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Large Cardamom Farming in Changing Climatic and Socioeconomic Conditions in the Sikkim Himalayas

The Mountain Institute-India

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Large Cardamom Farming in Changing Climatic and Socioeconomic Conditions in the Sikkim Himalayas

Prepared by

Uma Partap
Ghanashyam Sharma
Min Bahadur Gurung
Nakul Chettri
Eklabya Sharma

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Executive Summary

Large cardamom (*Amomum subulatum*) is an important cash crop and livelihood option for people in Sikkim. This high-value, minimally labour-intensive, and non-perishable crop is cultivated as an understory perennial crop in association with Himalayan alder (*Alnus nepalensis*) and other forest tree species that provide shade. It is cultivated in all districts at an altitude of 600-2,400 masl. Of the total 111,830 households in Sikkim, 16,037 (14.34%) have large cardamom plantations on their farms.

In 1997, a study conducted by the International Centre for Integrated Mountain Development (ICIMOD) revealed the ecological and economic importance of large cardamom to mountain farmers in the Sikkim Himalayas, estimating the contribution of this crop to household cash income at 45% in the case of small farmers (with up to 2 hectares of land) and 54% for large farmers (with more than 2 hectares of land) (Sharma and Sharma 1997). Many changes have taken place since then, including changes in land use patterns, socioeconomic conditions, and climate. The present study was carried out to analyze how these changes have affected large cardamom farming in Sikkim and the dependence of mountain farmers on this crop. This study particularly looked at the changes in large cardamom farming, the causes of such changes, and their impact on the household economy and livelihoods. It also examined the role of beekeeping with the indigenous honeybee (*Apis cerana*) in cardamom pollination in six large cardamom-growing areas in East, South and West Sikkim.

The methodology applied consisted of household surveys, key informant interviews, focus group discussions, and a literature review. A total of 88 households were selected at random and interviewed to investigate the range of livelihood options associated with large cardamom farming systems and their contribution to the household economy. This was supplemented by the field observation of cardamom plantations and interviews with 20 key informants including progressive farmers, scientists, and field officers from the Spices Board of India, extension officers from the Horticulture and Cash Crops Development Department and the Food Security and Agriculture Development Department of the Government of Sikkim. Representatives from marketing agencies were also interviewed.

The findings revealed that, despite its economic importance, large cardamom farming has declined in recent years, both in terms of plantation area and volume produced. Linear regression analysis also shows a negative correlation between cardamom production area (hectares) and production, indicating that yield per hectares is also decreasing. Yet, cardamom remains a major cash crop in Sikkim and the second most important source of income and livelihoods after employment and remittances, fetching around USD 911 per household per year, which is 29% of household income. Employment and remittances contribute the most at 53% of household cash income. Other sources of cash income include livestock, which contributes 12.37% of household income, and other cash crops and food crops, which contribute 5.63%.

The decline in large cardamom farming has been attributed to several factors including diseases and pests, old plantations and poor management, the unavailability of good quality planting material, and lack of irrigation facilities, training and financial support. There has also been a magnification of the indicators of climate change over the last two decades. Changes in local weather conditions such as long dry spells, changing seasons, and erratic, scanty, and unseasonal rainfall patterns have increased the incidence of diseases and pests. These climate change-related changes have also resulted in a decreased number of pollinator species, including honeybees and bumblebees. Such changes have had a devastating impact on both the socioeconomic security of mountain farmers and the ecological resilience of the system itself.

The lack of support from the government in building infrastructure and facilitating market options has negatively impacted on the economic resilience of large cardamom-based farming, as a result of which farmers have had to look for off-farm employment opportunities. This situation warrants a comprehensive, integrated, and adaptive approach to improve cardamom farming as an ecologically suitable, high-value, minimally labour-intensive, and non-perishable natural resource-based household livelihood option.

Introduction

Large cardamom (*Amomum subulatum*) is the most important cash crop in the eastern Himalayan region including Sikkim and the Darjeeling hills in India, the eastern part of Nepal, and southern Bhutan (Sharma et al. 2000). Sikkim is the largest producer of large cardamom in India and second largest in the world, after Nepal. Large cardamom contributes USD 500–1,700 to annual household cash income in Sikkim, depending on the landholding size and farm management efforts (Sharma 2013; Sharma et al. 2000). Cardamom forms a substantial part of people's livelihoods and food security and, for many families, is the only source of cash income. Over the last few decades, the cultivation of this crop has spread to other northeastern Indian states including Nagaland (550 hectares), Arunachal (400 hectares), Mizoram (400 hectares), Meghalaya (250 hectares), and Manipur (250 hectares) and to the central Indian Himalayan state of Uttarakhand (41 hectares) (Srinivasa 2006; www.indianspices.com).

Large cardamom is a perennial, shade-loving crop found at between 600–2,400 masl. It requires a high level of humidity (>90%) and soil moisture (>70%) and, therefore, grows best in areas with annual rainfall of 2,000–4,000 mm and ambient air temperature of 10–22°C (Sharma 2013; Sharma et al. 2000). During the dry months, especially in winter, cardamom requires regular irrigation to maintain soil moisture. The crop does not perform well under direct exposure to sun and is, therefore, cultivated as an understory crop in association with nitrogen fixing Himalayan alder (*Alnus nepalensis*) and other forest tree species that provide shade. The altitudinal range of Himalayan alder is sympatric with the agroclimatic range of large cardamom and is used as an associated shade tree for large cardamom in nearly 80% of plantations in Sikkim (Sharma et al. 2000). Sharma et al. (2009) reported that the 5–40 year old alder trees add 58–155 kg/ha of nitrogen to the soil through nitrogen fixation; with highest amount of nitrogen added by 10–15 year old trees. Other important shade tree species for large cardamom commonly found growing in Sikkim include *Albizia* spp., *Terminalia myriocarpa*, *Bucklendia populnea*, *Macaranga indica*, *Edgeworthia gardneri*, *Vibernum coriaceum*, *Maesa chisia*, and *Symplocos ramosissima*.

A well-managed cardamom farm, Hee-Gaon, West Sikkim

The cultivated species of large cardamom is *Amomum subulatum* Roxb., which belongs to the family Zingiberaceae. Seven wild species of cardamom – *A. linguiforme*, *A. kingii*, *A. aromaticum*, *A. corynostachyum*, *A. dealbatum*, *A. costatum*, and *A. plauciflorum* – are naturally occurring in the northeastern Himalayan region (Sharma 2013; Sharma et al. 2000). The cultivated species has 12 local cultivars (varieties) suitable for cultivation at different elevations and adapted to local environmental extremes such as water deficit and frost. The occurrence of local cultivars grown in Sikkim varies according to their altitudinal adaptability. Local varieties such as 'ramsai', 'sawney', and 'bharlang' are cultivated above 1,500 masl, whereas 'chibey', 'ramla', and 'ramnang' are grown at 1,000-1,500 masl and 'golsai', and 'seremna' below 1,000 masl. Subba (1984) reported six cultivars suitable for cultivation at different altitudes: 'ramsai', 'sawney', 'golsai' , 'bharlang', 'madhusey', and 'ramla' suitable for cultivation at different altitudes. Several other landraces including 'chibey', 'gardo', 'seto ramsai', 'ramnang', 'seto golsai', 'slant golsai', 'red sawney', 'green sawney', and 'mingney' are also reported (Gupta et al. 1984).

In 1997, ICIMOD conducted a study entitled 'Mountain agricultural transformation processes and sustainability in the Sikkim Himalayas, India' (Sharma and Sharma 1997). This study revealed the ecological and economic importance of this crop and estimated its contribution to household income at 45% in the case of small farmers (with up to 2 hectares of land) and 54% for large farmers (with more than 2 hectares). A socioeconomic study conducted in the year 2000 (Sharma et al. 2000) reported that nearly 17,000 households were engaged in large cardamom farming on about 23,500 hectares of land area in the Sikkim Himalayas. The study estimated the contribution of large cardamom to total household cash income at about 38% at that time. However, many changes have taken place since these studies in terms of socioeconomic and climate conditions. Hence, it is useful to revisit the large cardamom-based farm economy in today's conditions and amid current challenges.

Furthermore, large cardamom requires the cross pollination of its flowers for crop production. Scientific research on the pollination of large cardamom including its pollination requirements, pollinators, and the effect of pollination on production is lacking. Bumblebees are reported to be its most efficient pollinators (Sinu and Shivanna 2007, 2011; Deka et al. 2011; Kishore et al. 2011). Some studies (Verma 1987) have reported that honeybees are also cardamom pollinators and help enhance its yield, but others say that honeybees are merely 'pollen robbers' and poor pollinators, pollinating only 10-20% of cardamom (Sinu and Shivanna 2007; Kishore et al. 2011). Sinu and Shivanna (2007) reported that the indigenous honeybee, *Apis cerana*, leaves 70% of flowers unpollinated, while at the same time collecting all the pollen from the flower, decreasing the chance of pollination by other pollinators and resulting in a decline in cardamom yield of approximately 70%. However, beekeeping with *Apis cerana* is common in the cardamom farming areas of Sikkim, where *Apis cerana* and cardamom have coexisted for many years. Therefore it was also important to find out how *Apis cerana* foraging affects cardamom yield under field conditions.

Objectives of the Study

The present study had two broad objectives: to document the changes that have occurred in large cardamom farming and its associated livelihoods during the past decade influenced by changing climatic and socioeconomic conditions in the Sikkim Himalayas and to study its pollination system vis-a-vis the role of the indigenous honeybee, *Apis cerana*.

The specific objectives were to:

- assess the current contribution of large cardamom to livelihoods in Sikkim
- document changes in cardamom-based farming systems over the past decade
- enhance our understanding of the pollination system of large cardamom vis-a-vis the role of the indigenous honeybee, *Apis cerana*, and
- analyse the challenges emerging from different drivers of change, particularly ecological and climate change

Study Area

The study was conducted in Sang-Martam, Simik-Khamdong, and Dhanbari-Tumin of East District, Lingee-Sokpay in South District, and Hee-Pechreak and Hee-Martam in West District, which are considered the most important cardamom growing areas in Sikkim, besides Dzongu in North District (Figure 1). In addition to large cardamom, the altitudinal variation (600–2,200 m) and agroclimatic conditions of these areas are also conducive to the cultivation of a large number of other cash crops such as mandarin oranges, ginger, potatoes, broom grass, and a diverse array of horticultural crops. Keeping in mind the heterogeneity of the agroclimatic conditions along the vertical elevations, the farmers in Sikkim cultivate a diversity of crops including paddy, maize, finger millet, buckwheat, wheat, yams and other tubers, oilseeds, and vegetables in the lower elevations and maize, potatoes, cabbage, and cauliflower at higher altitudes.

The average annual rainfall across the study sites is 3,500 mm, with higher rates (2,000–4,000 mm) at higher altitudes and lower rates at lower altitudes (1,000–2,000 mm). The study sites mostly face south-west with a slope range of 15–30°. The sites of Dhanbari-Tumin, upper reaches of Simik-Khamdong, and Lingee-Sokpay experience occasional snowfall and frost during winter. The ambient air temperature ranges from 6–20°C in the higher elevations and 10–27°C in the lower sites (Table 1). Humidity ranges from 60–99% across all sites.

