Citation: Dhakal, B., Bigsby, H. and Cullen R. **Socioeconomic Impacts of Public Forest Policies on Heterogeneous Agricultural Households** *Environmental and Resource Economics*. Online publication date: 28 February 2012. Volume, Issue and page numbers of the article will be assigned in future. (Article ID: DOI 10.1007/s10640-012-9548-4)

Socioeconomic Impacts of Public Forest Policies on Heterogeneous Agricultural Households

Bhubaneswor Dhakal[1] · Hugh Bigsby · Ross Cullen

Abstract

Nepal has a long history of returning public forests to local people as part of its community forestry programme. In principle the community forestry programme is designed to address both environmental quality and poverty alleviation. However, concern has been expressed that forest policies emphasise environmental conservation, and that this has a detrimental impact on the use of community forests in rural Nepal where households require access to public forest products to sustain livelihoods. To study the effect of government policies on forest use, an economic model of a typical small community of economically heterogeneous households in Nepal was developed. The model incorporates a link between private agriculture and public forest resources, and uses this link to assess the socioeconomic impacts of forest policies on the use of public forests. Socioeconomic impacts were measured in terms of household income, employment and income inequality. The results show that some forest policies have a negative economic impact, and the impacts are more serious than those reported by other studies. This study shows that existing forest policies reduce household income and employment, and widen income inequalities within communities, compared to alternative policies. Certain forest policies even constrain the poorest households' ability to meet survival needs. The findings indicate that the socioeconomic impacts of public forest policies may be underestimated in developing countries unless household economic heterogeneity and forestry's contribution to production are accounted for. The study also demonstrates that alternative policies for managing common property resources would reduce income inequalities in rural Nepalese communities and lift incomes and employment to a level where even the poorest households could meet their basic needs.

Keywords: Community forestry policy, poverty reduction, linear programming, agroforestry

---

[1] Faculty of Commerce, Lincoln University, PO Box 84, Lincoln, Canterbury 7647, New Zealand
Corresponding e-mail:
B. Dhakal: Bhubaneswordhakal@gmail.com
H. Bigsby: Hugh.Bigsby@lincoln.ac.nz
R. Cullen: Ross.cullen@lincoln.ac.nz

Introduction

Since the 1970s, forest policies in many developed countries have been reformed to address growing problems of environmental degradation and wood product demands (Dhakal, 2009; Strassburg et al., 2009; Master Plan, 1988). The reforms have substantially changed production systems in community and public forests, and potentially changed supplies of various kinds of forest products including non-wood products. For example, forests in Nepal, which occupy 40 percent of the land area, have traditionally supplied inputs such as firewood, fodder/pasture, timber, charcoal and other non-wood products that are useful for rural households. However, recent Nepalese government policies, designed to protect forests, have reduced rural communities' access to local forest products and further marginalized poor people (Dhakal et al., 2011; Thoms, 2008; Shrestha and McManus, 2007; Maskey et al., 2006; Hjortso et al., 2006). Similar issues have arisen in other countries (Kumar, 2002; Agrawal, 2001).

Public forest resources are crucial for sustaining rural economies and improving the wellbeing of poor rural people (Graner, 1997). Agriculture is an important part of Nepal's economy but the average private landholding is less than 0.8 hectares and 47 percent of land-owning households own 0.5 hectares or less (CBS, 2003). Off farm employment opportunities are not accessible for many people and their private landholdings are generally inadequate to sustain their families. Due to the absence of motorized transport, and poor access to markets and other support services, many communities are required to be locally self sufficient. Many social problems in Nepal including armed conflict, frequent public demonstrations, and people trafficking are associated with limited access to resources and increasing unemployment (Murshed and Gates, 2005; NPC, 2003; Graner, 1997).

A number of studies have assessed the economic impacts on resource-based households caused by reforms to public forest policies, and have reported mixed results, particularly in developing countries (Karky and Skutsch, 2010; Strassburg et al., 2009; Thoms, 2008; Adhikari et al., 2007; Kumar 2002). These studies measure the impacts of changes in quantities of products or other direct economic returns from public forests that are available to households. However, the studies do not consider the economic effects of the complementary relationship between public forest resources and private farm resources. This relationship is often critical for rural households to sustain livelihoods, particularly when there are factors such as income constraints or remoteness from markets that mean households cannot source resources from external markets. Furthermore, few studies have assessed the effect of forestry policies across household income groups and their impacts on income inequalities within communities.

In cases where agriculture and forestry resources are complements, a model with endogenous consideration of inter-sector relationships can provide a better account of economic impacts of forest policy changes (Alig et al., 1998). Accounting for household economic heterogeneity and levels of dependency of users is crucial for a robust understanding of the economic effects of changes in the management of common property resources (Baland and Platteau, 1999). Anthon et al. (2008) developed a model that includes household economic heterogeneity, and integrated agriculture and forestry components to explain economic impact of public forest policy changes on farming communities in developing countries. However, their model is theoretical, not empirical, and could not be used to evaluate the impacts of different policy scenarios. Computational General Equilibrium (CGE) models, often used to assess socioeconomic impacts of forest policy (Shen et al., 2009; Stenberg and Siriwardana, 2007), are also not appropriate in developing economies. This is because the economy responds poorly to changing market prices or induced markets of forestry products. We believe our study is the first to assess the socioeconomic impact of changes of forest policies in a developing country using an empirical model that comprises a link between agriculture and public forestry resources and accounts for household heterogeneity in private resource endowments.

Evaluation of the likely economic impacts of alternative forest policies on rural communities is thus an important topic for investigation. An empirical model that recognises household heterogeneity[2], and that links agriculture and forest resources, is needed to evaluate alternative forest policies in Nepal. The objective of this study is to develop an empirical model that will allow the socioeconomic impacts of public forest policies in agriculture-based communities to be assessed, where there are limited opportunities to sustain livelihoods. A requisite of the model was to capture variation in household reliance on public forest resources to assess the impact of changes of government forest policies on individual households. This is accomplished by looking at changes to household income and employment. We assume that policy alternatives

[2] Land resources are the main source of income and employment in rural Nepal. Rural households are heterogeneous in private landholdings, which influences the impact of forest policies on household income and employment.

influence a household's behaviour, particularly how they manage their livestock and allocate time. Households strive to maximize their income subject to the constraints they face. Alternative forestry policies are evaluated in the paper by formulating and solving an optimization model. The following sections outline the analytical model, policy scenarios, data sources and results of simulations of the policy scenarios.

Community Forest Based Economies

The economy of a representative Nepalese rural community includes the private resources of its member households, markets for labour and local products, and access to community resources including forests. Members of the community use public forest resources to complement private land resources to sustain livelihoods. The community economic model, therefore, is an extension of a household production function model. However, the production function is quite different from other forest-based household models in that it incorporates the community management, distribution and use of products of the community forest, as dictated by government policies. There are many different forest policies for different localities and characteristics of the specific forest resources. Alternative forest policy options included in this study are discussed later. The following sections outline the structure of the model.

Household Resource and Production System

Each household in the community maximizes its income to meet its consumption requirements. In the household model, private land, community forest land and household labour are the key factors of production. Household consumption can be met by using its private land area (a_p) to produce goods, by forest products from community forestland (a_c) or by purchases in nearby markets. The private land area used to produce each of the different outputs (i to I) cannot be greater than its private endowment (Eq. 1). For modelling purposes, there are three different income groups, with different private landholdings between groups, and the same private landholding within a group. Our model also includes different categories of private lands (eg. upland, lowland, grassland and private forestland), which have distinct features in production systems, as explained in the method section.

$$\sum_{i=1}^{I} a_{pi} \leq a_p \qquad \text{Eq (1)}$$

For the following discussion, we drop the private and community land area subscripts, c and p, and refer to a generic land type k that can refer to a category of land and its ownership.

