Topic 2: Non-timber forest products (NTFPs), small-scale logging and rural livelihoods

Livelihood gains and ecological costs of NTFP dependence: assessing the roles of dependence, ecological knowledge and market structure in three contrasting human and ecological settings in south India

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SUMMARY

Non-timber forest products (NTFPs) constitute the single largest determinant of maintaining livelihoods of scores of forest fringe communities and people in the tropics. In India over 50 million people are believed to be directly dependent upon NTFPs for their subsistence. However, such human dependence on NTFPs for livelihood gains (wins) has most frequently been at a certain ecological cost (lose). It is clear that if livelihoods have to be maintained, the existing win-lose settings have to be steered to a win-win mode, otherwise, there could be a severe erosion of the biological resources and loss of livelihoods (a lose-lose situation).

Examining the dependence of forest fringe communities on NTFPs at three sites in south India with contrasting human and ecologically settings, we identify three key factors (extent of dependence on NTFPs, indigenous ecological knowledge and market structure) that are likely to constrain reaching the win-win situation. We examine how these factors shape the ecological cost of harvesting NTFP at the three sites. We show that within the parameter space of these three factors, it is possible to predict outcomes and associations that will conform to win-win or win-lose situations.

Using empirical data derived from the three study sites we discuss the casuality of the observed associations. We discuss the thesis that the key for long-term livelihood gains lies in reducing the ecological cost. Based on the specific results of the study we propose certain potential interventions and recommendations that could maintain or enhance livelihoods while minimizing the ecological cost.

Keywords: Livelihood gains, NTFP, Ecological Knowledge, Western Ghats, Ecological costs

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INTRODUCTION

NTFPs as important source of livelihoods

Non-timber forest products constitute an important source of livelihood for millions of people from forest fringe communities across the world. In India alone it is estimated that over 50 million people are dependent on NTFPs for their subsistence and cash income (NCHSE, 1987; Hegde *et al*. 1996). NTFPs also serve as a vital livelihood safety net in times of hardship. Furthermore, the NTFP extraction has multiplier effects in the economy by generating employment and income in downstream processing and trading activities (Nepstad *et al*., 1992). An important feature of the dependence is that almost all NTFPs are harvested from natural forest populations. Thus, NTFPs are often deemed to be semi-public goods, with no explicit property rights and no opportunity cost vested in the collector (Godoy and Bawa 1993). Consequently, extraction is often intense and exhaustive due to lack of alternative income sources, unreliable productivity and the pressure to maximize short-term income. In recent years with the advent of globalisation, there are indications of a rapid increase in the extraction, mostly from natural populations (Uma Shaanker, *In preparation*).

Ecological costs of NTFP dependence

The livelihood gains from NTFPs to forest communities, however, is not without a certain ecological cost. The cost could range from decline of the resources (Tewari, 1993; Nepstead *et al*., 1992; Uma Shaanker *et al*., 2000; Padmini et al., 2001; Uma Shaanker *et al*., 2001) to changes in the population dynamics and demography of harvested species (Sinha and Bawa, 2001). In southern Western Ghats in India, Chalvaraju *et al.* (2001) reported a monotonic decrease in the extraction volumes of bamboo, presumably as a consequence of over extraction of these resources. Associated with the decrease, there has been an increased use of bamboo substitutes in pulp industries in the state (Chalvaraju *et al.* 2001). In southern India, presumably due to extraction pressures, as many as 110 species of medicinal plants are reported to have become rare, endangered and threatened (Ved *et al*., 2001).

Besides the direct costs, extraction of NTFPs might entail a number of indirect costs. Extraction of NTFPs has been shown to impact at the level of genes (Padmini *et al*. 2001), community (Ganeshaiah *et al*. 1998) and the ecosystem (Uma Shaanker *et al*. 2001; Bawa *et al*., 2002) such as in disrupting ecosystem services, (eg., pollinator services; Ghazoul, 2001). Finally, there could be also a cost of knowledge erosion consequent upon the loss of resources. In southern India, loss of bamboo has lead to an erosion of the knowledge and skills associated with the working of bamboo in communities that have been traditionally dependent on bamboo (Chaluvaraju *et al*. 2001).

Aim of paper

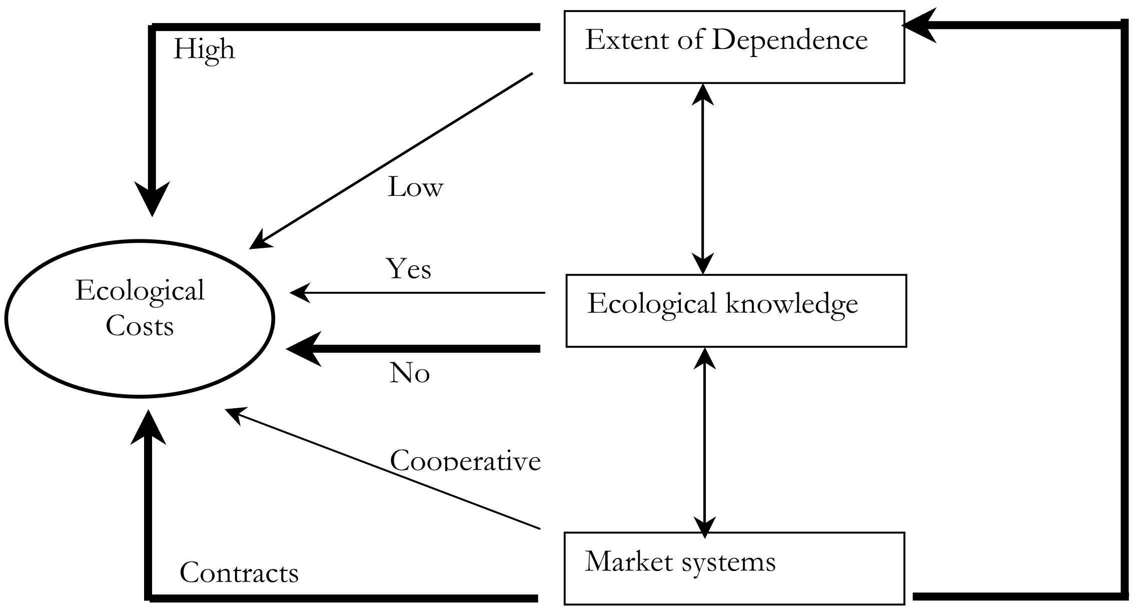
It is clear that continued dependence on NTFPs as a major source of livelihood is contingent upon minimizing the ecological cost of such dependence. A win-win mode that maintains livelihood gains without seriously impairing the resource base and the larger ecosystem health will ensure the long-term livelihoods security for the forest dependent communities. While a number of studies have documented the role of NTFPs in livelihoods, few have critically analysed the conflict between livelihood gains and ecological costs and how the long-term livelihoods could be safeguarded.

In this paper, we focus on the thesis that for long-term livelihoods to be secured, the associated ecological costs of forest use should be minimized. Crucial to the latter of course is to understand the factors that influence the ecology of the harvested species as well as the ecosystem at large. Among other factors, we examine in this paper, the role played by three namely, the extent of dependence, indigenous ecological knowledge and the market structure in influencing the cost in three ecological settings in south India. Based on the results of the study we propose potential interventions and recommendation that could help lower the ecological cost and thus maintain or enhance existing livelihoods.

Livelihood gains and ecological cost: hypothesis and predictions

Among other factors (see Discussion for alternate hypotheses), the use of forest resources for livelihood gains could feed into ecological costs, primarily as a function of a) extent of dependence, b) indigenous ecological knowledge and c) market structure and the interactions thereof (Figure 1).

Figure 1. Diagram illustrating the influence of dependence, ecological knowledge and market systems on the ecological cost of forest use. The thickness of the arrows indicates the relative cost (bold – higher and light – lesser). The bi-directional arrows indicate the possible feed-forward and feed-back interaction among the three variables (see text for details)



High dependence, low or no ecological knowledge and an exploitative market (say through private contractors) in contrast to cooperative marketing by forest stakeholders is likely to impose high ecological costs (illustrated by the thick arrows). When dependence on forest products is low, independent of the ecological knowledge status of the people as well as the market structure, the ecological costs are bound to be low (thin arrow). However when dependence is high, as is the case most often in countries such as India, the ecological costs will be primarily determined by the status of knowledge among the people and the market structure. In general, it could be hypothesised that high dependence coupled with a low knowledge status and a high degree of market failures could have a high ecological cost. On the other hand, high dependence if associated with a good knowledge status as well as a cooperative marketing structure is likely to lead to a milder ecological cost.