Figure 1: **Large cardamom growing areas in Sikkim**

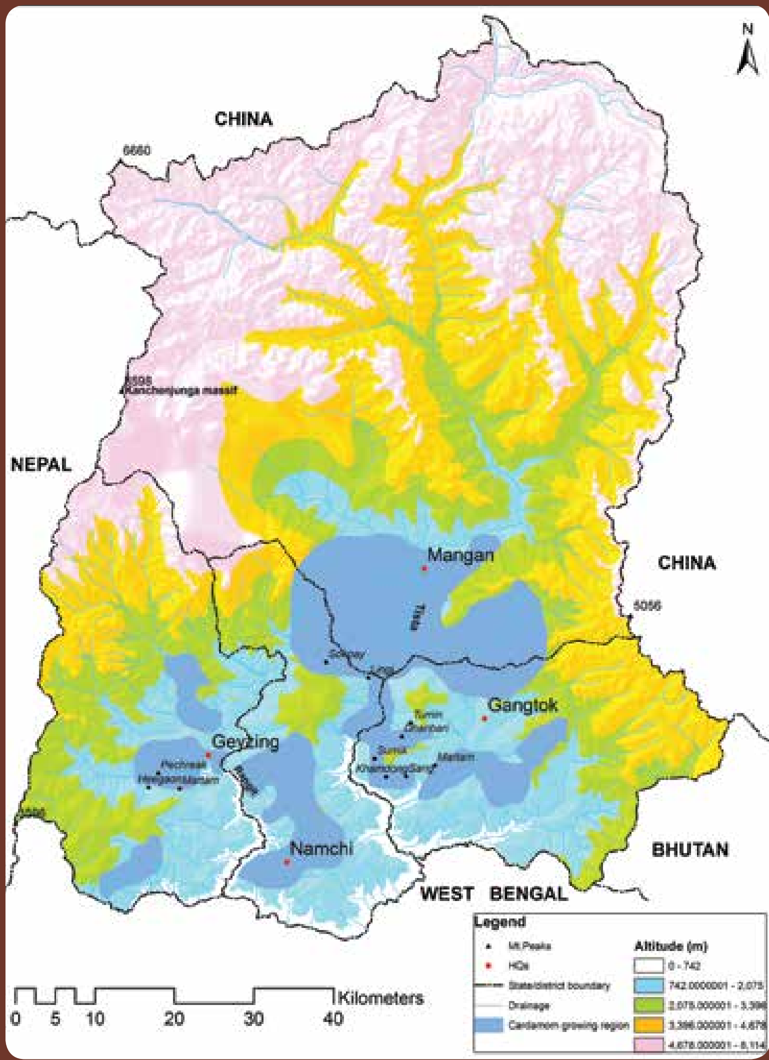


Table 1: **Biophysical and weather parameters of the three study areas in Sikkim**

Study site	Altitude (m)	Aspect	Slope (°)	Rainfall (mm)	Humidity (%)	Snowfall /frost	Ambient air temperature (°C)
East Sikkim (27° 17′ 22″ N, 88° 27′ 56″ E)							
Simik-Khamdong	1,500–1,900	West, southwest	15–30	1,000–2,100	70–98	Snow and frost on alternate years	10–23
Sang-Martam	1,000–1,700	West, southwest	10–20	1,000–1,800	60–90	Hailstorms occasionally	13–25
Dhanbari-Tumin	1,700–2,200	South-west	10–20	2,000–4,000	70–99	Frost and snow occasionally	6–20
South Sikkim (27° 21′ 39″ N, 88° 27′ 54″ E)							
Lingee-Sokpay	1,000–2,300	East, southwest	15–30	1,000–4,000	60–99	Snow and hailstorms occasionally	6–23
West Sikkim (27° 14′ 12″ N, 88° 08′ 04″ E)							
Hee-Pechreak	1,400–2,000	West, southwest	15–30	1,000–2,000	70–98	Hailstorms - occasionally	10–24
Hee-Martam	1,200–1,800	West, southwest	15–30	1,000–2,000	70–95	Mainly frost in upper reaches	14–27

Source: Sharma (2013)

Methodology

Data collection and sampling

Information on various aspects of the household economy, such as demographic features, literacy, community composition, education level, occupational structure, landholding, cropping pattern, crop yield, income and livelihood sources, was collected from six locations in large cardamom growing areas using a structured questionnaire. The study sites were identified based on the dependence of the local people on large cardamom-based farming systems. Respondents aged 25–80 years from a total of 88 households were selected at random and interviewed to investigate the range of livelihood options associated with large cardamom farming and the contribution of cardamom to the household economy. This was followed by the field observation of the cardamom plantations (Table 2). The number of respondents was almost uniform across five of the study sites, except for Simik-Khamdong, which is a large cardamom growing area, and, thus, more farmers were interviewed from this site.

Table 2: **Number of respondents and literacy rate in each study site**

Study site	Total number of respondents	Literate (%)	Respondents not having formal education (%)
Simik-Khamdong	22	77	23
Sang-Martam	14	43	57
Dhanbari-Tumin	14	79	21
Lingee-Sokpay	14	57	43
Hee-Pechreak	12	50	50
Hee-Martam	12	83	17

In relation to climate change, the value of farmers' perceptions was recognized as a key source of information and, accordingly, respondents were the primary informants for documenting climate change impacts on large cardamom-based farming, as well as adaptation strategies to revive the system, beekeeping and pollinators, and opportunities and challenges.

In addition to household interviews, another group of 20 key informants consisting of progressive cardamom farmers, panchayat members, academicians, extension and development workers, researchers, and professionals at the policy and planning level were interviewed to determine and document the dynamic changes that have

Focus group discussion on large cardamom farming, Hee-Martam, West Sikkim

taken place in large cardamom plantation area, production, and yield per hectare in Sikkim over the last two decades. This group of 20 key informants identified based on their experience also consisted of primary informants who provided information on the activities and interventions of various agencies in relation to the promotion of beekeeping, conservation of natural pollinators, and infrastructure development. Nine of these key informants were scientists working in research and development organizations, eight were from various government departments, and three were panchayat members. All of the key informants owned cardamom farms.

Secondary information, including a literature review of published information, was collected to support the qualitative information collected in the random surveys. Information on the marketing of large cardamom was collected from the North Eastern Regional Agricultural Marketing Corporation (NERAMAC) at Rangpo, East Sikkim.

Data analysis

To analyse the per capita land holding of cardamom growers, the total landholdings of the respondents were added together and divided by the number of households. Similarly, per capita household income was calculated by adding the total income of the respondent households and dividing it by the total number of households. Both qualitative and quantitative data was arranged into a matrix in Microsoft Excel. All of the quantitative data was analysed using statistical tools (Systat Version 10 and SPSS version 10). A linear regression was used to estimate the changes and trends of cardamom production and production area. Analysis of variance was also employed to relate the range of livelihood options and their contribution to the household economy across the six study sites.

Demographic Characteristics

Age

The age of the respondents ranged between 25–80 years. The highest number (41%) of respondents were from the oldest age group (61–80 years), 33% were from the middle age group (41–60 years), and 26% were from the youngest age group (20–40 years).

Employment

Of the respondents, 95% were actively engaged as farm workers and the remaining 5% were aged 70–80 years and played an advisory role in the household. The majority of households (80%) surveyed also had members working either as agricultural labourers, as job-card holders under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) of the Government of India, or as daily wage workers on roads or in construction. Among households with members working, around 43% had one or two members working in the government within or outside Sikkim. Thus, a considerable amount of household income in these households was generated from off-farm employment. As a result, in these households, cardamom farming is managed by older or middle-aged family members as the majority of young people are either government employees or students. This also indicates that, in future, cardamom farming in Sikkim could see a reduction in the number of growers due to off-farm employment opportunities.

Education

The majority of the respondents (78%) to the survey were literate. Among the key informants, nine were PhD scientists, eight were university graduates, and three possessed a secondary-level education.

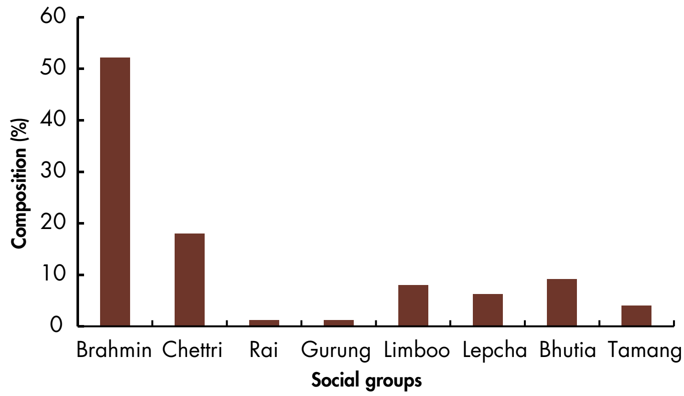
Gender

In Sikkim, women play a critical role in traditional farming and are equally involved in decision making for household activities. However, women have a low level of participation in cardamom farming in terms of farm management practices, such as weeding, harvesting, and curing, as well as in the marketing of the produce. Thus, the percentage of female respondents to this study was very low (9%).

Social groups

Brahmins, Chettris, Rais, Gurungs, Limboo, Lepchas, Bhutias, and Tamangs are the main communities in the study area (Figure 2). Brahmins constitute the majority, followed by Chettris, Limboo, Bhutias, Lepchas, Gurungs, and Rais, in that order. The highest concentration of Brahmins was recorded in Simik-Khamdong, Dhanbari-Tumin, and Lingee-Sokpay. Other communities were thinly populated in these sites, except for Limboo which were more common in Hee-Pechreak and Hee-Martam.

Figure 2: **Community composition across the study sites**



Contribution of Large Cardamom to Household Economy

Land use patterns and per capita landholding

The major farming land use patterns in Sikkim are traditional cardamom agroforestry, mandarin orange-based agroforestry, farm-based agroforestry, and terraced paddy cultivation. Within the mandarin-orange and farm-based agroforestry systems, farmers grow a variety of understory crops such as ginger, potatoes, vegetables, oilseeds, barley, buckwheat, yams, pulses, soybeans, and so on according to their availability and the suitability of land.

View of a mountain village and subsistence farming system, West Sikkim

Table 3: **Major cash crops and food crops in the study sites**

Study site	Major cash crops	Other cash crops	Food crops/ oilseeds	Per capita land (ha/ person)	Irrigated (%)	Non-irrigated (%)
East Sikkim						
Simik-Khamdong	Large cardamom, ginger	Broom grass, turmeric, vegetables, pulses, yams, cherry pepper	Paddy, maize, finger millet, buckwheat, oilseed	0.37	41.96	58.04
Sang-Martam	Large cardamom, mandarin oranges	Broom grass, turmeric, vegetables, pulses, yams, cherry pepper	Paddy, maize, finger millet, buckwheat, oilseed	0.51	51.80	48.20
Dhanbari-Tumin	Large cardamom	Broom grass, soybeans, potatoes, cherry pepper	Maize, barley, soybean, oilseed	0.36	42.85	57.15
South Sikkim						
Lingee-Sokpay	Large cardamom, ginger, mandarin oranges	Broom grass, turmeric, vegetables, pulses, yams, cherry pepper	Paddy, maize, finger millet, buckwheat, oilseeds	0.74	40.99	59.00
West Sikkim						
Hee-Pechreak	Large cardamom, ginger	Broom grass, turmeric, vegetables, pulses, cherry pepper, nakima	Maize, finger millet	0.35	63.45	36.54
Hee-Martam	Large cardamom, ginger	Broom grass, turmeric, vegetables, pulses, cherry pepper	Maize, finger millet	0.50	58.82	41.18

The principal cash crop in all of the study villages was large cardamom, followed by ginger and mandarin oranges. In areas where the cultivation of cardamom has declined, farmers have started growing broom grass and ginger as subsidiary cash crops. Broom grass, seasonal vegetables, pulses, 'dalle' chilli (cherry pepper), and yams are other sources of household cash income (Table 3).

In 2013, the average landholding size in the study sites was around 0.47 hectares per person, which is far above the state per capita landholding of 0.10 hectares (Sharma and Acharya 2013). The present study found the per household landholding of the respondents to be 2.63 hectares, of which 1.45 hectares (55%) was available for large cardamom (Table 4) and 0.73 hectares (28%) was often used for growing other cash crops, fodder crops, or timber trees. As a result, the land available for food crop cultivation was only around 0.45 hectares (17%). The vast majority of respondents (95.5%) reported that they were not able to produce sufficient food for the year from their farms and have to rely on cash crops to generate income to purchase rice and other necessary commodities from the market. Only about 4.5% of respondent households said that they grew enough food grains for the year on their available land.

Almost 50% of the land owned by respondent households is irrigated, and this irrigated land is used mainly for paddy cultivation. In some of the study sites, particularly in Lingee-Sokpay, Hee-Pechreak, and Hee-Martam, farmers have started irrigating cardamom plantations using sprinklers.