Output of any good i under production system t on land type k depends on the yield per unit area using a production system on a land type (R_{itk}) and the area of land type k allocated to a particular production system by a household (a_{tk}). As in many linear programming studies, it is assumed that marginal product (yield) is constant (eg. Das and Shivakoti, 2006). Land can include private land, land used under sharecropping and public forest land that is allocated to a household to use. Products can be a single output from a production system or byproducts. Agriculture and forestry production systems can produce more than one product simultaneously (Amacher et al., 1993). The outputs can include a range of cereal crops, livestock and forest products. Total output of any particular good by a household (q_i) is then a function of how much land of various types the household allocates to different production systems.

$$q_i = \sum_{k=1}^{K} \sum_{t=1}^{T} (R_{itk} a_{tk}) \qquad \text{Eq. (2)}$$

Community forest land can be used for multiple objectives, however this can be constrained by government policy. Two types of policies are considered here. The first policy affects the area of land type k that can be used for a particular output (G_{1ki}). In this policy, some proportion of community forest land may be allocated or restricted to achieve particular policy objectives (eg. erosion control). As such G_{1k} ranges from 0 to 1. The other type of policy constrains the level of production from an area that is being used for an output (G_{2ki}). An example of this constraint is where the government limits forest harvests to a proportion of its mean annual increment (MAI), such as for a contribution to global climate change mitigation. Again, the value of G_{2ki} can range from 0 to 1. The constrained production of output due to government policy is then,

$$q_i = \sum_{k=1}^{K} \sum_{t=1}^{T} \left(a_{tk} G_{1ki} \right) \left(R_{itk} G_{2ki} \right) \qquad \text{Eq. (3)}$$

Livestock farming is done by stall feeding of fodder, grass and crop by-products. Because of the differences in nutritional value of these feeds, their use is standardised to total digestible nutrients for that feed type (TDN_i). Farmers can also purchase supplementary nutrients (TDN_{SN}) as a substitute for fodder, grass and crop by-products. The total digestible nutrients requirements differ for each livestock type (TDN_u). The livestock unit holding of particular type (LU_u) can be calculated as,

$$LU_U = \frac{\left[\left(\sum_i^I q_i TDN_i\right) + TDN_{SN}\right]}{TDN_u} \qquad \text{Eq (4)}$$

In a subsistence agricultural household, household labour can contribute to a range of activities ranging from entrepreneur, manager and labourer (Taylor and Adelman, 2003; Bardhan and Urdy, 1999). In this model, the amount of labour required for the production of an output depends on the area of land area that is planted or managed, and on the volume harvested. The labour required to get a particular output ready for harvest is then a function of labour hours required per unit area ($h^a{}_{tk}$) to manage a production system t on land type k, and the land area under management (a_{tk}). The labour required to harvest a particular output is a function of output (q_i) and the labour hours per unit output for that good ($h^v{}_i$). Total household labour (L_q) required is then:

$$L_q = \sum_{t=1}^{T}\sum_{k=1}^{K}(h_{tk}^{a} a_{tk}) + \sum_{i=1}^{I}(h_i^{v} q_i) \qquad \text{Eq. (5)}$$

In this model, only labour that is hired (L_h) is incorporated as a cost. The amount of hired labour required is a function of total available household labour days (L), labour required for production, leisure days (L_0), and days contributed to community forestry (L_c).

$$L_h = L - L_q - L_c - L_o \qquad \text{Eq. (6)}$$

Similar to labour, only the production expenses that require cash purchases are defined as costs. The cost of inputs required by a household for a particular output may be a function of either the area under production or the quantity of output. Area-related cash costs (S_{tk}) depend on the input cost per unit area of land type *k*, allocated to a particular use *t*, by a household and the area allocated to that use (a_{tk}). When cash input costs are related to output then the cost depends on the costs per unit output for that good (S_{ik}) on land type *k*, and the amount of output (q_{ik}) from that land type. Total cash input cost (Ψ_i) is,

$$\Psi_i = \sum_{k=1}^{K}(q_{ik} \cdot S_i) + \sum_{k=1}^{K}(a_{tk} \cdot S_{tk}) \qquad \text{Eq. (7)}$$

A household consumes goods from their own production and from purchases in local markets. From their own production of particular products (q_i), the household sells surplus goods (q_i^s) such as food, firewood, timber and fodder in at the market wholesale price (P_i). A household can also make purchases (q_i^m) to cover deficiencies in supplies at the retail market price (p_i). For household income analysis purposes, the goods produced and consumed at home can be valued at either the wholesale farm gate price or retail market price. The retail market price is the sum of transaction costs, intermediary's profit and the wholesale farm gate price. We use wholesale farm gate price in our analysis because this is typically the price received by subsistence farmers. Therefore the value of home consumption of any good (D_i) can be written as,

$$D_i = P_i(q_i - q_i^s) + p_i q_i^m \qquad \text{Eq (8)}$$

Net household income (y) is the difference between revenue and costs. In addition to producing outputs, households are able to earn external income in the labour market (L_m) at rate (w). It is assumed that a household will either earn outside income (L_m) or employ outside labour (L_h), but will not do both. There are no taxes applicable on wages or farm product incomes.

$$y = \sum_{i=1}^{I} D_i + \sum_{i=1}^{I}(P_i \times q_i) + (L_m \times w) - (L_h \times w) - \sum_{i=1}^{I}\Psi_i - \sum_{i=1}^{I}(p_i \times q^m) \qquad \text{Eq (9)}$$

The Community Economic Model

Community forest user groups are composed of households of various income levels (Adhikari et al., 2004). In the model, the community is structured as (Z) different income groups with (N) households in each group. For simplification it is assumed that a community has households that fall into three income groups (high, medium and poor). In subsistence farming communities, land is the most important source of income and food self-sufficiency is an important determinant of household wellbeing. Income groups are categorized as poor, medium and high based on sufficiency of household income to meet basic needs. In this study poor households are defined as having insufficient private land to meet basic needs, medium households have sufficient land, and high households have a surplus of land to meet basic needs. Income groups in terms of land are then defined as,

$$a_p^{Pn} \leq a_p^{Mn} \leq a_p^{Rn} \qquad \text{Eq. (10)}$$

where land area of high-income households is a_p^{Rn}, medium income households is a_p^{Mn}, and poor income households is a_p^{Pn}.

In the model, the community is treated as another household. Similar to a household, the community forest can use its land for production and sell goods to earn income. It can also lease land to households, who then make individual decisions over a particular area. The labour endowment of the community forest is the sum of compulsory contributions by individual member households to the community forest. As the model considers the community forest as another source of household income, total community income (*Y*) captures income from the community forest.

The community objective is to maximize community income. This is the sum of the income from all households in each income group, including the community forest, subject to constraints on area, labour availability, employment opportunities, the need to meet basic food, heating and housing needs, and a restriction against making individual households worse off to maximize community income. Following relevant literature (Abdelaziz et al., 2004, Buongiorno and Gilless, 2003), forest policy was incorporated into the income maximization function as follows,

$$Max Y = \left[\sum_{j}^{J} \sum_{z}^{Z} \sum_{n}^{N} C_{aj} X_{znj} + \sum_{j}^{J} \sum_{z}^{Z} \sum_{n}^{N} G(C_{cj} X_j) \right] \qquad \text{Eq. (13)}$$

where the term (X_j) is a vector of decision variables, (C_{aj}) is a coefficient matrix of decision variables for private endowments, (C_{cj}) is a coefficient matrix of decision variables for the community endowment, (G) is the forest policy weighting for output from the community forest.

