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Case Study

STATUS OF LARGE CARDAMOM (*AMOMUM SUBULATUM* ROXB.) FARMING SYSTEMS IN THE CHANGING SCENARIO OF MODERN ECONOMICS OF SIKKIM, HIMALAYA

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ABSTRACT
Sikkim constitutes the lion's share (84%) of large cardamom production in India, where its varieties are cultivated in diverse agro-ecosystems and climatic regimes. However, during the last decade and so, gradual decline has been observed in production due to multiple factors. Considering the role of these highly productive systems towards the rural livelihood and economy, an in-depth analysis was attempted to understand the ongoing transitions across farming systems and the likely impacts on contribution to economics at various levels. Besides the historical background, the paper provided proportionate acreage of large cardamom in different agro-systems, carbon sequestration potential, its uses, cropping patterns and seasons. It also showed the relative production contribution of different states terms of production, particularly, focusing Sikkim with yearly statistics on acreage and production, which showed a declining trend. Cost-benefit analysis of different age group plants was also presented. Analysis of export and import quantity and earnings were analyzed, which revealed in actual the country is expending more on import than the earnings. Various factors were identified impacting the production viz. old plantations, diversification of agricultural system (vegetable, fruit and flowers), pollination syndrome, decline of pollinator abundance (diversity & density), lack of pollination knowledgebase pest and diseases. In view of the observations, the study recommended an integrated approach incorporating the real-time issues of farming communities along with corrective measures to address the various constraints impacting the cultivation and production of large cultivation.

KEYWORDS: Agriculture; Changing Scenario; Cropping; Diversity; Large Cardamom; Sikkim.

INTRODUCTION

Due to the expansion of human population and demands, many agro-ecosystems across the globe have been experiencing tremendous pressure either with intensive use of existing land or more extensive use of lands that are currently being used for other purposes. It is estimated that with the current methods, global food production will need to increase by at least 50% and it would require converting another one billion hectares of natural habitat in agricultural production with increased input variables in terms of fertilizers, water and pesticides[1]. The compounding impacts of these intensive agricultural practices and extensive land use conversion have led to many known and unknown threats resulting in reduced flow of ecosystem services and now been apparent infrequent reports of decreased output and crop failures.

Recognizing the multifunctional of role of Traditional Farming Systems (TFS) in the mountain ecosystem (ecological functioning) and rural livelihood, FAO has identified Sikkim Himalaya Agriculture as one of the potential sites for the globally –important ingenious Agricultural Heritage Systems (GIAHS). It comprises of trans-Himalayan agro-pastoral system of the Dokpas in the alpine plateaus, traditional Agroforestry such as alder-cardamom and farm-based systems in the temperate zones and terraced/valley rice systems in the lower sub-tropical zones (above 300 m). Similarly, GEF/FAO/UNEP and later on Earth watch institute selected the state for the implementation of the Global Pollination Project and mountain ecosystem service project, respectively. They identified and targeted large cardamom as the main focal crop to address the declining production of the spice, particularly due to declining pollination services.

Traditional Agriculture Systems

The agro-ecosystems in Sikkim have been characterized as innovative and adaptive, that has been sustainably managed and evolved over 600 years by the aboriginal Lepchas and Limboos. The system was later followed by Bhutias and later on subsequently adopted by other Nepalese (Rai, Yakha, Gurung, Mangar, Tamang, Sunuwar, Thakuri, Bahun, Chettri, Kami, Damai, Sarki, Majhi, Newar, Sherpa, Thami, Bhujel, Jogi) to the present state. The system got a sudden boon and strengthened during the British protectorate period (1817-1947 AD). Mass clearing of forest area for agricultural use was accelerated mainly after the policy of Nepali settlement in Sikkim for revenue rising by Mr. J.C. White (1889 to 1908 AD).The enactment gradually turned the century old

traditional shifting agriculture system into the sedentary system and the process of conversion is still continuing and visible. The sedentary system constitutes a combination of compartments such as agro-forestry, forestry, livestock, and parcel of agriculture land forming altogether a unit mountain garden-based farming system. Presently, the remains of shifting cultivation are rarely observed in the form of khoriya in Dzongu (traditional Lepcha area) and elsewhere [2].