The average family size of the respondent households was 5.5 persons. Per capita landholdings were the highest in Lingee-Sokpay area (4.46 hectares), but per capita income was lowest. The per capita income of large cardamom growers was highest at Hee-Martam, which could be attributed to both cardamom productivity and additional income from employment and remittances. In addition, the cardamom growers at Hee-Martam and Hee-Pechreak have adopted a revival strategy for cardamom farming, which is yet to be taken up by farmers at Lingee-Sokpay (Table 4). The irrigation of cardamom farms, development of new plantation areas by replacing the open-cropped area largely around households, management of diseases and pests, and the introduction of the new disease resistant and high yielding seremna cultivar are some of the adaptive options being applied by the more progressive farmers in Hee-Martam and Hee-Pechreak.

Table 4: **Average family size, landholding and per capita income of cardamom farmers in the study sites**

Study site	Average family size	Average landholding per household (ha)			Average landholding per person (ha)	Average annual income per person (USD)
		Cardamom agroforestry	Agriculture/ farm agroforestry	Total		
East Sikkim						
Simik-Khamdong	5.0	0.97	0.89	1.86	0.37	483
Sang-Martam	5.5	0.80	1.98	2.78	0.51	433
Dhanbari-Tumin	5.0	1.07	0.74	1.81	0.36	500
South Sikkim						
Lingee-Sokpay	6.0	2.83	1.63	4.46	0.74	428
West Sikkim						
Hee-Pechreak	5.5	1.23	0.67	1.90	0.34	523
Hee-Martam	6.0	1.82	1.15	2.97	0.49	994
All villages	5.5	1.45	1.18	2.63	0.47	560.5

Note: 1 USD = 54.4 INR

Contribution of large cardamom to household income

Six major sources of household income were identified in the study sites: employment and remittances, large cardamom farming, livestock, other cash crops, beekeeping and honey production, and off-farm labour. Of these, employment and remittances were the largest contributors to household income at 53% (Table 5). Large cardamom was the second largest contributor to household income (29.2%) in the study sites bringing in around USD 910 per year per household after employment and remittances which brought an average income of USD 1,654 per household per year (Table 5). Around 85% of households had one or two family members working in other areas, including government jobs, to earn additional income. The third most important source of household income was livestock, contributing 12.37% to the average total household income. Livestock has always been an integral part of traditional farming systems in Sikkim and is a source of manure, which is used to maintain the soil fertility of crop land. Livestock are also an important source of income through the sale of milk and dairy products, meat, and calves. The household share of income from livestock was around USD 386 per year. The remaining sources of income, such as other cash crops, beekeeping and honey production, agricultural labour under the Mahatma Gandhi National Rural Employment Guarantee Act together contributed around 4% of cash income.

Among the study sites surveyed and assessed, the household annual income of large cardamom farmers (from all income sources) was highest at Hee-Martam (USD 5,965), followed by its adjacent village Hee-Pechreak (USD 2,878) (Table 5). The high income level in these villages is accredited to the cultivation of the disease tolerant and high-yielding newly developed local cultivar called seremna, supplemented by income from employment and remittances. Some farmers also earned substantial amounts of money by raising the seremna cultivar in nurseries

Figure 3: **Contribution of large cardamom to total household income in the study sites**

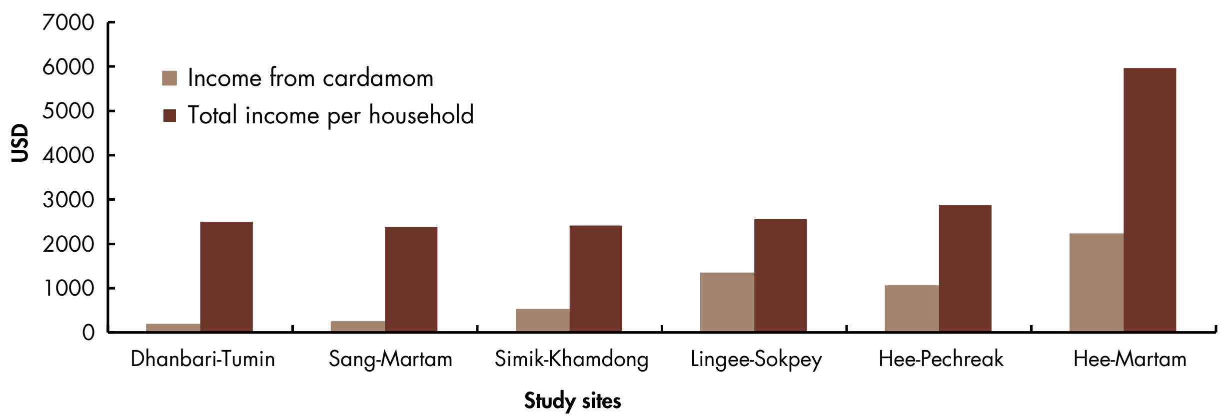


Table 5: **Income sources and their contribution to annual household income (USD)**

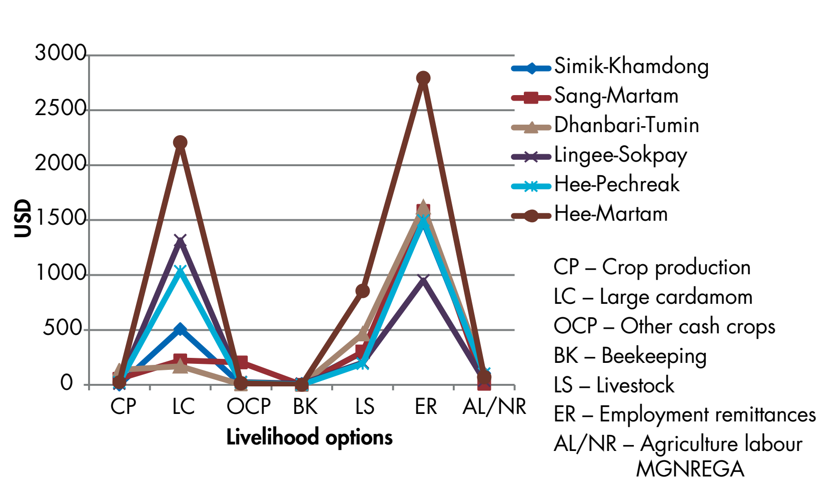
Study site / Crop production		Sources of household income: Large cardamom	Crop production	Other cash crops	Bee-keeping	Livestock	Employment/ remittance	Agricultural labour/ MGNREGA	Total average annual household income
Simik-Khamdong	Total contribution	508.33	3.04	7.15	10.52	298.28	1,482.32	104.38	2,414.02
	% contribution	21.06	0.13	0.29	0.44	12.36	61.40	4.32	100
Sang-Martam	Total contribution	223.61	56.75	205.03	0	301.59	1,583.99	10.32	2,381.29
	% contribution	9.39	2.38	8.61	0	12.67	66.52	0.43	100
Dhanbari-Tumin	Total contribution	168.78	138.23	4.64	0	461.59	1,616.93	107.94	2,498.11
	% contribution	6.76	5.53	0.18	0	18.48	76.73	4.32	100
Lingee-Sokpay	Total contribution	1,318.19	12.17	27.51	12.57	203.76	952.38	39.68	2,566.26
	% contribution	51.37	0.47	1.07	0.49	7.94	37.11	1.55	100
Hee-Pechreak	Total contribution	1,035.49	24.07	22.38	3.09	193.67	1,496.91	101.85	2,877.46
	% contribution	35.99	0.83	0.78	0.11	6.73	52.02	3.54	100
Hee-Martam	Total contribution	2,206.79	24.69	14.81	0	854.78	2,793.21	70.68	5,964.96
	% contribution	37	0.41	0.25	0	14.33	46.83	1.18	100
All study sites	Average contribution	910.20	43.16	46.92	4.36	385.6	1,654.29	72.48	3,117.02
	% contribution	29.20	1.38	1.51	0.14	12.37	53.07	2.33	100.00

MGNREGA = Mahatma Gandhi National Rural Employment Guarantee Act

and supplying good quality planting material to other farmers and to the Horticulture and Cash Crop Development Department of the Government of Sikkim and the Spices Board of Government of India at Gangtok for distribution.

Of all the study sites, Lingee-Sokpay had the highest contribution of large cardamom to total household income (51.37%), supplemented by 37.11% from employment and remittances (Table 5 and Figure 3). Large cardamom also contributed a considerable amount to total household income at Hee-Pechreak, and Hee-Martam (36% and 37%, respectively) (Figure 3). In the other study sites, although large cardamom is cultivated, the yielding area has noticeably declined. In Simik-Khamdong, Sang-Martam, and Dhanbari-Tumin, the contribution of cardamom to household income was 21%, 9%, and 7%, respectively, while the contribution of employment and remittances was 61–76%. The sharp decline in the productivity of large cardamom in these areas resulted in a dramatic change in the household economy, compounded by the fact that the new generation of farmers are migrating away from agriculture in search of more lucrative jobs in urban centres. As many as 95% of respondents informed that the productivity of large cardamom has declined by around 70–98% on a per hectare basis and, as a result, the management of farming systems for food and income as a whole has been drastically disturbed. A one-way analysis of variance showed significant variation among the range of livelihood options across the six study sites ($F_{6,35}$ = 15.54, P<0.001) (Figure 4).

Figure 4: **Range of livelihood options and their contribution to household economy across the study sites**



Changes in Large Cardamom Farming

Large cardamom cultivars in Sikkim

Farmers grow as many as eight different local cultivars of cardamom, which have been developed and tested in different agroclimatic situations and under different farm management conditions. Of these, six varieties are widely grown at an altitude of 600–2,400 masl throughout Sikkim and in some parts of the Darjeeling hills (Table 6). One of these, seremna, a variety developed by the Limboos of Hee-Bermiok in West Sikkim, is a location-specific cultivar that is tolerant to diseases. Seremna is the best-performing large cardamom cultivar in Sikkim. Another promising local cultivar is dzongu golsai, which was developed by the Lepchas of Dzongu. Although its cultivation in North Sikkim is limited (only in Timvong and Passingdong areas), it is considered the most disease-tolerant variety and is preferred by the majority of cardamom growers in these areas. The establishment of nurseries for the mass multiplication of dzongu golsai planting materials is slowly gaining momentum. Another variety, bharlang, is best suited for cultivation in middle to high altitudes (1,000–1,800 masl) and has a high market value due to its comparatively high productivity, large capsule size, aroma, and characteristic maroon colour.

During early 2000, the Indian Cardamom Research Institute (ICRI) of the Spices Board in Gangtok identified a potential disease tolerant variety of cardamom at the farmers' field and through selective breeding developed the cultivars 'Sikkim I' and 'Sikkim II'. The total six accessions collected from Sikkim I and II were planted in a germplasm conservatory. The plants were then transferred to multi-location trial plots and evaluated for comparative yield assessment. Both the varieties were identified as potential improved varieties and the genetic material was released by the Central Varietal Release Committee in 2002 (Table 6).

Trends in large cardamom farming

Sikkim produces about 40% of the world's large cardamom, standing second after Nepal. However, since 2006, more than 60% of the plantations have become non-productive resulting in a tremendous decline in cultivated area. The income of marginal and cardamom dependent farmers has also dramatically declined, which has led to a marked increase in the number of farmers shifting to other income generating activities such as other cash crops, the tourism industry, government jobs, and so forth.

As per the records of the Spices Board and Horticulture and Cash Crop Development Department of Sikkim, the total area under large cardamom production between 1999 and 2001 was 23,484 hectares and the actual production area was 19,912 hectares. In 2003, this area increased to 26,734 hectares, as a result of the area expansion mission initiated by the Food Security and Agriculture Department and the Horticulture and Cash Crop Development Department, Government of Sikkim. Accordingly, the actual cardamom yielding area increased to 22,714 hectares in 2003. In the following years, as a consequence of long dry spells and disease infestations, the area under large cardamom decreased, and by 2007/08 it was 12,500 hectares, which showed a decline of 45%

Table 6: **Basic characteristics and adaptability of local and improved cultivars of large cardamom in Sikkim**

Cultivar	Altitudinal suitability (m)	Plant height (m)	Flowering	Fruiting/harvesting	Seeds/capsule
Local cultivars					
Ramsai	1,500–2,300	1.5–2.0	May-Jun	Oct–Nov	25–40
Ramla	1,500–2,200	1.5–2.0	May-Jun	Oct–Nov	30–40
Bharlang	1,000–1,800	1.5–2.5	Apr-May	Sept–Oct	30–50
Sawney	800–1,600	1.5–2.0	Apr-May	Sept–Oct	50–70
Seremna	700–1,400	1.5–2.0	Mar-Apr	Aug–Sep	65–70
Dzongu golsai	600–1,000	1.0–1.5	Mar-Apr	Aug–Sep	50–70
Improved cultivars					
Sikkim I	1,400–1,800	1.5–2.0	Mar-Apr	Sep–Oct	35–50
Sikkim II	1,000–1,500	1.5–2.0	Mar-Apr	Sep–Oct	35–55

Source: Data for seeds and capsules from Spices Board 2013

(Figure 5). In an effort to address this issue, government agencies and the Spices Board, under its area expansion mission, initiated a nursery programme to produce planting material for affected cardamom growers. This slightly increased the area under cultivation to 14,520 hectares in 2010.