Income maximization is subject to a number of constraints.

$$\sum_{z=1}^{Z}\sum_{n=1}^{N}\sum_{k=1}^{K}\sum_{t=1}^{T} a_{tkzn}^{p} \le a^{p}$$

$$\sum_{z=1}^{Z}\sum_{n=1}^{N}\sum_{k=1}^{K}\sum_{t=1}^{T} a_{tkzn}^{c} \le a^{c}$$

$$L_{qzn} + L_{czn} + L_{mzn} + L_{ozn} \le L_{zn}$$

$$\sum_{z=1}^{Z}\sum_{n=1}^{N}\left(L_{mzn}\right) \le \sum_{z=1}^{Z}\sum_{n=1}^{N}\left(L_{hzn}\right)$$

$$q_{izn} + q_{izn}^{m} \ge d_{izn} \qquad i = \text{food, firewood and timber}$$

$$y_{zn} \ge y_{zn}^{0}$$

$$a_{pzn},\ a_c,\ L_{zn},\ q_{izn} \text{ and } y_{zn} \ge 0$$

The first constraint states that the total amount of private land type k used in production system t by n households in z income groups, cannot exceed the total amount of private land available (a^p). Similarly, the total amount of community land used cannot exceed the total amount of community land type available in the (a^c). This condition permits share cropping or rental arrangements. The second constraint is that the labour allocated by any household to their own farm (L_{qzn}), to community forest activities (L_{czn}), to outside employment (L_{mzn}), or to leisure (L_{0zn}) cannot exceed available labour for that household (L_{zn}). The third constraint states that employment opportunities are limited to those available in the community so off-farm employment (L_{mzn}) cannot exceed local employment opportunities (L_{hzn}). The fourth constraint states that a household is required to meet minimum quantities for food, heating and housing basic needs (d_{izn}) from either their own production (q_{izn}) and/or market purchases ($q^{m}{}_{izn}$). The fifth constraint is a restriction that prevents individual households from becoming worse off by the maximization of community income.

Equation (13) is a general model used to study alternative government policies that are modeled as varying constraints on production from the community forest. Although the alternative policies are notionally unconstrained, because the objective is to maintain environmental benefits, cereal production is constrained to private land and the only unconstrained activities allowed on community forests are some combination of fodder, firewood and timber production. As such, the alternatives represent an unconstrained agro-forestry option that is considered sustainable (Narain et al., 1997; Montagnini and Nair, 2004; McNeely and Schroth, 2006).

Policy Scenarios

Seven policy scenarios are evaluated, representing current government policy, actual forest use arrangements in particular communities, and other possible alternatives that are not in current practice. As was discussed earlier, in the linear programming approach, each scenario reflects differences in the application of constraints on the amount of land that can be allocated to particular type of use, or the proportion of the output available from a particular land use that can be harvested. As constraints are changed, the community has different options available to it to maximise income by changing the land use mix or the level of production from a land use. The only output constraint included the scenarios in this study is for timber production, along with the impact this has on byproducts available from timber harvest. Otherwise, the constraints are generally on allocation of land to different uses.

Base Case: This scenario models current government community forest policy. In this case community forestland is constrained to a timber production objective, with all land being allocated to timber production, and other products arising from under-story activities and residual outputs from timber production. Timber production is constrained to an annual harvest of 30% of the potential yield, or mean annual increment (MAI), for hardwoods and mixed deciduous forests, and 50% of MAI for pine forests[3]. Byproducts, including firewood from off-cuts or residuals, and fodder harvested from under-story species are produced for sale. Forest products are available at subsidised prices for members of the community group and at full market price for others. The income of the community forest is modeled as a separate household.

[3] This was government policy at the time the study was carried out.

Community Full Use: The community forest is modeled as a separate household, similar to the Base Case. In this scenario, the community forest has no policy constraints on land allocation for any product. This is also no constraint on the level of harvest of any product and full potential sustainable yield is available if desired. The land allocation for production of firewood, tree fodder or timber and their harvest is based on maximizing income through product sales. The community forest is assumed to have no compulsory labour supply, and it must employ labour for all production activities. As is common practice, households can purchase community forest output at subsidised prices fixed for community members and surplus products are sold at market prices.

Lease Full Use: Similar to the Community Full Use scenario, there are no constraints on the allocation of community forest for firewood, tree fodder or timber production, and the full potential sustainable yield is available if desired. However, in this scenario the community forest can be leased to individual households for the management plan period. This scenario allows households with surplus labour to use community forests as if the land was under private management, effectively increasing the land available to a household. The community earns a rental on the area leased to households, and also earns income from products from the land remaining in community management. This scenario is different from the current leasehold forestry policy in Nepal.

Full MAI: The community forest is modeled similar to the Base Case, where community forest use is constrained to timber production. However, the full MAI of the forest is allowed to be harvested. By-products, including firewood produced from off-cuts or residuals, and fodder harvested from under-story species, are also produced for sale.

Firewood: This scenario is similar to the Base Case but with the constraint on the level of firewood production relaxed to allow additional firewood harvesting to meet household requirements. In the Base Case households were strictly limited to residuals from timber harvest and dead branches. In the Firewood scenario, the maximum limit of firewood harvest was constrained to maximum annual firewood demand (2040 kg air dry weight per household as per Graner, 1996).

No Log Market: The difference between this scenario and the Base Case is that the level of timber production in this scenario is constrained to the level of household consumption and no external market sales of logs are permitted. The scenario represents the forest management policy dictated by the National Parks and Wildlife Conservation Act 1973, and applies to areas where community forests are located in national parks or wildlife buffer zones. The government expanded protected areas from 7 percent to 20 percent of national area between 1990 and 2007, and part of the expansion occurred in community forests.

Zero Income: This scenario applies where the community forests are completely restricted from any kind of use. This situation was the case for some community forestry user groups at the time of the field survey, and involved forests with particular characteristics, such as having rare species.

There are a number of assumptions that are common to all the policy scenarios. Forest user groups, in collaboration with government agencies, monitor the ongoing forest production and utilization activities in the community forest to ensure that there is no overuse or misuse of the forest. In communal management the forest user groups distribute community forest products equally between users when the supply of forest products from the community forest is insufficient to meet all households' needs. When there is sufficient supply of products from community forests each household is allowed to harvest or collect whatever they need.

4. Data and Methods

To study the various scenarios, a range of primary and secondary data was collected. The primary focus was on the use of secondary sources of data and where this was not available, primary data was collected. The biophysical parameters relating to productivity and production were obtained from a variety of sources. These include FAO (2005; 2003), DOF (2000), Master Plan (1988), MacEvilly (2003), Paudel (1992), and Paudel and Tiwari (1992). Information on forest production labour requirements was adopted from Kayastha et al. (2001). Socioeconomic information was collected from the National Planning Commission (NPC 2003) and the Central Bureau of Statistics (CBS 2003).

Data not available from secondary sources was collected by a household survey, a forest user group survey and a key informant survey. A summary of the information collected in each of these surveys is shown in Table 1. A structured, pretested survey instrument was used to collect household data using personal interviews. The household survey instrument was divided into three parts: forest and agricultural product consumption, farm production, and household socioeconomic attributes. Surveys were carried out by professionally trained enumerators working with local NGOs. The enumerators were coached on how to carry out this survey. Data was collected from 259 households in six forest user groups covering three districts, Dolakha, Kavre and Nuwakot.

Table 1: Surveys and Types of Information Collected

Survey type	Information type
Household	Land holding
	Crop yields
	Forest products uses
	Household size
	Labour endowment
	Livestock holding
Key Informant	Wage rate
	Prices of products
	Cost of other inputs
	Productivities of forest and crop products
CFUG Executive Committee	Forest management practices
	Forest utilization rules
	Prices of product

Key informants in the communities that were surveyed were asked to categorize the households in their community in terms of poverty. They used two main criteria to do this: sufficiency of household food production from their own land, and annual household cash income. In the households that were surveyed, income was strongly correlated with landholding size. This formed the basis of the classification used in Eq (10).

