Indian Journal of Traditional Knowledge
Vol. 8(1), January 2009, pp. 17-22

Traditional knowledge systems in large cardamom farming: biophysical and management diversity in Indian mountainous regions

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Received 10.07.2008

Large cardamom (*Amomum subulatum*) is a perennial cash crop grown under the Himalayan alder (*Alnus nepalensis*) or mix forest tree species in the hills of Nepal, Darjeeling hills, Sikkim and Bhutan. The cardamom based agroforestry system in the Himalayas has proved to be a sustainable land use practice at the landscape level supporting multiple functions and ecosystem services. Large cardamom agroforestry is a mountain adaptive slope land management and production system that helps conserving soil and water, maintain soil fertility and high rate of carbon sequestration than any other land use systems in the region. The system is a major contributor of sustainable development in the mountain region by providing socio-ecological sustainability, watershed functions, and cultural, educational and recreational values in additional to the employment opportunities in ecotourism. Some of the ecological functions of the system are habitat and corridor for wild animals, conduit of water, energy, gene flow, seeds, etc. barrier for wind, nutrients and animals, etc. while the system also help augmenting sustainability and well being of the upstream and downstream communities.

Keywords: Cardamom agroforestry, Traditional knowledge, *Alnus nepalensis*, Post-harvest management
IPC Int. Cl.[8]: A01N3/00

Conversion of forests to other forms of land management has been the general trend in mountainous areas[1]. The land management in the catchments and watersheds of mountainous region like the Himalaya essentially relates to the ecosystem services that they provide to the mountain people and downstream populations. Such ecosystem services essentially relates to soil and water conservation by proper land-use, protecting from deterioration of soil quality, increasing and maintaining soil fertility, reducing soil erosion, conserving water for drinking and other farm uses, increasing the availability of basic resources and achieving the optimum productivity of land-uses[1,2]. In the changing land management from forests to other forms, cardamom agroforestry in the Himalayas is a good traditional practice that would meet the demands of both economic activity and conservation. Cardamom has been a major agriculture cash crop and an export agricultural commodity in Southeast Asian countries in the last couple of decades. This is purely the adaptive approach through indigenous traditional ecological knowledge (ITEK) of the communities to devise an integrated natural resource management that will increase agricultural production in a sustainable manner. The paper discusses the ITK on cardamom-based agroforestry in Indian Himalayas with special reference from Sikkim. Organizational and management diversity, agroecological adaptability, resilience and sustainability are briefly discussed.

Cardamom-based agroforestry

Sikkim Himalaya

Cardamom-based agroforestry is a purely traditional land use adaptation in the fragile, inaccessible, vulnerable and marginal mountain slopes of the Sikkim Himalaya first initiated by the indigenous communities of Sikkim. This traditional adaptive management system has been a potential livelihood support to the small holders, a means to biodiversity conservation, environmental services and ecological health and social and economic well being of the people[3,4]. Large cardamom locally called, *alainchii* is believed to be one among the oldest spices known and its Ayurvedic preparations dates back to 6th century BC as mentioned by *Sashruta*. It was known to Greeks and Romans as *Amomum* during the 4th century BC and was recorded by Theophrastus the

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Greek philosopher. Large cardamom (*Amomum subulatum*) is native to the Sikkim Himalaya. The aboriginal inhabitants of Sikkim- *The Lepchas*– were believed to be the first to collect cardamom capsules from natural forests primarily for the purpose of medicine and as an aromatic edible wild fruit. While those cardamom forests eventually converted into ownership and the crop was domesticated in the process[5]. Cardamom seeds are sometimes administered orally for curing certain ailments and acts as carminative; stomachic, diuretic, an effective cardiac stimulant and is a remedial medicine for throat and respiratory troubles. Cardamom is also used for various food preparations, in confectionaries, making perfumes, and other medicines. The seeds contain about 3% essential oil rich in cineole which is used as flavoring agent and spice[6].

A total of 16,949 cardamom holdings have been recorded in Sikkim state, most of which are smaller than 1 ha. About 30% of the total area under cultivation is 1–3 ha large[7,8]. The cultivation area of large cardamom had increased by 2.3 times in the past 20 yrs that has now declined by almost by 30% in the recent years although gap filling and replantation under the same canopy cover is a regular management practice. About 1,316 ha of the reserved forest in Sikkim were used for under-canopy large cardamom cultivation on lease to farmers with no rights of cutting the trees[9]. However, most of these plantations were under protected areas and reserved forests which were withdrawn from the growers by the Department of Forest Wildlife and Environment, Government of Sikkim during 2004-2006.

