

EXTRACTION OF NON-TIMBER FOREST PRODUCTS IN THE FORESTS OF BILIGIRI RANGAN HILLS, INDIA.

3. PRODUCTIVITY, EXTRACTION AND PROSPECTS OF SUSTAINABLE HARVEST OF AMLA *PHYLLANTHUS EMBLICA*, (EUPHORBIACEAE)¹

UMA SHANKAR,² K. S. MURALI, R. UMA SHAANKER, K. N. GANESHAIAH, AND K. S. BAWA³

Uma Shankar, K. S. Murali (Tata Energy Research Institute, 50/7 Palace Road, Bangalore 560 052, India), **R. Uma Shaanker** (Department of Crop Physiology, University of Agricultural Sciences, GKVK Campus, Bangalore 560 065, India), **K. N. Ganeshiah** (Department of Genetics & Plant Breeding, University of Agricultural Sciences, GKVK Campus, Bangalore 560 065, India), and **K. S. Bawa** (Department of Biology, University of Massachusetts, Boston, MA 02125, USA). EXTRACTION OF NON-TIMBER FOREST PRODUCTS IN THE FORESTS OF BILIGIRI RANGAN HILLS, INDIA. 3. PRODUCTIVITY, EXTRACTION AND PROSPECTS OF SUSTAINABLE HARVEST OF AMLA *PHYLLANTHUS EMBLICA* (EUPHORBIACEAE). *Economic Botany* 50(3):270–279, 1996. Sustainable extraction of non-timber forest products (NTFPs) depends upon harvesting a small fraction of the total productivity. Over-exploitation can lead to a loss of biodiversity, but a low level of extraction, without value addition at the point of origin, is usually not economically feasible for extractors. Extraction and productivity levels per unit area for most non-timber forest products are unknown, nor do we have much information about value addition at various points in the marketing channels. Here we determine extraction and productivity levels for Amla trees (*Phyllanthus emblica*), which yield fruits that are used for a wide variety of purposes in preparation of various foods, beverages and medicines. We also present preliminary data on the price appreciation of the fruit for one of the processed products. We have determined that the current level of extraction, 60–80% of all fruits at the population level, may have a negative effect on new recruitment. We present a model for value addition that has the potential to enhance income and reduce the level of extraction. This model is currently being implemented by the Soliga community with the assistance of a non-governmental organization.

Extração de Produtos Florestais Não Madereiros Nas Florestas de Biligiri Hills, Índia. 3. Produtividade, Extração e Prospectos de Exploração Sustentável de Amla *Phyllanthus emblica*. (Euphorbiaceae). A exploração sustentável dos recursos florestais não madereiros está baseada na extração de uma pequena fração da produtividade total desses recursos. A exploração excessiva pode levar a perda da biodiversidade, e por outro lado, a exploração em pequena quantidade pode ser economicamente inviável. Níveis de extração e produtividade por unidade de área são desconhecidos para grande parte desses recursos, assim como informações sobre valores adicionais em vários pontos dos canais de mercado. Neste trabalho, nós determinamos níveis de extração e produtividade para frutos de Amla (*Phyllanthus emblica*), os quais são utilizados na preparação de comidas e medicamentos. Nós apresentamos dados preliminares de apreciação de preço do fruto para um dos produtos processados. Nós determinamos também que o nível de extração atual, 60–80% de todos os frutos produzidos a nível de população, pode ter um efeito negativo no recrutamento de plântulas. Nós apresentamos um modelo de valor aditivo que tem o potencial de aumentar a renda e reduzir o nível de extração. Este modelo está atualmente sendo implementado pela comunidade Soliga com a assistência de uma organização não governamental.

Key Words: NTFP; Soliga; Amla; sustainable extraction

¹ Received 19 December 1995, accepted 29 January 1996.

² Current address: Talá Energy Research Institute, Hakimpara, Ghoshpara, Siliguri 734401, INDIA.

³ Correspondence.

The Soligas, the native tribe of Biligiri Rangan Hills in southwest India, extract a wide array of non-timber forest products from tropical forests (Murali et al. 1996). One of these products is the fruit of the Amla tree (*Phyllanthus emblica* Linn.). The fruit is used as an ingredient for medicines of the indigenous Ayurvedic system, as a coolant, laxative and diuretic (Krishnamurthy 1993). It is also used as a source of dyes and tannins and for making pickles, jellies, and preserves (Krishnamurthy 1993). In an earlier paper we demonstrated inadequate regeneration of Amla trees, possibly due to the heavy extraction of fruits (Murali et al. 1996). We also know that the Soligas derive little economic return from the extraction of Amla fruits and other NTFPs (Hegde et al. 1996), but we do not know if the low returns contribute to excessive harvests.

Levels of extraction resulting in resource depletion are not uncommon for other non-timber forest products at other locations in the tropics (Browder 1992; Homma 1992; Nepstad et al. 1992). Unless levels of harvests are linked with total productivity, a sustainable level of extraction may be difficult to achieve. However, productivity levels for most NTFPs per unit area are not known, nor is there much information about market flows to determine how the returns for the extractor might be increased and the amount of extracted resource decreased. In the absence of such data, the notion that extraction of NTFPs is compatible with sustained use and conservation of forest resources remains untenable (Godoy and Bawa 1993).