Members of the Executive Committee of each forest user group were interviewed to collect information on management rules and forest production. A market survey of key informants was also done to collect information on forest and farm product prices, costs of different production levels, agricultural and off-farm wages, and farm byproduct and crop productivities on different land categories. The information from forest user groups provided the basis for scenario development and validation of the model. The lead author of this paper carried out the key participant interviews and local market surveys.

The empirical model was formulated in a linear programming structure. The objective function is to maximize the sum of household incomes, with forest resources under community management treated as an additional household. A description of the parameters and values used in the linear programming model are given in the Appendix (Tables A1 to A6). The policy models were evaluated with the 32 decision variables listed in Table A7 of the Appendix.

Table 2: Household and community forest land areas by land type

Land Types	Average Household Landholding (ha)		
	Poor	Medium	Rich
Lowland	0.28	0.60	0.64
Upland	0.07	0.28	0.72
Non-crop (marginal) land	0.07	0.10	0.14
Sharecropping upland	0.06	0	0
Sharecropping lowland	0.04	0	0
Community forestland area with hardwood		1.5	
Community forestland area with softwood		1.5	

A number of key assumptions are summarized here. A household is assumed to have the equivalent of five adults in terms of food consumption and the equivalent of three adults in terms of labour supply. Food requirements are 2350 kilocalories per person per day. Wood requirements are 408 kg of air dry firewood and 0.01 m^3 of timber per person per year (Graner, 1997; Master Plan, 1988). The study uses the National Planning Commission survival income standard of 33,626 Nepalese rupees (NRs) per household per year (NPC 2003), inflation adjusted. This income level is the official minimum for supplying food calories and other basic non-food requirements. Table 2 summarises the area of landholding by land type for different household income groups used in the model that were obtained from the surveys. The average landholding size from the survey is 1.0 hectare, which is slightly greater than the national average 0.8 hectare (CBS, 2003). The average community forest area as per survey results equaled 1.5 hectares per household, which is equivalent to the national average.

Each household voluntarily contributes four working days per year to community forest activities. This contribution maintains a household's interest in the benefits from the community forest. In practice, the income from the community forest goes into a fund that is used for communal infrastructure development and payment for other community services. For modeling convenience each household is assumed to benefit equally from this community funding. To be representative of all agro-climatic zones, forest composition is considered as half broadleaf species and half pine species.

Table 3: Agroforestry systems production parameters

Output	Units	Annual Volume
Hardwood yield from log system in broadleaf forest	m^3/ha/year	4
Softwood yield from log system in pine forest	m^3/ha/year	8
Fodder yield from fodder system	TDN kg/ha/year	2400
Firewood yield from firewood system	kg/ha/year	8446
Firewood yield from log system in broadleaf forest	kg/ha/year	2484
Firewood yield from log system in pine forest	kg/ha/year	4968
Firewood yield from fodder system	kg/ha/year	156
Grass yield from fodder system	TDN kg/ha/year	200
Grass yield in broadleaf forest from log or firewood system	TDN kg/ha/year	50
Grass yield in pine forest from log or firewood system	TDN kg/ha/year	0

Source: Master Plan (1988)

In all scenarios, including the unconstrained policy scenarios, the community forest was evaluated as in an agroforestry model. An agroforestry system is able to maintain environmental services of forests, such as reduced soil erosion, biodiversity maintenance and carbon sequestration, under a production regime (Narain et al., 1997; Montagnini and Nair, 2004; McNeely and Schroth, 2006). In this study this means that the community forest was constrained to forest crops being managed in timber, firewood or fodder systems. In each case, there are multiple products from each system. Table 3 outlines the maximum outputs of the various products for the agroforestry systems used in the study. With these output constraints, environmental services are maintained.

Private land uses were constrained to food, timber, firewood, and fodder/grass production, and some private land was required to be allocated for homestead use. Fodder production was evaluated for buffalo and goat farming systems. For lowland areas, a rice-based cropping system using irrigation and following a maize-rice-fallow crop cycle each year was assumed for the study. Upland areas were assumed to be completely rain-fed and follow a maize-finger millet-fallow cycle each year. Typical intercrop species, such as beans and peas, were also assumed. By-products of crops are used as fodder resources. Households were able to purchase inputs or products, or to produce them from their own land.

In some scenarios households were also able to buy products from the community forest. Following common practice in forest user groups, the prices of community forest products sold to local members are negligible. Most community forests contain naturally regenerated timber and firewood species, so the forest has no cost of production except for conversion for fodder forest. Food and livestock product prices and wage data were averaged from the surveyed forest communities. Farm and tree products prices were collected from business people and community leaders of the surveyed communities.

The model was validated with data collected from 259 households in six communities. Validation of the model showed that the prediction error was 3 percent in the aggregate analysis of all households, but varied between household income groups and characteristics of communities. Greater errors were shown in forest user groups closer to the district headquarters where other income and employment opportunities were more available. The errors were least for medium income households and highest in rich households. On average the model under-predicts income levels by 13 percent for poor households. This indicates the confidence limits under which results should be considered while interpreting the results. The validation details are available from the authors on request.

5. Results and Discussion

The allocation of community forest land to different agroforestry systems under each of the policy scenarios is shown in Table 4. As was discussed earlier, the Base Case reflects the current policy where communities are constrained to log production systems and limited use of the potential output of logs, firewood or fodder from the system. As constraints are changed, the agroforestry systems chosen can change. When comparing the changes to income resulting from the different policy scenarios, the changes will reflect the combined effect of the different outputs associated with each agroforestry system (Table 3), the amount of the potential output that the policy allows a community or individual to harvest, and the area of land allocated to the agroforestry system (Table 4).

Table 4: Use of community forest land resources by agroforestry system (hectares)

Agroforestry System	Base Case	Community Full Use	Lease Full Use	Full MAI	Firewood	No Log Market	Zero Income
Firewood	NA	0.00	0.00	NA	0.11	NA	NA
Fodder	NA	2.52	1.73	NA	NA	NA	NA
Pine	1.25	0.00	0.18	1.50	1.25	0.00	NA
Hardwood	0.75	0.48	1.09	1.50	0.75	0.31	NA
Unavailable	1.00	0.00	0.00	0.00	0.89	2.69	3.00

