Five

Large Cardamom Farming : An Indigenous Sustainable Production Option in the Sikkim Himalayas

History of Farming

The large cardamom is a native plant of Sikkim. While *Amomum subulatum* is the cultivated species, wild relatives such as *A. linguiforme, A. kingii, A. aromaticum, A. corynostachyum*, and *A. dealbatum* are still found in the state. Collecting large cardamom capsules from natural forests has been a traditional activity of one of the aboriginal ethnic groups in the state, the *Lepcha*(s). And, when the ownership of these forests passed into the hands of the village community, the crop was domesticated. Later, the cultivation of the crop spread among the *Bhutia*(s). For quite some time before 1950, the cultivation of the crop was monopolised by big *Bhutia* landlords, called *Kazi*(s). Since the state lies on the traditional trade route to Tibet, the use of cardamoms expanded to cities in the plains, and also to other countries. Likewise, because of the special attributes of the crop, namely, those of a high-value, low-volume, non-perishable cash crop; less dependent on external inputs; less infrastructure-intensive (roads); an assured market; and so on, the cultivation of cardamoms spread without much institutional and infrastructural support from the government. Its capsule is used as a spice/condiment and contains about three per cent essential oil — rich in *cineole*. The state accounts for around 80 per cent of the total world produce. The other producers of large cardamoms are Nepal, Bhutan, and the northern parts of West Bengal.

The crop is cultivated on marginal lands and can be grown between 600-2,000masl. It is a shade-loving tree and requires a lot of moisture with a perennial source of water around. It is propagated by raising seedlings from seeds in nurseries and also through separating the rhizomes from the plants. Traditionally, the farmers have been following the second method as it is relatively easy, less time-consuming, and cheaper. This method is, however, also responsible for the spread of diseases as the planting material is likely to carry disease, thereby reducing the productivity and also the lifespan (Subba 1984, Chapter 33). Harvesting of the crop commences from August and lasts until November, depending upon the elevations and variety.

Ecological Sustenance

The previous chapters amply demonstrate that the large cardamom agroforestry system has positive sustainability implications in terms of the quality of life and equity, for both intra- and inter-generations. Nonetheless, another important requisite for understanding the sustainability of a particular system is to assess its impact on different components of the natural resource base such as soil, water, forests, and biodiversity. Therefore, in this chapter, comparisons of ecological indicators pertaining to the natural resource base of the two dominant farming systems' areas are made.

The sustainability implications of large cardamoms as a production option are explained in Table 4.12. As shown and discussed, large cardamoms as a production option are perfectly compatible with mountain specificities and fulfill both the necessary and sufficient conditions to be sustainable.

Biomass and rates of production of different components of cardamom and maize-potato dominated production systems are given in Table 5.1. The standing biomass in the cardamom system is about 2.5 times higher than in the maize-potato system, thereby

Table 5.1: Comparison of Biomass and Productivity of Cardamom and Maize-potato Dominated Farming Systems

Parameters	Cardamom-dominated System	Maize-potato dominated System
Biomass (kg/ha)		
- Tree		
Bole	10094	4391
Branch	2871	1093
Leaf and twig	1443	337
Root	4144	1507
Total	18552	7328
- Crop/cardamon		
Above ground	4910	2205
Below ground	1868	701
Total	6778	2906
Stand total	25330	10234
Net productivity (kg/ha/year)		
- Tree		
Bole	1546	627
Branch	364	154
Leaf and twig	1440	1584
Root	541	193
Total	3891	2558
- Crop/cardamom		
Above ground	3044	2205
Below ground	367	701
Agronomic yield	330	7147
Total	3741	10053
Stand total	7632	12611

Source: Sharma et al. 1994 and 1995

Note: The tree density was 684 per hectare in cardamom agroforestry and 191 per hectare in the maize-potato dominated farming system. The age of the cardamom bushes was eight years at the time of estimation.

providing more biomass resources for farm family utilisation. The rate of production of the tree component is also higher in the cardamom system. The agronomic yield is very low in the cardamom system, as much as 21 times less than in the maize-potato system, indicating that cardamoms are a low-volume, high-value cash crop. The cardamom is a negligible input crop grown on marginal lands. Farming it is an excellent example of harnessing the local mountain niche.

