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Demand for Non-Timber Forest Products: The Case of the Sinharaja Peripheral Communities

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ABSTRACT. Proper management of tropical rainforests is crucial for biodiversity protection. Despite all the efforts undertaken during the last two to three decades, forest degradation continues. Lack of proper knowledge on forest-people interaction is one reason for the failure of many conservation policies. This study focuses on the behaviour of peripheral communities towards non-timber forest product (NTFP) harvesting by estimating the demand functions for NTFP. The paper develops a theoretical model in order to derive the shadow price for NTFP using time allocation among different economic activities. Then it tests the competitive time allocation hypothesis between NTFP extraction and agriculture. Results provide statistical evidence for existence of competitive time allocation between agriculture and NTFP extraction. Own price elasticities are consistently inelastic, except for one product. Income increase may not necessarily reduce subsistence NTFP extraction. Moreover, as indicated by the inelastic responses, pricing policies may not be very useful in manipulating subsistent NTFP extraction. Repeating similar studies for commercial NTFP is encouraged.

INTRODUCTION

Conservation of tropical rain forests has been a priority issue throughout the world for the last few decades. Earlier, the conservation issue was considered as a biological and ethno-botanical issue. The failure of many efforts taken to conserve forests, based on pure natural science orientation and command and control approaches, is experienced in many parts of the world. Among many reasons for such failures in developing countries, exclusion of the needs and aspirations of adjoining communities who have been utilizing forest resource for centuries occupies the foremost place (McDermott *et al.*, 1990; Ganguli, 1995; UNEP, 1996). The Integrated Conservation and Development Projects (ICDP) approach, which was developed to incorporate the local communities in forest conservation efforts, appeared sound for a sometime. This approach relies on less destructive forest use strategies such as biodiversity prospecting, eco-tourism and sustainable harvest of non-timber forest products (NTFP) for augmenting rural incomes. However, recent empirical evidences suggest that ICDPs also have failed in many instances to achieve their targets: protection of natural forest without great income losses to local communities (Simpson, 1995). This frustrating experience left no option other than continuous search for better strategies for protection of natural forests.

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This paper deals with the Non-timber Forest Products (NTFP) harvesting from natural forests in the context of forest conservation. There are some evidences that NTFP harvesting by local communities has lead to 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 the forests (MFE, 1995; Gunatilake, 1998). Reduction of community dependency on forests may be a need in the case of protected forests (Gunatilake. 1998).

Forest conservation for bio-diversity purpose cannot be economically justified by the value of collected NTFPs alone (Batagoda, 1998). Among the available values of NTFP, Peters *et al.* (1989) have estimated the value of standing NTFPs in an Amazonian forest as US $ 6330 per ha. This value is higher than 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 the forest is the US $ 50 per ha per year (Godoy and Bawa, 1993; Pearce and Moran, 1994; Pearce, 1997). 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 for justifying 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 bio-mass. Agriculture, which covers one third of the forest area, is supposed to be contributing to GDP 15 times as much as the forests contribute. One reason for this is supposed to be the lack of economic analysis regarding NTFP consumption and production (Linde-Rahr, 2000). 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 cover food deficiencies. Hence, analyses of the economic impacts of NTFPs on rural economy need to emphasize rural poverty (Linde-Rahr, 2000). The impact of NTFPs on income distribution is another important aspect. A study conducted in the Sinharaja area has shown slight changes in Gini co-efficient due to income from NTFPs (Batagoda, 1998).

A successful forest conservation program may need a rural development component so as to reduce the peoples' dependency on forest products. The declining trend of extracting NTFPs by the higher income groups provides the basis for this assertion (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 objective of this study is to further investigate the economic behavior of rural households with respect to NTFP gathering.