Here we present data on the productivity of Amla trees. We link productivity to the levels of extraction. We then trace the market flow of Amla fruits to determine the appreciation of price at various stages and to ascertain the fraction of the final price recovered by the extractor. We then suggest an alternative flow route that may lead to an increase in income to the extractor and to reduction in the level of extraction through management intervention. In undertaking the productivity studies and by tracing market flow, our overall goal is to determine how extraction of Amla fruits may raise rural income and, at the same time, result in the judicious use of a forest resource.

THE SETTING

THE SOLIGAS, BILIGIRI RANGAN HILLS AND AMLA TREES

The Soligas, an indigenous tribe of southwest India, have lived in the Biligiri Rangan (BR)

Hills for centuries. The BR Hills straddle the Eastern and Western Ghats in peninsular India. The undulating terrain comprises low hills that, at several places, reach an altitude of 1700m or more. Approximately 4000 Soligas inhabit the Biligiri Rangan Temple (BRT) Wildlife Sanctuary, which is the subject of the present study. The sanctuary occupies an area of 540 km² and contains four forest types, viz, deciduous, evergreen, scrub and "shola." The term shola is used for montane evergreen forests, dominated by members of the Lauraceae, that usually occur above 1500m. Further details on Soligas and the study site are provided in Hegde and co-workers (1996).

Amla (*Phyllanthus emblica*), also known as the Nelli tree in the local language, is found in all four types of forests, but is most common in dry deciduous vegetation. This medium sized tree is widespread in scrub and dry deciduous forests throughout India. The trees in BR Hills flower during February and March and fruit in November and December. The fruits are green and globose, fleshy, up to 3.00 cm in diameter, and are dispersed by spotted deer, mouse deer and sambur.

The extraction of Amla fruits in the BRT sanctuary begins with the onset of winter (mid-November) when the crop attains maturity, and continues till mid-February. Unlike other NTFPs, the extraction of Amla is a highly organized group activity. Individual collections are not done because the fruits should reach the industry in large quantities and readily (within 36 hours of the harvest) to avoid deterioration of quality.

Based on field surveys, the forest officers select the areas and dates for extraction of Amla fruits. The group of extractors arrives at the specified site in the morning and splits at the family level. The male member of the family climbs a tree and lops off branches bearing fruits. Other family members beat the branches on the ground to separate the fruits, and then gather the fruits from the forest floor. During a one-day harvest session, lasting approximately 4–5 hours, a family may exploit as many as five to ten Amla trees, depending on the family size, individual ability, proximity of the trees, terrain and production per tree. Each family carries its extracted Amla fruits to a nearby collection center of the Large-scale Adivasi (Tribal) Multipurpose Society (LAMPS). LAMPS are cooperative

societies consisting of tribals, set up and supervised by the state government to act as intermediaries between extractors and the contractors who take away the forest produce to urban centers for marketing or processing. The LAMPS agents, who are members of the Soliga community, supervise the extraction and maintain the record of the quantity collected by each family. The whole collection is then transported to the LAMPS office where it is registered and priced in conjunction with the contractors. Relative payments are then made to the extractors. Prior to daily harvesting, the LAMPS inform the contractors of the expected quantity of produce so that arrangements for its immediate purchase and transport to the processing industries can be made, thereby avoiding quality depreciation.

METHODS

POPULATION DENSITY OF AMLA TREES

An analysis of the vegetation map for the BR Hills prepared by Ramesh (1989) was used to estimate the area covered by each of the four forest types (deciduous, evergreen, scrub, and shola). Using a transect method, the density of "productive" Amla trees which were generally ≥ 10 cm dbh was determined for each of these forest types. Transects were 10 m wide and up to 1000 m long.

Ten hectares were sampled in deciduous forest, 5 ha in evergreen forest, 4 ha in scrub and 2 ha in shola forests. The dbh (diameter at breast height, 1.3 m) was recorded for all the individuals. In the scrub forest where tree growth is stunted and fruiting trees were found to be ≥ 5 cm dbh, separate stand densities were calculated for trees between 5 cm and 10 cm dbh, and for those ≥ 10 dbh. Though fruiting trees between 8 and 10 cm dbh are also found in deciduous, evergreen and shola vegetation types, the number of such individuals is small and not included in our estimates. Therefore, the total number of Amla trees ≥ 10 cm dbh in each forest type was estimated by multiplying the forest area by the per hectare density obtained from transect analysis.

FRUIT PRODUCTIVITY

In 1992–93, fruit production per tree was estimated by recording and weighing the fruits during extraction. The extractors do not completely harvest the fruits. Fruits located on the distal ends of the branches or on thin branches,

which are difficult and risky to approach, are left behind. By visual count, we estimated that about 70–85% fruits are generally harvested. Thus, our data on fruit productivity do not represent the total possible productivity.

The fruit production per tree was plotted against the dbh of the tree and a regression equation was obtained for trees ≥ 10 cm dbh (separately of trees between 5 cm and 10 cm dbh in scrub forest). Using these regression equations and average dbh for each vegetation type, we calculated the average production of Amla fruits per tree. On multiplying the average production per tree with the density per hectare, and then the result by the total area covered by a vegetation type, we obtained the total productive potential of that vegetation type.