The bi-directional arrows in the figure are indicative of the likely feed-forwards and feed-backs among the three variables. Thus the extent of dependence could causally influence the ecological knowledge of the people as much as the knowledge might influence extent of dependence. Market systems, such as collectors' cooperatives might induce knowledge amongst collectors than if the market were to be conducted by private contractors. On the other hand it is not unlikely that possession of a certain ecological knowledge could influence how a certain product is going to be marketed. The relative strengths of these linkages might be important in determining the final payoffs into the gains and costs. Accordingly and based on the above hypothesis, the following specific predictions or associations follow:

a. Sites or communities with higher dependence on forest resources but with a good ecological knowledge will tend to impose a lesser ecological cost compared with those that exhibit a poor ecological knowledge.
b. Sites with a cooperative marketing regime will impose a lower ecological cost than would those where markets are operated through private contractor ship

Thus the ecological cost of forest use could be driven besides by the extent of dependence, by the indigenous ecological knowledge of the harvesting communities and the market structure. Several additional factors could also influence the cost, such as the property rights and ownership rights, land tenure, proximity to market and market demand, forest legislations etc. We briefly explore these possibilities at later sections. Below we derive empirical data from three contrasting settlements in south India and discuss the causality of the observed associations and discuss strategies to lower the ecological cost while maintaining the livelihoods.

MATERIALS AND METHODS

Study Sites

The study was conducted at three sites in south India, namely Malai Mahadeshwara Hills (MM Hills), Biligirirangan Swamy Temple Wildlife sanctuary (BR Hills) and Rajiv Gandhi National Park (Nagarahole), all in Karnataka, south India (Figure 2; Table1). These sites provide contrasting human and ecological settings.

Of the three, MM Hills is a reserve forest, while the other two are protected areas. The latter by legislation are protected against human activities including harvesting of NTFPs, grazing etc. However, because of historical contingencies, at the two protected areas chosen for the study, people continue to extract NTFP. At BR Hills, an endogamous tribe, the *Soligas* reside within the sanctuary and live off the NTFP resources in the forest (Ganeshaiah and Uma Shaanker, 1998). The people are allowed to collect NTFPs and market them through a local cooperative, the Large-scale Adivasi Multi-purpose Society (LAMPs; Murali *et al*., 1996). At Nagarahole, which was declared a national park recently, the forest dwelling community, the *Kurubas*, have been moved out and rehabilitated in the forest fringes; however the people continue to depend on NTFPs. Most of the collection is done from the periphery and buffer zones of the sanctuary. The trade of the NTFPs is quite varied, involving LAMPs and private traders.

In MM Hills, tribal (*Soligas*) and non-tribal (*Lingayats*) collect forest products. Unlike the other two sites, marketing is conducted through private contractors who bid for the various products; in this process, the contractor is free to also employ collectors from within or outside the forest dwelling communities. At all the three sites, NTFP constitute semi-public goods. None of the communities have property or ownership rights, and thus extraction is inevitably done from natural populations from forestlands. At BR Hills, the Soligas do not have land-tenure; at MM Hills and Nagarhole, people have access to tenure rights over agricultural land within the forest jurisdiction.

Figure 2. Map showing the three study sites in south India

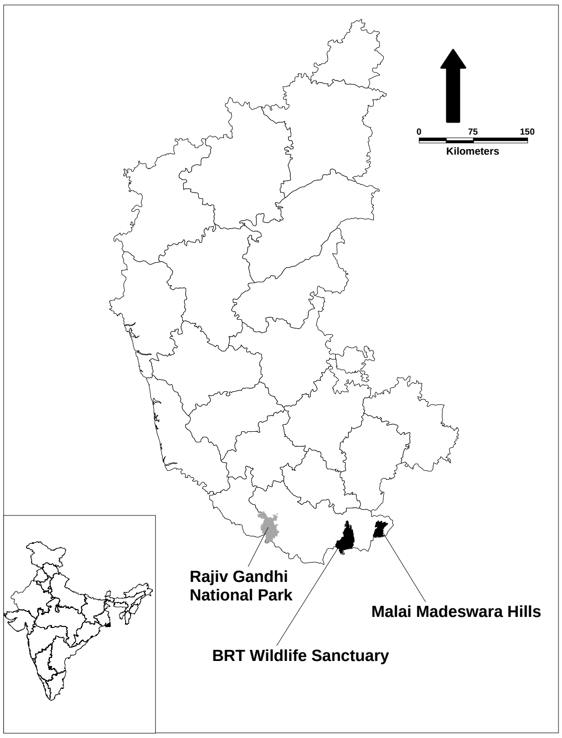


Table 1. Features of the three sites selected for the study

CHARACTERISTICS	MM Hills	BR HILLS	Nagarahole
Legal status	Reserve forest	Wildlife sanctuary (Protected area)	National park (Protected area)
LOCATION	11^0 56'-12^0 09' N and 77.30' -77.42' E	11° 40'-12° 09' N and 77° 05'-77° 15' E	11^0 45'-12^0 15' N and 76^0 05' -76^0 25' E
Area (sq km)	291	540	643
POPULATION	5614 (1991 census data)	4000 (Interior) + 11000 (Periphery)	Approx. 3000
Altitude in m (MSL)	300 to 1514	600 to 1800	700 to 959
Temperature ^{0}C	Minimum 10°C and Maximum 35-40°C	Minimum 8°C and Maximum 42°C	Minimum 10°C and Maximum 35°C
RAINFALL IN MM	400 to 600	600 to 3000	1300 to 1800
HUMAN SET-UP	*Soligas* (Tribal) *Lingayat* (Non tribal)	*Soligas* (Tribal) *Naiks* (Non tribals in the periphery)	*Jenu Kurubas, Betta Kurubas, Yeravas* (Tribals)
% TRIBALS	13% (Kombudikki) 17% (Ponnachi)	100%	100%
LAND TENURE(*)	Present	Absent	Absent
COLLECTION OF NTFPS	Permitted	Permitted(*)	Partially allowed(*)
MAIN SOURCE OF INCOME	Daily wage labour, agriculture and NTFPs	NTFPs and daily wage labour	Daily wage labour NTFPs and agriculture
MARKET REGIME	Private Contractors	Tribal cooperatives	Cooperatives

(*) for further details see text

A range of forest products is collected at the three sites (Table 2). Because of similar vegetation, a number of NTFPs are common to the sites. All the three sites are nearly equidistant from the major markets in south India. Very frequently the produce from the three sites are delivered to common traders in the markets of Mysore, Coimbatore and Salem in south India.

In summary, the three sites present interesting contrast to lend themselves for examining the factors influencing the ecological cost of dependence. Among the various factors, we discuss the role of extent of dependence, indigenous knowledge and market structure in influencing the ecological cost at the three sites.