The crop usually grows as under storey vegetation below the tree canopy and requires an annual rainfall of 1,500–3,500 mm. During the last 5-6 decades, a large area of agricultural lands such as rice terraces were converted to *Alnus*-cardamom agroforestry using monocultures of N_2-fixing *Alnus nepalensis* as shade tree. Looking into the increase in the cultivated area of large cardamom, the total area of large cardamom agroforestry increased by 2.75 times during the past three dexades. However, the total cultivated area between 1985 and 2005 has increased by 1.46 times[4]. The productivity potential, soil nutrient dynamics, stand energy efficiencies and relative ecological and economic performances of large cardamom grown under *Alnus* trees were better than grown under mix forest tree species[10-12].

Large cardamom plantation has been introduced to the northeastern states of India since the last decade. The cultivated cardamom has about 12 local varieties and seven species of wild relatives readapted to different agroclimatic conditions of the Eastern Himalayan region. The plantation areas of this crop in other Indian Himalayan region comprises of 550 ha spread over five states. Nagaland (35 ha), Mizoram (35 ha), Meghalaya (10 ha), Manipur and the central Indian Himalayan state Uttaranchal (41 ha) covering a total of 34,252 ha in India[13]. These plantation agroforestry are recently developed and no considerable production a

Genetic diversity of large cardamom in Sikkim Himalaya

The cultivated species is *Amomum subulatum* Roxb. and belongs to the family Zingeberaceae. Seven wild species such as *A. linguiforme*, *A. kingii*, *A. aromaticum*, *A. corynostachyum*, *A. dealbatum*, *A. costatum* and *A. plauciflorum* are naturally occurring in the region. The cultivated species has six local cultivars (varieties) suitable for cultivation at different elevations and adapted to various other environmental factors such as water deficit and frost. The common occurrence of local cultivars grown in Sikkim varies according to their altitudinal adaptability. Local varieties such as *Ramsai*, *Sawney*, *Bharlang* are cultivated above 1,500 m whereas *Sawney*, *Chibey*, *Ramla* and *Ramnang* are grown within 1,000–1,500 m and *Golsai*, and *Seremna* below 1,000 m elevations[5].

In large plantations of the cardamom agroforestry the shade tree is N_2-fixing Himalayan alder (*Alnus nepalensis* D. Don). About 70% of the cardamom-based agroforestry practices are under N_2-fixing *Alnus nepalensis* while 30% are under the mixed-tree agroforestry species. Some common shade trees for the mix-tree cardamom agroforestry are *Schima wallichii*, *Engelhardtia acerifolia*, *Ostodes paniculatus*, *Symplocus theifolia*, *Vibernum cordyfolium*, *Prunus nepalensis*, *Saurauia nepalensis*, *Eurya acuminata*, *Leucosceptrum canum*, *Maesa chisia*, *Quercus pachyphylla*, *Leucoseptrum cannum*, *Lyonia ovalifolia*, *Bauhinia purpurea*, *Osbeckia paniculata*, *Toona ciliata*, *Bassia butyracea*, *Celtis tentranda*, *Michelia excelsa*, *M. pustulata*, *M. indica*, *Quercus lamellosa*, *Q. lineata*, *Rhus semialata*, *Spondias auxillaris*, *Beilschmiedia* sp, *Cinnamomum* sp, *Ficus nemoralis*, *Ficus hookeri*, *Nyssa sessiliflora*, *Osbeckia paniculata*, *Viburnum cordifolium*, *Litsaea polyantha* and *Macaranga pustulata*. About 92 species of multipurpose tree species are grown in the cardamom based and associated agroforestry systems

while a large number of wild edibles and medicinal plants, mushrooms and tubers are a constant source of income for the farmers. These tree species are socio-culturally important for their multiple benefits such as wild edibles, timber trees, good quality fodder, etc. Such traditional tree-based farming help ecological restoration, conservation and improvement of steep slopes into production zones, optimize the biomass and forest growth and commercially viable under storey cardamom crop. Large cardamom agroforestry thus supports conservation of tree biodiversity in the region though the use of *Alnus*-cardamom systems has recently proved more profitable.

Production, economic potential and market chain

The cash income earned from the crop in Sikkim increased from 1.9 m USD in 1975 to 13.8 m in 2005. Sikkim contributes about 40% of the world's production of large cardamom after Nepal. The total area under cardamom based agroforestry in Sikkim in 2007 was 26,734 ha of which area that gives agronomic yield were only 19,343 ha. The difference of 7,391 ha area was under replantation and gap-filling. Similarly, large cardamom cultivation area in the Darjeeling hills during 2007-08 was recorded to be 3,305 ha of which only 2,715 ha gives the agronomic yield. The total production during 2007 in Sikkim was 4,358 MT while production in Darjeeling hills was only 614 MT[14]. The market rate estimate as per local market value for Sikkim in 2007 was 13.6 m USD while for Darjeeling was 1.9 m USD.