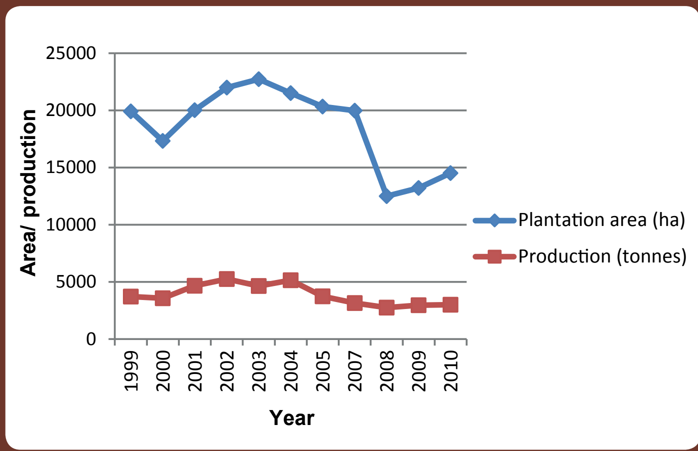
The quantity of cardamom produced has followed a similar trend since 1999. In 2004, Sikkim saw record production of cardamom (5,152 metric tonnes increasing from 3,710 metric tonnes in 1999) and became the largest producer in the world (Figure 5). However, after 2004, there was a continual decline in production. By 2008, production had declined to 2,745 metric tonnes, bringing Sikkim down to second position after Nepal.

However, from 2010 to 2012 production gained a little momentum, owing to increased awareness, motivation among farmers, and the provision of extension services by agencies aiming to raise the production area (HCCDD 2011). As a result, the total production of large cardamom increased by around 14% from that of 2007/08 to 3,316 metric tonnes fetching around USD 47.54 million. Similarly, the yield also decreased to the bare minimum (148 kg/ha) during early 1990s, after which it started improving and, in 2010, reached 234 kg/ha (Figure 6).

The average yielding area of large cardamom over the last 11 years (1999–2010) was 18,544 hectares. During this period, the average production of large cardamom was 3,875 metric tonnes per year with an average yield of 207 kg/ha.

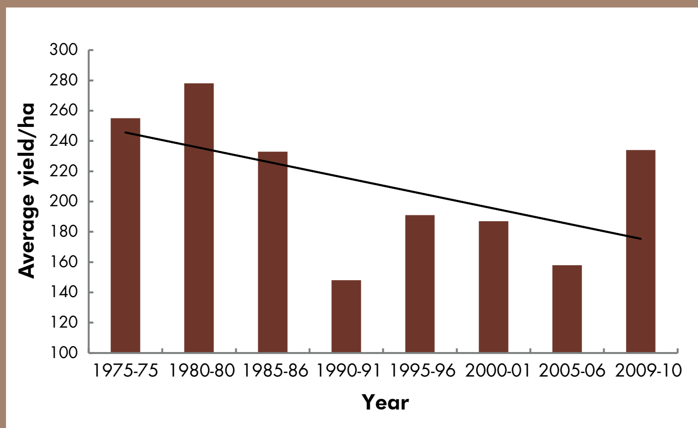
Linear regression analysis showed a negative correlation between cardamom plantation area (hectares) and production (metric tonnes) over time. This means that area under large cardamom plantation as well as its production has declined over the years. Cardamom production and plantation area show a positive linear relationship, which means that there is a positive correlation between its production and area under production (Figure 7).

Figure 5: **Large cardamom plantation area (ha) and production (metric tonnes per year) in Sikkim between 1999 and 2010**



Note: Based on data obtained from the DESME 2002, 2004–05, 2006–07, 2008–09; Horticulture and Cash Crop Development Department Annual Progress Report 2009–10 (HCCDD 2010)

Figure 6: **Large cardamom average yield per hectare in Sikkim between 1975 and 2010**



Note: Based on the DESME 2002, 2004–05, 2006–07, 2008–09; Annual Report 2009–10, Horticulture and Cash Crops Development Department, Government of Sikkim

Currently, 16,037 of the total 111,830 households in Sikkim (14.34%) have a large cardamom plantation on their farms. Among the various social groups in Sikkim, Scheduled Tribes posses around 23% of the cardamom farms, Most Backward Castes hold 13% and Other Backward Castes hold 11% (Table 7).

Sikkim's East District has the highest number of households (5,275) with large cardamom farms followed by the West (5,060), South (2,937), and North (2,759) districts. Of the 16,037 households in Sikkim with large cardamom farms, the total marginal households with less than 1 hectare of land under cardamom plantation was 14,476, of which 10,975 households had less than 0.5 hectares and the remaining 3,501 had between 0.5–1.0 hectare under cardamom. Around 1,060 households possessed 1–2 hectares of cardamom plantation, 143 possessed 2–4 hectares, and 321 possessed 4–10 hectares of land. As many as 37 households possessed more than 10 hectares of land (Table 8).

Figure 7: **Linear regression analysis of (a) large cardamom production area, (b) volume of production, and (c) cardamom production versus production area in Sikkim (1996–2010)**

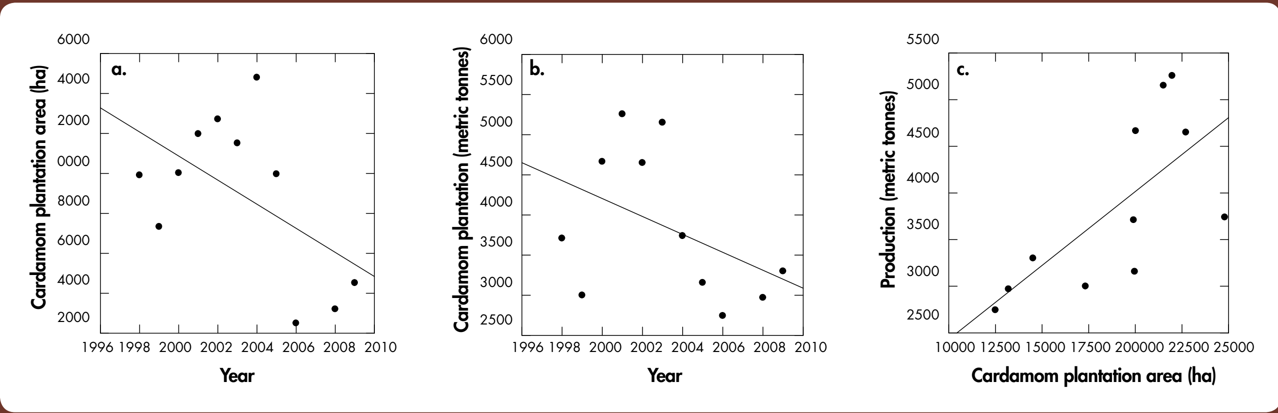


Table 7: **Number of households with large cardamom landholdings in Sikkim by social group**

Social group	Total number of households	Households with cardamom landholdings	
		Number	%
Scheduled Tribes (Bhutia, Lepcha, Limbu, Sherpa, Tamang)	41,200 (37%)	9,351	22.70
Scheduled Castes (Kami/Lohar, Damai, Sarki and Majhi)	7,376 (7%)	215	2.91
Most Backward Castes (Bhujel, Dewan, Gurung, Jogi, Kirat Rai, Magar, Sunuwar, Thami)	26,460 (23%)	3,664	13.85
Other Backward Castes (Bahun, Chettri, Newar, Sanyasi)	25,893 (23%)	2,797	10.80
Others	10,901 (10%)	10	0.09
Total number of households in Sikkim	111,830	16,037	14.34

Source: Data compiled from DESME 2006-07

Farmers' perceptions of changes in large cardamom production

The majority of respondents (78.51%) said that the area under cardamom agroforestry is the same, but the area under strict cardamom cropping has decreased considerably. The remaining respondents said that the area under large cardamom on their farms had increased (11.36%) or was unchanged (10.23%). On the importance of large cardamom for households in the last ten years or so, around 54.55% of respondents reiterated that it is an important source of income, 15.91% explained that it was the only cash commodity for farmers ten years ago, and the remaining 29.54% said that cardamom has always been a very important source of cash income for farmers compared to other cash crops or other livelihood options.

Table 8: **Households cultivating large cardamom in Sikkim and area under cultivation by district**

District	% households						Total households
	<0.5 ha	0.5–1ha	1–2ha	2–4ha	4–10ha	>10ha	
North	54.77	30.08	10.47	3.48	1.02	0.18	2,759
East	70.18	20.83	5.90	1.78	0.87	0.44	5,275
South	66.77	22.33	7.39	2.08	1.46	0.07	2,937
West	75.03	18.14	4.80	1.38	0.51	0.14	5,060

Source: Data compiled from DESME 2006-07

The study estimated the average contribution of large cardamom to the household economy to be 29.2% in 2012, compared to 50% in 1997 (Sharma and Sharma 1997) and 38% in 2000 (Sharma et al. 2000). Even though the share of large cardamom to household cash income has dropped by about 9% between 2000 and 2012, it is still the most important cash crop and remains the second most important source of cash income after employment and remittances. This also indicates that, in the future, cardamom farming in Sikkim could see a reduction in the number of growers due to off-farm employment opportunities.

A farmer showing a large cardamom plant affected by furkey disease, Bering Busty, East Sikkim

Disease and pest infestations

The direct interactions, interviews, and group discussions with the cardamom growers in the study sites revealed that chirkey (mosaic streak), furkey (bushy dwarf), pahenley (*Fusarium oxysporum, F. solani*), and rhizome decay were the main diseases in cardamom bushes (Table 9). Around 70% of respondents revealed that initially they were able to manage chirkey and furkey diseases and obtain some yield, but soon after the rhizome decay was observed, the entire plantation was damaged and they were unable to manage this disease. Farmers also reported that the leaf caterpillar is the main pest, in addition to a stem borer that eats up the pseudo-stem from the bottom to top causing the cardamom bush to wither and die.

Stem borer in large cardamom, Dhanbari-Tumin, East Sikkim

Apart from diseases and insect pests, some mammalian pests (monkeys, wild boars, bears, civet cats, and deer) also destroy cardamom crops at different seasons of the year. Regular monitoring of fields and guarding farms are the only measures taken by farmers to protect their crops from wild animals. Animals such as civet cats and wild boars destroy the crop during the night, and there is a serious need to control this problem. Farmers are discouraged due to the lack of effective measures to control the increasing number of wild animals visiting their crop fields and cardamom plantations from the adjoining forest areas. There is no provision for compensation from the government for crops damaged by wild animals.