Following the above description, the aim of this research is to estimate the demand for subsistent NTFPs and to examine the impacts of prices and income on NTFP gathering. Many subsistence NTFPs do not have a market and hence market prices are not available for them. This paper develops a methodology to estimate shadow prices for subsistence NTFP and incorporate them in the demand functions. The framework used in this analysis is time allocation between NTFP gathering and other economic activities. The paper first develops a theoretical model to derive the demand function for subsistence NTFPs. Then it tests the hypothesis on complementarity/substitutability of time allocation between NTFP gathering and agriculture. Finally, the paper estimates the demand functions for selected subsistence NTFP. The results show that there is a competitive time allocation between agriculture and NTFP gathering in the Sinharaja area. Demand functions show that own price effect is consistent for all the products while no statistical evidence is available for a negative income effect hypothesis for subsistence NTFPs.

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 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 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 they 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 non-timber forest products (NTFP). We assume that the households gather two types of NTFP: a subsistence NTFP and a marketable NTFP. The subsistence NTFP directly enter the household consumption and never enter the market exchange process, while the marketable NTFP provide cash income through market exchange. Marketable NTFP are not consumed by the household. They provide cash income to buy market commodities.

The household, thus, exchanges the agricultural products and the marketable NTFP 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:

$$u = u(z) \qquad (1)$$

where 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 z. The household production function is represented by:

$$z_i = z(X_m, X_f^s, T_{ci}) \qquad (2)$$

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.

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 weekdays and weekends. So T_{ci} is treated as a scalar. Although, in general, z, X_m, and X^s_f 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, marketable 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:

$$\begin{aligned} T_c &= \alpha z \\ T_f &= \beta_1 x_f^s + \beta_2 x_f^m \\ T_a &= \gamma x_a^m \end{aligned} \qquad (3)$$

where α, β_1, β_2 and γ are the time required to produce one unit of Z, X^s_f, X^m_f and X^m_a, respectively. T_f and T_a are total time spent on agriculture and forest gathering activities, respectively. X^m_f and X^m_a denote the representative forest and agricultural commodities that are exchanged in the market for the representative market commodity (X_m).

Also the input-output relations in household production for final consumption with X_m and X^s_f are given by:

$$\begin{aligned} X_m &= \sigma z \\ X_f^s &= \delta z \end{aligned} \qquad (4)$$

where σ and δ are the quantities of X_m and X_f^s required to produce one unit of z.

The household faces the following time and budget constraints:

$$T = T_c + T_a + T_f + T_w \qquad (5)$$

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

$$I = T_w w + P_a x_a^m + P_f x_f^m + V = P_c X_m \qquad (6)$$

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). 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.

Labour 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, too. In this model, however, these differences are ignored and the same wage rate is assumed for different categories of labour. Time constraint (5) and budget constraint (6) can be combined into a single constraint by substituting T_w from (5) into (6) that takes the form:

$$Tw - w\alpha z - w(\beta_1 x_f^s + \beta_2 x_f^m) - w\gamma x_a^m + p_a x_a^m + p_f x_f^m + v = p_c x_m \quad (7)$$

Equation (7) 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 (evaluated 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, marketable NTFP and agricultural product plus other income are spent on market commodity which is used to produce the final commodity (z), together with forest subsistence commodity (X^s_f) and time. The utility function of the household, after substituting z in (2), is represented by:

$$U = u(x_m, x_f^s, T_c) \quad (8)$$

It is assumed that household utility is non-decreasing in all three arguments. The utility maximization problem of the household can be represented as:

$$\max_{x_m, x_f^s, x_f^m x_a^m} u = u(x_m, x_f^s, T_c) \quad (9)$$

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

The first order conditions of the utility maximization problem are:

$$\frac{\partial u}{\partial x_m} = \lambda\{(\alpha/\sigma)w + p_c\} \quad (10.1)$$

$$\frac{\partial u}{\partial x_f^s} = \lambda\beta_1 w \quad (10.2)$$

$$p_f = \lambda\beta_2 w \quad (10.3)$$

$$Tw - w\alpha z - w(\beta_1 x_f^s + \beta_2 x_f^m) - w\gamma x_a^m + p_a x_a^m + p_f x_f^m + v = p_c x_m \quad (10.4)$$

