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ECOLOGY AND ECONOMICS OF DOMESTICATION OF NON-TIMBER FOREST PRODUCTS: AN ILLUSTRATION OF BROOMGRASS IN DARJEELING HIMALAYA

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UMA SHANKAR, LAMA, S. D. & BAWA, K. S. 2001. Ecology and economics of domestication of non-timber forest products: an illustration of broomgrass in Darjeeling Himalaya. Extraction of non-timber forest products (NTFPs) is an effective conservation strategy to safeguard biological diversity while enhancing rural income. However, excessive harvests may lead to the extinction of species populations or alternatively domestication by the rural people. Domestication is likely to be facilitated if the species is adaptable, market demand is greater than the production in natural populations, profitability from cultivation is high, and there are not many job opportunities or sufficient agricultural landholding with the forest dwellers. Owing to these circumstances, amliso, a broomgrass (*Thysanolaena maxima*), has been domesticated in Darjeeling Himalaya during the last three decades. Amliso promotes a sustainable use of fragile and easily degradable lands, provides fuelwood and fodder during lean periods and generates income from its infructescence, commonly used as broomstick. An amliso plantation has a cycle of about six years in which five annual harvests are taken. Broomstick yield in terms of number of culms, dry matter and length of culms rises up to the third harvest and declines thereafter. A six-year plantation cycle (five harvests) can generate a net revenue of US$ 3374 ha^{-1} against a total investment of US$ 1995 ha^{-1}, a return nearly 1.7 times the investment cost. Human labour accounts for 62% of the total investment. Thus, if the cultivator is self-employed as a labourer, the return goes up to 4.4 times the initial investment. The value addition pattern

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during movement and processing of broomstick indicates that nearly 35% of the final value realised from the customer reaches the cultivator. We show that this proportion can be raised to 52.5% if the cultivators process broomstick into brooms at the source.

Key words: Non-timber forest products - amliso - broomstick - *Thysanolaena maxima* - domestication - biodiversity - Darjeeling - Himalaya - India

UMA SHANKAR, LAMA, S. D. & BAWA, K. S. 2001. Ekologi dan ekonomi bagi pendomestikan hasil hutan bukan balak: satu ilustrasi bagi sejenis belukar (broomgrass) di Darjeeling Himalaya. Pengekstrakan hasil hutan bukan balak (NTFPs) merupakan strategi pemuliharaan yang berkesan untuk melindungi kepelbagaian biologi di samping meningkatkan pendapatan penduduk luar bandar. Bagaimanapun, penebangan secara besar-besaran akan menyebabkan kepupusan populasi spesies atau secara alternatif pendomestikan oleh penduduk luar bandar. Pendomestikan mungkin akan diberi bantuan sekiranya spesies tersebut boleh diubahsuai, permintaan pasaran lebih tinggi daripada pengeluaran dalam populasi semula jadi, keuntungan daripada penebangan adalah tinggi, dan tidak banyak peluang pekerjaan dan pemilikan tanah pertanian yang mencukupi untuk penduduk di hutan tersebut. Disebabkan oleh keadaan ini, amliso, sejenis belukar (broomgrass) (*Thysanolaena maxima*), telah didomestikasi di Darjeeling Himalaya pada tiga dekad yang lalu. Amliso menggalakkan penggunaan secara berterusan tanah yang lembut dan tanah yang mudah usang, menyediakan kayu api dan rumput ragut pada masa susah dan menjana pendapatan daripada buahnya yang selalunya digunakan untuk membuat batang penyapu. Sebuah ladang amliso mempunyai kitaran kira-kira enam tahun dengan lima kali penuaian tahunan. Hasil batang penyapu dari segi bilangan batang, bahan kering dan panjang batang meningkat sehingga kepada penuaian yang ketiga, dan kemudian merosot. Kitaran ladang enam tahun (lima penuaian) dapat menjana pendapatan bersih sebanyak US$ 3374 ha^{-1} berbanding dengan jumlah pelaburan sebanyak US$ 1995 ha^{-1}, pulangan hampir 1.7 kali kos pelaburan. Upah buruh ialah 62% daripada jumlah pelaburan. Oleh itu, jika penuai bekerja sendiri sebagai buruh, pulangan akan naik sehingga 4.4 kali pelaburan awal. Corak penambahan nilai semasa pemprosesan batang penyapu menunjukkan bahawa hampir-hampir 35% daripada nilai akhir yang diperoleh daripada pelanggan dapat dikecapi oleh penuai. Kami menunjukkan bahawa bahagian ini dapat ditingkatkan kepada 52.5% sekiranya penuai memproses batang penyapu kepada penyapu daripada sumbernya.

Introduction

Non-timber forest products (NTFPs) in recent years have assumed unusual significance as a means to enhance rural income and to conserve biodiversity in tropical regions (May 1991, Gillis 1992, Ros-Tonen *et al.* 1995, Bawa & Gadgil 1997, Hegde *et al.* 1996, Uma Shankar *et al.* 1996). A vital reason has been the renewable nature of NTFPs. The common hypothesis is that the NTFPs can be culled or harvested on sustained-yield basis from year to year for many years without threatening the survival of associate species. There are, however, many instances of over-exploitation of NTFP species with adverse effects on regeneration (Daniels *et al.* 1995, Murali *et al.* 1996, Ganeshaiah *et al.* 1998, Uma Shankar *et al.* 1998a,b). In general, excessive harvests of NTFPs may lead to the extinction of local populations or domestication of the species involved (Godoy & Bawa 1993). Only a small, unknown fraction of the species that face depletion of their natural populations has been domesticated. The conditions under which domestication occurs have generally not been explored (Homma 1992). Domestication of NTFPs is probably influenced by a number of factors that vary from one site to the other and over time. Both biological and socio-economic factors may inhibit or favour domestication.

Domestication of plant species began about 10 000 years ago and the earliest domesticated species were food plants (Homma 1992). Of an estimated total of 320 000 vascular plants (511 families), about 3000 (173 families) are regularly exploited for food (Hawksworth & Kalin-Arroyo 1995). Most of these (2500) are domesticated and only 20 are of major importance (NRC 1982, Ford-Lloyd & Jackson 1986). Despite relatively large numbers of plant domesticates, over 90% of the food supply comes from only 103 species (Prescott-Allen & Prescott-Allen 1990). A few fibre producing plants (cotton, hemp, flax and jute) rank next to food producing domesticates. Interestingly, of 25 000 plant species used for medicinal purposes, only a few are grown as crops (Akerele *et al.* 1991). Major domestication of food, fibre and medicinal plants had occurred by the nineteenth century.