Table 2. List, parts used and quantity of NTFPs collected in the three study sites

NTFP species and Scientific name		Parts Used	Total quantity in Kgs collector^{-1} y^{-1}			Mean
			MM Hills	BR Hills	Nagarahole	
Antuvala (soap nut)	*Sapindus laurifolius*	Fruits	5136.5	2673	120	2643.17
Arale	*Terminalia bellerica*	Fruits	7847.5	3728.5	0	3858.67
Bamboo poles	*Bambusa* sp. and *Dendrocalamus* sp.	Shoots	4220	0	0	1406.67
Bamboo shoots	*Bambusa* sp. and *Dendrocalamus* sp.	Stems	0	0	39.5	13.17
Bel	*Agele marmelos*	Fruits	0	650	0	216.67
Koodu (horn)	Spotted Deer and Sambar Deer	Antlers	0	230.25	0	76.75
Dhoopa	*Botswelli serrata*	Resin	0	2.5	0	0.83
Fuel wood	Trees and shrubs of any species	Stems and branches	0	1423	52	491.67
Genasu	*Dioscoria* sp.	Tubers	0	0	7866	2622.00
Jaenu (honey)	*Apis dorsata, A. floria* and *Serana indica*	Honey	32	6225.5	7559.65	4605.72
Honge	*Pongamia pinnata*	Seeds	118.25	0	0	39.42
Honne	*Pterocarpus marsupium*	Fruits	126	0	0	42.00
Kal paase	Lichen sp.	Thallus	0	13138.5	703	4613.83
Kasahullu	*Phonix* sp.	Leaves	69278	53829	0	41035.67
Magali	*Decalepis hamiltonii*	Roots	1655	17512	0	6389.00
Maavu (mango)	*Mangifera indica*	Fruits	0	125	0	41.67
Nelli	*Phyllanthus emblica*	Fruits	21600	58162.5	3100	27620.83
Seege	*Acacia concinna*	Fruits	8242.5	524.7	0	2922.40
Hunase (tamarind)	*Tamarindus indicus*	Fruits	4050	4170	0	2740.00
Anntu (wax)	*Apis dorsata, A. floria* and *Serana indica*	Honey comb	0	522.4	1129.35	550.58

DATA COLLECTION AND ANALYSIS

Livelihood dependence

The livelihood status of the people at MM Hills, BR Hills and Nagarahole were studied between April and September 2001. At all the three sites, approximately 10 percent of the total number of households was surveyed. At MM Hills, data was obtained from two settlements, namely Kombudikki and Ponnachi. At BR Hills, the households included those from the interior and exterior limits of the sanctuary. In

Nagarahole, data was collected from people rehabilitated in the forest fringes. The total numbers of respondents in these sites are: MM Hills- 126 (Kombudikki= 36; Ponnachi= 90), BR Hills- 53 and Nagarahole- 28 households.

Data on the following suite of livelihood parameters were obtained from each of the respondents following formal interview method: Size of the family, gender ratio, number of dependents, level of education, area of land owned and number of livestock owned, income from various sources, number of days spent for each source of income, household expenditure and the NTFPs collected (quantity, number of days spent for each).

Data analysis

The data was analysed by developing appropriate socio-economic indicators as described below.

Proportion income from NTFPs: We identified the portfolio of livelihood activities for the various sites using questionnaire method. For each component (eg: agriculture or daily wage) the income contributed to the total cash income was calculated using appropriate algorithm. For instance to estimate the income obtained from collection of *Phyllanthus emblica*, a forest fruit, the total quantity of fruits harvested by a household per year was multiplied by the unit price of the fruits (derived from that year). The proportion of income contributed by the fruits to the total income was then arrived at.

Multiple Linear Regression: We estimated the relative contribution of different sources of income (agriculture, daily wage, forest products, forest fruits, etc) to the total household income for the three sites by conducting a multiple linear regression using Statistica software package.

Wealth Index (WI): We computed the WI to determine the relationship between the total assets possessed by a household and the proportion of the total income from NTFPs. The assets included area of land owned, number of livestock owned, type of house, access to electricity, farm equipment and account in a bank. All the components were equally weighted. These variables were normalized (all the values were expressed in 0-1 scale) and the mean index per household was calculated and regressed against the proportion of income contributed by NTFP to the total household income.

Gini concentration ratio (GCR): Gini coefficient is a commonly used measure of the inequality in the distribution of income. We computed the GCR for the sites to evaluate the extent to which the contribution of income from NTFPs is an important feature in reducing the income inequities among people at a site. The GCR was computed following Kakwani and Podder (1976). The value of GCR ranges from 0 and 1. If the value is zero it denotes perfectly equal distribution, while 1 denotes inequality.

Ecological knowledge

The ecological knowledge of the people was assessed in MM Hills (Sept-Dec 2000), BR Hills (April-June 2001) and Nagarahole (July-Sept, 2001). The study was conducted in three villages of Ponnachi (MM Hills) with a sample of 90 households, 21 villages at BR Hills with 52 households and 28 households in Nagarahole. A questionnaire survey was conducted to ascertain the indigenous ecological knowledge of the people on specific forest fruit trees that were extracted such as *Phyllanthus emblica, P. indofischeri, Terminalia chebula, Acacia concinna* and the changes in the general forest conditions. Information was sought on the spatial distribution of NTFP trees, methods of harvesting employed, changes in the fruit productivity with time, regeneration status of NTFP species and other trees, influence of epiphytic parasites on trees, pollination and dispersal modes of the NTFP species, effect of fire and weeds on regeneration of the species etc.

Data analysis

For each site, the percent of the respondents that expressed knowledge on each of the above issues was computed. Respondents who had no idea of an issue were regarded as not possessing knowledge on the specific ecological feature. For responses where some knowledge was expressed, the answers were categorised as unambiguously as possible into discrete categories, keeping the ecological relevance in mind. The frequency responses were evaluated using a contingency "G" test (Sokal and Rohlf, 1981).

Market structure and price spreads

Information on the market structure of NTFPs, with specific reference to forest fruits (*Phyllanthus emblica*, *Terminalia chebula* and *Acacia concinna*), was obtained for MM Hills and BR Hills. Depending upon the nature of distribution of respondents over a geographical area and the reliability of data generated, different sampling methods were used including simple random, stratified and clustered sampling. The study was conducted with the help of prepared schedules (after pre-testing them for their relevance) at several places and at several stages.

The survey was conducted by personally interviewing the major marketing agencies involved in marketing forest fruits, namely, the contractors, processors and traders.The markets surveyed include those at Kaudalli, Mysore, Bangalore, Tumkur, (in Karnataka State), Salem, Erode, Coimbatore (in Tamil Nadu State), Union Territory of Pondicherry; Tuticorin and Kottekal (in Kerala State). The path that the forest products take from the collector to consumer was traced at BR Hills and MM Hills. The price of each of the commodity was also recorded at every step of the market.

Data analysis

Commodity flow charts: Based on the data collected, analysis was done to trace the path and develop commodity flow charts through which the forest fruits were marketed at BR Hills and MM Hills. Based on the flow charts, the main agencies involved in marketing the forest fruits were identified.

Price spread analysis: The consumer prices of each of the final product were spread into various components of costs according to the commodity flow from source to consumers. Since the margin of profits to contractor, processor and trader was not readily available, we computed the margin as = selling price of the commodity-the procurement price – the overhead cost (value addition).

The percentage share of the various marketing agencies in the consumer rupee was calculated for each commodity using the following function:Share =((Net margin orreturn to agent)/(Consumer price of the product))*100.

Since the wage rates per kg of NTFP in all the study sites were almost the same, the producer's share in consumer's rupee was taken as a proxy for the percentage returns to the collectors in the total value added to the NTFP.

In some instance due to lack of pertinent data, two assumptions were made in computing the price spread. First, the processor's margin was assumed to be 35 per cent of the market price, since the processor took the maximum risk of capital and technological investment. Second, the retailer's margin was considered as 10 per cent of the market price.

Vegetation analysis

Vegetation structure was analysed at MM Hills and Nagarahole. Vegetation was sampled along transects of 1200 m radiating from the settlement (in MM Hills at two sites, Kombudikki and Ponnachi) in five directions. With in each transect six plots of 50m x 20m was laid at an interval of 200m to enumerate trees (>10 cm DBH) and within this 10m x 10m plot was laid to sample under-storey species (<10 cm and >3 cm DBH). A 1m x 1m plot was laid to assess herb layers. Data on vegetation structure at BR Hills from an earlier study was used to compare across the three study sites (Murali *et al*., 1996). Besides the vegetation structure, several vegetation attributes such DBH, height, abundance, epiphyte load and number of cut and broken stems were recorded in each transect along with attributes such as GPS location, altitude, and distance from the settlement.