Soil fertility levels influence plant productivity considerably. Therefore, soil health is critical, especially in the mountains where erosion problems are quite conspicuous. The soil nutrient levels, especially organic carbon and total nitrogen, in the cardamom agroforestry system are comparatively higher than in the maize-potato dominated system (Table 5.2). Soil erosion rates measured in the rainy season reveal about 16 times lower values in the cardamom system. The nutrient losses through soil erosion and overland flow suggest that the cardamom agroforestry system provides a much better protective cover. The low volume of soil erosion and subsequently low soil nutrient loss from cardamom agroforestry in comparison to the maize-potato system indicate that the former is an ecologically viable system.

Table 5.2: Soil Nutrient Concentration, Soil Erosion and Nutrient Loss through Eroded Soils in Both Systems

Parameters	Cardamom-dominated System	Maize-potato Dominated System
Nutrient concentration (mg/g soil)		
Organic carbon	23.87	19.54
Total nitrogen	3.30	2.28
Total phosphorus	0.75	0.73
Soil erosion (kg/ha)	30	477
Nutrient loss through eroded soil and overland-flow (kg/ha)		
Organic carbon	1.87	11.86
Total nitrogen	0.42	2.35
Total phosphorus	0.02	0.68

Source: Rai and Sharma 1995

Note: Values are the means of six samplings spread over the rainy season

The large cardamom is cultivated usually on steep hill slopes under tree cover, either in natural forests or in plantations. It is a shade-loving plant and requires a lot of moisture with a perennial source of water around, and it is usually cultivated in areas where the mean annual rainfall varies between 1,500-3,500mm. The high moisture regime and relative humidity in the micro-climate of a large cardamom plantation have to be maintained. The percentage partitioning of incident precipitation into various pathways of the cardamom and maize-potato dominated systems is given in Table 5.3. The canopy interception of precipitation is much higher in the cardamom system. The overland flow is only 2.17 per cent of precipitation in the cardamom system and 9.2 per cent in the maize-potato system. These values suggest that the cardamom system retains more water from precipitation in the various sub-components than does the maize-potato

Table 5.3: Percentage Partitioning of Incident Precipitation (100%) into Various Pathways in Both Systems

Parameters	Cardamom-dominated System	Maize-potato Dominated System
Tree partitioning		
Throughfall	55.06	61.54
Stemflow	3.85	5.07
Canopy interception	38.92	23.83
Overland-flow	2.17	9.55
Floor partitioning		
Leachate	41.03	48.69
Interception	17.88	17.92

Source: Second Author

Note : Values are means of six samplings spread over the rainy season

system. The large cardamom system regulates the precipitation partitioning to adjust high moisture maintenance in the micro-climate, indicating its potential for moisture balance. This suggests an ecological sustenance of the cardamom system, in spite of its high moisture requirements.

Nitrogen and phosphorus are the two most important nutrients required by plants for their growth. Bio-geochemical cycling of these nutrients in various components of cardamom and maize-potato dominated agroforestry systems are provided in Table 5.4. The nitrogen level in the soil and the standing biomass of the cardamom system are much higher than those in the maize-potato system. The return of nitrogen to the soil through decomposition is also much faster in the cardamom system than in the maize-potato system.

Table 5.4: Nutrient Dynamics of Both Systems

Nutrient	Cardamom-dominated System	Maize-potato Dominated System
Nitrogen		
Soil (kg/ha up to 30cm soil depth)	8164.00	3850.00
Standing state in biomass (kg/ha)	300.24	181.71
Uptake (kg/ha/year)	112.20	125.69
Retention (kg/ha/year)	52.84	44.34
Return to soil (kg/ha/year)	56.45	37.99
Exit through agronomic yield (kg/ha/year)	2.91	43.36
Phosphorus		
Soil (kg/ha up to 30cm soil depth)	360.50	996.50
Standing state in biomass (kg/ha)	25.13	24.30
Uptake (kg/ha/year)	9.85	15.86
Retention (kg/ha/year)	5.08	5.05
Return to soil (kg/ha/year)	4.25	5.11
Exit through agronomic yield (kg/ha/year)	0.52	5.70