A rhizome rot on large cardamom, Dhanbari-Tumin, East Sikkim

Table 9: **Disease and pest infestations in large cardamom and control measures employed by farmers**

Infestation	Plant parts affected	Time of year	Control measures
Disease			
Leaf streak (*Pestalotiopsis* sp.)	Leaf area	Summer through winter	Bio-control agents (*Trichoderma harzianum, T. viride, Psedomonas fluorescens, Bacillus subtilis*); aqueous extracts of *Artemisia vulgaris, Schima wallichii*; fungicides (copper oxychloride, mancozeb, carbendazim)
Fungal disease (*Colletotrichum gloeoporiodes*)	Pseudo-stem and leaves	October through February	Fungicides
Leaf spot disease (*Phoma hedericola*)	Leaf area	All year	Copper oxychloride, Mancozeb, Carbendazim, Thyophanate methyl
Furkey (bushy dwarf)	New dwarf bushes	All year	Uprooting, drying and burning
Pahenley (*Fusarium oxysporum, F. solani*)	Leaf, some parts of pseudo-stem	All year	Uprooting, removing, drying and burning
Chirkey (mosaic streak)	Leaf area	All year	Uprooting, removing, drying and burning
Insect pests			
Leaf caterpillar (*Artona chorista*)	Leaf area	Winter through rainy season	
Shoot fly (*Merochlorops dimorphus*)	Plant shoots	Winter through rainy season	Neem kernel aqueous extract solution in plants
Stem borer (*Glyphipterix* sp.)	Pseudo-stem	Winter through rainy	
White grub (*Holotrichea* sp.)	Rhizome	Winter	Neem kernel aqueous extract solution in plants
Mammalian pests			
Himalayan palm civet	Fruit and seeds	During fruiting and fruit maturing (September–November)	Guarding the farm at night
Crestless porcupine	Entire plant	After harvest	Guarding the farm at night
Monkey	Entire plant	All year	Guarding the farm at day
Himalayan black bear	Entire plant	October through winter	Guarding the farm in the day and night
Indian wild boar	Entire plant	October through winter	Guarding the farm in the night
Barking deer	Eat new sprouts	All year	Guarding the farm at day

Source: Perception of respondents, personal observation, and Saju et al. (2011a, 2011b)

Impact of Climate Change on Large Cardamom Farming

Farmers' perceptions and adaptation practices

Ninety-one per cent of respondents, mostly from the mid and lower altitudes, felt that the weather during the onset of cardamom flowering season was becoming drier, while 4.5% (mostly from the high altitudes) felt it was becoming wetter (Table 10). Another 4.5% perceived no change or fluctuating weather conditions during cardamom flowering season. Around 95% of the respondents also said that during the peak flowering season for cardamom (May–June), erratic rainfall events caused flowers to fall and decay, resulting in the loss of fruiting intensity during September–October. Almost all of the cardamom growers and key informants perceived the climatic conditions to be changing and said that rising temperatures have led them to harvest cardamom 10–15 days earlier. Such changes also affect the yield and quality of the produce. Around 66% of the respondents observed that snowfall, a yearly phenomenon 15–20 years ago, has become rare during the past 4–5 years. Thus, there is a need to conduct research for the development of varieties suitable for cultivation under changing climate conditions at various altitudinal locations.

Table 10: **Perception of cardamom plantation, production and productivity decline**

Governing factors	Attributes of change	Key informants' perception (%) (n=20)	Cardamom growers' perception (%) (n=88)
Environmental/ climate change	Erratic rainfall/untimely rainfall	95	35.23
	Reduction in temporal spread of rainfall	95	12.5
	Long dry spells during winter until the flowering of cardamom	100	63.64
	Temperature rise	100	34.09
	Pollution/poison in the air	65	6.82
	Frost/hailstorms	60	93.32
	Snowfall during winter	55	11.36
	Shift in seasons	95	12.5
	Extreme winters/summers	85	6.82
Biological	Chirkey, furkey, fungal blight, pahenley	00	94.32
	Pests and insects	100	81.82
	Mammalian pests	80	2.27
	Low soil nutrient/fertility status	95	4.54
	Loose soil due to alder tree roots	55	2.27
	Decreased number of pollinators (due to climate change impacts)	95	72.27
	Old and nutrient exhausted farms	85	7.95
	Inadequate pollination of cardamom	85	63.64
	Lack of appropriate shade management	90	4.54
	Lack of disease free planting material	80	19.32
Socioeconomic	Weak farm management	85	15.91
	Fragmentation of family land and per capita land	60	5.68
	Low productivity of crops/cardamom	85	2.27
	Shortage of irrigation facilities	70	4.54
Institutional/ governance	Lack of appropriate policies to revive cardamom	70	52.27
	Lack of adequate extension services (financial/material support)	60	46.59
	Low level of research on mitigating disease problems	75	10.23
	Lack of local-level growers institutions/cooperatives/farmers clubs	75	3.41
	Lack of adequate forward and backward linkages	65	13.64
	Lack of training on disease management, lack of training on irrigation facilities	65	31.82

Climate change induced changes in local weather conditions such as erratic and unseasonal rains, changes in rainfall patterns, and long dry spells during winter have led to a change in the crop cycle and the emergence of new diseases and pests. This has significantly altered the management of crops. Cardamom farming is now demanding more labour and increased investment in the form of irrigation, quality planting materials, and manure (Table 11).

Indicators of climate change

On the basis of interactions with key informants and cardamom growers across the study sites and other cardamom growing areas, five main indicators of climate change were identified as causing the decline in large cardamom productivity:

- the emergence of diseases and pests;
- altered seasons for flowering and fruiting of cardamom along the agroclimatic gradients (600-2,400 m);
- erratic, unseasonal, and scanty rainfall patterns;
- loss of soil moisture and fertility; and
- long dry spells and rising temperatures across cardamom growing elevations.

Table 11: **Large cardamom crop cycle, disease management and impact of climate change**

	Crop cycle	Farm management for plantation improvement and control of diseases and pests			Environmental/ climate change
		Activities	Pests	Diseases	
Jan		Sorting the diseased plants, uprooting Manuring bushes Irrigation using sprinklers	In some areas monkeys destroy the cardamom bushes and break new spikes.	Rhizome part decays and dries during dry months	Dry period continues Frost, hail, and snow falls occasionally
Feb					
Mar	Flowering starts from lower to higher altitudes followed by fruiting Pollination period			Chirkey, furkey, and fungal disease Monitoring of disease	
Apr		Replanting/gap filling with the healthy suckers Weeding, bush clearing etc. during flowering and fruiting	Rodents and birds damage the flowers. Caterpillars attack the leaves.		Strong winds sometimes destroy cardamom
May					
Jun	Pollination continues Fruiting starts at lower and moves to higher altitudes			Incidence of *Colletotrichum* blight, phoma leaf spot disease Monitoring of the disease	Scanty or sometimes erratic rainfall takes place causing flowers to fall or decay Loss of soil fertility due to excessive rain, mudslides, and landslides in some areas
Jul			Civet cats eat the mature cardamom capsules causing heavy losses.		
Aug		Harvesting and curing, starting at lower altitudes Selling of some fruit during festivals		Monitoring of the incidence of *Colletotrichum* blight, phoma leaf spot disease	
Sep					
Oct					Dry period starts Loss of soil moisture Sunny days impact on the cardamom leaves
Nov	New spikes start appearing	Monitoring of diseased and healthy plants	Monkeys, bears, and boar destroy the bushes.	Drying of leaves and spikes due to disease during dry periods	
Dec					

All of these factors affect the yield and quality of cardamom produce. However, the majority of respondents identified the emergence of diseases and pests and erratic, unseasonal, and scanty rainfall patterns as key causes of the decline in cardamom farming (Figure 8a). The rise in temperatures and occurrence of long dry spells are responsible for the increased incidence of diseases and pests.

Management measures to increase production

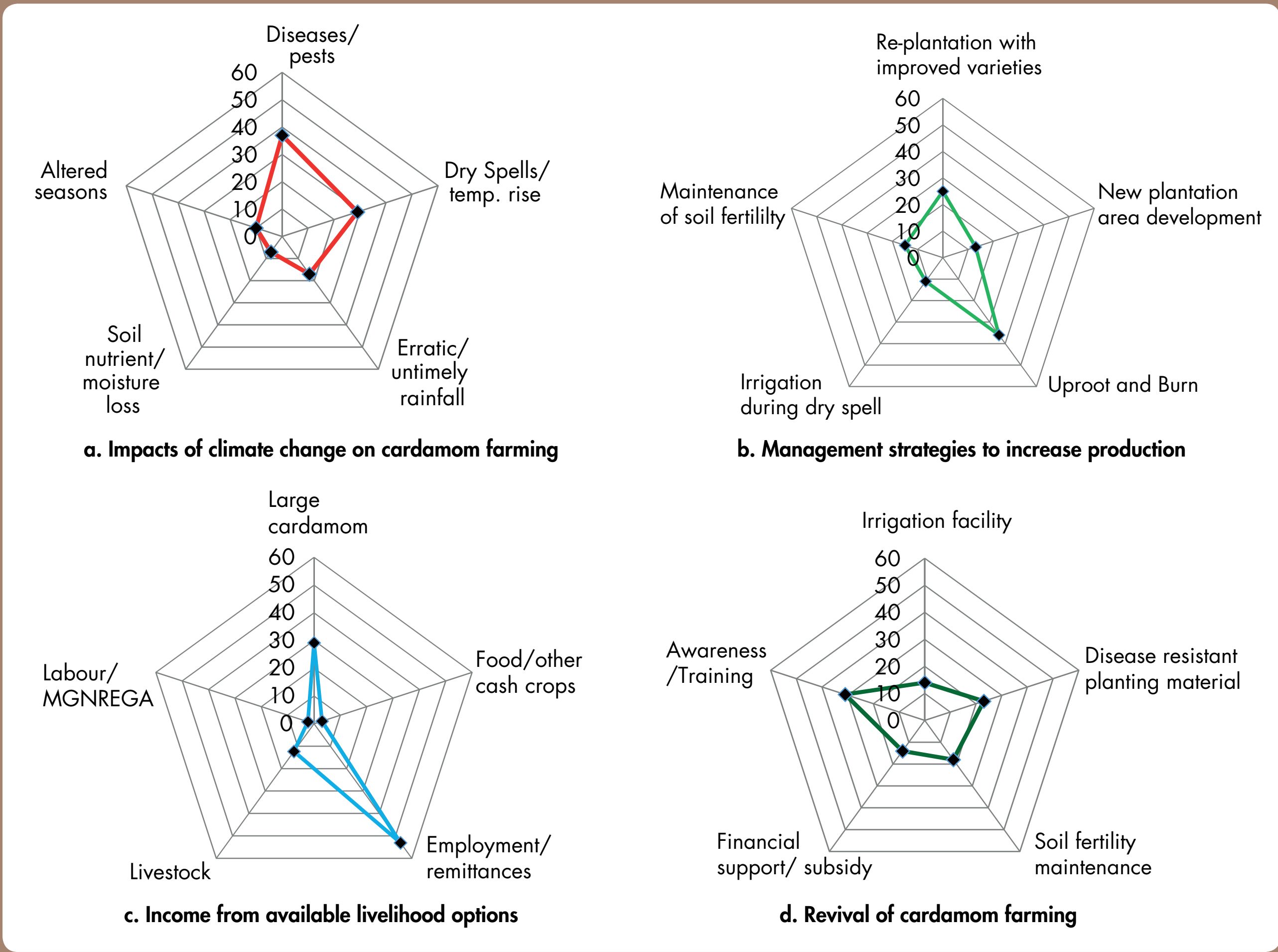
In response to these observed climate changes, many cardamom farmers are using adaptive practices – both traditional and scientific interventions – developed by concerned institutions. Some of the key adaptive measures adopted by farmers in study areas include (Figure 8b):

- development and introduction of disease tolerant cultivars;
- plantation on new farmlands replacing food crops such as maize or paddy;
- maintenance of soil fertility by applying manure;
- irrigation during dry winter months;
- management of diseases and pests by uprooting plants; and
- drying and burning infected plants.

Shift to other livelihood options

Among the different livelihood options, employment and remittances were found to be the most important sources of income for sustaining household livelihoods in the study areas. Large cardamom is the second most important

Figure 8: **Cardamom farmers' perceptions of the impacts of climate change, adaptive strategies, household income from different livelihood sources, and revival of cardamom farming**



source of income. However, with climate variation affecting large cardamom farming, more and more farmers are looking for other sources of income, such as employment or even labour under the Mahatma Gandhi National Rural Employment Guarantee Act. Discussions with respondents and key informants revealed that migration, particularly of young people looking for jobs in cities and towns has increased. Thus, a significant amount of household income is shifting away from cardamom and to these sources (Figure 8c).