Estimates of total productive potential are highly conservative since they are based on the "extractable production" and exclude that part of production which: 1) is not harvested by the extractors from the tree; 2) might have been consumed by wild animals before harvest and 3) might have fallen on the ground prior to collection. During our field visits, we found that two common loranthaceous parasitic plants, *Taxillus tomentosus* (Roth.) var. *Tiegh* and *Dendrophthoe falcata* (L.f.) Etting. affected fruit production of Amla trees. Since it is difficult to estimate the extent to which these parasites affect fruit productivity, this factor was not used in determining our estimates.

EXTRACTION

The amount of extraction for 1992–93 was estimated in two ways. First, as determined from records kept by LAMPS, the quantity of fruit extracted per day per person was multiplied by the number of days over which the fruits were collected by LAMPS. This product was then multiplied by the number of individuals participating in collection. Second, the amount of fruits auctioned by LAMPS for 1992–93 was recorded.

MARKET FLOW

Information on the existing market channels was collected from interviews with LAMPS agents and contractors. The revenue generation potential of Amla was calculated by multiplying the current fruit value with the actual quantity extracted for each of the three ranges within the sanctuary. All costs and values are described in

TABLE 1. ESTIMATED FRUIT PRODUCTION OF AMLA (*PHYLLANTHUS EMBLICA*).

Vegetation type	Area in ha A	Density per ha B	Production of fresh fruit		Total (ton) E = (B × D)/1000
			kg/tree C	kg/ha D	
Normal growth forest					
Evergreen	3 510	1.8	19.6	35.3	123.8
Deciduous	33 264	20.5	20.2	414.1	13 774.6
Stunted growth forest					
Shola	432	1.0	14.5	14.5	6.3
Scrub	15 228	2.5	14.4	36.0	548.2
(5 to <10 cm DBH)	15 228	81.5	1.7	138.6	2110.6
Sub-total	52 434*	21.5			16 563.5**
Estimated production					9938.1

* The remaining area of about 1566 ha is under savanna type vegetation, devoid of *P. emblica* trees.

** Using phenological data on *P. emblica*, it was found that only 60% of the trees fruit in any given year. Therefore, this value is multiplied by 0.6 to get a value of real productivity.

Indian Rupees (US \$1 = IRs 31.00, 1995 exchange rate). The maximum revenue that could have been generated (if Amla fruits were processed into pickle by a non-profit, in-house industry), was calculated by accounting for the costs which would be incurred in processing and packaging, and the likely price at which the final product would enter into the market.

RESULTS

FRUIT PRODUCTIVITY

Table 1 illustrates the wide variation in stand density of Amla trees ≥ 10 cm dbh among forest types; density is highest in deciduous forest and lowest in scrub forest. The difference between the two is approximately nine fold. In the scrub forest, trees with dbh between 5 and 10 cm fruit quite frequently. Though fruiting for trees <10 cm dbh occurs in other forest types, productivity is rather limited. Since trees of between 5 and 10 cm dbh form a significant part of the fruit production in scrub forest, they were included in estimates of productivity. The density in this class is potentially higher (81.5 trees/ha), than that of stems of ≥ 10 cm dbh class found in the other forests. The fact that 5–10 cm dbh size trees have higher fruit productivity in the scrub forest in comparison to other forest types may be due to the stunted growth and low stature of trees in the scrub forest.

The mean observed dbh of Amla trees does not differ significantly (t-test, $P > 0.05$) between deciduous (16.7) and evergreen (16.3), or scrub (12.9) and shola (13.0); the standard deviations of the mean values of dbh were also comparable.

The deciduous and evergreen forests exhibit high stature of the constituent trees, whereas scrub and shola are characterized by low stature. The dbh differed significantly between the "normal" and "stunted" forest types (t-test, $P < 0.01$).

Data on fruit productivity illustrate three important points. First, the dbh of the trees is positively correlated with fresh fruit productivity; larger dbh trees yield greater amounts of fruits (Fig. 1). This relationship is more pronounced for trees between 5 and 10 cm dbh (Fig. 1a) compared to trees ≥ 10 cm dbh (Fig. 1b). Second, the fruit yield per tree varies among forest types. The deciduous and evergreen forests yield significantly more fruits per tree (t-test, $P < 0.01$) than the scrub and shola forests of lower stature. However, within each growth type, yield per tree between the two forest types does not differ significantly (t-test, $P > 0.05$) (Table 1). Lastly, fruit yield per hectare, as a function of tree density/unit area and production potential of the average sized tree, is highest in deciduous forest and lowest in shola forest, the difference between the two being approximately 28 fold. On the whole, the average potential yield of fresh Amla fruits within the sanctuary is 189.5 kg/ha/year, the total for the whole sanctuary for 1992–1993 is estimated to be 9938 tons.