Source: Sharma et al. 1994 and 1995

The nitrogen exit from the maize-potato system via agronomic yield is very high, as much as about 15 times that of the cardamom system. However, phosphorus levels in the soil were higher in the maize-potato dominated system, presumably as a result of pH regulation (Sharma 1995). The standing state, retention, and return of phosphorus to the soil are similar in both systems. The uptake and phosphorus exit through agronomic yield are high in the maize-potato dominated system; the uptake being 1.6 times higher, whereas the exit is as high as 11 times from the maize potato system than from the cardamom system. The nutrient dynamics suggest that the cardamom agroforestry system is much less nutrient-exhaustive. This crop does not require any external nutrient inputs. It being a low-volume and less nutrient-exhaustive crop, it has a high degree of sustenance in terms of nutrient cycling.

Influence of *Alnus* as a Shade Tree

The large cardamom is cultivated either under mixed tree species or under *Alnus nepalensis* cover. New plantations and large patches of cardamom agroforestry systems have been recently converted into monocultures of *Alnus nepalensis* to be used as shade trees. Biomass, net primary productivity, and agronomic yield in the cardamom agroforestry system increased while under the shade of *Alnus* (Table 5.5). The agronomic yield of the large cardamom is about 2.2 times higher beneath the *Alnus* tree than

Table 5.5: Productivity, Yield and Nutrient Dynamics of Large Cardamom Agroforestry under *Alnus* and Mixed Tree Species as Shade Trees

Parameters	*Alnus*-Cardamom	Forest-Cardamom
Biomass (kg/ha)	28422	22237
Net primary production kg/ha/year)	10843	7501
Agronomic yield (kg/ha/year)	454	205
Nitrogen		
Standing state in biomass (kg/ha)	395.15	205.26
N_2-fixation (kg/ha/year)	65.34	-
Uptake from soil (kg/ha/year)	78.49	80.56
Retention (kg/ha/year)	56.12	27.45
Return to soil (kg/ha/year)	83.67	29.23
Exit through agronomic yield (kg/ha/year)	4.04	1.78
Use efficiency	73	93
Back-translocation from senescent tree leaf (%)	3.85	17.49
Phosphorus		
Standing state in biomass (kg/ha)	32.357	17.900
Uptake from soil (kg/ha/year)	13.178	6.517
Retention (kg/ha/year)	6.328	3.840
Return to soil (kg/ha/year)	6.146	2.347
Exit through agronomic yield (kg/ha/year)	0.704	0.330
Use efficiency*	823	1151
Back-translocation from senescent tree Leaf (%)	22.62	31.37

Source: Sharma et al. 1994

* *Nutrient use efficiency is the ratio between annual net primary productivity and nutrient uptake.*

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beneath mixed tree species. *Alnus nepalensis* is an actinorhizal tree capable of fixing atmospheric nitrogen (Sharma and Ambasht 1984, 1988; Sharma 1988). According to the data, 65.34 kg/N/ha/year were fixed in the cardamom agroforestry system. This has accelerated nitrogen cycling. Phosphorus cycling in *Alnus*-cardamom also accelerates.

Nitrogen and phosphorus concentrations of different tissues of N_2-fixing *Alnus* are higher than those of mixed tree species (Sharma et al. 1994). The nitrogen and phosphorus back translocation before leaf abscission is lower in *Alnus* than in mixed tree species because of higher availability and uptake of these elements in the *Alnus*-çardamom stand (Table 5.5). The general concept of inverse relationship between availability and conservation stands authenticated by this study. *Alnus* has more availability of these elements than mixed tree species and hence records a lower back translocation, indicating its poor strategy. This has caused retention of a higher concentration of these nutrients in litter, which on decomposition are available in greater volume to the large cardamom for uptake. Nutrient-use efficiency may be expected to drop as the use of that nutrient increases because the availability of some other resource (such as water, energy, or light) limits production. Nutrient-use efficiencies in cardamom-based agroforestry systems decreased as an influence of N_2-fixing *Alnus*, a pattern consistent with the expectation that efficiency should decrease with increasing rates of uptake (Table 5.5). Production in *Alnus*-cardamom could be further improved if other limiting factors were to be removed as nutrient availability is not a constraint. The large cardamom agroforestry system under the umbra of *Alnus* is more productive since it has faster rates of nutrient cycling. The poor nutrient conservation and low nutrient availability are not constraints.