Interventions required for the revival of large cardamom farming

Large cardamom continues to be the lead crop in the farm economy of Sikkim and, therefore, warrants immediate intervention for its revival. This came up strongly in discussions with farmers who identified several interventions required for the revival of this crop. Table 12 shows that there is an increasing realization that the problems associated with large cardamom farming can be substantially reduced by adopting appropriate measures to maximize the economic and ecological functions of cardamom farming.

In fact, related institutions are making efforts to revive large cardamom, particularly in areas that have the most potential for cardamom production. Major revival practices include the provision of irrigation facilities, soil fertility maintenance strategies, the plantation or re-plantation of disease resistant or disease tolerant varieties, awareness and training on cardamom farming, and financial support and subsidies (Figure 8d). These revival practices are now widely practiced in Hee-Pechreak and Hee-Martam in West Sikkim, but are yet to reach other more remote cardamom growing areas in Sikkim.

Newly planted large cardamom farm showing dry and diseased leaves on cardamom bushes

Table 12: **Needs assessment and peoples' perception of the revival of cardamom in Sikkim**

Problem	Interventions immediately required by cardamom farmers
Crop management for disease control	Development of disease free planting materials as per the suitability of cultivars in cardamom growing altitudes (600–2,400 m) Development of protocols for control of diseases and pests in existing farms and appropriate training and awareness for progressive farmers Development of biopesticides and biofungicides
New area expansion and re-plantation in existing areas	Development of nurseries for mass multiplication of suckers in different cardamom growing locations Distribution of good quality planting suckers to progressive farmers at subsidized rates
Soil fertility maintenance	Training and subsidies for establishment of units for the preparation of bio-composts, vermi-composts, and manure
Prolonged dry spells	Irrigation facilities such as pipes and sprinklers during dry season Water supply/irrigation canals from nearby streams and rivers
Shade management	Phasing out of the old alder and other trees Plantation of species for multi-strata canopies according to the suitability of land for appropriate understory moisture retention
Curing technology and the quality of produce	Development of fuel efficient, farmer-friendly curing houses suitable to the farmers' field situation Quality produce with retention of colour and oil content
Market linkages	Forward and backward market linkages, farmers' cooperatives and value chain analysis
Policy	People-centric policy development for the revival and improvement of large cardamom-based farming and diversification of livelihoods for human wellbeing

Processing and Marketing of Large Cardamom

Processing

After harvesting, large cardamom is collected and transported to curing units and prepared for storage. Freshly harvested large cardamom contains around 70–80% moisture content, which must be reduced to 10% (maximum) in order to store it properly without rotting (Zala 2002). The traditional curing unit (kiln), or 'bhatti' as it is called locally, is a simple curing device made from materials found locally, such as stone and mud, with a wire mesh layer sitting above an open chamber. A fire is lit below the shelf and the heat absorbed in a stonewall or heat sink, which radiates the heat and dries the capsules (Rao et al. 2001). However, the various inadequacies of this system make traditional bhattis less than desirable for producing a marketable end product. Drawbacks include uneven heating and drying; loss of volatile oils in the cured capsules (Zala 2002); loss of the characteristic rich, dark red colour; charring; and an infusion of smokiness from the wood fire below (Rao et al. 2001). Recognizing these drawbacks, the Spices Board of India has developed a modified bhatti with a 200 kg or 400 kg capacity. This modified bhatti uses heat that is more evenly distributed to cure the cardamom and generate a higher quality product and is offered at a subsidized rate by the Spices Board under the scheme 'Export Oriented Production and Post Harvest Improvement of Spices' (Spices Board 2011).

Harvesting of large cardamom, Hee-Gaon, West Sikkim

Traditional method of drying cardamom capsules, Hee-Gaon, West Sikkim

Marketing

Once the large cardamom capsules are cleaned, cured, and graded there are several avenues that farmers can pursue for marketing. Many farmers sell their product directly to local merchants or those in nearby towns. In exchange, the merchant sets up an account for the farmer, which the farmer can use to buy provisions for the following year. The main drawback of this practice is that farmers are at the mercy of the merchants and are offered less than the actual value of the large cardamom.

It is also common to sell produce through a middleman. The middleman visits each farm in a locale, buying and collecting the cardamom from each farmer along the way. The middleman then sells the product either to local merchants or wholesalers in Siliguri. This method is prevalent in areas with little or no access to roads and with mostly small-scale farmers who have neither the time nor the money to bring their produce to market. Here, the farmer is at a disadvantage as s/he must provide the cardamom at the rate that the middleman proposes to pay, which is generally less than s/he would get directly from the merchant. Once in the hands of the local or external wholesaler, the cardamom is sold at a higher rate on local, national, and international markets. While India continues to be the largest consumer of large cardamom in the world, a huge percentage is also sold internationally. The second largest consumer of large cardamom is Pakistan, followed by United Arab Emirates, United Kingdom, United States of America, Canada, and South Africa (Maheskumar 2010).

Since 2010, a third marketing channel has been developed by the North Eastern Regional Agricultural Marketing Corporation, whereby auctions are held monthly in Rangpo, a nearby market town. This large cardamom auction has increased the return to farmers by Indian rupees (INR) 25 (USD 0.46) per kg (Personal communication with North Eastern Regional Agricultural Marketing Corporation on 11 February 2013) by creating a competitive bidding process between merchants. The record price one farmer received was INR 1,240 (USD 23) per kg. The auction also incentivizes farmers to improve their cultivation and post-harvest processing methods. The danger of receiving too low an offer is eliminated by giving the farmer the opportunity to withdraw his or her submission, even after the bidding has taken place.

Plans for the development of a new 'E-auction' are underway. An E-auction would improve the situation in many ways, including by facilitating international buyers to purchase cardamom and creating even more competition among potential buyers, resulting in a higher return for farmers. However, if large cardamom is made available to the global market, Indian merchants could easily be outbid and the price of cardamom would increase for Indian consumers.

In 2010/11, the North Eastern Regional Agricultural Marketing Corporation sold 4 metric tonnes of cardamom through an open auction. The following year, the sale grew to 16 metric tonnes. In the year 2013, it is expected to exceed 40 metric tonnes. The average auction price for cardamom in 2010 and 2011 was INR 1,100 (USD 20.4) per kg, which is expected to grow to INR 1,300 (USD 24) per kg in 2013. The North Eastern Regional Agricultural Marketing Corporation operates the only large cardamom auction centre in India at Rangpo in Sikkim. The marketing system for large cardamom in Sikkim is improving, however the remaining produce of large cardamom (>3,000 metric tonnes) is sold without organized marketing channels, thus resulting in a minimum premium price to farmers (Table 13).

Pollination of Large Cardamom

Main pollinators

Large cardamom is essentially a cross-pollinated crop and requires the cross-pollination of its flowers for crop production. Different species of bees are its main pollinators. However, despite its economic importance, there are very few studies on the pollination eco biology of this crop. Preliminary research by Verma (1987) reported the honeybee, *Apis dorsata*, to be one of the pollinators of large cardamom by directly relating the increase in cardamom production to an increase in the number of *Apis dorsata* colonies. However, in recent years, interest in cardamom pollination is growing among the scientific community, resulting in an increase in information about its pollination requirements, pollinators, and the impact of pollination on cardamom production. A few studies have reported that common native species of bees including *Apis cerana*, *A. dorsata*, *A. florea*, and *A. laboriosa*, as well as the less noticed stingless bee, *Trigona* sp. (putka), visit large cardamom flowers (Singh et al. 2012). Further studies by Sinu et al. (2011) reported that *Bombus haemorrhoidalis*, *Apis cerana*, *Megachile lanata*, *Episyrphus balteatus* (hover fly), *Macroglossum stellatarum* (hawk moth), and *Aethopyga siparaja* (crimson sunbird) also visit the flowers of large

Table 13: **Wholesale price of large cardamom in major markets centres in India in 2012 and 2013**

Major market centre	Quality	Wholesale price in 4th week of January (USD per 100 kg)			
		2012		2013	
		Minimum	Maximum	Minimum	Maximum
Gangtok, Sikkim	Badadana (large size capsules)	1,157.4	1,250.0	1,296.2	1,296.2
	Chotadana (small size capsules)	1,111.2	1,157.4	1,250.0	1,250.0
New Delhi	Kainchicut (graded)	-	-	1,463.0	1,796.3
Siliguri, West Bengal	Badadana with tail	1,212.9	1,388.9	1,333.3	1,351.9
	Badadana without tail	1,296.3	1,574.1	1,388.9	1,444.5
	Chotadana with tail	1,111.1	1,259.3	1,259.3	1,259.3

Source: Spices Board 2013a Note: 1 USD = 54 INR cardamom and that *B. haemorrhoidalis*, *M. lanata*, and *A. siparaja* were the most effective pollinators of large cardamom. Deka et al (2011) reported that two bumblebees, *Bombus haemorrhoidalis* Smith and *B. breviceps* Smith were the predominant pollinators of large cardamom.

Bumblebee pollinating large cardamom flower

The findings of the present study show that cardamom growers are aware of the importance of pollination to cardamom production. The majority of key informants (95%) and cardamom growers (72%) said that pollination is very important for cardamom productivity, although 28% of cardamom growers had no idea about the value of pollination (Table 14).

Role of *Apis cerana*

A recent study on large cardamom pollination by Sinu and Shivanna (2007) showed that 70% of its flowers visited by the indigenous honeybee *Apis cerana* remain unpollinated, affecting the cardamom yield. These authors further reported that *Apis cerana* collects a large portion of the pollen from the flowers of large cardamom leaving less chance for pollination by other pollinators. However, *Apis cerana* beekeeping is an age-old traditional practice and an integral part of traditional farming system in Sikkim. The local people keep native species of honeybee in log or box hives made of wood hung against the wall. A few households also keep bees in wall hives. The findings of the study revealed that nearly two-thirds (64%) of the respondent households engage in beekeeping. In addition to beekeeping, honey hunting is also practised in Sikkim, especially in forest areas and cliffs. Thus, it is common to find the indigenous bees co-existing with cardamom farms in many villages.

Honeybee pollinating large cardamom

Large cardamom farmers in the study sites were asked whether or not they have experienced a decline in cardamom production because of *Apis cerana* beekeeping in their villages. Almost all (99%) of the respondents said that bumblebees and honeybees pollinate large cardamom. Around 59% of cardamom growers also observed that honeybees are important agents of pollination (Table 14). Over 70% of respondents reported that honeybees do not affect cardamom production negatively, a small number (around 7%) said that honeybees do affect cardamom production negatively as they rob them of pollen, and 23% had no idea whether or not honeybees have a positive or negative effect on cardamom production. Interestingly, none of the key informants mentioned that honeybees negatively affect cardamom production. Ninety per cent of key informants and 71% of cardamom growers expressed the view that honeybees are not responsible for the decline in cardamom production.

Interpreting this information from farmers, it is possible that, even though under control conditions (i.e., when there is only *Apis cerana* visiting cardamom flowers and other pollinators are absent) *Apis cerana* may not be a very effective pollinator of large cardamom flower due to its small body size, it does not appear to have a significant negative impact in the open field as reported in earlier studies (Sinu and Shivanna 2007). There are a large number of other pollinators that help in pollinating cardamom under open field conditions; however, further research is needed to verify this. One thing that is very clear from the present study is that it is very important to conserve and protect the major cardamom pollinators, namely, bumblebees, as in their absence farmers may not be able to harvest cardamom of an optimal quantity and quality.

The majority of farmers who responded to the survey (74%) and almost all of the key informants cited bumblebees as the most important pollinators of cardamom, a finding that confirmed the scientific studies (Sinu and Shivanna 2007; Deka et al. 2011). Additionally, as many as 88% of cardamom growers and 65% of key informants said that they have seen honeybees in the wild and in their surrounding areas.