Domestication of timber and non-timber forest species (other than food and fibre) is a recent phenomenon. Timber species such as *Tectona grandis, Shorea robusta* and *Pinus* spp. were domesticated in India in the late nineteenth century. The cultivation of NTFP species began largely in the twentieth century, when natural populations of these species had been decreased by clearfelling for land and timber, and the demand expanded in proportion to increasing human numbers. Several NTFP species have been domesticated, but remain largely undocumented.

Thysanolaena maxima, a broomgrass locally called as amliso in Nepalese, is an important NTFP species in northeastern India. The species is not only harvested from the wild, but has been cultivated recently in Darjeeling Himalaya. There are several ecological and economic considerations for which an understanding of amliso cultivation deserves attention. Ecologically, it promotes a more sustainable use of fragile and easily degradable lands. And economically, it has an important role to play in rural, urban and national economies. To the rural societies, it provides fuelwood and fodder during lean periods and generates income through the sale of infructescences that form a valuable base material for brooms. A sizeable labour force gets employment as the broom industry spreads into several towns. Broom export earns significant foreign exchange for the nation.

Our objective in this paper is to investigate the biological and socio-economic factors that trigger the domestication of NTFPs with particular reference to amliso, and discuss the implications of domestication of NTFPs on deforestation and biodiversity loss. Specifically, we hypothesise that the domestication of NTFPs is stimulated by 1) the adaptability of the species to newer and relatively inhospitable habitats and availability of land; 2) optimum yield in space (per unit area), and time (per rotation); 3) high profitability; 4) increasing and persisting market demand; and 5) lack of alternate job opportunities.

Material and methods

The species

Thysanolaena maxima (Roxb.) Kuntze (Syn. *T. agrostis* Nees and *T. acarifera* Nees & Arnott, Poaceae) is popularly known as 'amliso' in Nepalese, and as 'tigergrass', 'broomgrass' or 'bouquetgrass' in English (Anonymous 1949). Amliso is distributed throughout northeastern India, Sikkim, Darjeeling and Jalpaiguri districts of West Bengal, Bihar, Andaman and Nicobar Islands, Bhutan, Burma, Nepal and New Guinea (Palni *et al.* 1994). It ascends generally up to 2000 m. The grass successfully grows in a wide array of habitats such as shady slopes, canopy gaps, damp and steep banks along ravines and water courses, mature thinned plantations, completely open areas including old landslips and weed infested slopes along the roads, and even in gravelly soil and weathered rock surfaces.

Amliso is immensely important both ecologically and economically for the hill dwellers. It plays a pivotal role in the household economy of rural communities. Amliso is a multipurpose species with its infructescence (panicle) used for tying brooms, leaves and tender shoots for forage, and woody stem for fuel, paper pulp, reed-pens, mulch material and support sticks in crop fields for peas, beans and other trailing crops. The root-mat effectively protects topsoil and nutrients from erosion on sloping terrain and landslide-affected areas. The roots have also been claimed to have useful medicinal properties. Nepalese in Darjeeling (Palni *et el.* 1994) and the tribes of Chhota Nagpur (Kirtikar & Basu 1935) use a decoction of roots as a mouth wash during fever. A paste of dried or fresh roots is applied on the skin to check boils (Rai & Sharma 1994). The forage is believed to reduce the incidence of liver fluke in the cattle (Lachungpa 1998).

The inflorescence of amliso is a large panicle, soft and glabrous with numerous branches (Kirtikar & Basu 1935). The infructescence, commonly known as broomstick, has long been used for soft-brooming the house in those ecological zones where the grass grows naturally. Of late, particularly after Indian independence in 1947, amliso brooms started gaining popularity in distant plains where it did not grow. Currently, the amliso broom is in demand not only within the country but also abroad, particularly in the Middle East. The infructescence of amliso is appreciated as a broom for its peculiar morphological and anatomical properties. The fox-tail like panicle is quite long (80–150 cm), dense, soft and pliable. A fresh broom drops behind floral parts such as palea, lemma, glumes and grains on the floor during the first 3–4 sweepings. However, the broom is considered fit once all these floral parts have dropped. The broom can sweep wooden, stone and mosaic floors, and even carpets. The amliso broom is considered superior to those made from *Cocos nucifera, Phragmites* spp. and *Saccharum* spp.

The leaves are very large, coriaceous, linear-lanceolate (30–60 × 5–10 cm) tapering to a fine point, many veined, base cordate, sheaths glabrous, striate, with a resemblance to those of bamboo (Kirtikar & Basu 1935). The leaf and tender shoot provide good quality fodder for cattle. The chemical composition of leaf and tender shoot is shown in Table 1. The importance of amliso as fodder lies in the fact that its leaves stay green long after flowering in November when the monsoon season has ended, other fodder grasses are withered and green forage is exhausted for livestock feeding. Amliso continues to stay green until March when new growth resumes with spring showers. Thus amliso serves as an invaluable green fodder for lean periods in the hills of Darjeeling. Feeding trials with amliso on Assamese bullocks showed the positive balances for calcium, phosphorus and nitrogen (Anonymous 1949, and references therein).

Amliso regenerates through one-seeded grains under natural conditions. On crop maturity in February–March, the infructescence withers and fruits detach and disperse passively. The grains are extremely light in weight and thereby easily disseminated to far distances even by gentle wind. Fruit dispersal is further effected by water in moister conditions. The seeds germinate in the beginning of ensuing rainy season that starts in April–May. The early development of the seedling is favoured on loose and exposed substratum such as landslide, rock outcrops, and freshly disturbed soil where light interception is good. However, seeds may also germinate under dense canopy, particularly moss layer. Systematic data on percentage of seed germination and early seedling mortality under natural conditions are not available. It is also not clear whether damage from fire or drought proves fatal to the seeds and young seedlings. The natural regeneration of amliso is seriously impeded due to biotic pressures in at least two ways: a) greater seedling mortality owing to grazing, and b) depletion of the seed bank. On gentle and easily accessible terrain, the young amliso seedlings often are grazed owing to good fodder value. The closure of such naturally regenerating areas may thus yield strikingly beneficial results. Large-scale collection of the panicle for brooms impoverishes the soil seed bank. The panicle is hand-pulled when mature and green, i.e. prior to the senescence and dispersal of fruits. The seeds thereby face permanent off-site loss.