Equation (10.1) shows that the marginal utility obtained from the market commodity is equal to the marginal utility of money income (λ) times the price of the 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 (10.2) 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 (10.3) shows that the price of the marketable forest commodity is equal to the marginal utility of money times the value of time spent on gathering it. Equation (10.4) says that cash income earned from wage work, agriculture, marketable 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. Note that, NTFP is valued based on the time spent on these activities in this model. 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:

$$x_f^s = f(w, p_c, p_a, p_f, v)$$

DATA

The present analysis was carried out with the data collected from 180 households in the periphery of the Sinharaja forest. The 180 villagers were randomly picked up from 17 *Gramasevaka* divisions in Rathnapura, Kalutara, Galle and Matara districts. A list of all the households in the 17 *Gramasevaka* divisions was prepared and random number tables were used to select the households (Appendix 1). A member of each household, who was mainly responsible for the household decisions, was interviewed. The survey was conducted 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, non-timber forest product extraction per year, and time allocation among different economic activities.

NTFP production model

The above described theoretical model is based on the time allocation among the 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, intensification of labour 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 takes place when labour is not utilized for agriculture. If there is no competitive labour allocation between agriculture and NTFP gathering, agricultural development will not be a proper strategy for forest conservation, as suggested by Gunatilake and Chakravorty (2001). Moreover, competitive/complementary labour allocation may vary between subsistence and commercial forest gathering activities. In this section we test the hypothesis of competitive/complementary labour allocation between NTFP gathering and agriculture. We accomplish this by estimating the production function for NTFP. Hypothesis was tested including the labour allocation in agriculture in the NTFP production function.

NTFP production is assumed to depend on two factors: number of labour days required to extract NTFP and labour requirement 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. Among the products people extract, fuel wood, *Beraliya*, *Goraka*, *Hal*, and *Kitul* products are prominent, in terms of frequency and quantity collected. In addition, green leaves, canes, some wines, mushrooms, resins, bee honey and yams are the other frequently collected products. People collect several products in one trip, but product wise time allocation data for all the products is not available. Given this reason all the NTFP are aggregated to a common one in this analysis. This common good is the index reflecting the quantity (Appendix 2). The quantity of each good collected within a year is indicated by this index.

The R^2 for the NTFP production model is 53.9%. In the NTFP production model, labour contribution for NTFP is significant at 0.05 level and is positive. The labour requirement for tea production is negatively and significantly related to NTFP production. Thus, NTFP gathering and agriculture are competing activities for labour, as assumed. This results provide supportive empirical evidence for the Gunatilake and Chakravorty (2001) proposition that labour intensive agricultural development can be used to reduce forest dependency of local communities in protected forests. Moreover, this result validates the theoretical model presented earlier that assumes competitive labour allocation between agriculture and NTFP harvesting (Table 1).

Demand models for NTFP

As derived in the theory section, demand for subsistence NTFP is a function of many variables such as price of agricultural commodities, price of market commodities, wage rate, price of marketed forest product, and income from other sources (Equation 11). Among these variables, wage rate, prices of market commodities, prices of marketed forest products, and 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 above described derived demand function was modified to suit it for a cross sectional study including, own price, substitute price 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 labour days and the opportunity cost of a labour day is w, the price of that good, P, was calculated as P = wN / Q. Note that this formulation of own price is in agreement with the first order condition (10.2).

Table 1. Results for the NTFP production model.

Variable	Coefficient	Standard error	T-ratio	P-value
Labour days for NTFP	3428.4	203.8	16.83	0.000*
Labour days for tea	-0.24024E+07	0.1430E+06	-16.80	0.000*
Intercept	956.28	81.73	11.70	0.000*

* significant at 0.05 level.