Table 14: **Perception of pollination of large cardamom**

Research question	Perception	Key informants' perception (%) (n=20)	Large cardamom growers' perception (%) (n=88)
Do you think pollination is important for large cardamom?	Yes	95	78.75
	No	5	28.41
Do you think honeybees help to pollinate cardamom?	Yes	95	59.09
	No	5	10.23
	No idea	0	30.68
Do you think that cardamom is adequately pollinated?	Yes	20	28.41
	No	80	43.18
	No idea	0	28.41
Have you heard that honeybees affect your cardamom production negatively?	Yes	0	5.68
	No	90	70.45
	No idea	10	23.86
Do you think that due to climate change these insects do not appear on cardamom?	Yes	85	72.27
	No	10	5.68
	No idea	5	17.05
Compared to 10 years ago, what have you observed about local insects?	Increase	5	14.77
	Decrease	80	60.23
	No change	15	25
Do you think bumblebees are important for pollination?	Yes	100	73.86
	No	0	0
	No idea	0	26.14
Do you think there were more insects visiting your cardamom flowers 10 years ago compared to now?	Yes	100	82.95
	No	0	5.68
	Same	0	11.36
Have you seen honeybee colonies in the wild?	Yes	65	86.64
	No	35	11.36

Farmers' perceptions of large cardamom pollination under climate change

All of the key informants (100%) and 83% of the cardamom growers reported a serious decline in pollinating insects and a consequent decline in cardamom production over the years. The majority of key informants (90%) and cardamom growers (70%) believe that this decline is due to the impacts of climate change. Although it appears that much of this decline is due to a lack of pollination resulting from climate change and a decline in pollinator populations, how much of it is due to other factors could not be established. However, it is clear from the study that climate change is negatively affecting populations of insect pollinators. Around 15% of key informants and 80% of cardamom growers categorically observed and confirmed that the rising temperatures, long dry spells, and fluctuating rainfall patterns have resulted in the transformation or destruction of the micro-habitats of insects and altered their breeding patterns. Farmers believe that the decrease in populations of insect pollinators is also due to the change in cropping patterns, land use change, and unregulated developmental activities such as road construction, building construction, hydropower projects, pollution, and the accumulation of dust particles in the air (Table 14).

Climate change-induced changes in local weather conditions have been shown to increase the incidence of pests and diseases and affect pollinator populations and pollination in various crops (Partap and Partap 1997, 2002, 2009). Climate change is reported to affect the flowering patterns of various crops and plants and the availability of pollinators (Rana 2010; Sharma and Partap 2011), and to shift cropping patterns in the Himalayan region (Bhatt 2010).

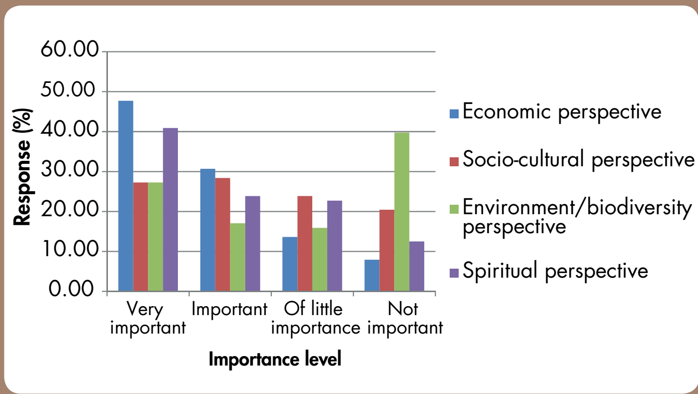
Respondents have seen the nests of wild bees hanging on the cliffs and once a year some villagers collect honey from these bees. This honey is considered to have high medicinal value and is distributed among village households. A few farmers also keep stingless bees called 'putka' (*Trigona* sp.) in their houses. The honey from putka is believed to have great medicinal value and is sold at USD 112 per kg.

A young beekeeper with *Apis cerana* log hives, Payong, South Sikkim

Importance of beekeeping to farmers

Beekeeping, being a traditional activity, has an influence on the sociocultural, economic, agroecological, and spiritual dimensions of rural life in Sikkim. Of the total respondents surveyed, nearly half (48%) said that beekeeping is very important from a spiritual/religious perspective and around 27% said that it is very important from both socio-cultural and environmental perspectives. Nearly one-third (31%) of respondents thought that beekeeping is important from an economic perspective, while 28% and 24% perceived it as important for socio-cultural and environmental reasons, respectively (Figure 9). However, some respondents expressed the view that beekeeping is not an important activity from an economic, social, cultural, spiritual, or environmental perspective (Figure 9). This could be because these farmers do not keep bees and are not aware of the importance of beekeeping.

Figure 9: **Perception of the importance of beekeeping from different perspectives**



Involvement of women in beekeeping

Women are involved in beekeeping in nearly half (46%) of the households that engage in beekeeping in the study areas. Forty per cent of the women involved in beekeeping assist men in selling honey. The low participation of women in beekeeping is due to their engagement in other household activities such as tending the kitchen garden, cooking, caring for livestock, and caring for children as well as due to lack of interest, training, and skills required for beekeeping. Traditionally, training and motivation of women for beekeeping is not considered important by people in the study areas.

Table 15: **Values associated with beekeeping in the traditional farming systems**

Value	Local uses
Social	• Honey is shared with neighbours in times of illness and injury. • Honey is bartered with neighbours and local shopkeepers in exchange for seeds, household and food items, and farm labour. • Honey is offered to guests/relatives as a food item.
Religious and spiritual	• Honey is used during religious rites and for cultural and customary festivals by tribal communities. • Honey is used as an offering to local deities.
Environmental	• Honeybees are important pollinators of several flowers and farm crops. • Genetic biodiversity conservation is improved through pollination by honeybees. • Honeybee pollination supports agriculture production.
Health and medicinal	• Honey is used as a medicine for the treatment of fever, pneumonia, coughs and colds, body ache, and joint pain. • Honey is given to pregnant women and elderly people. • Honey is applied on wounds and abrasions. • Honey is used as a medicinal tonic, energizer, and appetizer.

Farmers' perceptions of changes in beekeeping practices

Table 16: **Perceptions of changes in beekeeping practices**

Research question	Perception	Large cardamom growers' perception (%) (n=88)
Do you think beekeeping is increasing in your village?	Increasing	20.45
	Decreasing	32.95
	No change	13.64
	No idea	32.95
Why do you think bees are declining?	Pollution	20.45
	Predators (wasps, hornets, civet cat etc.)	4.54
	No idea	75
Did you receive any support from the government for beekeeping?	No	96.59
	No response	3.41

One-fifth (20%) of respondents revealed that the practice of beekeeping is increasing in the village, although one-third (33%) said that it had declined over the years. According to the respondents, this decrease is a result of a decline in the population of local bees because of climate change impacts, rising temperatures, changing flowering times in the adjoining forest areas and farms, and air pollution. Respondents also mentioned that farmers lack appropriate support services and capacity building for innovative beekeeping. Around 14% of the respondents informed that the practice is almost the same over the years. Only 7% of the respondents replied that there are commercial beekeepers in their villages (Table 16). As per the perceptions of the large cardamom farmers, the main purpose of beekeeping for most of the households was to produce honey for household consumption; the generation of cash income and cultural and spiritual purposes were secondary.

Regarding the reasons for the decline in beekeeping, around one-fifth (20%) of respondents felt that air pollution could be a main reason for the decline, while 5% of respondents said that one of the causes for the decline in beekeeping could be predator species (wasps, hornets, and civet cat), which prey largely on bees (Table 16). Furthermore, a lack of interest among the younger generation in beekeeping, the low level of income generated from beekeeping, dry spells, which impact on flowering, and forest fires were also cited as causes of the decline in beekeeping in Sikkim.

In relation to government/institutional support for beekeeping, the majority of respondents (95%) reiterated that they have not received any extension services for beekeeping from government departments or other agencies. During the interviews most of the respondents asked for extension and support services such as training and capacity building on beekeeping and technical and material support such as the provision of beehives. Almost all of the farmers said that not much investment is required for beekeeping at the local level, except for a minimal amount of labour for the construction of beehives. Respondents showed a strong interest in taking up beekeeping, provided that the extension agencies are ready to provide them with adequate training, supported by the distribution of bee colonies and beehives.

Farmers' Responses to Challenges

Replacement and transformation

The majority of farmers revealed that they have turned to silviculture (timber trees), livestock farming (cattle, dairy, poultry) and the development of agroforestry systems including broom grass (*Amliso*) and other fodder species on the once-productive cardamom patches. In Sang-Martam, most of the farmers have taken up mandarin orange farming as a means of cash generation. In addition, many farmers in the high altitudes of Lingee-Sokpay, and Dhanbari-Tumin acknowledged that they had to abandon their land altogether due to the decrease in yield.

During the 1980s, a large tract of paddy fields in the study sites, especially Simik-Khamdong and Dhanbari-Tumin, was converted to cardamom cultivation. However, due to the decline in cardamom production during the late 1990s, those farmlands have been rendered barren or are afforested with multipurpose agroforestry species.

Once again, in more recent years (2009–2012), large swaths of agricultural land (paddy fields) and domestic kitchen gardens have been converted into cardamom growing patches, particularly in areas where cardamom is reviving and productive, such as Hee-Pechreak and Hee-Martam. In these villages cardamom has replaced food grain crops such as paddy and maize and other cash crops such as ginger and vegetables. This reinvestment in large cardamom could easily be attributed to the rising price per kilogram at the marketplace and also due to the identification of the variety seremna, which is adapted to the agroclimatic conditions in these areas.

Institutional support for the revival of large cardamom farming

The Spices Board of India has created a scheme called 'Special Purpose Fund for Replantation and Rejuvenation of Large Cardamom Plantations' as a way to motivate farmers to continue large cardamom production. This scheme is divided into two programmes: re-plantation and rejuvenation. Under the re-plantation scheme, small and marginal landholders are encouraged to re-establish existing plantations that have been neglected over the years through the use of certified disease-free planting materials. Farmers with up to 4 hectares of landholdings are eligible for up to INR 12,500 (USD 225) per hectare (provided in two instalments) and farmers with between 4–8 hectares are eligible for INR 9,500 (USD 175) per hectare, upon successful completion of the re-plantation programme.

In the rejuvenation programme, old, poorly yielding, and diseased plants are identified and removed from pre-existing plantations. The resulting gaps are filled with new, disease-free plants, and farmers are additionally provided with new scientific methods for disease control, fertility, and irrigation management, as well as general best management practices as per the 'Large Cardamom Package of Practices 2013' information guide (Spices Board 2013b). Under this scheme, only farmers with landholdings of up to 4 hectares are eligible for subsidies, which amount to INR 5,808 (USD 120) per hectare, given in a single instalment. Additionally, the Spices Board's special purpose fund for the re-plantation and rejuvenation of large cardamom gives provisional technical support for the development of on-site certified sucker nurseries and is willing to purchase certified planting materials from nurseries at the rate of INR 1.15 (USD 0.02) per sucker.

In addition to the re-plantation and rejuvenation programme, different organizations in Sikkim are conducting a great deal of work to research and disseminate information related to the best management practices for responding to these changes within the agroecological context of Sikkim. As a result, the Spices Board of India in Sikkim recently released an information guide called the 'Large Cardamom Package of Practices 2013', which provides up-to-date management recommendations for everything from site selection to propagation techniques, disease management, weed and pest management, fertility management, harvesting, curing, and processing for

Table 17: **Support and services rendered by institutions and agencies to large cardamom growers**

Extension service	Institutions and activities
Research	The Indian Cardamom Research Institute-Spices Board, Tadong office is working on pollination studies, the development of disease-free lines and quality planting materials, cost effective curing kilns, and the development of bio-pesticides and fungicides.
Development of quality planting materials	Four nurseries, one in each district, have been established by a Task Force formed for the revival of large cardamom to develop quality planting material. In 2011, the Horticulture and Cash Crop Development Department of Sikkim procured around 700,000 tissue-cultured planting materials developed by Tata Energy Research Institute Gurgaon, Haryana.
Awareness and capacity building	Both the Spices Board and the Horticulture and Cash Crop/Agriculture development departments in Sikkim organize training on disease management, farm development, the preparation of bio-pesticides and fungicides, and post-harvest technology, among other things. These bodies also organize exposure visits for farmers to different cardamom growing areas.
Financial support	Financial support for re-plantation, nursery establishment, the development of water harvesting tanks, irrigation facilities, bio/vermi composting units etc. is provided by both the Spices Board and the Horticulture and Cash Crop /Agriculture development departments of the Government of Sikkim. These agencies are also providing financial support to interested farmers for the expansion of new cardamom plantation areas by about 400–500 hectares every year.
Marketing	The North Eastern Regional Agricultural Marketing Corporation, a Government of India undertaking, has taken up the task of market development and established an auction centre for cardamom at Rangpo in East Sikkim. The Sikkim Marketing Federation is involved in value addition and packaging of cardamom.

maximum marketability. This publication is the result of research and collaboration with local farmers and could serve as a valuable resource for maximizing the effectiveness of farmers who are seeking to either rejuvenate their current plantation or begin a new one.