EXTRACTION LEVEL

The average amount of fruits collected by an extractor in 1992–1993 was 70 kg per day and the total number of days engaged in collection were 55. Approximately 325 extractors (7.5% of

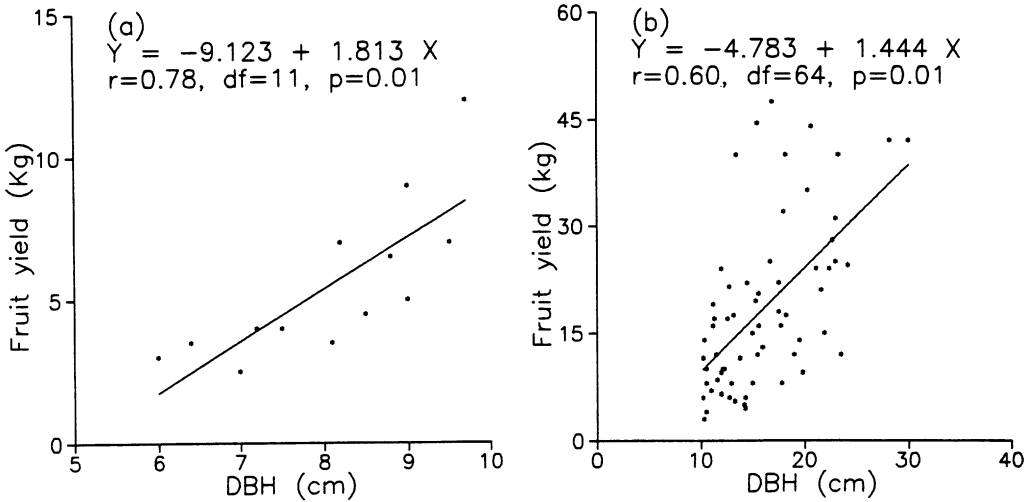


Fig. 1. Linear relationship indicating that Amla fruit yield can be estimated by the size of the tree in terms of diameter at breast height (dbh). (a) dbh class 5 to <10 cm, and (b) dbh class ≥10 cm.

the total population) were involved in collection. Thus, the total amount extracted was $70 \times 55 \times 325$ or 1,251,250 kg, or 1251.25 tons. This represents 13% of the total productivity. The LAMP records indicate that 544 tons of fruit were auctioned in 1992–1993. The discrepancy is due to the fact that we have directly estimated the amounts collected, whereas LAMPS figures represent the amount auctioned. The difference between the amount extracted and the amount auctioned could be accounted for by the amounts kept by the Soligas for their own consumption, underreporting by LAMPS agents at the time the fruits are weighed, losses due to spoilage between the time of collection and auction of the fruits, and rejection of diseased or low quality fruits by agents.

It is also important to note that extraction levels in recent years have been increasing (Fig. 2).

MARKET FLOW AND PRICE APPRECIATION

As mentioned earlier, Amla fruit is used for a wide variety of purposes. We do not know the relative amounts of fruits used for the various purposes, but our inquiries in the retail markets of surrounding towns indicate that a bulk of the Amla fruit from BR Hills is used for pickles. One kg of Amla pickle costs the processors Rs 8, but the price paid by the consumer is Rs 36. The extractor, however, obtains only Rs 1.5 of the final value of Rs 36 (Rs @ 31/ USA).

DISCUSSION

The fruits of the Amla tree play an important role in the cash economy of the Soligas. The LAMPS society records indicate that 70% of the households collected, on average, 1000 kg of Amla, realizing Rs 1500 as cash income from the Amla fruits. At the household level, this represents 11% of the total cash income of the Soligas (H. Sudarshan, pers. comm.). Clearly, Amla fruit constitutes a significant component of the household economy of the Soligas. Below, we first explore whether the harvest of Amla fruits is excessive or unsustainable and then consider alternative mechanisms to increase income from Amla while maintaining or reducing current levels of extraction.

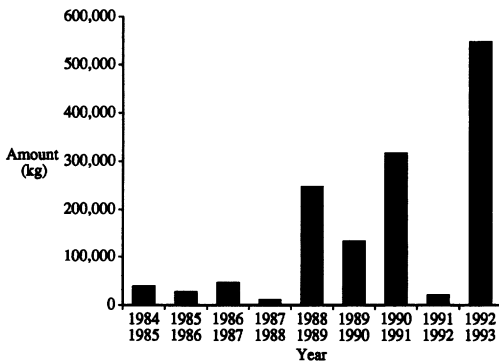


Fig. 2. Annual collection of Amla fruits by the LAMPS in B R Hills.

SUSTAINABILITY

Recently, Costanza and Daly (1992) classified natural capital into two groups: renewable natural capital, and nonrenewable natural capital. The former is active and self-maintaining. For example, ecosystems include a renewable natural capital that can be harvested repeatedly and regularly, if harvested prudently. On the other hand, nonrenewable natural capital, such as fossil fuel and mineral deposits, are passive.