Table 1. Chemical characteristics of amliso at pre-flowering stage as compiled from various sources

Parameter (%)	Palni *et al.* (1994)	Singh *et al.* (1989)	Anonymous (1949)
Digestibility	57.9	-	-
Insoluble ash in dry matter	11.8	3.7	-
Ether extract	6.67	-	5.55
Nitrogen-free extract	33.1	-	42.8
Crude protein	18.1	6.6	9.5
Crude fibre	30.4	30.8	30.4
Total carbohydrates	63.5	-	-
Cellulose	30.2	-	-
Hemicellulose	29.6	-	-
Lignin	9.1	-	-
Calcium	-	0.82	0.23
Phosphorus	-	0.40	0.11

Amliso can be propagated artificially through seeds, slips (underground stem with buds) and wild seedling transplant. The nursery technology is not well developed. Grains can be collected from senescing panicles in March. Although it is not clear how long the viability of seeds lasts, preliminary trials by some foresters have shown that the grains should be broadcast-sown in shaded nursery beds soon after collection. About 10 g grains would suffice for a 4 × 1 m bed. The soil in a nursery bed should be thoroughly pulverised, freed from all root material, weeds and gravel and supplied with adequate quantities of farmyard manure. Germination commences within one month after sowing. Irrigation and weeding are required for optimum growth of seedlings. The seedlings become ready for transfer into another nursery bed about three months after sowing, i.e. at the onset of the monsoon in June. The minimum spacing now should be kept as 10 × 10 cm. The seedlings are allowed to grow in the bed for one year with necessary irrigation and weeding. At the onset of the ensuing monsoon, individuals can be transplanted into the field.

In most cases, amliso is propagated through slips. The field is cleaned in March and slash is burnt in the first week of April. Staking is done at 1.5 × 1.5 m, resulting in 4444 pits ha^{-1}. A pit measures about 25 cm in diameter and 30 cm in depth. The soil is piled along the side of the pit. After six weeks of weathering, the soil is mixed and returned to the pit. Nearly 200 g of decomposed cowdung is applied in each pit. The slips are obtained from old plantations or forests and planted during the third or fourth week of June. A slip with 4–5 buds is planted in a single pit. Several culms sprout from each node resulting into a clump of culms from every pit.

Under circumstances when a villager misses the opportunity to propagate slips, wild seedling transplant is opted for. The wild seedlings are procured from the forest in late June or early July. Protection from desiccation during transfer is of paramount importance. For this reason, seedling collection is done on a rainy or humid day, the root system is covered with a small ball of earth, and the transplant is accomplished on the same day of collection.

Maintenance requires two weedings every year. In the year of planting, flowering is negligible and hence there is no production of panicles for brooms. Notwithstanding, fodder is available on crop maturity. From the second year onwards, leaves are harvested for fodder once in the monsoon (August). The final harvest is done between January and March. The panicle is hand-pulled and air-dried. The culms are cut at 5–10 cm above the ground level. The culms are separated into leaves and tender shoots for fodder and the woody stem for fuel. Where fuelwood is in abundance, the stem is left in the field for decomposition. Fertilisation of amliso is now gaining popularity. Villagers apply *c.* 200 g of decomposed cowdung annually to each clump. Application of inorganic fertilisers is still unknown.

Caution in panicle harvest is necessary for maximum returns. If panicles are harvested prematurely (5–7 days in advance), the production declines dramatically. Similarly, if harvest is delayed, senescing occurs. When senescent, panicles show a deep brown colour, lose flexibility, and are discarded in the market.

Study site

We carried out this study in Karmat village of Darjeeling district in West Bengal (Figure 1). Karmat is located at 600–700 m altitude, 26°56' N and 88° 26' E. The average annual rainfall at Latpanchar Cinchona Garden (*c.* 3 km aerial distance) is 4275 ± 518 mm (n=3 years, 1991 to 1993), with 95% falling in the monsoon (May to September), 4.3% in winter (October to February) and 0.7% in summer (March to April).