Moreover, the low nutrient use efficiency of *Alnus* and malleability of nutrient cycling under its influence make it an excellent associate, promoting higher availability and faster cycling of nutrients. Therefore, use of N_2-fixing *Alnus* as a shade tree for large cardamom agroforestry provides multi-facet beneficial attributes which are not available to that extent from other mixed species of shade trees.

Performance of *Alnus* and Cardamom on Aging

Plant performance is a function of age. Aging causes loss in productive potential, vigour, and amplitude of resilience, especially in perennial plants. With this in mind, the effects of the age of *Alnus nepalensis* on its functions and large cardamom on its agronomic yield have been assessed. Experiments show that woody biomass accumulation of *Alnus nepalensis* continued with aging, having just 99t/ha in a seven-year stand to as much as 597t/ha in a 56-year stand (Sharma and Ambasht 1991). This species has the potential for producing large quantities of wood suitable for both fuel and timber purposes. The net primary productivity of *Alnus* increased sharply in the juvenile stage to an optimum value of 25t/ha/year in a seven-year stand. The productivity remained fairly high for up to 30 years in *Alnus,* and it has the potential of fixing atmospheric nitrogen which shows a function of stand age. Nitrogen accretion beneath mixed tree species. *Alnus nepalensis* is an actinorhizal tree capable of fixing atmospheric nitrogen (Sharma and Ambasht 1984, 1988; Sharma 1988). According to the data, 65.34 kg/N/ha/year were fixed in the cardamom agroforestry system. This has accelerated nitrogen cycling. Phosphorus cycling in *Alnus*-cardamom also accelerates.

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Biodiversity for Sustenance

Biodiversity is yet another indicator for sustainability. Biologically, diversified systems have a greater capacity for resilience and hence show more sustenance. The large cardamom is a native of the Himalayas of Sikkim and occurrences of five species of wild cardamom (*Amomum linguiforme, A. kingii, A. aromaticum, A. carynostachyum, and A. dealbatum*) are recorded in the region. *Amomum subulatum* is a cultivated species of large cardamom. Large cardamom is cultivated as a monocrop and the agri-biodiversity issue does not arise in this system. However, this practice has supported highly diverse tree components as shade trees (Table 5.6). The system supports as many as 23 tree species. The diversity index is high. These trees have multiple uses for

Table 5.6: Species' Diversity of Trees in Cardamom and Maize-potato Dominated Systems

System	Tree species' number	Tree diversity index*	Prominent trees of occurrence
Cardamom-dominated	23	4.10	*Acer oblongum, Actinodaphne* sp., *Alnus nepalensis, Casearia glomerata, Castanopsis tribuloides, Engelhardtia acerifolia, Eurya accuminata, Ficus hookerii, Juglans regia, Leucosceptrum canum, Litsaea polyantha, Lyonia ovalifolia, Maesa chisia, Nyssa sessiliflora, Osbeckia paniculata, Ostodes peniculatus, Prunus nepalensis, Saurauia nepaulensis, Schima wallichii, Symplocos theifolia, Toona ciliata, Viburnum cordifolium*
Maize-potato Dominated	15	2.81	*Acer pectinata, Alnus nepalensis, Antidesma diandrum, Bassia butyracea, Bauhinia purpurea, Celtis tetrandra, Engelhardtia spicata, Ficus clavata, Ficus hookerii, Ficus nemoralis, Litsaea polyantha, Ostodes peniculatus, Saurauia nepaulensis, Schima wallichii, Vitex sp*

Source: E. Sharma
* *Shannon and Weaver diversity index*

farmers, e.g., fodder, fuel, timber, materials for field implements, and residues for animal bedding. These trees also support birds and other wildlife, and this has direct bearings on the ecosystemic structure and its functioning. Maize-potato dominated agroforestry also supports about 15 tree species with various uses, especially fodder and fuelwood values (Table 5.6). The diversity index of the tree component is lower in the maize-potato system than in the cardamom system. Agri-biodiversity is high in the maize-potato dominated system. Table 5.7 shows the local germ plasm varieties of agricultural crops available in Sikkim and also the hybrids that have been tested. The varieties of local germ plasms for many of the crops are noteworthy.