Sustainable harvest of renewable natural capital like NTFPs can contribute to the economic well being of the forest people and involve them in conservation of biodiversity. Sustainable harvest is defined here as the level of harvest that does not impair the ability of the harvested population to replace itself (Hall and Bawa 1993). In a natural ecosystem, edible fruits serve as food for a variety of animals, some of which act as effective seed dispersers. Seed dispersal results in the maintenance of existing populations or stocks and in the colonization of new habitats. Also, in natural ecosystems, nutrients in the edible fruits are returned to the soil both through excreta and after the death of the consumers. However, with export of the fruits from the system, ecosystem functions such as nutrient cycling and soil fertility might be affected. Thus, sustainability for the whole system is difficult to define and ascertain.

Nevertheless, however we might define sustainability, we cannot address the issue of resource depletion without information about productivity and extraction levels. Our data suggests that approximately 13% of the fruits are harvested. We believe this estimate to be conservative with respect to productivity, because we have probably overestimated productivity and underestimated harvests. Although we have good data on the density of Amla trees in various types of forests, our figures for the area occupied by different types of vegetation is derived from Ramesh (1989). The total land area in the sanctuary is estimated to be 540 km² and, according to Ramesh, 520 km² are under different types of forests. In reality, however, the 'forested' area, because of the presence of an extensive network of roads and a large number of settlements, is considerably less than 540 km². If estimates of forested area were to be revised downward the estimated productivity would decline. In calculating extraction levels, we have

taken into account only the amounts harvested by the Soligas. Non-Soligas also extract Amla fruits, but the number of such persons or the amounts extracted are not known. Moreover, we have assumed that the fruits are harvested more or less evenly throughout the area. In fact, there is little evidence of uniform collections. More fruits are likely to be harvested from those areas where the species is abundant, that are closer to Soliga settlements and occupy gentle terrain. Thus the extraction levels in "source" populations (Pulliam 1988) may far exceed the average figure of 13%.

It is important to keep in mind that 13% harvest represents the fruits captured by human populations alone. In natural populations a large proportion of fruits are also removed by seed dispersal agents. Furthermore, up to 99% of the seed crop can be lost to pre- and post-dispersal seed predators (Janzen 1971). Thus, extraction by humans can push the seed banks below thresholds required to maintain populations. In an earlier paper (Murali et al. 1996) we have shown a deficiency of small size classes in population of Amla trees at the study site. We, of course, do not have direct evidence linking collection by humans to a deficit of small size classes, though studies are underway to determine the factors that regulate regeneration.

We can also examine the impact of extraction from historical records. The Working Plan Report of the then Chamarajanagar State Forest (Muthanna 1935) provides data on the population stock of Amla trees within deciduous forests in the five cbh (circumference at breast height) classes for the year 1931. Approximately 28 compartments in which the stock evaluation survey was conducted can be identified. The ten transects we established in 1992 were within the deciduous forest within seven compartments (Nos. 1 and 2 of Bedguli Felling Series, and Nos. 1, 2, 3, 6 and 7 of Gudi Felling Series). Therefore, we selected 1931 census data from only these seven compartments to analyze the changes in the population structure of Amla as a consequence of fruit harvest over last six decades. In the 1931 survey, which was primarily aimed at the estimation of workable timber stock in the forest, only those trees above 45 cm in cbh were counted and classified in five cbh classes: 45–90 cm, 90–135 cm, 135–180 cm, 180–225 cm and >225 cm. We censused all trees ≥ 10 cm dbh or about 30 cm cbh. Sampling

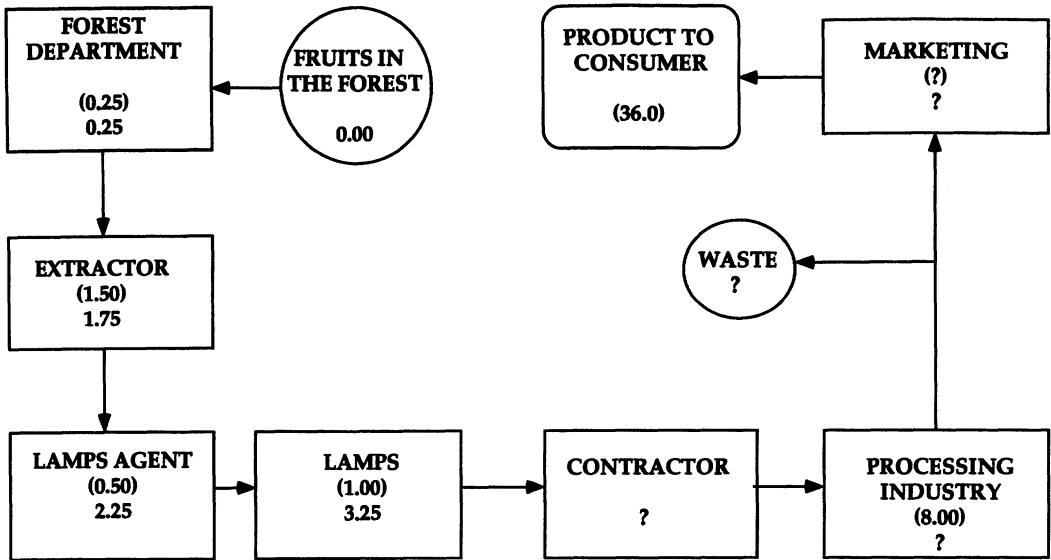


Fig. 3. The model depicting existing flow route of Amla fruits starting from the forest to the customer. The price added to the fruits at every step in the flow cycle is shown in parentheses; cumulative value at that step is shown outside parentheses.

intensity in 1931 was far greater than that in 1992; about 278 ha in 1931 vis-a-vis 10 ha in 1992. The comparison of the population structure of Amla between 1931 and 1992 shows that the density of trees ≥ 45 cm dbh in 1992 is less than one half the density for the two largest size classes for which data are available.