Large cardamom in Traditional Agriculture Systems

Large cardamom (*Amomum subulatum* Roxb.), belonging to family Zingiberaceae, constitutes an integral part of traditional farming systems. It is considered a high value crop-based agroforestry practice comprises of large cardamom based called alainchi-bari and mandarin orange (*Citrus reticulata*) based called suntola-bagan practices, along with diverse tree species. About 70% of the cardamom-based agroforestry practices are under N-fixing Himalayan alder (*Alnus nepalensis*) while 30% are under the mixed-tree agroforestry species.

Large cardamom is an understory perennial cash crop cultivated along the Himalaya mainly in Sikkim, Darjeeling, Uttarakhand (in some parts) and in neighboring nations of Nepal and Bhutan. The Himalayan alder is an excellent tree associate to cardamom agroforestry for its appropriate shade, N2-fixation ability (100–155 kg ha-1 year^{-1}) and nutrient rich litter. In the lower altitudes, between 600–1200 m, *Albizzia* and alder are grown together as shade trees [3, 2].

The cardamom based-agroforestry systems are considered ecologically more viable and sustainable than the rain-fed agriculture systems. In terms of carbon sequestration, the cardamom based-agroforestry system stores 3.5 times more carbon than the rainfed agriculture system, similarly, in terms of monetary returns farmers are benefitted 5.7 times more in cardamom based-agroforestry systems as compared to the rainfed systems. The agroforestry is regarded as an efficient management system that demands fewer inputs where the ratio of output to input is more than 13 compared to rain-fed agriculture. The systems also contribute significantly towards sustainable development of the mountain region benefitting the upstream and downstream communities by ensuring/accelerating the flow of multiple ecosystem services like, conservation of water and soil, rejuvenation of soil, nutrient recycling, conservation of biodiversity diversity of habitats, watershed functions, aesthetic values *etc*.[3]. However, like any other agro-ecosystems the farming practices in Sikkim have gone through many substantial changes to cope with the changing market scenario, changing climatic patterns and many more factors impacting the production.

Uses of large cardamom

Large cardamom is believed to be among the oldest species known mankind with record dates back to 6th century BC in Ayurvedic preparations mentioned in *Sashruta* and 4th century BC recorded by *Theophrastus*, the Greek Philosopher. It is native to Sikkim Himalaya and *Lepchas* were believed to use it first for the purpose of medicine and as an aromatic edible wild fruit. Cardamom seeds have several medicinal properties and often administered orally for curing certain ailments. It acts as carminative, diuretic and as an effective cardiac stimulant along with treatment of stomachache and various types of throat and respiratory troubles as a remedial medicine. However, it is quite extensively used in various culinary preparations, confectionaries, cosmetic and pharmaceuticals. Large cardamom seeds contain 3% essential oil rich in cineole and used as flavouring agent and spice [2].

Diversity of Large cardamom diversity in Sikkim Himalaya

Amomum salbulatum Roxb. is the cultivated large cardamom species across the region with are seven species of wild relatives *viz. A. linguiforme*, *A. kingii*, *A. aromaticum*, *A. corynostachyum*, *A. dealbatum*, *A. costatum* and *A. plauciflorum* naturally occurring in the region[2]. The cultivated species has twelve local cultivars (varieties) that have evolved in succession and readapted to various environmental factors such as water deficit at different elevations [3]. However, the following six cultivars of large cardamom viz., Ramsey, Ramla, Sawney, Varlangey, Seremna and Golsey are widely grown across the region (Table. 1).

TABLE 1. Large cardamom cultivar diversity in Sikkim Himalaya

S.N.	Variety	Morphological Identification traits	Capsule/seed characteristics
Above 1500 m			
1.	Ramsey (Cultivated even in steep slopes)	Tall & robust with large number of tillers Plant height: 1.5 to 2.0 meters Tiller colour: Maroonish Leaves: Narrow	Size: Small Seeds: 25-40 seeds
2.	Sawney* (Widely adapted cultivar, which is most suited to medium (975-1500m amsl) and high (> 1500 m amsl) altitude areas)	Tall & robust Plant height: 1.5 to 2.0 meters Tiller colour: Maroonish Leaves: Ovate and broad	Size: Bigger and bold Seeds: 35 - 50 seeds
3.	Varlangey	Plant height: 1.5 to 2.5 meters Tiller colour: Maroonish Leaves: Narrow leaves. having wavy margins	Size: Bold Seeds: 50 - 70 seeds The productive tiller and spike ratio is relatively high in this cultivar
1000-1500m			