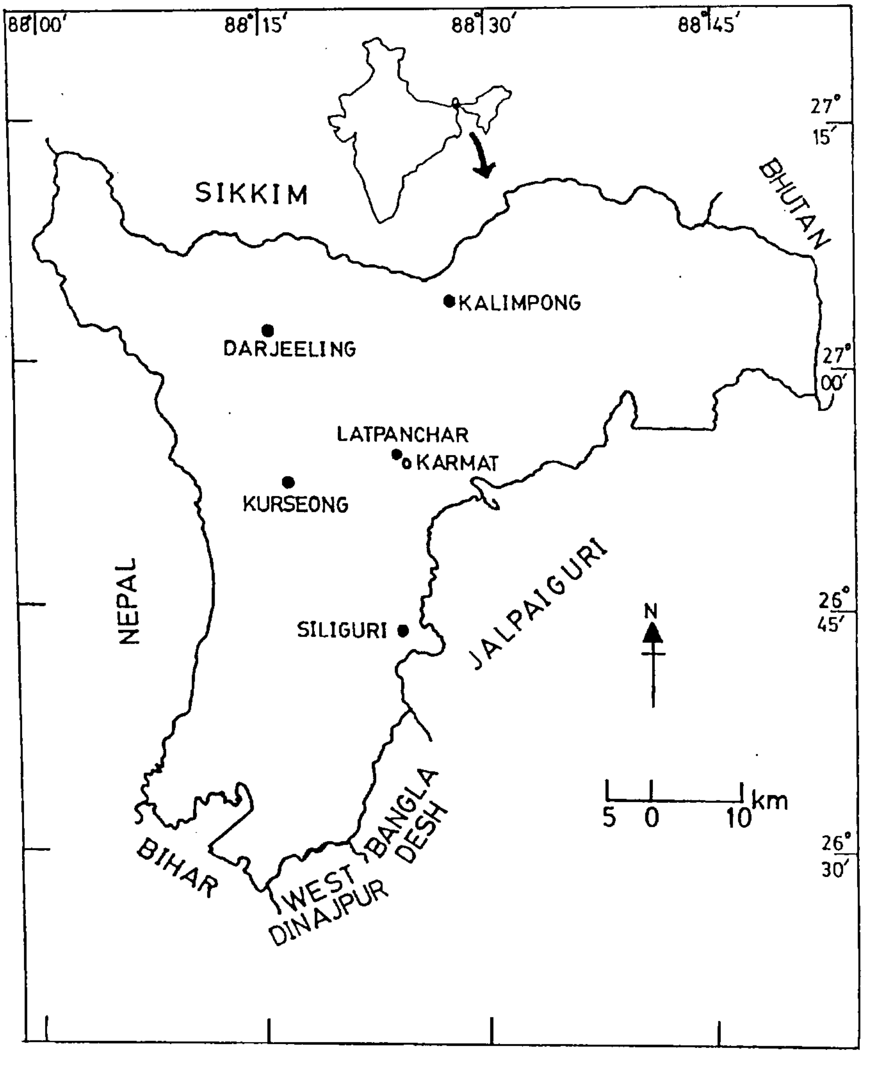

Figure 1. Geographical location of Karmat in Darjeeling district

Data collection

Data on phytosociology and dry matter yield of amliso were recorded in three economically important above-ground vegetation compartments, viz. panicle, leaves and tender shoots, and woody stem from an age series of plantations. Five amliso plantations created respectively in 1989, 1990, 1991, 1992 and 1993 were selected within a 1 km distance of Karmat village. The ages of these plantations in January 1995 thus count as 5.5, 4.5, 3.5, 2.5 and 1.5 y respectively, meaning that these plantations had undergone 4, 3, 2, 1 and 0 annual harvests before January 1995. All these plantations were propagated from slips, not supplied with fertiliser, and located on well-drained soil under good light interception (70–90%). Slope was gentle to moderate, but steep in the 1991 plantation. In general, soil structure in the 1989 and 1990 plantations was inferior to that in the other three plantations (Table 2).

Table 2. Micro-environmental characteristics of five amliso plantations in Karmat village

Parameter	Year of planting				
	1993	1992	1991	1990	1989
Microhabitat	Saddle slope	Saddle slope	Open blank	Roadside landslip	Roadside landslip
Slope	Gentle (20°)	Gentle (20°)	Steep (40°)	Moderate (30°)	Moderate (35°)
Light interception (%)	70	70	70	80–90	80–90
Soil substratum	Fine	Fine	Gravelly	Stony	Stony
Drainage	Fair	Fair	Good	Good	Good
Organic matter accumulation	Fair	Fair	Fair	Poor	Poor
Soil moisture in dry season	Fair	Fair	Fair	Poor	Poor
Ground flora	Fair	Fair	Poor	Poor	Poor
Tree growth	Fair	Fair	Fair	Poor	Poor

Amliso is a clump or tussock-forming grass. A clump has 20 to 50 culms with a maximum height of 2.5 m at maturity. Only some culms flower and produce infructescence in a clump. The non-flowering culms may not attain a stem height equal to the flowering culms. Thus the culms in each clump may be classified into three categories: flowering culms (bearing panicles), non-flowering culms (with a stem height close to the flowering culms) and small culms (with less than half of the height of mature culms).

Five plots of 5 × 5 m size were laid out in each plantation at crop maturity. All the clumps in each plot were counted, marked and mapped. The culms in the three categories were counted. The harvest was done in two phases. First, the panicle was hand-pulled from the flowering culms. Later, all the culms in each clump were cut at 8 cm above the ground level and separated into fodder (leaf and tender shoot) and fuel (woody stem). Fresh weights were measured immediately after the harvest. A subsample of about 1 kg was taken from each of the three compartments in five replicates for moisture determination after air-drying and oven-drying to introduce corrections for weight measurements.

Data on market demand and supply patterns of broomstick were collected from the State Forest Department. The broomstick quantities emerging from the area were recorded in a transit pass register. The daily entries from these registers were noted for 1991, 1992, 1994 and 1995; the entries for 1993 were partly missing, thus excluded. The forest department records broomstick quantities in 'bundles'. A bundle weighs approximately 50 kg and by taking this into account, we converted quantities into kilograms. As a precaution, we emphasise that the broomstick supply figures should be used to depict trends rather than absolute quantities.

Results and discussion

Phytosociology and productivity

The total number of culms (Figure 2a) and flowering culms (Figure 2b) increased with age up to 3.5 y and declined thereafter in the 4.5- to 5.5-y plantations. The average length of panicle or broomstick at harvest also varied with the age of the plantation. It increased up to 3.5 y and declined marginally in the 5.5-y plantation (Figure 2c).

Total above-ground dry matter production was 5.4 t ha^{-1} in the 1.5-y plantation, which nearly doubled in the 2.5-y (10.4 t ha^{-1}) and 3.5-y (9.9 t ha^{-1}) plantations (Figure 2d). The dry matter production declined with further increase in age. Of the total above-ground production, 10.6 to 12.1% was apportioned to panicle, 48.5 to 61.4% to leaf and tender shoot, and 26.8 to 40.8% to stem in the different plantation ages. The broomstick productivity was 0.65 t ha^{-1} in the 1.5-y plantation increasing with age to 1.1 t ha^{-1} in the 2.5-y and 1.49 t ha^{-1} in the 3.5-y plantations (Figure 2e). With further aging, it declined rapidly to 0.85 t ha^{-1} in the 4.5-y and 0.57 t ha^{-1} in the 5.5-y plantations.

An upward trend of dry matter production with plantation age is directly linked to the concomitant increase in production of culms. Similarly, the increase in broomstick production is associated with the number of flowering culms. These trends, however, are not sustained beyond 3.5 y of plantation age. The most probable cause appears to be the competition for underground space due to overcrowding of aged stems, which restricts the production of newer culms. Systematic studies on dry matter yield of amliso are few and far in between (Gangwar & Ramakrishnan 1989, Singh *et al.* 1989, M. A. Sultan, pers. comm.).

Singh *et al.* (1989) planted amliso from slips at 50 x 20 cm spacing and fertilised with 100 kg N ha^{-1} y^{-1} to get an above-ground dry matter production of 29 t ha^{-1} after 1.5 y, of which 7.78 t ha^{-1} was broomstick. Our figures for 1.5 y plantation are only 18.6% for total dry matter yield and 8.3% for broomstick of those of Singh *et al.* (1989). Although fertiliser application coupled with narrow interplanting space could have triggered the yield, Singh *et al.*'s (1989) estimates sound exceptionally high. If they expressed values on air-dry weight basis, which is most likely, the broomstick production corrected to oven-dry weight could easily come down by 40–60 per cent. The forest department study which represents merely estimates based on crude measurements, recorded an increase in broomstick productivity with plantation age as follows: 250 kg ha^{-1} in 1.5 y, 375 kg ha^{-1} in 2.5 y and 750 kg ha^{-1} in 3.5 and 4.5 y. Our results are in close conformity with those of Gangwar and Ramakrishnan (1989) who in a seven-year rotation cycle near Cherrapunji recorded broomstick production increasing up to the third harvest and stabilising subsequently up to the final harvest.