Ecological costs

As a measure of the ecological costs, we estimated the following:

i. *Per cent of cut and broken stems at regions proximal and distant to settlements:* At each site, the percent of cut and broken stems of the total stems was computed for regions proximal to (0-600m) and distant (600-1200m) from the human settlements. Sites with greater per cent of cut and broken stems are assumed to bear a larger ecological cost than those with less percent cut and broken stems. The cut and broken stems may be consequent to the destructive means of harvest of NTFPs besides due to indirect pressures on the forest (such as for fuelwood collection).

ii. *Percent reduction in regeneration of species at sites proximal to settlements:* As a measure of the effect of human disturbance, the frequency distribution of size class of stems of NTFP species (<10 and >10 cm dbh) at regions proximal (0-600 m) and distant (600-1200m) to settlements was computed. We further computed the percentage reduction in the regeneration of the NTFP species at proximal regions over that at distant regions. The analysis was done for two sites, MM Hills (see above) and BR Hills (data obtained from Murali et al., 1996).

iii. *Percent of people adopting ecologically friendly harvesting practices:* Among the various methods used for harvesting forest fruits, broadly two categories could be identified, viz., those that are destructive to the trees and those not destructive. The former include practices such as cutting and breaking the branches, while in the latter fruits is dislodged from the tree by shaking or beating the branches with sticks. Across the three sites, we computed the percentage of respondents that adopted ecologically friendly (non-destructive) method of harvesting fruits of Phyllanthus sp., the predominant NTFP from the sites.

iv. *Percent of people adopting prudent harvesting:* While harvesting fruits from trees, collectors could harvest the entire lot (*to maximise returns to their initial costs of having climbed the tree or having spent time at the tree*) or leave behind a certain proportion that presumably could be used by the local wildlife as well as to favour regeneration (such prudent practice could be at the expense of the short-term gains of the collector (Prasad, et al. 2001). We computed the percentage of the respondents that adopted such prudent practices in harvesting of forest fruits (leaving behind some fruits on the tree, not harvesting all) at the three sites.

RESULTS AND DISCUSSION

Basic patterns

Livelihood dependence

The three sites differed markedly in the dependence on NTFPs. The community at BR Hills derived nearly 59 percent of their total cash income from NTFPs, followed by that in Nagarahole (24 percent) and in MM Hills (16 percent) (Table 3a). Within MM Hills, the dependence was significantly affected by both the location of settlements and the ethnicity of the people. At one of the settlements in MM Hills, Kombudikki, 40 per cent of the total income was obtained from NTFP, while at another settlement, Ponnachi, it was only 6 per cent. At both these settlements, the tribal community (Soligas) derived a greater proportion of their total income from NTFPs than the non-tribal community (Lingayats, Table 3b).

At all the three sites, a range of NTFP's are extracted from the forest, including bamboo, forest fruits and other forest products. In BR Hills, for example, over 10.8 percent of total income was derived from three forest fruits (*Phyllanthus emblica, Terminalia chebula, Acacia concinna*) while that in MM Hills and Nagarahole it was 4.8 and 1 per cent respectively (Table 3). Besides fruits, forest products including honey, lichens, broomstick grass, herbal roots etc contribute nearly 45 and 24 percent of the total income at BR Hills and Nagarhole respectively (Table 3). At MM Hills, in the Kombudikki settlement, the tribal community obtained about 34 per cent of their total income from bamboo compared to a meagre 0.11 per cent only by the non-tribals. Thus it appears that the patterns of dependence on different NTFPs is likely to be fashioned by the availability and accessibility of the resources, besides by the ethnic predispositions.

Table 3a. Percent income (mean ± standard deviation) from different sources in the three sites and two ethnic groups in two settlements in MM Hills (marked as #)

SOURCES OF INCOME	Kombudikki#		Ponnachi#		MM Hills	BR Hills	Nagarahole
	Tribals	Non Tribals	Tribals	Non Tribals			
Agriculture	03.12	03.65	09.33	18.66	09.60 ± 18.23	09.29 ± 23.41	12.24 ± 25.42
Live stock	01.92	08.24	03.46	07.17	06.41 ± 14.10	01.80 ± 05.71	00.61 ± 01.61
Daily wage labour	39.40	51.20	59.28	29.22	46.86 ± 37.18	23.37 ± 43.93	62.05 ± 33.64
Others	00.49	11.01	15.50	44.82	21.21 ± 33.47	06.33 ± 31.45	01.42 ± 05.03
% income from Non-NTFP	**44.93**	**74.10***	**87.56**	**99.86*** **	**84.09**	**40.79**	**76.31**
Bamboo	33.88	00.12	06.52	00.0	06.60 ± 17.82	02.92 ± 18.12	00.04 ± 00.18
FOREST FRUITS	15.80	08.28	05.56	00.14	04.79 ± 09.14	10.80 ± 22.73	01.00 ± 03.56
Forest products	05.39	17.51	00.36	00.0	04.52 ± 13.59	45.49 ± 71.53	22.65 ± 29.06
% income from NTFP	**55.07**	**25.90****	**12.44**	**00.14*****	**15.91**	**59.21**	**23.69**

The mean and standard deviations refer to the sample respondents interviewed at each site. The data of MM Hills refers to the pooled estimate from two settlements, #Kombudikki and #Ponnachi.

t-test assuming unequal variance; *P=0.0004, *P=0.0333, ***P=0.0001

Table 3b. t- test values for differences in income from NTFP and NTFP between pair of sites

Category	Sites	*T Stat*	*P=*
	MM Hills and BR Hills	1.546	0.062
Non NTFP	MM Hills and Nagarahole	0.535	0.297
	BR Hills and Nagarahole	-0.874	0.193
NTFP	MM Hills and BR Hills	-7.737	0.000
	MM Hills and Nagarahole	-2.107	0.022
	BR Hills and Nagarahole	1.319	0.097

The major determinant of total household income for each of the site was computed. At BR Hills, daily wage labour ($p<0.03$) and tree crops ($p<0.03$) contributed significantly to total income. At Nagarhole, besides daily wage, agriculture ($p<0.00$) and forest products ($p<0.00$) were significant determinant of total income. In contrast to the above two sites, at MM hills, forest fruits and forest products contributed weakly to total income. Percent income from NTFPs was negatively correlated with percent income from agriculture (BR Hills, $R^2=0.375$, $p<0.01$; MM Hills (at Ponnachi): $R^2= -0.009$, $p>0.05$; Nagarahole, $R^2 = 0.049$, $p>0.05$;), indicating that at all sites, increasing access to land tenure and agriculture could relieve or reduce the dependence of people on NTFPs.

Within a give site (except in Nagarahole), the percent dependence of households on NTFP was found to decrease with increase in the wealth index of the households. In other words, it appears that at BR Hills and MM Hills, the poorer households seem to depend more on income from NTFPs than do the richer households (Table 4).

Table 4. Relation between Wealth Index (x) and income from NTFPs (y)

Sites	N	y=bx + a	R^2	P
Kombudikki(*)	36	-0.360x+0.54	0.075	0.106
Ponnachi(*)	89	-0.052x+0.08	0.002	0.649
BR Hills	52	-0.206x+0.39	0.029	0.229
Nagarahole	28	0.273x+0.040	0.065	0.191

(*) Two sites at MM Hills. For details see text

As a measure of the distribution profile of income among households within a settlement, we developed Lorenz curves for the various settlements by respectively including and excluding the income from NTFPs in the total household income. Except for Ponnachi (tribals) and Nagarhole, the area between the Lorenz curve and the equity (or the egalitarian) line increased when NTFP was included in the total household income, suggesting that income from NTFPs tend to reduce income inequalities among households. These patterns are reflected in the Gini concentration ratio (GCR). For most settlements, the GCR was smaller (indicating a more equitable distribution) when NTFP was included in the analysis compared to when it was excluded. These results indicate that the income obtained from NTFPs help minimize the income disparities among the people and render the community economically more equitable (Table 5).

Table 5. Gini concentration ratio (GCR) for the three sites with and without NTFP as a source of income

Sites		Kombudikki*		Ponnachi*		BR Hills	Nagarahole
Ethnic group		Tribals	Non tribals	Tribals	Non tribals	Tribals	Tribals
Gini concentration ratio	**WithoutNTFP**	0.28	0.74	0.33	0.37	0.76	0.34
	With NTFP	0.10	0.28	0.19	0.34	0.56	0.36

*Two settlements at MM Hills. Tribals and Non tribals refer to the two ethnic groups over which the study was conducted.