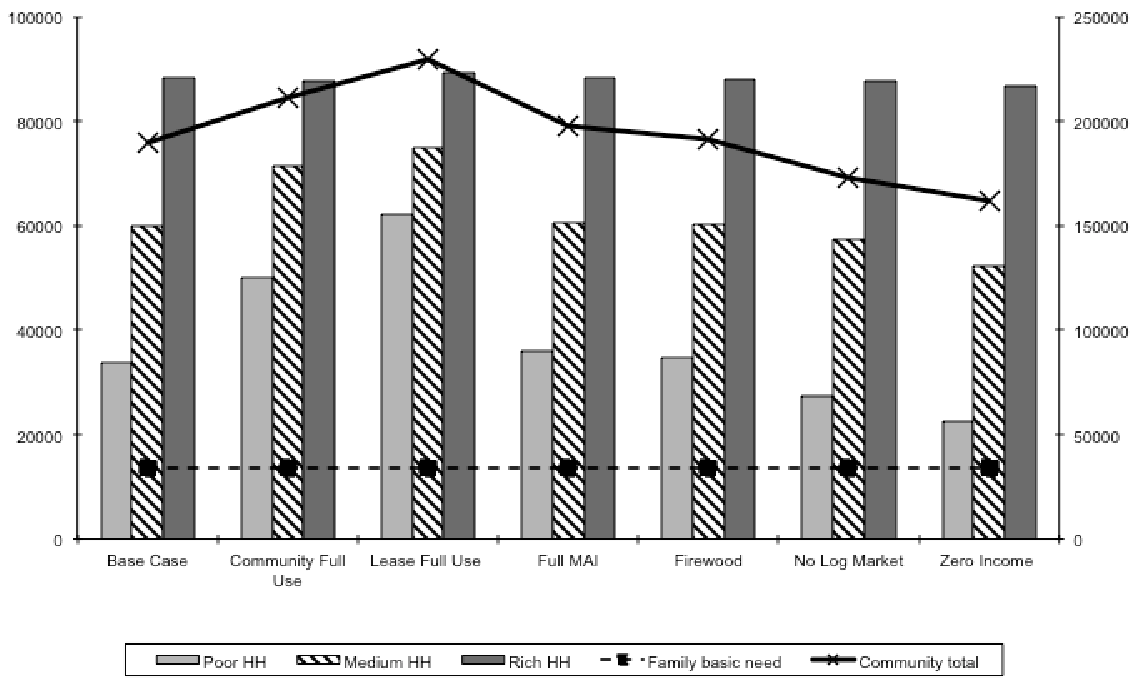
Note: Total Community Forest area in each case is 3 ha.
NA means agroforestry system is not allowed due to forestry policy.
Unavailable means effectively unavailable for community use due to forestry policy constraints.

A comparison of the effects of different policy scenarios on total community and household incomes (in Nepalese rupees[4]) shows that higher total community income is obtained from the Community Full Use and Lease Full Use policies (Figure 1). Neither of these policy alternatives is currently used in Nepal. The smallest predicted income resulted from both the Zero Income

[4] USD 1 equivalent to NRs 72.0 at the time of the survey.

and No Log Market scenarios. Compared to the Base Case (current policy), the total community incomes are 21.1, 11.4, 4.0 and 0.6 percent higher under the Lease Full Use, the Community Full Use, Full MAI and Firewood scenarios respectively. Total community and household incomes decreased as more restrictive forest policies were imposed. The result showed that total community and household incomes increase by a small amount when the forests are managed for timber production alone or to provide sufficient firewood for household use.

Figure 1: Effect of Policies on Household and Total Community Incomes

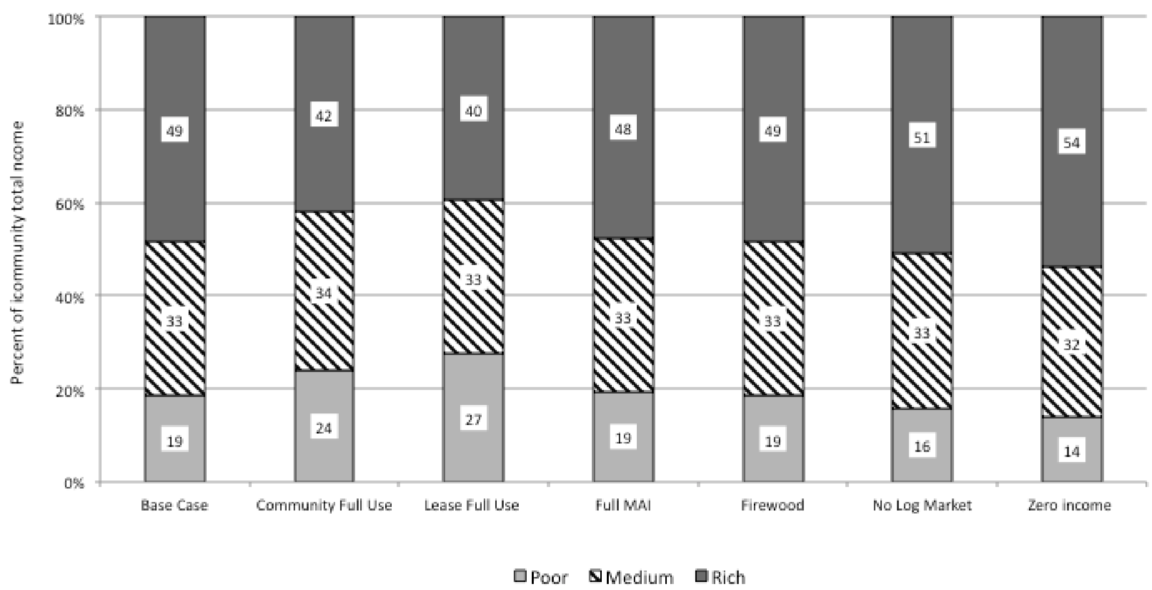


Compared to the Base Case, incomes for poor and medium income households increase by 83.6 and 25.1 percent respectively with the Lease Full Use policy, and 48.3 and 19.4 percent respectively with the Community Full Use policy. Incomes for the poor and medium income households increase by only small amounts with the Full MAI and Firewood policies. The income of rich households has negligible changes in each of the policy scenarios. The results indicate that the potential contribution of community forest resources to household income is highest for poor households, and that policy constraints on community forest use have a relatively higher impact on poorer households.

The Family Basic Need line in Figure 1 indicates the income required to provide minimum calories and other basic non-food items. The survival income baseline comes from the National Planning Commission (NPC 2003). In the Community Full Use and the Lease Full Use scenarios, all households have more than sufficient income to meet these minimum requirements. In the Full MAI model and Firewood scenarios, the income barely meets the minimum needs of poor households. Under the Current Policy, the No Log Market and the Zero Income scenarios provide insufficient income to meet the needs of poor households. The results show that poor and medium income households do better under any alternative policy, but are particularly benefited by the unconstrained policies.

A distinct feature of the Lease Full Use policy is that households are able to lease community forest land and manage it as private land. In this scenario, 69 percent of community forest land is leased to households (Table 3), with the difference remaining in community management. Of the land that is leased to households 55 percent goes to poor households, 33 percent goes to medium income households and 12 percent goes to rich households. This is a key factor in the increase in benefits flowing to poor and medium income households from this policy.

Figure 2: Share of Total Community Income by Household



Income distribution across the household groups under the different policy scenarios is shown in Figure 2. The greatest income inequality is produced by the Zero Income scenario, followed by the No Log Market scenario. The least income inequality is found in the Lease Full Use and Community Full Use policy scenarios. In effect, income inequality increases as forest policy constraints are imposed, and the impact is greatest on poor households. Forest policies affect poor households the most because their private land holdings are small and insufficient to meet their income needs, and they have the potential to benefit most from access to community forest resources.