4.	Ramla (Restricted to few high altitude areas in North Sikkim) Below 1,000	Plant height: 1.5 to 2.0 meters Tiller colour:Maroonish Leaves: Broad and long	Colour: Dark pinkish Seeds: 30 - 40 seeds
5.	Seremna (Small pocket of the Hee-Goan, West Sikkim at low altitude)	Plant height: 1.5 to 2.0 meters Tiller colour: Green Leaves: Mostly drooping type, hence named as "Seremna"	Seeds: 65 - 70 seeds Known for high yield potential On an average 2-3 spike in each productive tiller with average 10 capsules in each spike
6.	Golsey	Not robust as other cultivars Plant height: 1.0 to 1.5 meters Tiller colour: Green Leaves: Narrow and erect	Size: Bigger and bold Seeds: 50 - 70 seeds

Source: http://www.sikkimagrisnet.org/General/en/Cardamom_Varieties.aspx

For cultivation in Sikkim and Darjeeling, two High Yielding Varieties ICRI Sikkim 1 and ICRI SIKKIM 2 (selected from Sawney) was released in addition by Indian Cardamom Research Institute in the year 2004 and now are mostly used in tissue culture for planting material production.

Cropping pattern of large cardamom

Plantation of large cardamom is done through nursery grown seedlings and suckers. Land preparation for new plantation generally starts in month of April with *plugging and weeding* of the land. Planting is done during May-July after the onset of monsoon showers with enough moisture content in the soil. Usually, it started with the formation of pits with 30 x 30 x 30 cm of size and at the spacing of 1.5 to 1.8 m depending upon the type of cultivars to be grown. The pits were left for weathering for a fortnight and filled with topsoil blended with manure along with the planting of seedlings or suckers at the center (not very deep). Thereafter, the planting material could be staked and base of the plant mulched with dried leaves.

TABLE. 2 Cropping season of different cardamom varieties across Sikkim Himalaya

Varieties	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
	Flowering Season								Harvesting season			
Ramsey												
Sawney												
Varlangey												
Ramla												
Seremna												
Golsey												

Usually the large cardamom flower bloom for a month and flowering starts from March on wards and ends by the end of July. In some cultivars, like Sawney and Varlangey, which are grown all along the different altitudinal regimes, the flowering season extended up to three months. The *harvesting* of large cardamom started after 4-5 months of the flowering. It started from *September onwards and finished up to November* in 1-3 months, depending upon the cultivar type and the altitudinal location.

Cost-benefit analysis of Large cardamom system: Across different age series

For establishing a new plantation, the input cost of labour and planting material for the first year was estimated around 33,894ha-^{1}(US $ 538). For refilling the gap and weeding in 2nd year the cost was estimated around 4,742ha-^{1}(US $ 75.27). The benefit /cost ratio was calculated from inputs (harvest and post-harvest cost in successive years) and output cost on 3rd year onwards as cardamom plantation starts producing yield after the weeding. Annual cash-benefit analysis and monetary evaluation per hectare of large cardamom (amount US $ = 63) after three year of plantation in Sikkim shows an inclining trend from 3rd year (1.04 time more) onwards with maximum cost benefit ratio in the 7 -12 year (8.83 times more) old plantations (Fig. 1). Thereafter, the ratio declines steadily in progression and in reaches up to 5.94 times in 21-30 year old plantations. However, in cash benefit analysis the input cost varies in concurrence with the output cost with few exceptions. It was highest in the 7-12 year plantations attributing to harvest and post - harvest cost, and decline after wards in 13- 16 & 17–20 year old plantation as the production dips progressively, however, the input cost again increase slightly (cost involved in maintenance of old plantation) in 21 -30 year old plantation without impacting the declining cost benefit ratio[2].