ENTERPRISE

Can the harvest levels be reduced and the income the Soligas derive from the extraction of Amla fruits raised? We believe the answer to the question is yes. The income of the Soligas could be raised several fold by introducing an enterprise component. With an increase in income, the quantity of Amla that are harvested can be reduced. To investigate this idea, we traced the market route of Amla fruits from collection to consumer, then developed a working model to illustrate how the enterprise component could be introduced and implemented. Though Amla fruits have several uses, we consider only one of the most important uses, the conversion of fruits to pickle.

In Fig. 3, we have identified the existing market flow of Amla fruits starting from the forest to the consumer. Each value added during the market flow was recorded. Consequently, a great deal of monopolizing by external agencies was

found. Though 1 kg Amla pickle costs the processors Rs 8, the final market value to the consumer is Rs 36, almost a four fold return. Unfortunately, only Rs 1.5 reaches the extractor in the way of cash income (Fig. 2). To remedy this highly self-depreciating situation, we suggest a model containing a non-profit, in-house cooperative processing industry.

The model (Fig. 4) is based on the assumption that harvested fruits can be processed into products that are in demand, such as pickles, jams etc., by employing the forest people in a non-profit, in-house industry. From there, the finished products can be sent directly to the market. The model shows that by enterprising fresh Amla from fruit to pickle, Rs 36 can be realized from the customer. The costs involved are as follows: Rs 0.25 for the Forest Department toll, Rs 8 for processing and packaging, Rs 6 for marketing, and Rs 1.75 for wastage in processing and maintenance within the industry, yielding a total wholesale cost of Rs 16 for the transformation of raw Amla fruit into marketable goods. Thus, the difference between the final cost (Rs 36) and the wholesale cost, including marketing and retail costs (Rs 16), generates a "net profit" of Rs 20 per kg of Amla pickle.

To promote "wild, edible fruit extraction" as a livelihood option for the forest dwellers, two

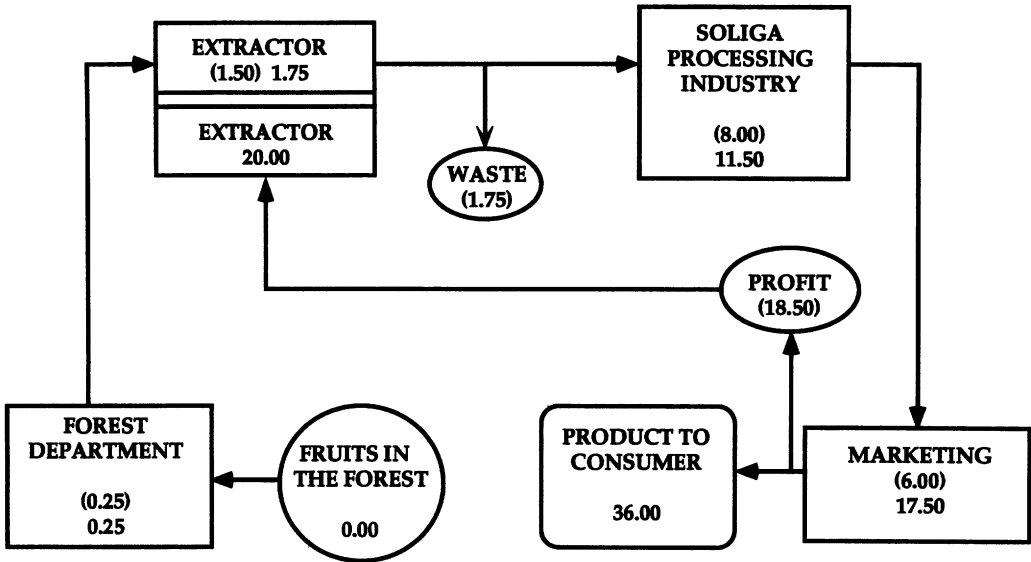


Fig. 4. The model depicting suggested flow route of Amla fruit starting from the forest to the customer. The price added to the fruits at every step in the flow cycle is shown in parentheses; cumulative value at that step is shown outside parentheses.