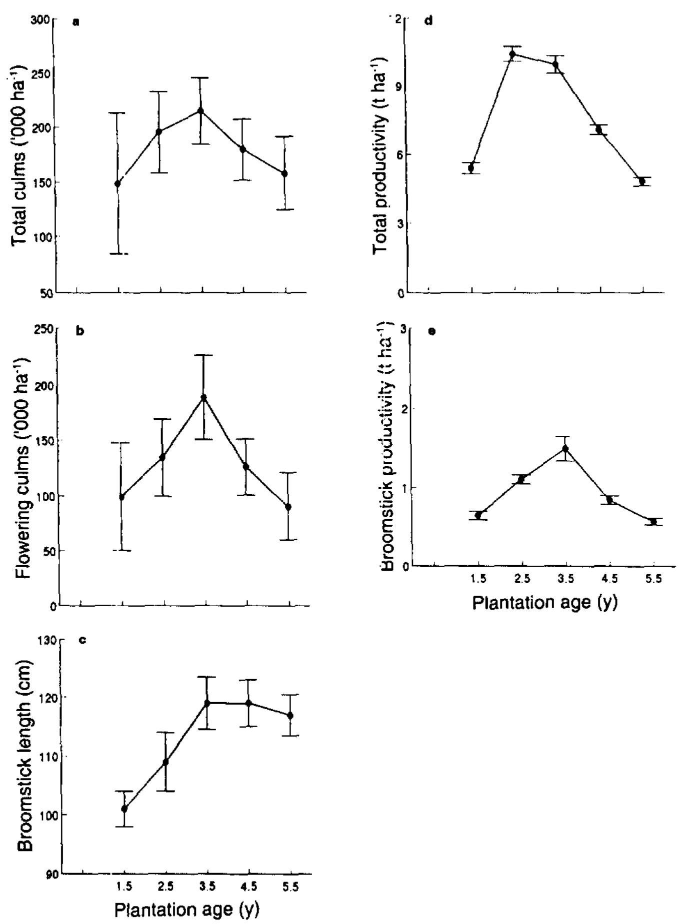

Figure 2. Relationship of various growth parameters with plantation age

The above mentioned productivity patterns help the villagers to decide to abandon an amliso plantation after the fourth or fifth harvest and raise a thoroughly new plantation. Most of the villagers verified that they take five crops from an amliso plantation in one cycle.

Plantation economics

The cost of raising a new amliso plantation and maintaining it for several years, and the fiscal return from this venture are the primary concern of a cultivator. The per hectare input required for performing various operations in establishing a plantation was worked out in terms of labour (man-days), currency (US Dollar) and the quantities of materials. Our emphasis was to calculate input costs maximally and returns minimally to arrive at a realistic profit margin.

Fiscal 1995 was considered the seed year. The total cost in the first year amounts to US$ 320.20 ha^{-1}, of which about 58% is in 140 man-days of labour (Table 3). Although none of the plantations studied here was supplied with farmyard manure (FYM), a provision for it was kept in the economic assessment.

Table 3. Estimated input cost in labour, material supplies, protection and land rent for performing various operations in raising and maintaining an amliso plantation for six years

	Month	Man-days (ha^{-1})	Unit rate (US$ d^{-1})	Cost (US$ ha^{-1})
I. LABOUR				
First Year (1995)				
Site cleaning	April	20	1.33	26.60
Staking at 1.5 × 1.5 m (total 4400)	May	12	1.33	15.96
Pit digging (25 × 25 × 30 cm each)	May	22	1.33	29.26
Manuring and earth filling	June	22	1.33	29.26
Propagule collection from forest	June	22	1.33	29.26
Planting the propagules	June	22	1.33	29.26
Weeding (2 times)	Jul, Sept.	20	1.33	26.60
Second year (1996)				
Manuring	May	22	1.38	30.36
Weeding (2 times)	Jul, Sept.	20	1.38	27.60
Harvesting broomstick	Jan '97	16	1.58	24.32
Harvesting leaf and shoot	Jan '97	16	1.38	22.08
Third year (1997)				
Manuring	May	22	1.43	31.46
Weeding (2 times)	Jul, Sept.	20	1.43	28.60
Harvesting broomstick	Jan '98	16	1.57	25.12
Harvesting leaf and shoot	Jan '98	16	1.43	22.88
Fourth year (1998)				
Manuring	May	22	1.49	32.78
Weeding (2 times)	Jul, Sept.	20	1.49	29.80
Harvesting broomstick	Jan '99	16	1.64	26.24
Harvesting leaf and shoot	Jan '99	16	1.49	23.84

continued

Table 3 (continued)

Fifth year (1999)				
Manuring	May	22	1.54	33.88
Weeding (2 times)	Jul, Sept.	20	1.54	30.80
Harvesting broomstick	Jan '00	16	1.69	27.04
Harvesting leaf and shoot	Jan '00	16	1.54	24.64
Sixth year (2000)				
Manuring	May	22	1.60	35.20
Weeding (2 times)	Jul, Sept.	20	1.60	32.00
Harvesting broomstick	Jan '01	16	1.76	28.16
Harvesting leaf and shoot	Jan '01	16	1.60	25.60
II. SUPPLIES				
Bamboo for staking	1st year	20 Nos.	0.50**	10.00
Farmyard manure	1st year	900 kg	27.00*	24.00
Farmyard manure	2nd year	450 kg	28.01*	12.60
Farmyard manure	3rd year	450 kg	29.06*	13.08
Farmyard manure	4th year	450 kg	30.15*	13.57
Farmyard manure	5th year	450 kg	31.28*	14.08
Farmyard manure	6th year	450 kg	32.46*	14.61
III. PROTECTION				
Safeguarding	2nd year	90	1.00	90.00
Safeguarding	3rd year	90	1.04	93.38
Safeguarding	4th year	90	1.08	96.88
Safeguarding	5th year	90	1.12	100.51
Safeguarding	6th year	90	1.16	104.28
IV. LAND RENT				
Opportunity cost of the land	1st year	1 ha	100.00#	100.00
Opportunity cost of the land	2nd year	1 ha	103.75#	103.75
Opportunity cost of the land	3rd year	1 ha	107.64#	107.64
Opportunity cost of the land	4th year	1 ha	111.68#	111.68
Opportunity cost of the land	5th year	1 ha	115.87#	115.87
Opportunity cost of the land	6th year	1 ha	120.21#	120.21
Total				1994.74

**rate per bamboo; *rate per 1000 kg; #rate per year.

Maintenance of the plantations in subsequent years requires only 74 man-days ha^{-1} for manuring, weeding and harvesting to cost US$ 310.71 in the second, 322.16 in the third, 324.79 in the fourth, 336.82 in the fifth, and 360.06 in the sixth years (Table 3). An inflation of 3.75% was considered after studying the performance of the Indian rupee relative to the dollar. The labour for harvesting broomstick is marginally higher (10%) than the normal to include incidental expenses, since workers for harvesting are called from adjoining villages.