Ecological knowledge of communities

Among the three sites, the community at BR Hills appeared to be the most knowledgeable (Figure 3). Thus a larger percent of the respondents at BR Hills had information on issues such as the adverse effects of invasive species on regeneration, effect of fire on regeneration, productivity cycles of trees etc. For example, a greater proportion of respondents at BR Hills were knowledgeable of the effect of an epiphytic parasite on the productivity of the *Phyllanthus* trees (Figure 4). While 92 percent of the people in BR Hills knew that the epiphyte lowers the productivity, at MM Hills only 58 percent of the people thought so. Besides the knowledge on specific plants that are extracted, people were also examined on their insights of general ecosystem processes such as pollination, dispersal, effect of grazing on forest structure etc. On an average, the percentage of respondents knowledgeable on these issues was again higher for the community at BR Hills, followed by those at Nagarahole and MM Hills.

Market channels and price spread at MM Hills and BR Hills

BR Hills and MM Hills differed strikingly with respect to the marketing channels of NTFPs. At BR Hills, tribal cooperatives involving the collectors were responsible for the marketing of NTFPs. In MM Hills, NTFPs were harvested through private contractors. This single difference seems to play an important role in determining the extraction pattern, return to the harvesters, marketing channels, price-spread and value addition to the raw products. The commodity flowchart for the forest products in BR Hills, where the cooperative itself undertook trading of the commodity is shorter compared to that at MM Hills; in the latter a distinct agent is involved in marketing the commodity. The shorter channel at BR Hills compared to the longer channel at MM Hills could be expected to be more cost effective and efficient.

However, the ultimate reach of markets of products emerging from M.M.Hills was found to be larger than those from BR hills. The latter might be attributed mainly due to the initiative undertaken by the private contractors and traders to search for more profitable markets and better returns to their resources and products. The contrasting patterns of marketing significantly affected the price-spread and the per cent share of the consumer rupee to the collectors. The percent share of the consumer rupee was significantly lower for all three forest fruits (*Phyllanthus* sp., *Terminalia chebula* and *Acacia concinna*; Figure 5) at MM Hills compared with that at BR Hills. The harvesters of amla at B.R.Hills received 0.65 percent higher wages than those at MM Hills. Similarly for yet another NTFP, *Acacia concinna*, the harvesters at MM hills received 12.5 per cent lower share as compared to those in BR Hills.

Figure 3. Percent of respondents possessing knowledge on issues related to pollination, dispersal, seedling development, weeds, harvesting method and parasite attack at the three sites. N refers to the number of households interviewed

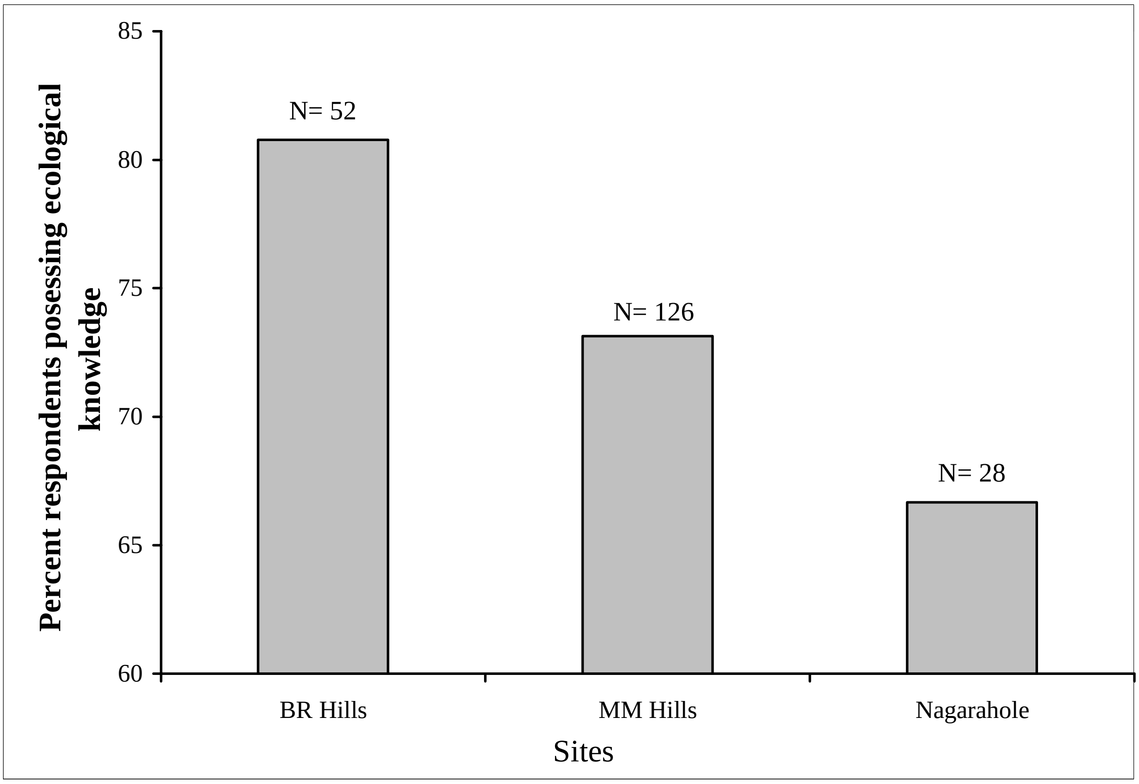


Figure 4. Percent of respondents knowledgeable about the effect of epiphytic parasites on the productivity of *Phyllanthus* sp. in the study sites

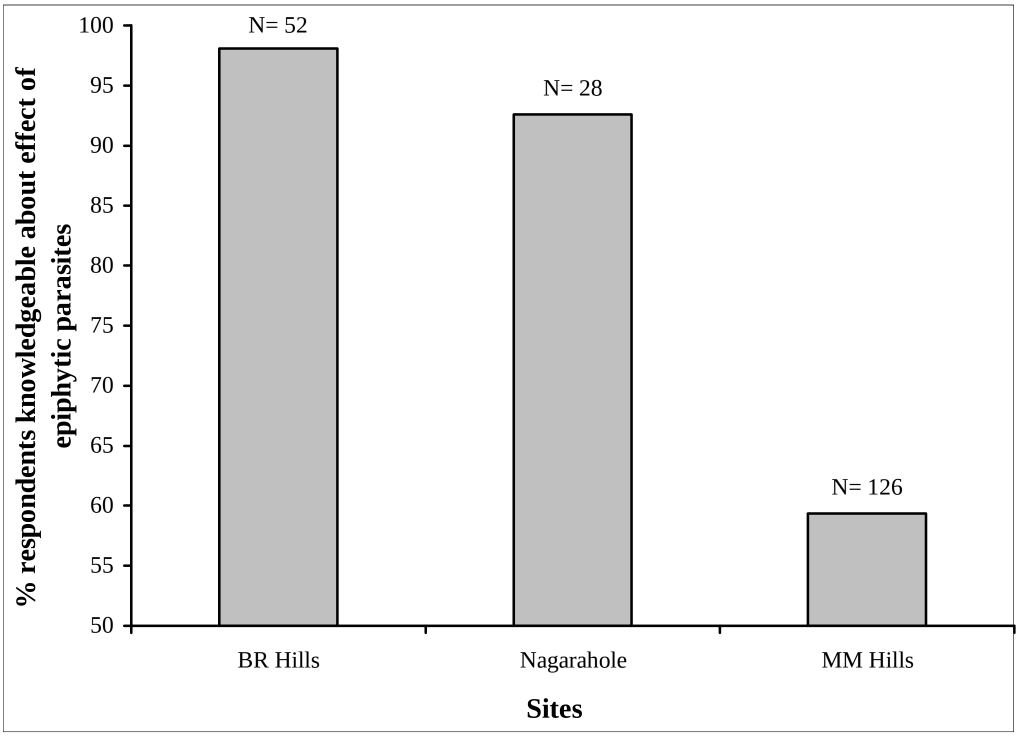
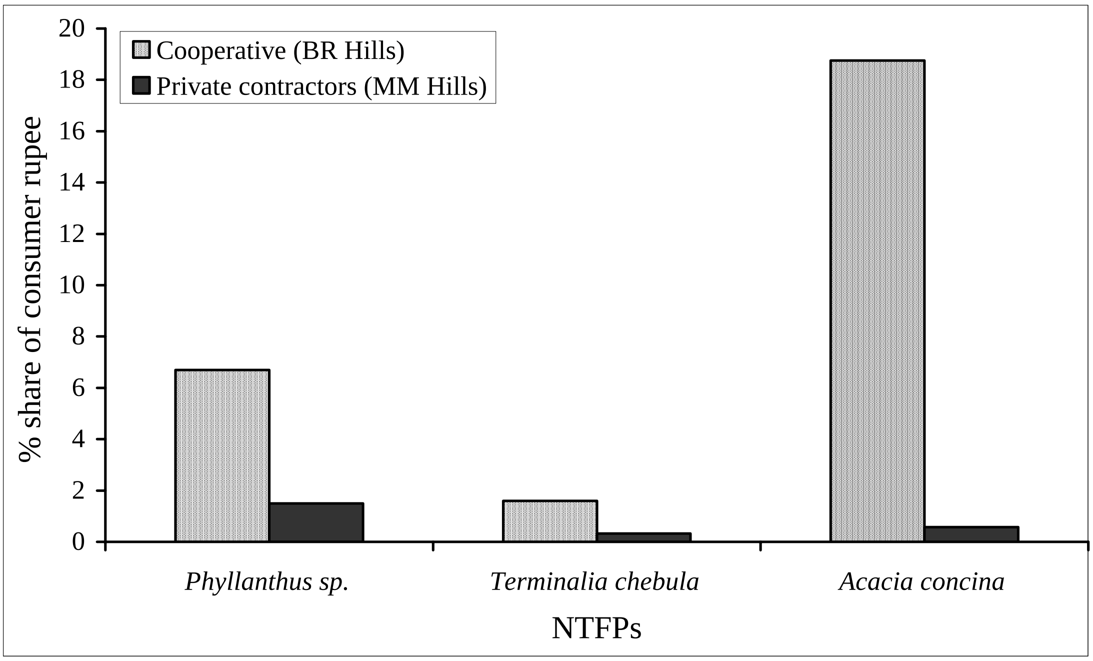