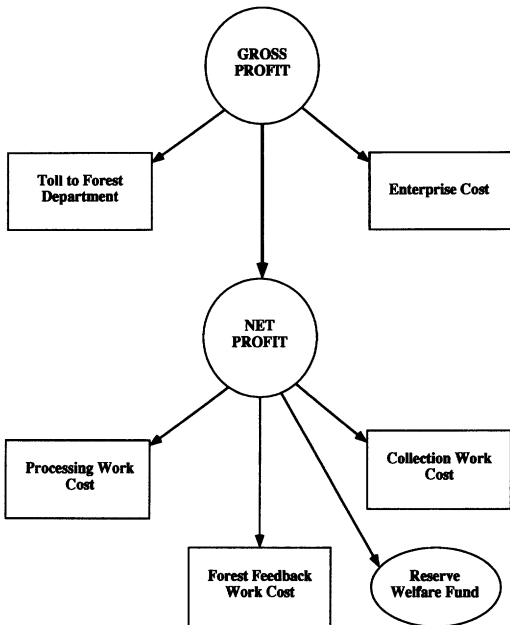


Fig. 5. The suggested model to show how the profit realized from Amla processing can be reaped by forest people.

points need to be stressed: 1) that maximum profit be realized by intact or processed fruit export and 2) the majority of profit reaches the forest people. However, in economic terms, the net profit cannot be taken as such because collection and processing labor costs, as well as forest feedback costs have not been taken into account. In fact, this is exactly where we wish to assert that, exclusive of these costs, "net profit" should be shared by the forest people in proportion to their investment of labor and skills in the enterprise.

The net profit could be channelled to the forest people at three different times in four different ways (Fig. 5). A part of the profit could be distributed to the people in proportion to the quantity of fruits collected weekly or monthly during the harvest season. A second portion of the profit could reach the forest people through their participation in the processing industry. A portion could be used for community welfare such as education or health. Finally, a small proportion should be allocated for silvicultural work, which we call "forest feedback." This work could involve forest regeneration by broadcasting unused seeds of Amla acquired during processing. The Amla harvest season ends during the transition between winter and spring. It is during this time that forest feedback

work can be started, to be continued through to the monsoon season. Silvicultural work, however, cannot be the entire responsibility of the Soligas: part of the toll collected by the Forest Department also should be invested in the management of the resource. Furthermore, although in Figs 3 and 4 we start with 0.00 in the central box, ecosystems incur costs when the fruits are produced and removed. A more realistic model should have a negative figure that becomes positive with the forest "feedback." Also, we have deliberately not assigned values to boxes in figure 4. These values should be worked out by the community itself.

Had the total harvest of Amla fruits, 544 tons in 1992–93, been enterprised a net revenue of Rs 10 880 000 could have been generated, translating into a revenue of Rs 2720 per capita, as compared to the current figure of Rs 204 per capita based on the realization of Rs 1.50 per kg of Amla. Given the family size of 4.5 individuals, a net annual income of Rs. 12 240 could be realized by every Soliga family, translating into a little more than Rs. 1000 per month. According to current market standards, this level of income is close to minimal wage for an individual. Of course, Amla is one of the many NTFPs extracted and, with value addition to other products, the income can be raised even further, and extraction levels reduced. It is worth noting that for the Amla enterprise, we are taking into account the extraction levels indicated by LAMPS records and not the actual amount collected.

The model proposed here for value addition is not an abstract idea. The model is being implemented by a non-government organization, Vivekananda Girigan Kalayna Kendra, representing the Soligas and located in the BRT sanctuary. Parallel to the enterprise component is an ecological monitoring component which is designed to monitor productivity and extraction levels and to evaluate the effects of different levels of harvest on regeneration and population growth rate of Amla trees. A socio-economic monitoring component will examine the impact of enhanced income on resource conservation and the lifestyle of the Soligas.

It is, of course, difficult to state at this stage if the enterprise will succeed. Success will require a greater control by the Soligas over the forest resources, an equitable flow of benefits from the enterprise, and adequate management of the resources by the major stakeholders.

These ingredients have been generally missing in commercial extraction of NTFPs and their absence has led to unsustainable extraction (Bawa and Gadgil 1996). There is no guarantee that the fate of NTFP resources will be different in the BR Hills.

ACKNOWLEDGMENTS

This paper represents contribution number 33 of a research program in Conservation of Biodiversity and the Environment jointly coordinated by the Tata Energy Research Institute and the University of Massachusetts at Boston. The program is supported in part by the MacArthur Foundation. Work on this manuscript has also been supported, in part, by a grant from the Biodiversity Conservation Network of the Biodiversity Support Program of the World Wildlife Fund. Our collaboration with the Vivekananda Girijana Kalyana Kendra, BR Hills, greatly facilitated the field work. The Secretaries of the LAMPS at BR Hills, Chamarajanagar and Hanur kindly provided access to their collection records. Many officials of the State Forest Department of Karnataka, especially A. N. Yellappa Reddy, S. N. Rai, S. M. Puttabudhi, and Sanjay Mohan not only provided access to the old forest records, but also shared their views from time to time. The guidance rendered by the two Soliga youths, Basava and Kumbha, during field surveys made this work possible. We also thank numerous forest people for interacting and appraising us of their invaluable knowledge about the forest. Joseph Rose offered comments on the manuscript, and assisted in the compilation of figures and tables.