Table 5.7: Local Germ Plasm Varieties and Hybrids of Crops Tested in Sikkim

Crop	Growing elevation (m)	Number of local germ plasms	Number of hybrids tested
Large cardamom	600-2000	5(1)	-
Ginger	up to 1500	4+	2
Turmeric	up to 1500	5	4
Finger millet	500-1600	4	5(1)
Buckwheat	300-2500	1	-
Pulses	up to 2200	18	402(5)
Paddy	up to 1800	19	60(6)
Maize	up to 2400	4	43
Wheat	up to 2200	-	34(1)
Barley	800-2800	-	5
Potatoes	up to 2800	-	13(5)

Source: E. Sharma

Note : Values in parentheses are the number of hybrids/germ plasms performing well.

Cardamom Processing and Constraints

The post-harvest technology continues to be traditional. The farmers have devised indigenous ways of processing cardamoms. The capsules are dried in locally-made *bhatti*(s) (curing houses or kilns). These are made of smoke-proof stones and mud walls on all four sides with a small opening in front to put the firewood. These kilns are installed in the cardamom fields. A bamboo mat is spread on the top of the *bhatti* and fresh capsules are spread on it. These are smoked continuously for three to four days until the capsules are completely dry. Raw wood is used for curing cardamoms, as they have to be dried gradually by smoke. Around 300- 400kg of raw wood are required to cure 100kg of cardamoms. The wood is culled from the plantation field and a continuous process of thinning the old trees goes on. The capsules, when completely dry, turn dark brown. The dried capsules are stored in gunny bags, each containing about sixty kilogrammes.

The office of the Spices' Board of India, established under the 'Cardamom Act of India', was opened in Gangtok in 1979 to encourage the cultivation of the large cardamom by providing suitable technologies both for propagating the crop and for processing the produce. Ever since, the Board has taken measures to provide improved know-how to farmers. The Board devised a fuel-efficient *bhatti* in which cardamoms can be dried by passing hot air through. In contrast to the traditional *bhatti*, the capsules dried in the *bhatti* devised by the Board retain their original colour (pink) and require less firewood. To begin with, these *bhatti*(s) were installed in major cardamom-producing areas; there were two such kilns at the cardamom-dominated study site.

The *bhatti*, however, did not find favour with the farmers because of three reasons. First, the amount of the capsules dried in the modern *bhatti* was too small to make any impact on the market. Consequently, the produce with the original colour was not accepted by the traders, and they paid a lower price. Second, the amount of cardamoms dried in the modern *bhatti* remained small as the process was time-consuming and costly for the farmers, as they had to bring their produce to a central place, where the *bhatti* was installed, and queue up for their turn. It was also costly to install the modern *bhatti* in the cardamom field. Third, the producers who dried their produce in the modern *bhatti* were of the opinion that, instead of being fuel efficient, it consumed more fuel and time and was, therefore, more costly. Produce dried in the modern *bhatti* had a poor shelf life or keeping quality. These factors, *inter alia*, led to the non-adoption of the improved *bhatti* designed by the Spices' Board of India.

Further, the activities of the Spices' Board are restricted to the major cardamom-growing areas like the northern district. For example, it has not made its presence felt in the maize-potato dominated area where the cultivation of cardamoms has spread rapidly in the last ten years or so. This is evident from the fact that only 20 per cent of the sample households knew of its existence.