Most of the cultivation occurs on marginal lands that are unfit for agriculture or other economic use. These lands may be either State-owned or private. Even if cultivation is done on the former, villagers do not pay any royalty for it. However, we consider an opportunity cost of land as US$ 100 ha^{-1} for 1995 that would rise annually by 3.75% due to inflation. This is based on the current lease price in the village for uncultivable land. Fencing is avoided to reduce investment and cattle are discouraged from grazing in and around plantations. The plantations are watched to safeguard against cattle during the flowering and fruiting period (November–January). The sum of all the expenditures in raising and maintaining an amliso plantation for six years would thus be US$ 1994.74 with 61.85% in labour, 33.04% in land rental, and the balance in material inputs.

Amliso yields fiscal return through three biomass compartments, viz. broomstick, leaf and tender shoot, and woody stem (Table 4). For calculating fiscal return, productivity, as observed in Figure 2, was taken into account. The selling rate of broomstick by the cultivators was estimated following market trend in 1996. The selling rate varies greatly with the quality of broomstick, time of harvest, individual's bargaining skill, and among localities. Here, we consider an average selling rate of US$ 466.67 t^{-1} for 1996 and expect an increase by 3.75% due to inflation. Leaf and tender shoot are not saleable items and are fed to the cattle in households. However, their price has been determined by inquiring "willingness to pay" in needy times. The price of woody stem has been taken as 50% of the prevailing fuelwood price in the local market. The return from all products collectively for all the six years amounts to US$ 3373.85 of which 69.2% is from broomstick, 16.7% from leaf and tender shoot, and 14.1% from woody stem (Table 4). The gross return translates to 1.7 times the total investment over six years.

Table 4. Harvestable primary productivity (HPP) and monetary return in the form of broomstick, leaf and tender shoot, and woody stem in an age series of amliso plantations

	Broomstick			Leaf and tender shoot			Woody stem		
Year	HPP (t ha^{-1})	Rate (US$ t^{-1})	Gain (US$ ha^{-1})	HPP (t ha^{-1})	Rate (US$ t^{-1})	Gain (US$ ha^{-1})	HPP (t ha^{-1})	Rate (US$ t^{-1})	Gain (US$ ha^{-1})
1st	0.000	-	0.00	0.000	-	0.00	0.000	-	0.00
2nd	0.649	466.67	302.87	2.878	26.67	76.76	1.879	33.33	62.63
3rd	1.104	484.17	534.52	5.068	27.67	140.23	4.248	34.58	146.90
4th	1.491	502.32	748.96	4.823	28.70	138.42	3.635	35.88	130.42
5th	0.846	521.16	440.90	3.940	29.78	117.33	2.263	37.23	84.25
6th	0.571	541.70	309.31	2.959	30.90	91.43	1.292	38.62	49.90
Total			2336.56			564.17			474.10

A return of 1.7 times is not very lucrative at the first instance. However, 62% input is in labour and 33% in land rental. Since villagers contribute labour and the land is available free of rent, total gain divided by material inputs amounts to a 33.1 times return. Furthermore, the villagers do not even invest in farmyard manure. Hence, broomstick cultivation is actually an enterprise of self-employment for the villagers.

Singh *et al.* (1989) in their cost-benefit analysis found an output/input ratio of 6.84 which is substantially higher than 1.8 obtained by Gangwar and Ramakrishnan (1989) and 1.7 in this study.

Marketing and value addition

Siliguri is the second largest supply centre of broomstick in the country. Siliguri collects the entire production of sub-Himalayan West Bengal including Darjeeling and Jalpaiguri districts and Sikkim. In what follows, we trace the broomstick pathway from field to customer with value addition during various stages of movement and processing (Figure 3). Although variations occur at every stage, we present all the values on an average basis for the year 1996.

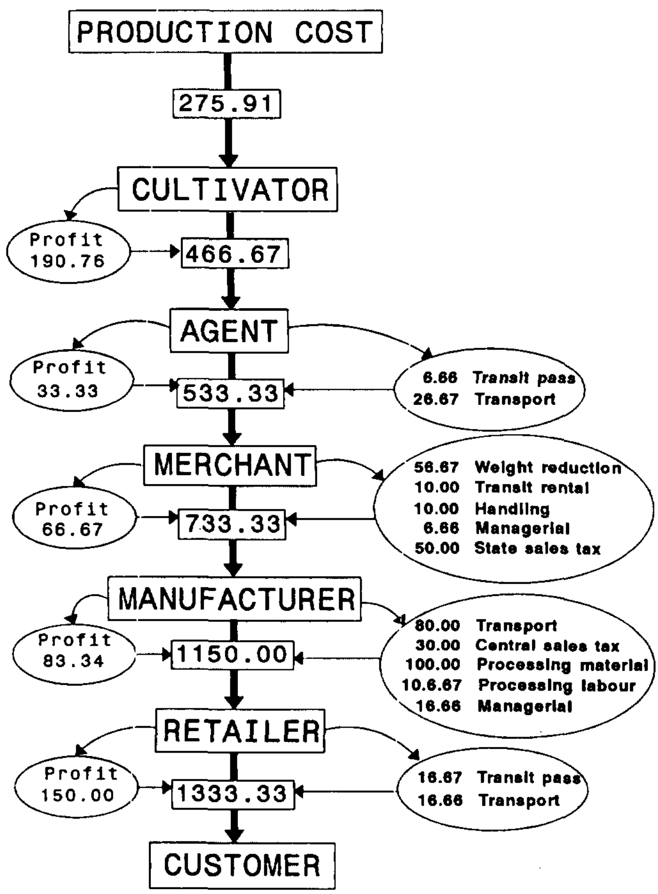

Figure 3. Broomstick pathway from fields to customer depicting price appreciation (US$ t^{-1}) during various stages of movement and processing. For each tonne of broomstick, the cultivator earns a profit of US$ 190.76 and sells it to the agent for US$ 466.67 who in turn sells it to the merchant for US$ 533.33 after adding his profit and the costs incurred on transit pass and transport. This way the customer finally pays US$ 1333.33.