Substitute price was calculated as the opportunity cost of time in the tea sector following the same approach. Shadow value of labour according to tea production is the returns per labour 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 labour units. Demand for five items are estimated; aggregated NTFP, fuel wood, *Beraliya* (*Doona cordifolia*), *Hal* (*Veteria copalifera*), and *Goraka* (*Garcinia cambogia*). These NTFP were selected based on the high frequency of collecting them. Respectively, 142, 132, 124, 102 and 123 households reported that they collect Fuel wood, *Beraliya*, *Hal*, and *Goraka*. 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 OLS method for diagnosis of heteroscedasticity and multicollinearity. Coefficient of determination was below 0.2 for all the models. Examination of the covariance matrix indicates that there was no severe multicollinearity in the data for all the demand models. However, heteroscedasticity was present in all the models (Appendix 3). 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 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, 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. Substitute price shows a statistically significant positive impact on the NTFP demand. This is quite opposite of the expectation. When opportunity cost of time allocated to NTFP, that is the returns to time allocated for agriculture increases, people should extract less quantity of NTFP. This may be true for income earning NTFP. However, since majority of the NTFP has subsistence uses, the expected results may not be observed. The NTFP fulfill diverse needs of the local community and this may be the reason to observe the positive relationship.

Table 2. Demand for NTFP.

Product	Variable	Coefficient (Standard error)	T-ratio	P-value
NTFP	Own price	-787.35 (44.90)	-17.5300	0.000*
	Income	-0.78300E-02 (0.5367E-03)	-14.5900	0.000*
	Shadow wage rate	4.8799 (0.3640)	13.4100	0.000*
	Inercept	7604.0 (430.1)	17.6800	0.000*
Fuel wood observation - 132	Own price	-5060.0 (364.6)	-13.8800	0.000*
	Income	0.52661E-02 (0.1941E-02)	2.7130	0.007*
	Shadow wage rate	2.1391 (0.5550)	3.8550	0.000*
	Intercept	7128.4 (591.5)	12.0500	0.000*
Beraliya observation - 124	Own price	-0.44256 (0.2837E-01)	-15.6000	0.000*
	Income	-0.58356E-05 (0.3489E-05)	-1.6730	0.094**
	Shadow wage rate	-0.62170E-02 (0.5703E-03)	-10.9000	0.000*
	Intercept	30.184 (1.969)	15.3300	0.000*
Hal observation - 102	Own price	-1.9228 (0.1736)	-11.0700	0.000*
	Income	-0.64162E-04 (0.1478E-04)	-4.3400	0.000*
	Shadow wage rate	0.86038E-03 (0.3086E-02)	0.2789	0.780
	Intercept	56.501 (4.827)	11.7100	0.000*
Goraka observation - 123	Own price	-0.56117 (0.5051E-01)	-11.1100	0.000*
	Income	0.16763E-04 (0.9875E-05)	-1.6970	0.090**
	Shadow wage rate	-0.13475E-01 (0.3040E-02)	-4.4320	0.000*
	Intercept	45.837 (4.143)	11.0600	0.000*

* Significant at 0.05 level ** Significant at 0.1 level

In the case of fuel wood, price is negatively related to the quantity demanded as expected. 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. 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 labour 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 has shown this relationship while other products which as inputs for the final product shows positive relationships. This may be due to the dominant income effects.

Estimated own price and income elasticities 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 Kohilin (1998) and Amachar *et al.* (1998) show price elasticity for fuel wood is -1 to 0 and -1.47, respectively. Our price elasticity value for fuel wood is between their values. Elasticity estimates from previous studies are not available for other products, for comparative purposes. Overall, the majority of the products show inelastic price responses. Inelastic responses to prices show that subsistent NTFP are a type of essentials in 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 only the variable that can be manipulated is the wage rate. Even if the wage rate is increased, the response will be not significant, as price elasticities are mostly inelastic.

Table 3. Elasticities with respect to price and income.