LITERATURE CITED

- Bawa, K. S., and M. Gadgil.** 1997. Ecosystem services, subsistence economies and conservation of biodiversity. *In* G. Daily, ed., *Ecosystem services: their nature and value*. Island Press, Washington, DC. (in press).
- Browder, J. O.** 1992. Social and economic constraints on the development of market-oriented extractive reserves in Amazon rain forests. Pages 33–42 *in* D. C. Nepstad and S. Schwartzman, eds., *Non-timber products from tropical forests: evaluation of a conservation and development strategy*. *Advances in Economic Botany* 9. The New York Botanical Garden, Bronx, NY.
- Constanza, R., and H. Daly.** 1992. Natural capital and sustainable development. *Conservation Biology* 6:37–46.
- Godoy, R., and K. S. Bawa.** 1993. The economic value and sustainable harvest of plants and animals from the tropical rain forest: assumptions, hypotheses, and methods. *Economic Botany* 47:215–219.
- Hall, P., and K. S. Bawa.** 1993. Methods to assess the impact of extraction of non-timber forest products on plant populations. *Economic Botany* 47: 234–247.
- Hegde, R., S. Suryaprakash, L. Achoth, and K. S. Bawa.** 1996. Extraction of non-timber forest products in the forests of Biligiri Rangan Hills, India. 1. Contribution to rural income. *Economic Botany* 50:243–251.
- Homma, A. K. O.** 1992. The dynamics of extraction in Amazonia: a historical perspective. Pages 23–31 *in* D. C. Nepstad and S. Schwartzman, eds., *Non-timber products from tropical forests: evaluation of*

- a conservation and development strategy. *Advances in Economic Botany* 9. The New York Botanical Garden, Bronx, NY.
- Janzen, D. H.** 1971. Seed predation by animals. *Annual Review of Ecology and Systematics* 2:465–492.
- Krishnamurthy, T.** 1993. Minor forest products of India. Oxford & IBH Publishing Co., Pvt. Ltd.
- Murali, K. S., Uma Shankar, R. Uma Shaanker, K. N. Ganeshiah, and K. S. Bawa.** 1996. Extraction of non-timber forest products in the forests of Biligiri Rangan Hills, India. 2. Impact of NTFP extraction on regeneration, population structure, and species composition. *Economic Botany* 50:252–269.
- Muthanna, M. M.** 1935. Revised working plan report of the Chamarajanagar State Forest, Mysore district, Karnataka Forest Department, Mysore.
- Nepstad, D. C., I. F. Brown, L. Luz, A. Alechandra, and V. Viana.** 1992. Biotic impoverishment of Amazonian forests by tappers, loggers and cattle ranchers. Pages 1–14 in D. C. Nepstad and S. Schwartzman, eds., *Non-timber products from tropical forests: evaluation of a conservation and development strategy*. *Advances in Economic Botany* 9. The New York Botanical Garden, Bronx, NY.
- Pulliam, H. R.** 1988. Sources, sinks, and population regulation. *American Naturalist* 132:652–665.
- Ramesh, B. R.** 1989. Evergreen forests of the Biligirirangan Hills, South India. Doctorate Dissertation. French Institute, Pondicherry, India.

BOOK REVIEW

Evolution of Crop Plants. 2nd Ed. J. Smartt and N. W. Simmonds (eds.). 1995. Longman Scientific & Technical, Longman House, Burnt Mill, Harlow, Essex CM20 2JE, England, distributed in the USA by Wiley, 605 Third Avenue, New York, NY 10158. 531 pp. (hardcover). \$175.00. ISBN 0-582-08643-4.

My copy of Simmonds' first edition of *Evolution of Crop Plants*, published in 1976, has many underscored passages and numerous marginal notes—signs of a much used and valued book in my library. Thus I looked forward to seeing this new second edition with high expectations—some of which were fulfilled, others of which were not.

The application of molecular techniques and phylogenetic analysis has revived the study of the evolution of crops in recent years. Many chapters, such as those on cotton and maize, incorporate some of these recent findings, but many others (e.g., wheat) do not. There is not a single cladogram to be found in the entire volume; this is not necessarily bad, given the complex reticulate evolution of most major crops. The chapter format used in the first edition—Introduction; Cytotaxonomic Background; Early History; Recent History; Prospects—is retained in this new book, and this format may have discouraged the incorporation of some new information. There is only brief discussion of the potential for production of transgenic rapeseed

crops, an area of intensive research and development in both the public and private sectors.

Some of the crop treatments have been expanded and extensively rewritten, including those for sweet potato, the cucurbit crops, sorghum, soybean, and cotton. The chapter on temperate forage grasses provides a thoughtful discussion on improving germplasm in a changing world. Other chapters have changed very little, such as those for kapok, safflower, the mustard crops, rubber, and oats, although all chapters contain at least a few citations to literature published since the first edition. The second edition contains more chapters but fewer treatments than the first. Chapters on tung, castor, flax, breadfruit, cola, mango, papaya, the aroids, and pyrethrum have been dropped. Simmonds included a section at the end of the first edition with synopses for about 80 minor crops. About a quarter of these minor crops are now included in new or expanded chapters, but the other three quarters also have been dropped.

Like the first edition this new book does provide a wealth of information and anyone teaching an economic botany class, or even most introductory botany courses, will find it to be an extremely valuable reference. The high price is discouraging, especially considering that much of the material has been carried over from the first edition.

STEVEN P. McLAUGHLIN
OFFICE OF ARID LANDS STUDIES
THE UNIVERSITY OF ARIZONA
TUCSON, AZ 85721