Figure 5. Percent share of the consumer rupee to collectors at BR Hills and MM Hills



DISCUSSION

Our studies reiterate the important role played by NTFPs in contributing to the livelihoods of the forest dwelling communities in south India. In fact it is interesting to note that at one of the sites, BR Hills, the percent of total income obtained from NTFPs has remained nearly unaltered (~55 - 59 per cent) over the last decade (Hegde *et al.*, 1996). However it is increasingly realised that such continued dependence of communities on forest products will be contingent upon minimizing the ecological costs that might be incurred. Understanding the features of forest use that contribute to ecological cost could help in formulating rational management strategies to avoid or reduce the costs and thus securing the long-term livelihood interests. Our study on the three human settlements in south India have provided a rich canvas of contrasts to examine some of the direct and indirect cost that dependences on forest can have. Using these contrasts as the template, we provide below the first order evaluation of the predictions and associations relating to the ecological costs in these forest communities and discuss approaches that could lower the cost and hence ensure the livelihoods.

Sites or communities with higher dependence on forest resources but with a good ecological knowledge will tend to impose a lesser ecological cost compared with those that exhibit a poor ecological knowledge.

The results of our study show that ecological knowledge of people scales positively with the extent of their dependence on the forest. Thus the community at BR Hills that depend on forest resources to a larger extent exhibited a greater awareness of the ecological issues than did communities at Nagarahole and MM Hills. This association might be a consequence of the historical linkages that the communities might have had with the resources they have to depend upon. In BR Hills the higher awareness of the community might also have come through acquiring information from nongovernmental (NGOs) and community based organizations (CBOs) actively promoting ecologically friendly methods of forest use at the region.

We examined two parameters of the community as a possible measure of the ecological cost, namely, the percentage of collectors at each of the site that a) adopted ecologically friendly harvesting methods and b) that adopted certain degree of resource prudence while harvesting fruits.

Our results showed that with increase in the dependence on NTFPs, the percentage of the collectors that adopted ecologically friendly harvesting methods and harvesting prudence increased. A greater proportion of the people at BR Hills and Nagarahole (with higher percent dependence on NTFPs) resorted to beating branches to dislodge fruits from trees (Table 6). These collectors seem to have a clear knowledge that other methods of harvesting (such as cutting) could be destructive to the long-term productivity of the trees. On the other hand, at MM Hills only a smaller proportion of the collectors resorted to beating branches, while others adopted destructive methods of harvesting fruits from trees. Similarly, the people at BR Hills and Nagarahole resorted to a less intense harvest, choosing to leave behind fruits for tree recruitment and consumption by wildlife compared to that in MM Hills. Thus it appears that communities with a greater degree of ecological knowledge might be more prudent in the use of forest resources than those not well informed. This finding might have important implications for the rationale management of NTFP resources.

Table 6. Percent dependence, percent respondents knowledgeable about non-destructive harvest method and practising prudent harvesting

ATTRIBUTES	BR Hills	Nagarahole	MM Hills
Dependence	51.21	23.69	15.91
Harvest method (Non destructive)[1]	44.23	85.19	24.01
Intensity (Prudent harvesting)[2]	63.46	77.78	5.33

[1]This included respondents who resort to beating branches to dislodge fruits from *Phyllanthus* sp., the predominant NTFP collected from the sites.

[2]This included respondents who leave behind a certain proportion of fruits on trees of Phyllanthus sp.

Sites with a cooperative marketing system will impose a lower ecological cost than would those where markets are operated through private contractor ship.

The observed differences in the method and intensity of harvesting could also be viewed as a consequence of the different marketing systems in the study sites. At MM Hills, the contracts for harvest of the forest produce are awarded on the basis of a competitive bid and hence continuity and long-term approaches to harvesting cannot be assumed. This is likely to result in market failure since there is an element of uncertainty to the private contractor of collection rights in the long run which is likely to undermine incentives to conserve the NTFP by the private contractor. Thus it may lead to exploitative nature of harvest, wherein the contractor is forced to maximise his short-term gains.

Under a private market structure, poor collectors could be forced to resort to excessive extraction in order to earn their subsistence living since their returns per unit of collection is very low. Thus private markets may not only be exploitative to the collectors (by way of providing a small proportion of the consumer rupee to the collector) but also to the natural habitat. Another feature of the marketing through the private contractors is that they are free to employ collectors, either from within the forest settlement or outside. This is also likely to influence the ecological responsibility of collectors' harvesting practices. These two features together could significantly influence the ecological cost of extraction of forest products. In an apparent support of this argument is the fact that people at MM Hills were on an average less knowledgeable about the ecology of forest trees that were the people at BR Hills or Nagarahole. Because of the interest in maximizing short term gains a larger percentage of the collectors at MM Hills resort to a) very intense collection per tree (as much as the contractor, the collector is also maximizing his or her return) and b) destructive harvesting of the trees (see data provided in prediction 1).

The result could also be viewed in the light of the theory of evolution of prudence in communities. To be prudent incurs a cost and unless the gains are justified in the context, it would not pay to be prudent. Thus in MM Hills, where selection on individual collectors and contractor is to maximize the short term gains, prudence could be weakly if at all selected that an BR Hills where the existing market structure in fact favours maximizing long-term gains.

Measure of ecological cost

But are the differences in ecological knowledge among the communities actually manifested in a better health status of the trees at sites such as BR Hills compared with that at MM Hills? We used two indicators that could be comparable across the sites to address this question, namely, the percent cut and broken stems, as a measure of the extent of disturbance to the forest, and regeneration status of certain focal species harvested by the communities.

At both sites, the percentage of cut and broken stems and the size class of stems were estimated near human settlements (proximal) and away (distant). The percent cut and broken stems was less in Nagarhole and BR Hills at both the proximal and the distant regions compared with that at MM Hills (Table 7). At both sites, the regeneration of focal NTFP species such as *Phyllanthus* sp, the predominant NTFP, was affected more in proximal than distant regions (Figure 6); however, at BR Hills the percent reduction of stems (<10 cm dbh) in proximal over that in distant regions was substantially less than that at MM Hills (Figure 7). Thus though at both sites there is a decrease in regeneration at regions proximal to the settlements (perhaps due to an increased level of harvesting and other human-mediated disturbances), in BR Hills the effects seem to be subdued.