However, when asked whether they receive any support from government institutions, almost all of the cardamom growers in Sumik-Kham dong, Tumin-Dhanbari and Lingee-Sokpay said that although they need institutional support to help revive cardamom farming, they have not yet received any from government or non-governmental organizations. Farmers said that they need support in areas such as capacity building and training, disease-free planting materials, and infrastructure such as irrigation system development with poly-pipes and sprinklers to use during the drier months.

On the other hand, in Hee-Gaon in West Sikkim almost all the cardamom growers have received minimal financial support to raise nurseries in their fields, materials for re-plantation, and advice about farm management from the Spices Board office in Gangtok. Hee-Gaon Pechreak has the high yielding local cultivar seremna and, as a result, cardamom farming has revived in this area of Sikkim and the farmers are supplying good planting materials to the government department (at INR 3 per sapling) for free distribution, while also selling saplings to farmers directly from their nurseries.

In 2011, the Horticulture and Cash Crop Development Department in Sikkim procured around 700,000 tissue-cultured saplings of large cardamom, which are now under mass propagation in nurseries established at Ravangla in South Sikkim, Buriakhop in West Sikkim, and Lingtam in East Sikkim. The mother stock for tissue culture was provided from the SBLC I and II (improved cultivars) from Sikkim. As of 2013, no disease or pest has been reported among these nursery-raised cultivars. The nursery-raised saplings will be distributed to progressive cardamom farmers once they attain maturity. A variety of support services and financial assistance are provided to the large cardamom growers in Sikkim either by the Agriculture-Horticulture Department, Government of Sikkim or the Spices Board of India (Table 17).

Discussion and Conclusion

The importance of large cardamom to livelihoods

The agricultural economy in the Sikkim Himalayas is largely based on high-value cash crops, with large cardamom being the most important cash crop. Rural farming families have by and large built their lifestyle around the income generated from large cardamom in terms of food, housing, education, health, social activities, and farm management. The decline in cardamom production has had a direct impact on local livelihoods. Large cardamom is the second largest contributor to household income in the study areas after employment and remittances, fetching around USD 910 per family per year. This study estimated that almost one-third of household income is derived from large cardamom. Earlier studies by Gupta et al. (1984), Sharma and Sharma (1997), Sharma et al. (2000), Avasthe et al. (2011), and Singh et al. (2011) made similar estimates of the contribution of large cardamom to household income. The study by Sharma et al. (2000) further reported that the gross income of households was almost double in large cardamom-dominated systems, compared to traditional mixed-forest systems.

However, the contribution of large cardamom to overall household cash income has declined from about 50% in 1997 (Sharma and Sharma 1997) to 38% in 2000 (Sharma et al. 2000) and 29% in 2013 (Sharma 2013). There are two possible explanations for this: Firstly, the emergence of new income generating opportunities such as government jobs, work under the MGNREGA, and employment in tourism sector, as reported by Sharma (2013), and, secondly, a decline in cardamom farming area and production due to the emergence of new diseases and pests as a result of climate change-induced changes in local weather conditions (Sharma 2013). Yet, large cardamom continues to be the main cash crop in Sikkim and second most important source of household cash income in the study areas.

The trees in large cardamom-based agroforestry systems provide fodder, timber, and fuelwood and are important livelihood sources for rural households. Large cardamom farming is thus a self-sustaining system and has been adapted independently by low-income, marginal farmers of Sikkim.

A number of institutions in Sikkim and Darjeeling are currently working to improve rural livelihoods through research and development, the provision of subsidies, technical expertise, and capacity building. In Sikkim, the Horticulture and Cash Crops Development Department, and the Food Security and Agriculture Department of the Government of Sikkim are collaborating with the Indian Cardamom Research Institute (ICRI) of Spices Board of India to provide expert extension services for improving large cardamom farming (FSAD 2010; HCCDD 2012; Sharma and Acharya 2013; Spices Board 2004, 2014). Different departments of the Government of Sikkim and the Spices Board have initiated a number of programme activities including the development of quality planting materials, establishment of nurseries under a certified nursery scheme, a replanting scheme, the supply of sprinkler irrigation units, and low-cost cardamom curing plants over the last 30 years. However, some of these schemes are not yet fully acceptble to cardamom growers in local situations. In most cases these schemes use a linear and sectoral approach of training farmers on new techniques and disseminating scientific findings for best management practices. Unfortunately, there is a lack of interdepartmental convergence when it comes to the implementation of 'improvement' schemes. Moreover, though the beneficiaries of these schemes are always the farmers, no effort is made to include them in the process of designing these interventions. The loss of large cardamom cultivation practices brings with it a host of interconnected issues, including a change in land use patterns, a loss of genetic biodiversity, family members seeking income from external sources, rural to urban migration of youth, and ultimately the loss of traditional knowledge systems in Sikkim (Hunsdorfer 2013).

Pollination of large cardamom: The role of *Apis cerana*

With regards to pollination, large cardamom is a self-fertile crop, but requires cross-pollination to produce fruit/capsule. However, literature is scarce on the pollination and pollinators of this crop. There have only been a few research studies carried out on large cardamom pollination. Bumblebees including *Bombus braviceps* Smith and *Bombus haemorrhoidalis* are reported to be its most efficient pollinators (Deka et al. 2011; Kishore et al. 2011; Sinu and Shivanna 2007; Sinu et al. 2011). Singh et al (2011) reported several species of pollinators including bees, butterflies, beetles, and mammals as important pollinators of various crops cultivated in Sikkim. These authors further reported the declining number of hive-kept honeybees and wild colonies of honeybees as one of the reasons for declining crop production.

A recent study by Sinu et al. (2011) reported *Bombus haemorrhoidalis*, *Apis cerana*, *Megachile lanata*, *Episyrphus ballatus* (hover fly), *Macroglossum stellatarum* (howk moth), and *Aethopyga siparaja* (crimson sunbird) as common visitors of cardamom flowers. Among these *Bombus haemorrhoidalis*, *Megachile lanata*, and *Aethopyga siparaja* were found to be the most efficient pollinators based on the transfer of pollen to stigma following a single visit of the pollinator to virgin stigma.

In relation to the indigenous honeybee, studies by Sinu and Shivanna (2007), Deka et al. (2011), and Kishore et al. (2011) concluded that *Apis cerana* is a pollen robber. Sinu and Shivanna (2007) reported that *Apis cerana* bees visit cardamom flowers to collect pollen, but do not touch the stigma and, hence, do not pollinate the flower. They reported that *Apis cerana* leave 70% of large cardamom flowers un-pollinated, while collecting all the pollen from the flower, thus negatively affecting its pollination chances (even by other visitors) resulting in severe crop declines. However, farmers in this study reported they have not noticed such a decline in their large cardamom yield as a result of *Apis cerana* visits, even though *Apis cerana* beekeeping is common in the cardamom farming areas of Sikkim. A possible explanation for this is that the previous studies were conducted in a controlled environment where no other pollinators were allowed to visit the flowers. Under open field conditions *Apis cerana* is not the only insect visiting cardamom flowers, but one among many including different species of bumblebees. In-depth research on large cardamom pollination requirements, its pollinators, and their effectiveness is needed to validate these findings under open field conditions.

Impact of climate change on large cardamom farming

Climate change is a well-known phenomenon in the Himalayas and is causing unpredictable and erratic weather conditions, the rapid melting of snow, and the drying up of water sources (Sharma et al. 2009a ; Chaudhary and Bawa 2011; Chaudhary et al. 2011). Climate has a variety of affects on mountain ecosystems and the livelihoods of mountain people including on agriculture, biodiversity, water availability, and water quality (Chaudhary et al. 2011, Chettri et al. 2012): Local communities in the study areas appear to have substantial awareness of climate change and their observations concur with the scientific research on climate change trends, the flowering cycle of various crops and plants, and agricultural productivity (Chaudhary et al. 2011). An article published by Chaudhary and Bawa (2011) in Biology Letters validated local perceptions of climate change and its concurrence with scientific evidence in the Himalayas.

Climate change has had a pronounced impact on large cardamom-based traditional farming, as well as on pollinator species, especially honeybees and bumblebees. Earlier studies in the western Himalayas conducted by Partap and Partap (1997, 2002, 2009) and Partap and Tang (2012) found that climate change-induced changes in local weather conditions affect the pollination of various crops by affecting the plant-pollinator relationship. Climate change affects the emergence and foraging activities of pollinators and influences the flowering time and duration of various crops and plants (Partap and Partap 2002; Partap and Tang 2012). However, so far, farmers in Sikkim have not experienced pollination-related productivity issues in large cardamom.

Climate change-induced changes in local weather patterns are reported to have increased the incidence of diseases and pests in various crops. Studies conducted by Partap and Partap (2002, 2009) in the western Himalayan state of Himachal Pradesh and by Partap and Tang (2012) in Maoxian County in the southwestern part of Sichuan province of China reported similar findings in apple and other fruit crops.

A few studies have reported the impacts of climate change in the Sikkim Himalayan region. Rahman et al. (2012) have reported that the mean minimum temperature has increased by 1.95°C while maximum temperature did not exhibit any significant departure from long term average. They further reported that rainfall over 30 year period increased by 124 mm (measured from 1981 to 2010 at Tadong,1350 m). The communities in the region have enough awareness to show climate change trends, phenology and agriculture productivity in the region which are in concurrence with scientific research (Chettri et al 2012). Sharma (2012) reported that the phonology of a number of multipurpose agroforestry species in the cultivated systems of Sikkim Himalaya has altered over the last 10 years. Sharma and Rai (2012) have described pronounced effect on agricultural crops in low, medium and high altitudes, and also in response to reduced pasture lands in the greater and trans-Himalayan region. They also emphasized traditional ecological knowledge, agrobiodiversity, land uses and diversification of livelihoods among local communities to cope with changes, and that each of these will play an important role in true adaptation to climate change. Sharma et al. (2010) and Tambe et al. (2012) have reported indirect evidence of decline of spring water availability during the dry season and have suggested an approach to monitor spring water flows, which will not only address the needs for irrigation facilities in agriculture but also help provide drinking water to rural communities.

Sikkim has completed micro-level climate change related vulnerability assessment of the rural communities at the Gram Panchayat level. The state Action Plan on Climate Change has been prepared after detailed multi-sectoral consultations and village participatory rural appraisals in consonance with the National Action Plan on Climate of the Government of India (Arrawatia and Tambe 2012). In the Khanchendzonga Landscape, the ICIMOD has been promoting large scale conservation planning for promoting habitat connectivity through corridors development, as well as building capacity of the community for economic interventions based on conservation linked livelihood options (Chettri et al 2008, 2012).

Recommended interventions

Urgent research and development interventions are required to establish disease free varieties of large cardamom; improve farm management; and conserve effective pollinator species to counter the impacts of climate change and the decline in production and yield. Interventions are also needed to improve post-harvest technology to improve quality, thereby increasing the price received by farmers.

Large cardamom farming is less labour intensive than any other farming system in Sikkim and does not require large or expensive infrastructure at the growers' level. However, a growers association could give farmers greater negotiating power, enabling them to negotiate fair prices for their produce. The North Eastern Regional Agricultural Marketing Corporation has developed a marketing channel whereby auctions are held monthly in Rangpo, a nearby market town in Sikkim, to assist growers to sell their produce at better prices. However, growers' co-operatives that could pool produce and bring it to primary auctioning centres are still lacking.

Apart from the management and upkeep required by large cardamom, some future objectives could be to further improve the quality of planting materials through certified sapling nurseries, increase the spread of best management practices, facilitate more efficient farmer innovation processes through communication, improve product quality through improved post-harvest technology, and increase market channel efficiency.

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International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal
Tel +977 1 5003222 **Fax** +977 1 5003299
Email info@icimod.org **Web** www.icimod.org

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