Since the modern kilns for curing the capsules have been more or less rejected, the Board is now concentrating on providing nursery plants and subsidies to encourage people to replace disease-affected plantations. Subsidies are provided at a rate of around rupees* four thousand to five thousand per acre. Most of the households in the cardamom-dominated area have made use of this facility. Some farmers, particularly the marginal ones complain, however, that most of the subsidies are pocketed by a few influential farmers.

The market for cardamoms is controlled by private traders. The margin between the producers' price and the market price is around Rs 10 to Rs 15 per kilogramme. Many producers, particularly the small-scale ones, take an advance from private traders and sell their crops before hand at a much lower price. The government did intervene some time ago in order to regulate the market, but without success. The Spices' Board is also concentrating on educating the farmers about the prices prevailing in the national and international markets and the different marketing avenues available to them.

The major problem endangering the sustainability of the crop is the rapid spread of diseases. *Phurkey* and *chirkey* are the two viral diseases which have brought about a

There are 35.50 Indian rupees to the US dollar great deal of damage to the crops. However, there is no strong institutional back-up to deal with this problem. In spite of the fact that a regional research station of the Indian Council for Agricultural Research (ICAR) is located in the state, not much attention has been given to evolving disease-resistant varieties and to a suitable package of production practices for the crop. The farmers themselves have taken some measures to combat the disease. The Spices' Board and Department of Agriculture advise the farmers to uproot and burn disease-affected plants, and sometimes whole stands which are infected. This advice is not acceptable to farmers. As one farmer puts it:

> *"if we follow their advice what shall we eat, as we largely depend on cardamoms for our livelihood? Despite the plantations being affected by the disease, we still reap something".*

The gestation period of four to five years is, perhaps, too long for the farmers to wait and follow scientists' advice to use new planting materials from seeds. Another problem is that, over the generations, farmers have been harvesting this crop with virtually no labour expended and only by visiting the plantation a couple of times in a year, mostly at harvest time.

> In spite of the important role of the large cardamom in the state economy in terms of accounting for around 17 per cent of the total cropped area, providing a source of income for a significant proportion of the population, contributing around four to five per cent of the total non-tax revenue to the state exchequer, and also earning foreign exchange for the nation, the crop suffers from the problem of marginalisation. As seen above, it has not received adequate attention neither from scientists, nor from policy-makers. The state unit of the Indian Council for Agricultural Research Station, which is mandated to look after the crop, is concentrating on crops such as wheat, rice, ginger, etc, that are not only less suitable to the mountain ecology, but are also much more nutrient-exhaustive than large cardamoms. Not only that, the research station itself suffers from the problem of marginalisation. It has always remained understaffed; the scientists posted from other states try to get transferred as soon as possible. In sum, in spite of the state having overcome the problem of political marginalisation, it has itself marginalised, to varying degrees, the crops and sectors that are more compatible with the mountain ecosystem and which bode well for sustainable mountain agricultural development. This is in contrast to the experiences of the spread of horticultural crops, mainly apples, in the state of Himachal Pradesh. Apples, like cardamoms, are a high-value cash crop and a source of livelihood to a significant proportion of the population. To cater to the needs of the farmers for technical know-how about horticultural crops, the state government has set up a fully-fledged University of Horticulture and Forestry, which is one of its kind in Asia.

An old farmer succinctly sums up the state of affairs:

> *"Now when the crop demands more care and attention, they are simply not prepared for it. Cardamoms have spoiled our work ethic and have made us lethargic.*

Nevertheless, farmers are struggling hard to overcome this bad practice and have begun devoting more attention to the crop as per the need of the hour. Further, while large farmers have begun to rotate the crop on different plots, as recommended by scientists, the marginal and small farmers, who cannot afford to rotate the crop, have resorted increasingly to the practice of uprooting disease-affected plants quickly and planting new saplings to control disease.

To conclude, the large cardamom is an excellent crop, eminently suited to the mountain environment and ecology. To repeat, cardamoms are grown on marginal and barren lands; they are a low-volume, high-value, non-perishable cash crop; have an assured market; and are not infrastructure intensive. Efforts should, therefore, be directed towards mitigating diseases and saving crops from further damage. Other high-value cash crops which have a local niche need to be identified and brought into the mainstream to improve the sustainability of mountain agriculture.