The traders in Siliguri collect broomstick from the cultivators through agents. An agent establishes a rapport with the villagers in his operational area and fixes purchase rate with the cultivator by mutual consent. The cultivators do not get an opportunity to bargain since the agents are territorial. After closing the deal, the agent gives a token advance to the cultivators as a deposit for the assurance of the crop supply. In certain cases, the agent lends huge sums of money to the needy cultivators who in turn have to accept the purchase rate and the terms dictated by the agent.

The forest department facilitates the movement of broomstick from cultivators to merchants by issuing a transit pass at a toll (Figure 3). Siliguri merchants sun-dry the broomstick to reduce the moisture. Subsequently, they clean, grade, and pack broomstick in 50 kg bundles for dispatch to broom manufacturers. The manufacturers in different towns process broomstick into brooms while keeping in view the customers' choice. A retailer buys brooms from the manufacturers and sells to the customers, thus acting as the last link in the chain (Figure 3).

Each tonne of broomstick after processing into finished brooms fetches US$ 1333.33 of which only 35% reach the cultivator (Figure 3). Of the rest, 25% is realised as profit by different agencies (agent, merchant, manufacturer and retailer), 8.8% goes for wages, 11.7% toward the costs of processing, 9.3% in transport, 6.5% as tax and 3.7% for rent and management.

Enterprise at source

Realisation of 35% of the final value by the villagers is a much better return when compared with the Soliga in Karnataka who get only 4% of the final value by extracting *Phyllanthus emblica* fruits (Uma Shankar *et al.* 1996). Comparison with older data on the selling price of broomstick by cultivators (Singh *et al.* 1989) and then the market rate of broom indicated that percentage return to the cultivator has gone up considerably (Figure 4). Although the difference between the final value and the return to the villager is narrow, can we still elevate return by introducing an enterprise component?

The concept of processing brooms at the source to increase returns was popularised by the forest department in 1996. Though seemingly simple, this enterprise is difficult in practice. After harvest, broomstick requires a long sun-drying treatment to free it of moisture, since fresh broomstick contains 50–60% water. In hill areas, limited availability of sun in short spells, heavy cloudiness, and occasional showers render the drying extremely difficult when broomstick is harvested. There are a number of variants of brooms used in different parts of the country. The cultivators are not aware of market preferences. Therefore they would need thorough training in broomstick binding, an important issue in marketing of brooms. The villagers will have to establish their own marketing network, face stiff competition from merchants and manufacturers and meet varied preferences for the broom size, shape and style. It is widely advocated that the processing of broomstick into brooms at source will provide added employment opportunities in the Darjeeling hills. However, if you increase employment in the Darjeeling hills, you necessarily decrease employment elsewhere.

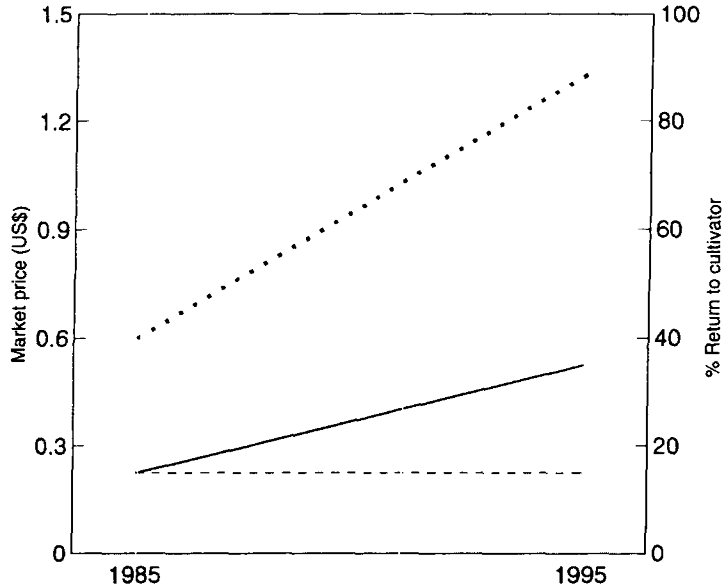

Figure 4. Increase in market price (dotted line) and return to cultivator (solid line) from 1985 to 1995. The dashed line indicates the percentage return to cultivator at 1985 level, as if it had continued unchanged through 1995.

Broom processing in the hills is feasible only if the above-mentioned difficulties are overcome. Increase in return to the cultivator can be assured by short-cutting the flow route to market and curtailing costs. Additional relief could be provided by the government by considering broomstick processing a cottage industry and exempting it from all taxes and levies. If this is done, the return to the cultivator can be raised from US$ 466.67 to 700.00 (Figure 5). To help cultivators sell their finished brooms, a Broom Producers Association can be founded.

Supply and demand

The total supply of broomstick from Siliguri has increased from 3482 t in 1991 to 4961 t in 1995 (Table 5). An increase in market price associated with rising demand, and increasing proportion of the final value that reaches the cultivator due to competition among the manufacturers have lured villagers to raise more plantations. Siliguri supplies broomstick to almost every corner of the country (Table 5). However, a major portion of the total supply is captured by a handful of giant broom manufacturers located in different states who in turn sell the finished brooms with their own brand names.

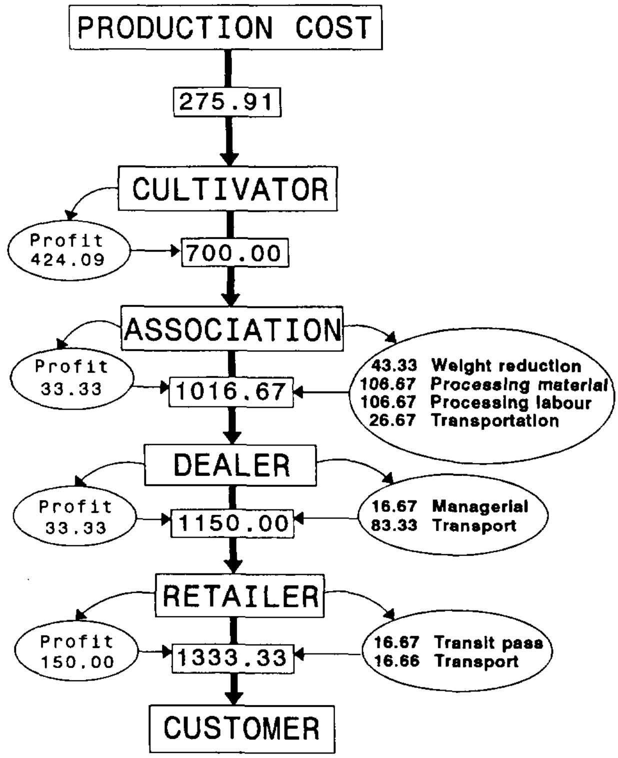

Figure 5. Broomstick pathway advanced for enterprising the brooms at source with price appreciation (US$ t^{-1}) during various stages of movement and processing. See also Figure 3.