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

Income elasticities are not consistently negative. Firewood and *Goraka*, that go as input in cooking show positive income elasticities while other subsistent NTFP have negative income elasticities. Thus, the results show that all NTFP are not inferior. Extraction of some of the products will decline while it can increase for other products as income increases. Therefore, 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 policiy makers have limited knowledge on the interaction between forest and local communities. This study carries 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 the allocation of more labour for agriculture result in reduction of the dependency on NTFP and, thus, promote 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, no empirical evidence was available. This study tests the competitive time allocation between agriculture and NTFP extraction and results show that agriculture and NTFP extraction is competing for labour 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 labour in the competing agriculture sector. With these two imputed prices and income the demand functions for selected NTFP were estimated. Results show that the impact of substitute prices show variation from one product to another. Effect of income on NTFP extraction also show some inconsistent results indicating all the NTFP products are not inferior products. Except for *Beraliya*, price elasticities are inelastic. Income elasticities are inelastic for all the products. This result indicates that income increases in the rural community have limited impact on extraction levels.

The results have important policy implications. First, the results provide supportive evidence for the theme that agricultural development in the periphery of protected forest can reduce labour allocation for forest extraction and hence enhance conservation. Second, income increase may not necessarily reduce dependency on NTFP if they serve subsistent needs. Third, subsistent NTFPs are not very price responsive. Therefore tax or subsidy oriented pricing policies (on wages) cannot be successfully used to control the extraction levels. 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. Depending on the data availability we confined this study to a few subsistent NTFPs. Further studies on the demand for commercial NTFPs are encouraged.

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APPENDICES

Appendix 1. Sample frame.

The sample is selected from GN divisions adjoining to forest areas newly added to the Sinharaja forest.

Forest area	GN division	# of families	# of families using forest	# of selected families
Delwala PR	Delwala	1315	500	47
Walankanda FR	Rambuka	483	187	18
	Thanabela	261	220	21
Runakanda FR	Diganna	261	150	14
	Thiniyawala	634	75	7
	Batagodawila	275	50	5
	Kalukandawa	46	40	4
Dellawa PR	Pahalamillawa	292	25	2
	Ihalamillawa	140	35	3
	Happitiya	226	95	9
	Miyanawatura	105	50	5
Diyadawa FR	Kotapola - North	540	100	9
	Deniyaya - West	325	150	14
	Pallegama - South	538	72	7
	Pussawela	268	100	9
	Deniyaya	570	40	4
	Beliattakumbura	318	20	2
Total			1909	180

The sample is of 180 forest using families. Number of forest using families each GN division contributes to the sample is based on the percentage of forest using families each GN division poses in the population of forest using families.

Appendix 2. Quantity index for environmental goods.

People extract different kinds of goods from forests. They are measured in different units. Therefore, the addition of these collected goods does provide a correct idea of quantities. Hence, a quantity index for collected goods indicates a picture of common good. A quantity index for NTFP was prepared by using the following formula.

$$Q_i = \Sigma_i P_i \Sigma_i X_i / \bar{P} \qquad \text{Where;} \qquad \bar{P} = \Sigma_i \Sigma_j P_{ij} \Sigma_i \Sigma_j X_{ij} / \Sigma_i \Sigma_j X_{ij}$$

$\bar{P}$ -common price for goods ; P - price for a good; X - quantity extracted of a good

Appendix 3. Diagnostic tests for heteroscedasticity.

		Yhat test	Yhat** 2 test	Log Yhat** 2 test	B-P-G test	Arch test	Harvey test	Glejser test
	Critical value	3.841	3.841	3.841	7.815	3.841	7.815	7.815
NTFP	Chi-square value	0.051	0.352	0.218	0.600	0.000	11.738	9.81
	Heteroschedasticity	No	No	No	No	No	Yes	Yes
Fuel wood	Chi-square value	4.796	6.893	1.618	5.547	0.009	7.677	16.337
	Heteroschedasticity	Yes	Yes	No	No	No	No	Yes
Beraliya	Chi-square value	6.289	13.161	3.553	6.319	0.051	11.074	25.811
	Heteroschedasticity	Yes	Yes	No	No	No	Yes	Yes
Hal	Chi-square value	4.464	5.936	2.375	5.496	0.210	12.754	24.107
	Heteroschedasticity	Yes	Yes	No	No	No	Yes	Yes
Goraka	Chi-square value	3.062	6.165	2.097	3.097	0.037	15.481	13.999
	Heteroschedasticity	No	Yes	No	No	No	Yes	Yes