The finished product of Large cardamom is commercially graded as *Badadana* (big capsules) and *Chotadana* (small capsules), *Kainchi-cut* (capsules tails removed) or non-*Kainchi-cut* (capsule tails not removed). Pakistan is the single largest market importing up to 9,000 MT of large cardamom in a year[13]. It is also exported to UAE, Iran, USA, Afghanistan, UK, Malaysia, South Africa, Japan, and Argentina which are other potential markets. The major domestic markets in India are Kolkata, Delhi and Guwahati. India is the largest market of large cardamom produced in Nepal and Bhutan. Value addition to large cardamom at the growers' level, institutionalization, market intelligence and market chain analysis has been the major challenges. The high market price of the products goes to the retailers and distributors at local *hatts* (markets) and major collection centers such as Kolkata, Delhi and Guwahati. While due to the lack of proper institutional support growers receive proportionately very less price for their products. R&D institutions such as Spices Board and the state government line departments in India have to work on this line.

Firewood demand and post harvest management system

The post-harvest methods and storage of cardamom are still traditional in the large cardamom growing areas of Nepal, Darjeeling hills of West Bengal, Sikkim and Bhutan. In a few cases cardamom is dried using low quality fuel wood in old traditional kilns resulting in a poor quality products that fetches considerably low market price. This problem has been realized in the Sikkim Himalaya, Bhutan, Vietnam and in Nepal[5,15,16]. For a good commercial finished product the cardamom capsules should retain dark pink colour, minimum moisture and bold sizes containing original flavour and aroma. Post harvest starts from mid June at lower agroclimatic zones (600 m and above), advances to higher elevations with time until late October in higher altitudes (2,100 m). Comparing all farming practices and systems in the eastern part of the Himalayas, large cardamom farming has been considered as a self sufficient system that does not require any external inputs other than relatively low manpower for one time weeding and one time harvesting.

Until now farmers have devised indigenous ways of processing harvested cardamom where the capsules are dried in traditional kilns made up of mud and stone walls under the thatched roof with an oven below where fuel wood is burned for direct heating of capsules. Cardamom capsules are spread over the bamboo mats placed just over the oven and the fire is constantly monitored until the next 12-15 hrs while reshuffling of capsules will be done several times. Fuel-wood requirement is about 500 kg of wood to dry 1,000 kg freshly harvested capsules to give about 200 kg of finished product. Usually the fuel wood supply is met from the same plantation and sometimes from the adjacent agroforestry systems. In additional to this regular thinning of intensively managed trees also supply fuel wood demand for curing of capsules. This dried cardamom retains about 10-12% of moisture which can be kept for one or more years in a damp-free storage. Thus farmers store their products of one or more years for one time income when the market rate raises high. There is a serious lack of channalization of markets, sub-sector analysis, intelligence, risk assessment and information system for a commercially potential cash crop cardamom.

Cost-effectiveness of the *Alnus*-cardamom agroforestry

To understand the cost effectiveness of *Alnus*-cardamom stands across the age series and altitudinal ranges input: output analysis was analyzed. Input: output ratio was highest between 15-20 yrs old stands when compared in the agroforestry age series. A general trend of input: output ratio showed that the ratio was low in lowest and highest altitudinal range agroforestry stands. Firewood, timber and fodder are other by products from the system apart from the agronomic yield (Table 1). The cash-benefit analysis after three years of plantation of *Alnus*-cardamom crop is given in Table 2. Large cardamom is a perennial crop that gives yield form 3rd year of plantation. In the first year, the plantation around Rs 25,000 ($538) per ha is required for planting material and labour. Refilling of gaps and weeding requires Rs 3,500 ($75)/ ha in the second year. After this, from third year onwards weeding, harvest and post-harvest labour costs are the only cash inputs required for the system.

Major threats and challenges on cardamom farming

Large cardamom based agroforestry has been an adaptive system in the mountain landscapes for ecosystem services and human well being. Recently, some irresistible problems on crop management, disease and pest control and lack of market intelligence have caused serious setbacks on livelihoods of people. The most worrying factor in large cardamom farming is the decrease in yield per ha by 30-40% recorded in recent years. The yield of the large cardamom depends upon the age and that most of the plantations (about 15,000 ha) that existed before 1980s are very old and have actually not been producing more than 100 kg ha^{-1} capsules. But the majority of new plantations (about 13,500 ha) are well maintained and produce between 250–350 kg ha^{-1}. Farmers find constraints in terms of proper infrastructure and incentives for replantation and gap filling of older plantation by new disease tolerant or disease resistant varieties. The Indian Spices Board which is looking after both R&D activities in the Sikkim Himalaya in the last three decades are yet to channelize these constraints and contribute with concrete scientific backups to these vulnerable small holders of cardamom. Large cardamom starts producing from the 3rd year after planting, and yield declines considerably after the 20th year. Filling the gaps created by withering cardamom bushes and carrying out selective felling of old trees is not enough.