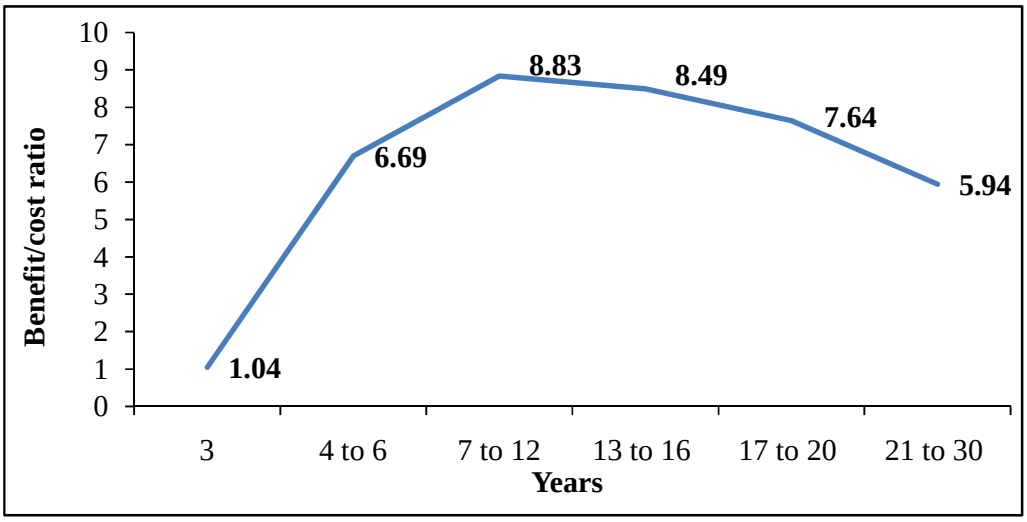

FIGURE 1: Annual cash-benefit analysis of an alder-cardamom based monetary system

Area under large cardamom farming system

In the years 2010-11, the total area under large cardamom in India was estimated around 27655 ha that spread across seven states (Fig.2). Sikkim and West Bengal together constitute 97.57 % of the total area (26984 ha) under large cardamom farming system [2,4].

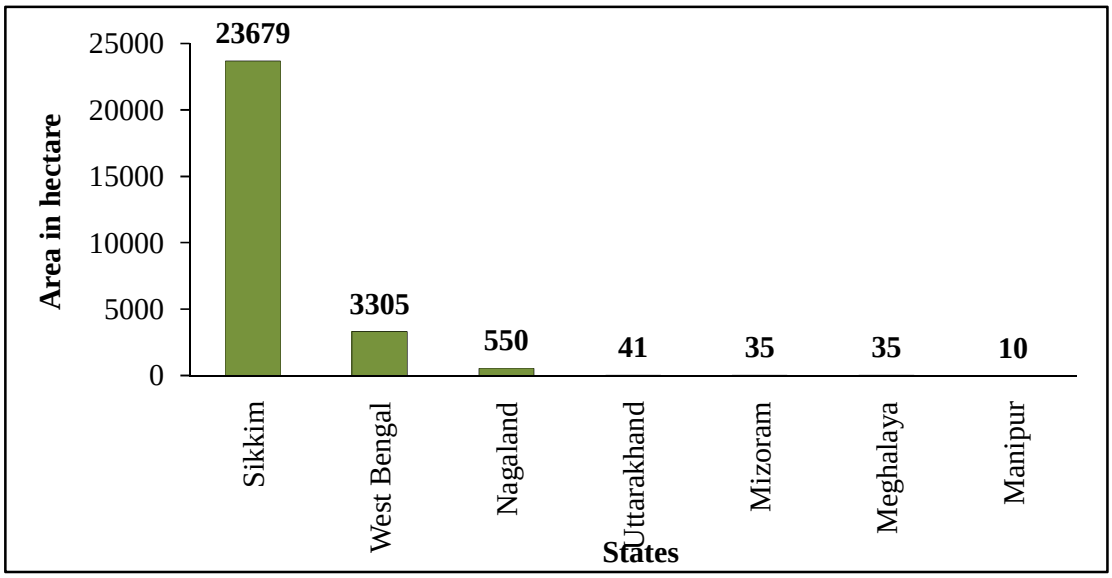

FIGURE 2: Area under large cardamom cultivation: India

Statistics on area under cultivation and production of large cardamom: Sikkim

In Sikkim, the cultivation area of large cardamom had increased by 2.3 times in the past 20 years that has now declined by almost 30 % in the recent years, despite the regular gap filling and replantation under the same canopy as a management tool [2]. During 2004-2005, most of the leased plantations about 1316 ha were also withdrawn from the growers that were leased to growers under reserve forest and protected areas by the department of Forest wildlife and Environment, Government of Sikkim. *In the surveyed area about 70 % of the farmers are dependent on their traditional farms, whereas, the remaining 30 % are establishing new plantations.*

The area and production (Fig. 3) have been in continuous and steady decline in Sikkim despite the increasing productivity. In 2007-08, the area under large cardamom cultivation was 26734 ha with the production of 4305 tons (productivity 6.2), thereafter; the trend showed a steady decline and the large cardamom area was reduced to 23679 ha with the production of 3310 tons (productivity 7.2) in 2010-11. Further, the value of 2011-12 was estimated to be 23155 ha with estimated production of 3234 tons (productivity 7.2) [4].

