and income elasticity of different forest products in Sinharaja Rain Forest, Sri Lanka.

Product	Price elasticity	Income elasticity
NTFP	−0.84	−0.22
Fuel Wood	−0.86	0.13
Beraliya	−1.90	−0.07
Hal	−0.68	−0.25
Goraka	−0.92	0.09

elasticity value for fuel wood is between their values. Elasticity estimates from previous studies are not available for other products, for comparison purposes. Overall, the majority of products show inelastic price responses. Inelastic responses to prices show that subsistence NTFP are an essential part of the rural lifestyle. The diverse roles played by them in rural households as medicinal plants, seasonal foods and delicacies, ornamental plants, spices, etc. will not vary substantially with price changes. Unlike the market commodities, the prices here are shadow prices and the only variable that can be manipulated is the wage rate. Even if the wage rate is increased the response will not be significant, as price elasticities are mostly inelastic. Results also suggest that even if wage rate fell and technology improved, extraction will not increase substantially assuming that NTFP continued to be for subsistence use in study sites.

Income elasticities are not consistently negative. Firewood and Goraka, used as input in cooking, show positive income elasticities, while other subsistence NTFP have negative income elasticities. Amacher et al. (1998) also found that the effect of household income on the consumption of forest products is generally small and some forest products are inferior goods in some economies. The study findings show that all NTFPs are not inferior. Extraction of some of the products will decline while it can increase for other products as income increases. Therefore, an aggregate level analysis is inadequate for policy formulation. It is necessary to conduct the analysis at the product level separately.

Conclusions

Protection of tropical rainforests is vital for sustainable development. Failures of legislative approaches and subsequent failures of the ICDP approach indicate that policy makers have limited knowledge of the interaction between forest and local communities. This study has carried out further work to expand the knowledge on forest-people link in terms of NTFP harvesting. Previous studies on the subject have asserted that agricultural development that leads to allocation of more labor for agriculture results in a reduction of the dependence on NTFP and thus promotes forest conservation. These studies rely on the hypothesis of competitive time allocation between agriculture and forest activities. While this hypothesis is vital for the theory of forest resource extraction, empirical evidence has been lacking. This study tests the competitive time allocation between agriculture and NTFP extraction and the results show that agriculture and NTFP extraction are competing for labor in the Sinharaja area.

In the household production function framework, the derived demand for NTFP depends on many variables. However, in a cross-sectional study, such variables do not show adequate variation to estimate the demand function. This study develops a theoretical model to show that subsistence forest product prices can be imputed using the time allocation for collection of the product. Results indicate that the method used for estimation of imputed price is accurate as all the demand models obey the law of demand with the imputed prices. In a similar manner, substitute price was imputed using the returns to labor in the competing agriculture sector. With these two imputed prices and income the demand functions for selected NTFPs were estimated. The results show that the impact of substitute prices varies from one product to another. The effect of income on NTFP extraction also shows some inconsistent results indicating all the NTFPs are not inferior products. Except for Beraliya, price elasticities are inelastic. Income elasticities are inelastic for all the products.

The results have important policy implications. The study findings provide supportive evidence for the thesis that agricultural development in the periphery of protected forests can reduce labor allocation for forest extraction and hence enhance conservation. Subsistence NTFPs are not very price-responsive. According to the study findings, 4 out of 5 products show inelastic responses to shadow prices calculated from the opportunity cost of time. However, the estimates are not highly inelastic as 4 out of 5 products are greater than 0.8. Hence, under present conditions, policy makers should not expect higher responses to changes in the opportunity cost of time for subsistence products. It is quite important to separate the subsistence and commercial NTFPs in designing future studies, as these two categories may have quite different responses to price and income changes. Our study, due to lack of data, was confined to a few subsistence NTFPs. Further studies on the demand for commercial NTFPs are encouraged.

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