Large cardamom plantation area is declining over the years. Natural calamities such as draught, hailstorm, snowfall in plantations at higher agroecological zones, widespread occurrence of fungal diseases and viral diseases are the major threats causing reduced production and reduction of agroforestry areas. Of these, the prime cause of cardamom plantation and agronomic yield decline is

Table 1—Annual input and output of energy and cash in alder-cardamom and forest cardamom agroforestry system in Sikkim Himalaya

Output/Input	Alder-cardamom		Forest-cardamom	
	Energy ($x10^4$ kJ ha^{-1})	Cash (US $ ha^{-1})	Energy ($x10^4$ kJ ha^{-1})	Cash (US $ ha^{-1})
Input				
Labour	2.1	2.8	4.2	5.6
Weeding	8.4	11.2	4.2	5.6
Post harvest	42	55.8	21	27.9
Firewood collection	12.6	16.7	6.3	8.4
Firewood used in curing	1064	34.9	465	17.4
Total	1129.1	121.4	500.7	64.9
Output				
Agronomic yield	920	2112**	411	954**
Firewood extraction	3087	101	1486	56
Fodder	---	---	596	7
Total	4007	2213	2493	1017
Output: input ratio	3.55	18.23	4.98	15.67

Human labour $hour^{-1}$ = 0.15 $x10^4$ kJ ha^{-1} (Freedman 1982)
**Calculated as per 1999 average rate, Cash conversion @ US $ 1 = Rupees 43

Table 2—Annual cash-benefit analysis and monetary evaluation per hectare (amount in US$ 1 = 46.50 rupees) of large cardamom after three years of plantation in Sikkim. (First year plantation cost =$538 ha^{-1} for planting material and labour; 2nd year =$75.27 ha^{-1} for refilling of gaps and weeding; 3rd year onwards cardamom gives yield and after this weeding, harvest and post harvest cost are cash inputs)

Cost evaluation	Plantation age (year)					
	3	4 – 6	7 – 12	13 – 16	17 – 20	21-30
Cost (UD$)	77.42	120.43	161.29	133.33	124.73	131.81
Output (US$)	80.65	806.45	1427.73	1532.90	953.76	784.09
Benefit/cost ratio	1.04	6.69	8.83	8.49	7.64	5.94

The timber and monetary return by the harvest of *Alnus* tree before replanting (20-year rotational cycle) =$12,387. This is in addition to cash income from large cardamom yield from 3rd year onwards.

due to the infestation mainly by viral diseases viz. *Chirkey* and *Phurkey*. This is one of the reasons for production decrease sharply by about 30% in during 2005-2007. Uprooting and burning of all the infected plants has been the only possible alternative to control these viral diseases. The above mentioned constraints and problems of diseases are seen in almost all cardamom growing areas of Sikkim and Darjeeling hills of West Bengal. While cash input for such management to large plantations is a primary constraint to growers if not otherwise any such incentive mechanism is developed by government sectors. The *Dzongu Golsai* and *Hee Seremna* varieties have been found to be resistant to these diseases. Until now cardamom hybrids have not been developed by any research and development institutions.

In conclusion, cash crop farming holds the key to maintaining the viability of small and marginal farmers in the mountain region. Further expansion of the landholding size is almost impossible. The potentiality for sustainable management of a marginal/fragile mountain land needs serious evaluation.

Conclusion

Large cardamom based agroforestry systems in the Eastern Himalayan region is a multifunctional system predominantly managed by the smallholders as their adaptive traditional practice since time immemorial. Due to its ecological resilience, social acceptability and mountain specific niche cardamom has been described as high value, low volume and non-perishable cash crop. In addition, it is less labour intensive and non-nutrient exhaustive system compared to other systems. The system bestows multifunctional attributes such as ecological and economic sustainability and well being of the upstream as well as downstream communities through a number of ecosystem and environmental services. While the cardamom growing communities and the agroforestry system requires appropriate policies and institutional support to overcome the threats and challenges. The higher net primary productivity rates and carbon fixation rates of the alder cardamom system also contribute to the mitigation of climate change[4].

Acknowledgement

Authors are thankful to the United Nations University (UNU), Tokyo and International Center for Integrated Mountain Development (ICIMOD) Kathmandu for facilities. Japan Society for Promotion of the Sciences (JSPS) Tokyo provided funds to G Sharma for a part of postdoctoral research in Southeast Asian countries.

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