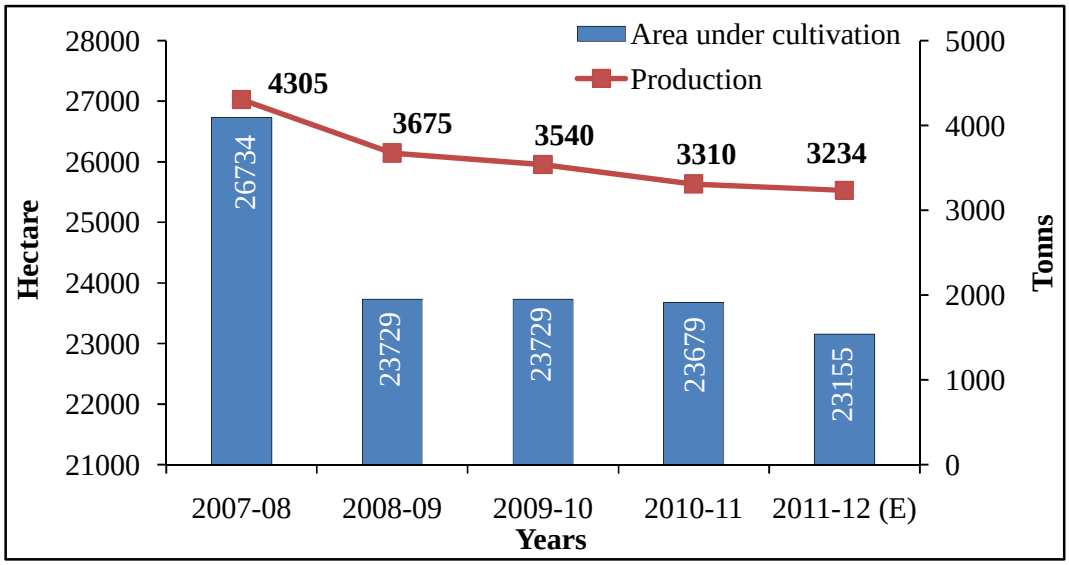

FIGURE: 3 Trend of cultivated area and large cardamom production over the last five years in Sikkim

Production, economic potential

Sikkim, prime cardamom territory, contributes about 84% of the total large cardamom production in India followed by West Bengal (16%). In 2007-2008, export contributed 30.78 % of the total large cardamom production, which increased to 51.02 % in 2008-09. Thereafter, the export decline substantially over the years and to reached 28.91 % of the total production (Fig. 4). The net decline in export primarily attributed to production decline as well as increasing domestic consumption

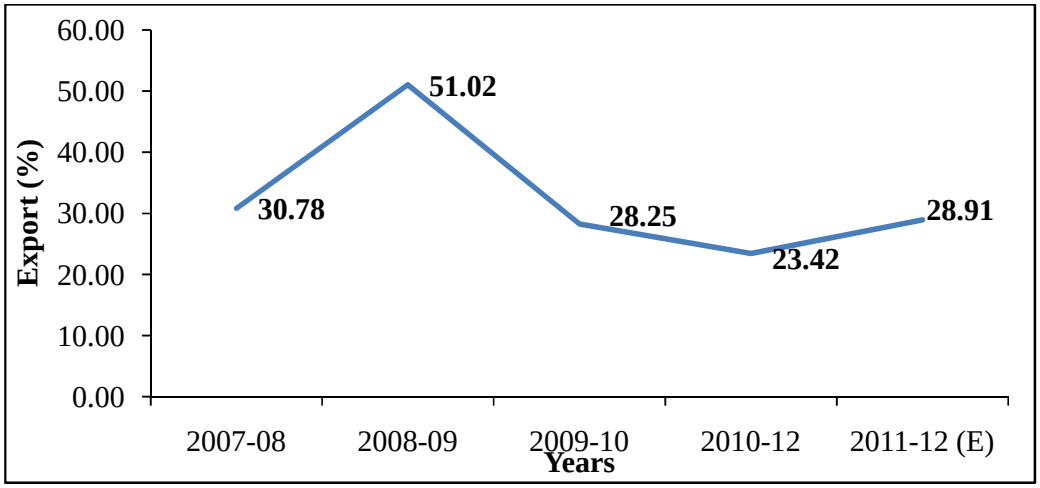

FIGURE: 4 Relative contribution of large cardamom export

Export and Export earnings

The export of large cardamom has been severely impacted during the last five financial years from 2007-2008 to 2011-12 with declining production [4], thus, less availability for export. However, the less availability led to price inflation across the international market and fetched good returns in export earnings.