A reliable estimate of the annual broomstick demand in the country is not readily available. Seshan (1995) reports an Indian broom market size of nearly US$ 100 million. It is widely agreed that an average amliso-broom-user household annually consumes approximately 1 kg broomstick (3 to 4 brooms). An average household size of 5 individuals will translate the country's population of 900 million into 180 million households. If those below the poverty line (40%) and those using alternate brooms (10%) are deducted, 90 million households are expected to be the regular consumers. Even if each household consumes 0.5 kg broom annually, the total demand can be projected close to 45,000 t y^{-1}. At the rate of final value of US$ 1333.33 t^{-1}, the broom market size is estimated to be nearly US$ 60 million. Siliguri supplies only 11% of the projected demand. A large quantity flows from the northeastern states, particularly Meghalaya. A small part of the demand is met by the production in Garhwal and Kumaon Himalaya, Western Ghats, in Karnataka and Orissa. Significant quantities are imported from Nepal.

Table 5. Broomstick supply (metric tonnes) from Siliguri to different states from 1991 to 1995. The data for 1993 were not available.

State	1991	1992	1994	1995
Increasing trend				
Delhi	741.6	1139.8	1047.9	1206.1
Kartanaka	58.9	31.7	238.2	789.9
Punjab	305.5	430.6	436.6	500.1
Haryana	59.4	82.6	136.6	231.2
Chandigarh	31.0	32.5	40.0	40.0
Bihar	47.2	77.6	87.8	47.5
Orissa	0.0	9.6	27.0	26.2
Jammu & Kashmir	0.0	0.0	20.8	32.5
Tamilnadu	0.0	0.0	9.0	9.0
Declining trend				
West Bengal	501.8	659.1	477.8	387.9
Maharashtra	356.6	670.9	547.6	522.9
Madhya Pradesh	247.4	121.7	119.3	192.3
Up-down trend				
Uttar Pradesh	461.3	647.8	518.2	544.1
Andhra Pradesh	374.8	308.9	370.5	138.7
Gujrat	179.6	60.8	234.8	169.8
Rajasthan	117.6	105.0	178.3	123.4
Total	3482.5	4378.1	4490.1	4961.4

Implications of domestication

Several advantages and disadvantages are associated with the domestication of NTFPs. The advantages can be grouped into the following three categories: a) on the part of the producers or ecosystem people, b) on the part of the market or consumer, and c) on the part of biodiversity conservation or forest management.

The producers benefit from the domestication of NTFPs in at least three ways. First, domestication increases the productivity of land. Many of the NTFPs in natural habitats are not the dominant species, and thus restricted in distribution. Low densities result in limited production per unit area that may often fail to fulfil market demand. Domestication could afford much greater densities and ensure high production. Second, domestication increases the productivity of labour. The extractors have to spend more time and energy in collecting NTFPs from natural populations due to sparse distribution, inaccessibility and difficult terrain than if the collections were made under cultivation. Third, domestication generates more employment and income. Low productivity of land and labour in collecting NTFPs from natural habitats attracts feeble response from the forest dwellers.

The consumer market benefits from the domestication of NTFPs in two ways. First, elasticity of supply of products is assured. If supply of NTFPs depends entirely on the production in natural populations, enough production to meet the market demand may not be achieved, and considerable variations may occur in the productivity from year to year as reported in *Phyllanthus emblica* (Uma Shankar *et al.* 1996). On the other hand, a minimum production level can be determined if the supply emerges from cultivation, unless epidemics take place. In addition, cultivation is an open-ended phenomenon, holding option for further expansion. Second, assured supplies from domestication of NTFPs benefit the consumer by exercising a control on price rise (Homma 1992).

Biodiversity may benefit from the domestication of NTFPs in the following ways. First, domestication leads not only to the discovery of new variation, but in many cases to a proliferation of new forms and a range of forms far beyond the variation in the original progenitor wild species (Bisby 1995). Second, domestication curtails human interference in natural populations, thus minimising disturbance-dependent losses of biodiversity. It has been shown that NTFP extraction in natural populations even at moderate levels may change floristic composition, erode species diversity and affect population structure (Daniels *et al.* 1995, Murali *et al.* 1996, Uma Shankar *et al.* 1998a). Third, domestication of NTFP species can be utilised as an opportunity for maintaining ecosystem health. Several NTFPs, such as amliso, may be promising in arresting soil and nutrient erosion, controlling landslips, reconstructing vegetation cover and canopies, and enhancing ecosystem productivity. Considering the multifaceted ecological benefits, the forest department has encouraged cultivation of amliso in the hills of Darjeeling Himalaya.

Domestication of NTFPs may also carry certain disadvantages. First, limited availability of land for cultivation may encourage encroachment on the protected forest. For example, high profitability associated with amliso domestication has encouraged villagers to destroy forest and plantations to make room for amliso cultivation. Although such practices are of recent origin and limited in extent, they may have wider consequences on the fragility of the forest ecosystems, and thus need to be addressed in the management policies urgently. Second, domestication generates genetically differentiated human-controlled races (domesticates) within the species (Bisby 1995). In some cases, domesticates become profoundly different from their wild forebears and totally dependent on humans for reproduction and regeneration. Changed selection pressure due to continued cultivation over many generations may result in domestication syndromes such as changed growth form, life-form and breeding system, and suppression of sexual reproduction (Bisby 1995). Third, a variety of organisms associated with humans (as parasites and diseases) or domesticated plant species (weeds and pests) undergo a parallel domestication process and thrive in human-made environments (Bisby 1995). Fourth, genetic diversity (gene pool) of domesticated species erodes due to repeated cultivation of uniform cultivars in a uniform environment (Hawksworth & Kalin-Arroyo 1995).

Conclusion

This study highlights the proposition that the domestication of non-timber forest products such as broomstick could be a highly remunerative activity to strengthen rural economies and maintain the environment. Cash generation is advocated to decrease dependency of the villagers on the forest thus reducing pressure on natural resources. However, high profitability may also induce encroachment in the forest to make room for cultivation. Encroachment brings on undesired changes in landuse pattern and results in deforestation and loss of biodiversity. Therefore, forest policies must be updated in order to tackle the issues related to the domestication of non-timber forest products.

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