Table 7. Proportion, mean and standard deviation of cut and broken stems at regions proximal and distant to settlements in the study sites

Area	% cut and broken stems	% cut and broken stems (Proximal)[1]	% cut and broken stems (Distant)[2]
B. R. Hills*	02.60	05.00 ± 00.44	00.30 ± 00.43
Nagarahole	00.77	00.77 ± 00.78	00.65 ± 00.75
M. M. Hills	10.58	15.88 ± 07.75	07.85 ± 02.75

* from Murali et. al., 1996

[1]Proximal region: represents region <600m from settlements.

[2]Distant region: represents region between 600 and 1200m from settlements

Figure 6. Percent of stems of *Phyllanthus* sp (<10 and >10 cm dbh) at regions proximal and distant to settlements at a) MM Hills and b) BR Hills

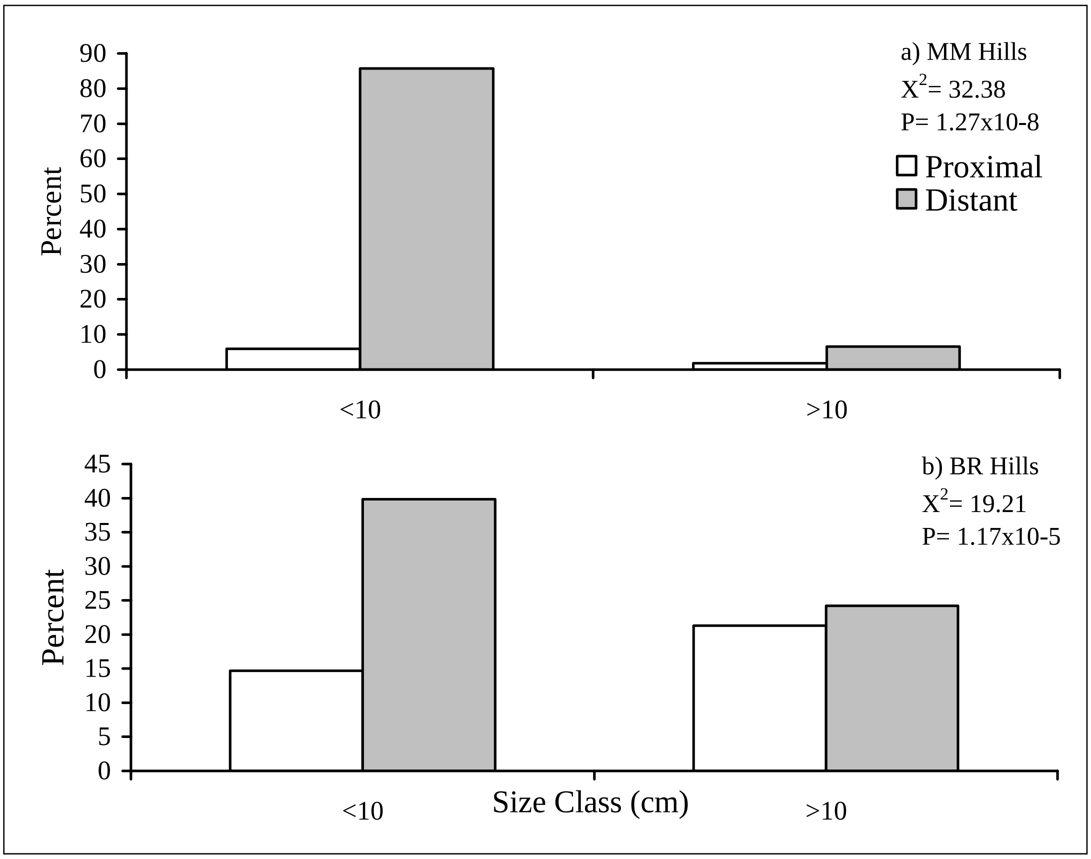
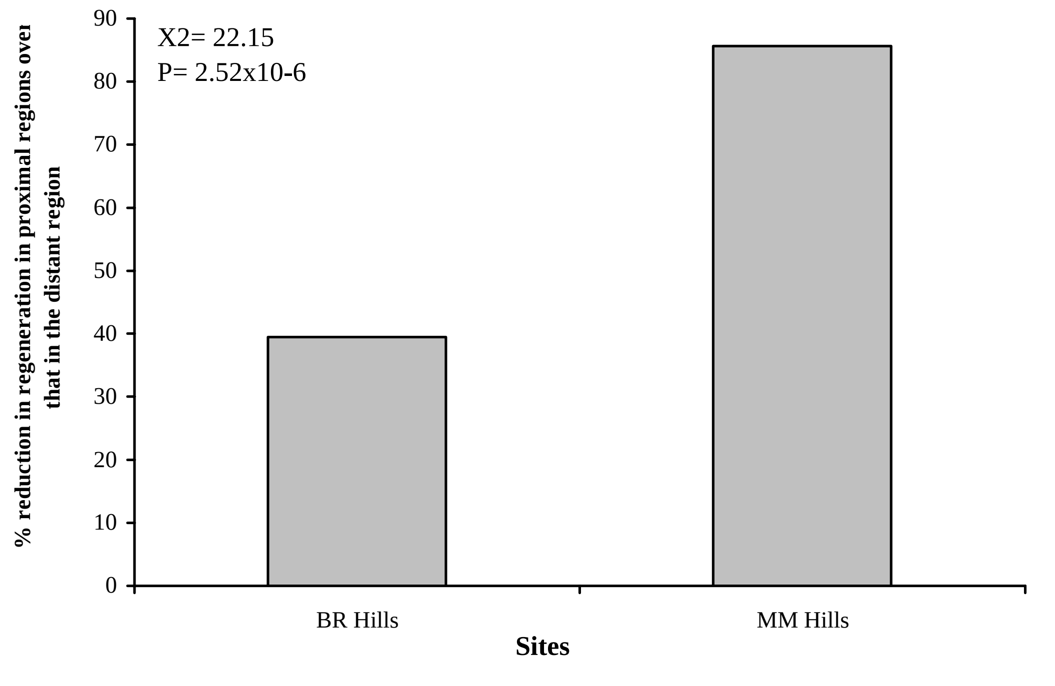


Figure 7. Percent reduction in regeneration (<10 cm dbh) of *Phyllanthus* sp. at regions proximal to settlements compared to that in the distant region at BR Hills and MM Hills



The results of the study collectively indicate that despite high dependence, communities could have evolved strategies for reducing the ecological cost, provided of course they are knowledgeable of the ecosystem in which they operate. These communities (that have a high dependence) are by nature traditionally wedded to the resources and therefore might have had the time to evolve the necessary wherewithal to maintain the productivity of the specific resources. In contrast, communities with low dependence and associated private marketing systems are characteristic of opportunistic exploitation, interested mainly in maximizing the short-term gains. Our studies provide important pointers to the management of the NTFP resources, considering the level of dependence of communities on the NTFP. These results also hold important implications for defining optimum marketing systems to minimize the ecological cost of collection. Private contractor marketing could be made conditional upon regulations pertaining to ecologically friendly methods of harvesting, coupled with close monitoring of the process.

While our study has demonstrated the possible role of the extent of dependence, indigenous knowledge and market structure in influencing the ecological cost, there could be several competing alternate factors that merit mention. It is often not easy to tease these explanations apart and it is likely that in reality a host of factors overlay each other in determining the costs. For example, the reduced ecological cost observed at BR Hills and Nagarhole could also arise because of the protected nature of these forests compared to that at MM Hills. Similarly land tenure and property rights could also influence the ecological costs by modulating the extent to which people are dependent upon NTFPs. Lack of land tenure at BR Hills compared to those at MM Hills could drive people to have a greater share of income from NTFP collection than settled agriculture. Or for the matter the proximity to markets and the market demand (in contrast to market structure as discussed above) could strongly influence the extent of dependence and thus have implications for the ecological costs. Unfortunately, the lack of suitable contrasts in sociological settings constrain sieving the observed causality of associations.

Enhancing livelihoods, minimizing ecological costs

Under most current extractive practices, gains in livelihoods attract an ecological cost (win-lose situations; Figure 8). Situations of lose-win (with no apparent livelihood gains and thus no ecological cost) are perhaps typical only of nationally protected areas, from where extraction of NTFPs is prohibited. On the other hand, the lose-lose cells are probably typical of wastelands where either due to past exploitative extraction events or natural processes, livelihood gains are absent and hence there are no overt ecological costs. The most ideal cell to reach is the win-win, where there is a certain extent of equilibrium between the livelihood gains and ecological costs. Within the available possibilities, it appears that unless efforts are taken to reduce the skew between the gains and the costs (in the win-lose cells), sooner or later the elements in the cell will graduate to a lose-lose mode (because of over-extraction). Reduction of skew between the gains and costs could be the first step in redirecting the trajectories of change to a win-win mode.