In 2007-08, a total of 1325.03 MT of large cardamom was exported to various countries across the globe (Fig. 5). The top ten importer countries of large cardamom were Pakistan (1081.66 MT), U.A.E. (97.20MT), UK (67.45MT), U.S.A (12.94MT), South Africa (10.79MT), Canada (9.60MT), Saudi Arabia (3.50MT), Australia (2.82 MT), Bahrain (1.90 MT) and Oman (0.13. MT). In 2011-12, the quantitative export of large cardamom dipped to 934.91 MT and experienced a total decline of 390.12 MT over last five years. The import spectrum has also changed substantially and the top importers' countries of large cardamom in 2011-12 were Pakistan (719.52 MT), U.A.E. (87.30 MT), UK (35.12MT), U.S.A (30.84 MT), Saudi Arabia (14.16 MT), Canada (10.52 MT), South Africa (6.91 MT), Oman (5.54 MT), Bahrain (4.91 MT) and Australia (4.78 MT).

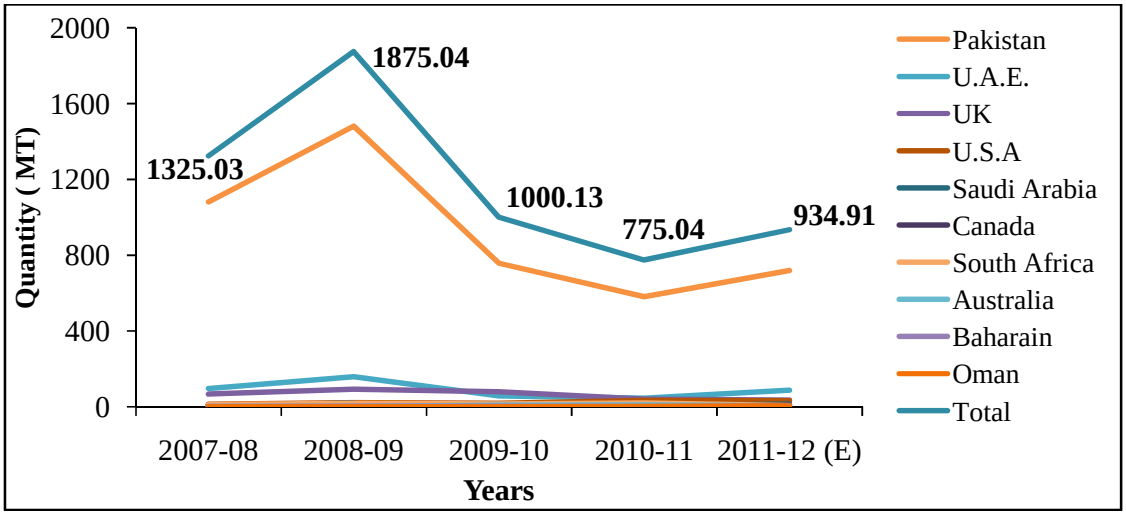

FIGURE: 5 Export of large cardamom from India during 2007-08 to 2011-12 (quantity in MT)

On contrary to export quantity of large cardamom, the export earnings of large cardamom have experienced a continuous inclining trend over the last five years (Fig. 6). In 2007-08, the earnings from the export (1325.03 MT) was calculated 1500.01 lakhs, whereas, in 2011-12 despite the low availability for export (934.91 MT), the earnings was estimated of 6829.99 lakhs.