Figure 3. Effects of Forest Policies on Household Unemployment

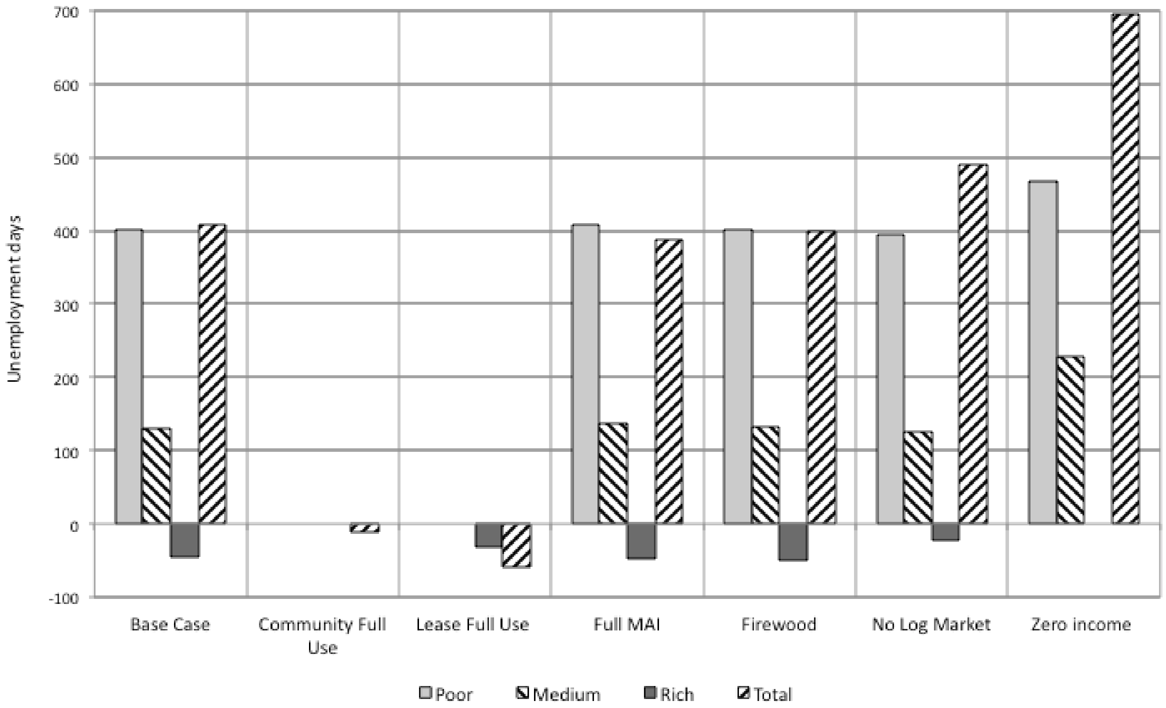


Figure 3 shows annual household unemployment under the different policy scenarios. The results show that community forestry policies can have a big effect on household employment. The level of employment is directly related to household access to land resources. Under the Community Full Use and Lease Full Use scenarios, unemployment within the community disappears and there is a net requirement of labour from outside the community. In all other scenarios there is significant unemployment, with generally only small differences between scenarios. High income households are net employers in most scenarios because of the relative size of private land holdings and family labour supply.

6. Conclusions

The purpose of this study was to evaluate the impacts of existing and alternative forest policies governing the use of community forests on economically heterogeneous, agriculture-based households in Nepal. The findings indicate that forest policies which are aimed primarily at environmental conservation, as is the case with current policy governing community forestry in Nepal, substantially affects household income and employment, income inequality in rural communities, and aggregate economic benefits. Our findings show that current policies constrain the poorest households' ability to meet even survival needs. The impacts on households of current Nepalese forest policies aimed at conserving environmental resources are much greater than previously recognised, particularly for poor and medium income households. The findings imply that the socioeconomic impacts of public forest policies may be underestimated in developing countries unless forestry's contribution to agricultural production and household economic heterogeneity are accounted for.

Among the policy options that were analysed, allowing the leasing of community forestland by individual households (Lease Full Use) provided the greatest benefits in terms of both income and employment generation, and reducing household income inequality. This policy is potentially also superior to alternative policies in terms of reducing the administrative costs of management and in reducing social barriers in forest product distribution, which will have the greatest benefits for the poorest households. The Community Full Use policy also has significant benefits, and could also eliminate the potential for conflicts created by leasehold forestry. The Community Full Use policy would be most effective in communities where forests require closer or stricter management than could be achieved under individual management. However, both of the full use community forest management models are based on agroforestry practices which minimize over-use and other environmental degradation problems in public forests. The findings indicate that there are alternative policies for managing common property resources that would reduce income inequalities in Nepalese rural communities and lift incomes and employment to a level where even the poorest households could meet their basic needs.

The conclusions are similar to the theoretical, integrated integrated agriculture and forestry model used by Anthon et al. (2008) which concluded that public forest policy, biased towards environment conservation, affect the economies of forest based communities and has the greatest impact on the poorest households. There are no similar studies in Nepal that could be used to directly compare the findings of this study. However, our findings challenge the general conclusions of previous studies that have examined the impact of community forestry policies on direct economic returns from public forests to households, including Thoms (2008), Adhikari et al. (2007), Adhikari et al. (2004), and Varughese and Ostrom, (2001). For example, Adhikari (2007) reported that current forest policies increased benefits for rural households despite reducing household livestock holdings.

Another important result of our study is that it showed that household and community wellbeing would change by only a small amount even if forest policies were relaxed to allow communities to harvest timber volumes equal to the mean annual increment. This casts doubt on the conclusions about the economic profitability of forest carbon trading as reported by Karky and Skutsch (2010) because the benefit is evaluated without taking into account the opportunity costs of alternative land uses to timber. Alternative policies evaluated in our study would provide greater immediate benefits to poor households and increase income for rural communities where poverty and unemployment are of critical importance than would other policies or programmes.

The study has used a linear programming model to account for the effects of government forest policies on households using community forests. The model captured the economic effects of forest policy changes across households that have different endowments of private land resources. The model accounts for the effect of policy on supplies of public forest products, and shows how public forests can complement private land resources and contribute to meeting the basic needs of local people. To our knowledge, this is the first application of this approach to the study of community forestry.

There are a number of potential extensions of this model. Most of the parameters available to model policies could be considered to be for most likely scenarios and for an average community forest. To understand the effect of policies on specific local situations, a similar study could be done including factors specific to that community. A lack of data prevented the inclusion of commercial, non-timber forest product options. The model would also be useful to assess policy impacts of payment for ecosystem services implemented in developing countries or an estimation of ecosystem services. The model could be extended to examine the tradeoffs between different environmental services from community-based forest resources under different policy scenarios, and economic benefits under different payment options for environmental services.

Acknowledgement

We acknowledge the generous financial assistance provided by Winrock- Nepal and Lincoln University, New Zealand, for the field survey.

References

Abdelaziz FB, Martel JM and Mselmi A (2004) IMGD: an interactive method for multiobjective group decision aid. J. Op Res Soc. 55, 464–474

Adhikari B, Williams F, and Lovett J (2007) Local benefits from community forests in the middle hills of Nepal. For Pol and Econ 9(5), 464-478.

Adhikari B, Falco1 S, and Lovett J (2004). Household characteristics and forest dependency: evidence from common property forest management in Nepal. Ecol Econ 48(2), 245-257.

Agrawal B (2001) Participatory Exclusion, Community Forestry, and Gender: An Analysis of South Asia and a Conceptual Framework. World Dev 29 (10), 1623-1648.

Alig RJ, Adams DM, McCarl BA (1998) Impacts of incorporating land exchanges between forestry and agriculture in sector models. Journal of Agricultural and Applied Economics 30:389–401

Amacher G, Hyde W, and Joshee B (1993) Joint production and consumption in traditional households: fuelwood and crop residues in two districts in Nepal. J Dev Stud 30 (1), 206-225.

Anthon S, Lund, JF, and Helles F (2008) Targeting the poor: Taxation of marketed forest products in developing countries. J For Econ 14, 197–224

Aune J, Alemu A, and Gautam K (2005) Carbon Sequestration in Rural Communities: Is It Worth the Effort? J Sus For 21(1), 69-79

Baland J, and Platteau JP (1999) The Ambiguous Impact of Inequality on Local Resource Management. World Dev 27 (5), 773-788

Bardhan P, and Urdy C (1999) Development Microeconomics. New York: Oxford University Press.

Buongiorno J, and Gilless J (2003) Decision Methods for Forest Resource Management. San Diego: Academic Press.

Central Bureau of Statistics (CBS) (2003) National Sample Census of Agriculture Nepal. 2001/02. Kathmandu: National Planning Commission.