Figure 8. 2X2 matrix of livelihood gains and ecological costs. The bold arrows indicate the trajectory of change that is desired. The dotted arrow indicates the likely trajectory if disparities between gains and costs widen

Livelihoods Gains	**Ecological Costs**	
	Win	**Lose**
Win	**Win-Win** ← **(Desired)**	**Win-Lose** **(Existing)** ↓
Lose	**Lose-Win** **(Protected area)**	**Lose-Lose** **(Wastelands)**

While conceptually the 2x2 matrix of win-lose offers a rich canvas to navigate the options, in practice reaching up to a win-win situation has been far from that desired. In absence of green tree felling in countries such as India, NTFPs have come to stay as the major extractable produce of the forest. Under these conditions, managing NTFP extraction is a key to both conserving the forest at large as well as in securing the continuous needs of the rural poor. While there has been a general realization that dependence of forest fringe communities on forest resources could entail a certain ecological cost, there have not been many efforts to explicitly address the costs. Our study has examined the consequences of livelihood dependences by people on the ecological consequences with the ultimate goal of exploring the possibilities of bridging the gap between the livelihood gains and the ecological costs. Within the short-term of the study, we have shown that the extent of dependence on NTFPs, indigenous ecological knowledge and market structure could have important bearing on the ecological cost and that addressing these factors could form an approach towards mitigating the loss However this does not necessarily preclude or undermine the possible role that other factors (property rights, land tenure, alternative income opportunities etc) could have in minimizing the ecological cost. Thus the approaches to reducing the costs could be several and perhaps need to be carefully prioritized based on locale-specific features.

We argue that adaptive management that enhance the ecological knowledge bases of harvesting communities and that regulate the market structure to favor long rather than short term gains could narrow the disparities between livelihood gains and the ecological cost and thus lead to a greater livelihood security to the poor communities. Among the potential interventions and possible recommendations, our study indicates that while maintaining or enhancing livelihoods from forest, focus should also be laid on reducing the ecological cost of dependence. These interventions could include an array of features including adoption of ecologically friendly methods of harvesting, spatial and temporal monitoring of harvesting by collectors, enabling the operation of efficient markets (that are not exploitative on the collectors and the ecosystem) etc. Several major policy issues that could help lower the ecological cost would include the implementation of the concept of NTFP working plans, similar to the timber working plans and semi-domestication of at least the most important and threatened plant resources.

REFERENCES

Bawa, K., J. Rose, K. N. Ganeshaiah, N. Barve, M. C. Kiran, and R. Uma Shaanker. 2002. Assessing biodiversity from space: an example from the Western Ghats, India. *Conservation Ecology* **6**: 7. [online] URL: http://www.consecol.org/ vol6/iss2/art7

Chaluvaraju, B. S. Deepali Singh, M. N. Rao, G. Ravikanth, K. N. Ganeshaiah, and R. Uma Shaanker. 2001. Conservation of bamboo genetic resources in Western Ghats: Status, threats and strategies. In. *Forest Genetic Resources: Status, Threats and Conservation Strategies*. Eds. Uma Shaanker, R., K. N. Ganeshaiah, and K. S. Bawa. Oxford-IBH Publications, New Delhi. Pp. 97–113.

Ganeshaiah, K. N. and R. Uma Shaanker. 1998. BRT Sanctuary: A biogeographic bridge of the Deccan Plateau. In *Biligiri Rangaswamy Temple Wildlife Sanctuary: Natural history, biodiversity and conservation.* Eds. Ganeahaiah, K. N. and R. Uma Shaanker, ATREE and VGKK, Bangalore. Pp. 4-6.

Ganeshaiah, K. N., R. Uma Shaanker, K. S. Murali, Uma Shaanker and K. S. Bawa. 1998. Extraction of non-timber forest products in the forests of Biligiri Rangan Hills. 5. Influence of dispersal mode on species response to anthropogenic pressures. *Economoc Botany*. 52: 316-319.

Ghazoul, J. 2001. Direct and indirect effect of human disturbance on the reproductive ecology of tropical forest trees. In: *Tropical ecosystems: Structure, diversity and human welfare*. Eds. Ganeshaiah, K. N., R. Uma Shaanker and K. S. Bawa. Pp.97-100. Oxford-IBH Publications, New Delhi.

Godoy, R. A. and K. S. Bawa. 1993. The economic value and sustainable harvest of plants and animals from the tropical forest: assumptions, hypotheses, and methods. *Economic Botany*. 47: 215-219.

Hegde, R., S. Suryaprakash, L. Achoth and K. S. Bawa. 1996. Extraction of NTFPs in the forests of B R Hills 1. Contribution to rural income. *Economic Botany* 50: 243-250.

Kakwani, N. C. and N. Podder. 1976. Efficient estimation of Lorenz curve and association inequality measures form grouped observation. *Econometrics.* 44: 138-148.

Murali, K. S., Uma Shankar, R. Uma Shaanker, K. N. Ganeshaiah and K. S. Bawa 1996. Extraction of NTFPs in the forests of B. R. Hills 2. Impact of NTFPs extraction on regeneration, population structure and species composition. *Economic Botany* 50: 251-269

NCHSE. 1987. *Documentation of Forest and Rights.* Volume 1. National Centre for Human Settlements and Environment, New Delhi.

Nepstad, D. C., I. F. Brown, L. Luz, A. Alechandra and V. Vlana. 1992. Biotic impoverishment of Amazonian forests by tappers, loggers and cattle ranchers. In: *Non-Timber Products from Tropical Forests: Evaluation of Conservation and Development Strategy*. Eds. Nepstad, D. C. and S. Schwartzman. *Advances in Economic Botany* **9**. The New York Botanical Garden, Bronx, NY. Pp. 1–14.

Padmini, S., M. N. Rao, K. N. Ganeshaiah, R. Uma Shaanker. 2001. Genetic diversity of *Phyllanthus emblica* in tropical forests of South India: Impact of anthropogenic pressures. *Journal of Tropical Forest Science.* 13: 297-310.

Sinha, A. and K. S. Bawa. 2001. Impacts of anthropogenic pressures on population dynamics, demography, and sustainable use of forest species in the Western Ghats, India. In: *Tropical ecosystems: Structure, diversity and human welfare*. Eds. Ganeshaiah, K. N., R. Uma Shaanker and K. S. Bawa. Oxford-IBH Publications, New Delhi. Pp. 101-103.

Sokal, R.R. and F.J. Rohlf. 1981. *Biometry*. W.H. Freeman and Company, New York.

Tewari, D. N. 1993. Non-Timber Forest Produce in Poverty Alleviation. *Indian Forester,* Dec.: 959–968.

Uma Shaanker, R., K. N. Ganeshaiah and M. N. Rao. 2001. Genetic diversity of medicinal plant species in deciduous forest of South India: Impact of harvesting and other anthropogenic pressures. *Journal of Plant Biology*. 28: 91-97.

Uma Shaanker, R., K. N. Ganeshaiah, C. Meera and H. R. Anuradha. 2000. Bamboo Bazaar, *Deccan Herald, Spectrum*, 7th April 2000.

Ved, D. K., C. L. Prathima, N. Mortan and Darshan Shankar. 2001. Conservation of India's medicinal plant diversity through a novel approach of establishing a network of *in situ* gene banks. In: *Forest Genetic Resources: Status, Threats and Conservation Strategies*. Eds. Uma Shaanker, R., K. N. Ganashaiah, and K. S. Bawa. Oxford and IBH Publications, New Delhi. Pp. 183–195.

Prasad, S., R. Chellam and J. Krishnaswamy. 2001. Fruit removal patterns and dispersal of Emblica officinalis (Euphorbiaceae) at Rajaji National Park, India. In: *Tropical Ecosystems: Structure, diversity and human welfare*. Eds. Ganeshaiah, K. N., R. Uma Shaanker and K. S. Bawa. Oxford-IBH Publications, New Delhi. Pp. 513-516