Das R, Shivakoti G (2006) Livestock carrying capacity evaluation in an integrated farming system: A case study from the mid-hills of Nepal. International Journal of Sustainable Development and World Ecology 13(3):153–163

Dhakal B (2009) Carbon Liability, Market Price Risk and Social Impacts of Reducing Emission from Deforestation and Forest Degradation (REDD) Programme. J For and Live 8(1), 67-77

Dhakal B and Bhatta B (2009) An Institutional Model to Explain Utilization Problems of Community Forest Products. *Int. J. of Social For*, 2(2):23-48

Dhakal B, Bigsby H and Cullen R (2011) Forests for food security and livelihood sustainability: Policy problems and opportunities for small farmers in Nepal. *J of Sus Ag 35(1):86-115*.

DOF (2000) *Guidelines for Inventory of Community Forests. Ministry of Forest and Soil Conservation*. Department of Forest, Community and Private Forest Division Kathmandu, Nepal.

FAO (2004) Food and Agricultural indicators. http://www.fao.org/es/ess/ compendium_2004/pdf/ESS_NEP.pdf

FAO (2003) FAO NUTRIENT RESPONSE DATABASE: FERTIBASE Retrieved from http://www.fao.org/ag/agl/agll/nrdb/country.jsp?lang=en&what=&setting= &COUNTRY_ID=NEPAL&CROP_GROUP=CEREALS&CROP=ALL&ZONE=&SOILID=

FAO (2000) FRA 2000-Forest Resources of Nepal Country Profile. FAO http://www.fao.org/documents/show_cdr.asp?

Gilmour D, Bonell M, and Cassells D (1986). The effects of forestation on soil hydraulic properties in the middle hills of Nepal: a preliminary assessment. Mount Res and Dev 7(3), 239-249.

Graner E (1997) The Political Ecology of Community Forestry in Nepal. Saarbruken: Verlag fur Entwickungspolitik.

Gurung G (2004). An Overview Paper on Overseas Employment in Nepal. Series 4. International Labour Organization. Kathmandu, Nepal

Hjortso C, Straede S and Helles F (2006) Applying Multi-Criteria Decision-Making to Protected Areas and Buffer Zone Management: A Case Study in the Royal Chitwan National Park, Nepal. J For Econ 12(2), 91-108

Kayastha B, Pradhan S, Rasaily N, Dangal S and Arentz F (2001) Community Forest Product Marketing Options for Timber and Non-timber Forest Products 2001. Discussion Paper. Nepal Australia Community Forestry Management Project. No-Frills Consultants.

Karky BS and Skutsch M (2010) The cost of carbon abatement through community forest management in Nepal Himalaya. Ecol Econ 69, 666–672

Kumar S (2002) Does "participation" in common pool resource management help the poor? A social cost–benefit analysis of joint forest management in Jharkhand, India. World Development 30(5):763–782

MacEvilly C (2003) Cereals. In Edited by Benjamin Caballero, Luiz C Trugo and Paul M Finglas. *Encyclopedia of Food Science and Nutrition*. Second Edition. Amsterdam: Academic Press.

Maskey V, Gebremedhin TG, and Dalton TJ (2006) Social and cultural determinants of collective management of community forest in Nepal. J For Econ 11(4), 261-270.

Master Plan (1988) The Forestry Sector Master Plan. Kathmandu: Ministry of Forest, Nepal.

Merz J, Dangol PM, Dhakal MP, Dongol BS, Nakarmi G and Weingartner R (2006) Rainfall-runoff events in a middle mountain catchments of Nepal. J Hyd 331 (3-4), 446-458

McNeely J and Schroth G (2006) Agroforestry and biodiversity conservation – traditional practices, present dynamics, and lessons for the future. J Biod and Cons 15(2), 549-554.

Montagnini F and Nair P (2004) Carbon sequestration: An underexploited environmental benefit of agroforestry systems. J Agrofor Syst 61-62(1-3), 281-295.

Murshed S and Gates S (2005) Spatial–Horizontal Inequality and the Maoist Insurgency in Nepal. Rev Dev Econ 9(1), 121-134.

Narain PR, Singh N, Sindhwal NS and Joshie P (1997) Agroforestry for soil and water conservation in the western Himalayan Valley Region of India: runoff, soil and nutrient losses. J Agrofor Syst39(2), 175-189.

NPC. (National Planning Commission) (2003) The Tenth Plan 2002–2007 (Poverty Reduction Strategy Paper). His Majesty's Government. National Planning Commission, Kathmandu, Nepal. Downloaded on December 10, 2003.
http://www.npc.gov.np/tenthplan/docs/Formated10Plan_A4_size.doc

Oli K.P. 1987. On-farm research methodologies for livestock development at Pakhribas Agricultural Centre. PAC Working Paper 03/87. Pakhribas Agricultural Centre, Dhankuta, Nepal.

Paudel K. 1992. Implication of Forage and Livestock production on Soil Fertility. In Edited by J.B. Abington. *Sustainable livestock production in the mountain agro-ecosystem of Nepal*. Pp. 155-170. Rome: Food and Agricultural Organization of the United Nation.

Paudel K. and Tiwari B (1992) Fodder and Forage Production. In Edited by J.B. Abington. *Sustainable livestock production in the mountain agro-ecosystem of Nepal.* Pp. 131-154. Rome: Food and Agricultural Organization of the United Nation.

Shen Y, Liao X and Yin R (2009) Measuring the Aggregate Socioeconomic Impacts of China's Natural Forest Protection Program. In An Integrated Assessment of China's Ecological Restoration Programs. Springer, Netherlands

Shrestha K and McManus P (2007). The Embeddedness of Collective Action in Nepalese Community Forestry. Small-Scale For 6(3), 273-290

Strassburg B, Turner RK, Fisher B, Schaeffer R and Lovett A (2009) Reducing emissions from deforestation-The ‘‘combined incentives’’ mechanism and empirical simulations. Glob Env Change 19, 265–278

Stenberg LC and Siriwardana M (2007) Forest conservation in the Philippines: An economic assessment of selected policy responses using a computable general equilibrium model. For Pol and Econ 9, 671–693

Taylor E and Adelman I (2003) Agricultural Household Models: Genesis, Evolutions, and Extensions. Rev Econ of House 1 (1/2), 33-58

Thoms CA (2008). Community control of resources and the challenge of improving local livelihoods: A critical examination of community forestry in Nepal. Geoforum. 39(3): 1452-1465

Varughese G, Ostrom E (2001) The contested role of heterogeneity in collective action: some evidence from community forestry in Nepal. World Dev 29(5):747–765

Appendix

Table A1. Conversion Factors

Information Type	Value	Unit
Per capita/day calorie requirement [1]	2350	kcal
Per capita firewood kg requirement [2]	408	kg per year
Per capita construction and building timber material [2]	0.05	m^3 per year
Softwood forest MAI useable as log in timber system [2]	60	percent
Hardwood forest MAI useable as log in timber system [2]	60	percent
Forest MAI useable as firewood in firewood system [3]	85	percent
Finger millet-refined yield proportion from raw yield [3]	90	percent
Rice-refined yield proportion from raw yield [3]	70	percent
Maize-refined yield proportion from raw yield [3]	80	percent
Beans and peas-refined yield proportion from raw yield [3]	100	percent
Nutritional value of maize [4]	4.056	Mega calories/kg
Nutritional value of rice [4]	2.821	Mega calories/kg
Nutritional value of finger millet [4]	2.822	Mega calories/kg
Nutritional value of peas and beans [4]	1.735	Mega calories/kg
One goat [2]	0.2	stock unit
One female buffalo [2]	1	stock unit

Source: 1= NPC (2003), 2= Master Plan (1988), 3 = Key informant survey, 4 =MacEvilly (2003)

Table A2. Agricultural Production Parameters

Crop Production Parameters	**Value**	**Unit**
Maize seed used (self produced) [1]	22	kg/ha
Rice seed used (self produced) [1]	55	kg/ha
Finger millet seed used (self produced) [1]	8	kg/ha
Pulse seed used (self produced) [1]	5	kg/ha
Maize yield [1]	1729.3	kg/ha
Rainy season rice yield [1]	2680.6	kg/ha
Finger millet yield [1]	1107.7	kg/ha
Pulses yield [1]	801	kg/ha
Animal production parameters		
Average milk production per year [2]	980	liter
Meat yield per goat [2]	24	kg
Goat manure production per day [4]	0.3	kg/day/adult
Buffalo manure production per day [4]	3.0	kg/day/adult
Goat production to sale stock ratio [2]	50.0	percent
Goat annual nutrient (TDN) requirement [3]	70	kg/adult
Buffalo annual nutrient (TDN) requirement [3]	1013	kg/adult
Concentration feed supplement [2]	5%	percent
Land area required to shelter and handle a unit buffalo [2]	10	m^2
Land area required to shelter and handle a unit goat [2]	4	m^2

Source: 1 = FAO (2004), 2 = Key informants’ value converted into TDN using conversion factors of Master Plan (1988), 3 = Master Plan (1988), and 4 = Oli (1987)

Table A3. Forest Production Parameters

Parameter	Value	Unit
Hardwood productivity [1]	4	m^3/year/ha
Softwood productivity [1]	8	m^3/year/ha
Fodder yield in fodder forest [1]	2400	kg/ha
Firewood production in firewood forest [1]	8446	kg/ha
Firewood production from fodder forest [1]	156	kg/ha
Intercrop grass in tree fodder system [1]	700	TDN kg/ha
Grass production in broadleaves forest for log or firewood [1]	50	TDN kg/ha
Grass yield under pine forest for log or firewood [1]	0	TDN kg/ha
Maize and wheat straw [1]	280	TDN kg/ha
Rice straw [2]	660	TDN kg/ha
Millet straw [2]	610	TDN kg/ha
Grass production with crops [2]	1400	TDN kg/ha
Intercrop tree fodder in upland [2]	150	TDN kg/ha
Inter crop tree fodder in lowland [2]	50	TDN kg/ha
Grass product in fodder forest [2]	200	TDN kg/ha
Wood byproduct in fodder forest [2]	0.1	m^3/ha

Source: 1 = Master Plan (1988), and 2 = Key informants

Table A4. Labour inputs and parameters

Activities	Value	Unit
Hardwood log harvest from timber system	11.0	person day/ m^3
Softwood log harvest from timber system	7.7	person day/ m^3
Firewood collection from firewood system	200	kg/person day
Firewood collection as residual from timber harvest	90	kg/person day
Inferior firewood collection	50	kg/person day
Management input for fodder system	24	person days/ha/year
Management input for firewood and grass system	2	person days/ha/year
Buffalo tending from private and lease land feeds	8	head/person/day
Goat tending from private and lease land feeds	35	head/person/day
Buffalo tending from CF land feeds	6	head/person/day
Goat tending from CF land feeds	30	head/person/day
Upland maize-bean intercrop farming	237	Person days/ha/year
Upland rainy season millet-blackgram intercrop farming	255	Person days/ha/year
Lowland maize-bean intercrop farming	201	Person days/ha/year
Rainy season rice-soybean intercrop farming	385	Person days/ha/year
Purchasing timber from the market	0.25	m^3/person day
Purchasing fodder from the market	24	TDN kg/person day
Purchasing animal feed from the market	40	TDN kg/person day
Purchasing firewood from the market	200	kg/person day
Purchasing food from the market	282	mcal/person day
Economically fully active labour	2.5	persons/family
Working days for a fully economically active person	265	days/year
Working hours for family labour	10	hours/day
Working hours for hired labour	7	hours/day
Compulsory labour for community forestry work	4	Person days/household

Source: Key Informants

Table A5. Prices and Costs Parameters for Agricultural and Forestry Production

Item	Price	Unit
Hardwood timber sale price within community	5400	NRs/m^3
Hardwood timber sale price outside community	3500	NRs/m^3
Softwood timber sale price within community	2800	NRs/m^3
Soft wood timber sale price outside community	1400	NRs/m^3
Hardwood timber purchase price outside community	8000	NRs/m^3
Soft wood timber purchase price outside community	5000	NRs/m^3
Firewood price	0.5	NRs/kg
Residual firewood price	0.2	NRs/kg
Forest fodder price	3	NRs/kg
Inferior firewood/byproduct fuel price	0.001	NRs/kg
Community forest grass within community	1.3	NRs/kg
Community forest grass outside community	1.4	NRs/kg
Rice straw	6	NRs/kg
Maize stalk	3	NRs/kg
Finger millet stalk	3.5	NRs/kg
Private land grass	3	NRs/kg
Farm tree fodder	3.5	NRs/kg
Production buffalo price	25000	NRs/head
Production goat price	3000	NRs/head
Milk price	180	NRs/kg
Meat price	20	NRs/kg
Maize farm-gate selling price	16	NRs/kg
Maize market purchase price	19	NRs/kg
Rice farm-gate selling price	18	NRs/kg
Rice market purchase price	21	NRs/kg
Finger millet farm-gate selling price	11.50	NRs/kg
Finger millet market purchase price	14.50	NRs/kg
Pulse (average) farm-gate selling price	24	NRs/kg
Pulse market purchase price	30	NRs/kg

Sources: Key Informants and Executive Members of User Groups

Table A6. Price and Cost Parameters for Agricultural and Forestry Production

Parameter	Cost	Unit
Regular wage	90	NRs/day/person
Skilled labour cost for timber harvest	3893	NRs/m^3
Net wage working outside the community	80	NRs/day/person
Rice planting wage	120	NRs/day/person
Annual interest rate on cost	20	percent
Annual costs for goats (e.g housing, medicine, breeding)	200	NRs/head
Annual cost for buffalo (e.g housing, medicine, breeding)	1500	NRs/head
Cost of maize-bean production excluding labour	3870	NRs/ha
Cost of rice-soybean production excluding labour	700	NRs/ha
Cost of finger millet-soybean production excluding labour	5126	NRs/ha
Non-labour cost of natural forest conversion into fodder production	6583	NRs/ha
Hired labour cost for natural forest conversion into fodder forest	3893	NRs/ha
Annual management cost for fodder system on private land	1900	NRs/ha
Annual management cost for firewood and timber systems on private land	1740	NRs/ha
Annual management cost for firewood and timber system in community forest	1400	NRs/ha

Source: Key Informants and Executive Committee members

Table A7. List of Decision Variables

Resource category	Production activity or source	Unit
Private upland use	Crop food production	ha
	Firewood	ha
	Fodder buffalo	ha
	Fodder goat	ha
	Softwood timber	ha
	Hardwood timber	ha
Private lowland use	Crop food production	ha
	Firewood	ha
	Fodder for buffalo	ha
	Fodder for goat	ha
	Softwood timber	ha
	Hardwood timber	ha
Private non-cropping land use	Firewood	ha
	Ownland Fodder buffalo	ha
	Ownland Fodder goat	ha
	Softwood timber	ha
	Hardwood timber	ha
Community forest land use	Firewood	ha
	Fodder buffalo	ha
	Fodder goat	ha
	Softwood timber	ha
	Hardwood	ha
Purchased products	Food from market	mcal
	Fodder for buffalo from community forest	kg
	Fodder for goat from comunity forest	kg
	Fodder for buffalo from market	kg
	Fodder for goat from market	kg
	Firewood from community forest	kg
	Firewood from market	kg
	Inferior quality firewood	kg
	Softwood timber from market	m^3
	Hardwood timber from market	m^3