Current price, market chain & top exporter companies

The finished product of large cardamom is commercially categorized into different grades as *Badadana* (big capsules), *Chotadana* (small capsules), *Kainchi-cut* (capsules with tails cut) and non-*Kainchi-cut* (capsule with tail intact).There are three major centers for large cardamom sale in India, namely, Gangtok, New Delhi and Siliguri. In year 2012, the wholesale price of large cardamom varied between a minimum of 62500/qt (Chotadana) to maximum of 95000/qt (Kainchicut). Similarly, in year 2012 the wholesale price of large cardamom varied between a minimum of 80000/qt (Chotadana) to maximum of 110000/qt (Kainchicut) with increase of 12500/qt in minimum and 15000/qt in maximum whole price of chotadana and kainchicut, respectively (Table. 3)

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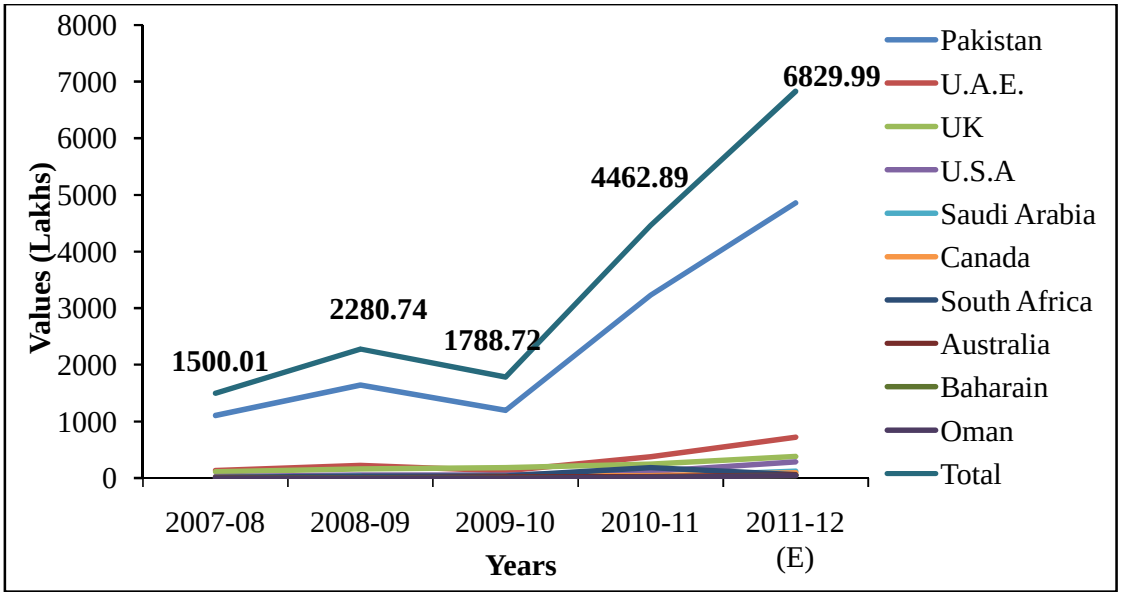

FIGURE: 6 Earnings of large cardamom export during 2007-08 to 2011-12 (value in Lakhs)

TABLE 3: Wholesale Price of LC in Major Market Centres in India for years 2012 & 2013

S.N.	Market Centre	Grade Details	Year 2012 (Week ending 26/10/2012)		Year 2013 (Week ending 26/10/2013)	
			Min.	Max.	Min.	Max.
Cardamom (Large) Price in /Qtl						
1.	Gangtok	Badadana	65000	65000	85000	87000
		Chotadana	62500	62500	80000	84000
2.	New Delhi	Kanchicut	78000	95000	95000	110000
3.	Siliguri	Badadana with tail	65000	68000	87500	90000
		Badadana without tail	72500	75000	94000	95000
		Chotadana	62500	65000	85000	85000

Source: *Spice market weekly, Vol. XII, No.44 -2013*

In year 2012, among the ten major export companies in India, five companies were based in Maharashtra and one in each following states, Uttar Pradesh, Punjab, Gujarat, Rajasthan and Tamil Nadu. Each company has an assigned code, however, as far as the rank in concerned Uttar Pradesh (S396) tops the rank, followed by Punjab (J612), Maharashtra (H026, M677 & L059), Gujarat (K824), Maharashtra (M071 & T322), Rajasthan (G446) and Tamil Nadu (N334). ***Source:*** http://www. spicesboard. in/ directory/ tis/processTopExp.php

Import and Import expending: The import expending of large cardamom has experienced a continuous inclining trend despite of decline in import quantity over the last five years (Fig. 7). In 2007-08, the expending on the import (5,950 MT) was calculated 4996.25 lakhs, whereas, in 2011-12 despite the low export quantity (3895 MT), the expending was estimated of 14558.8 lakhs.

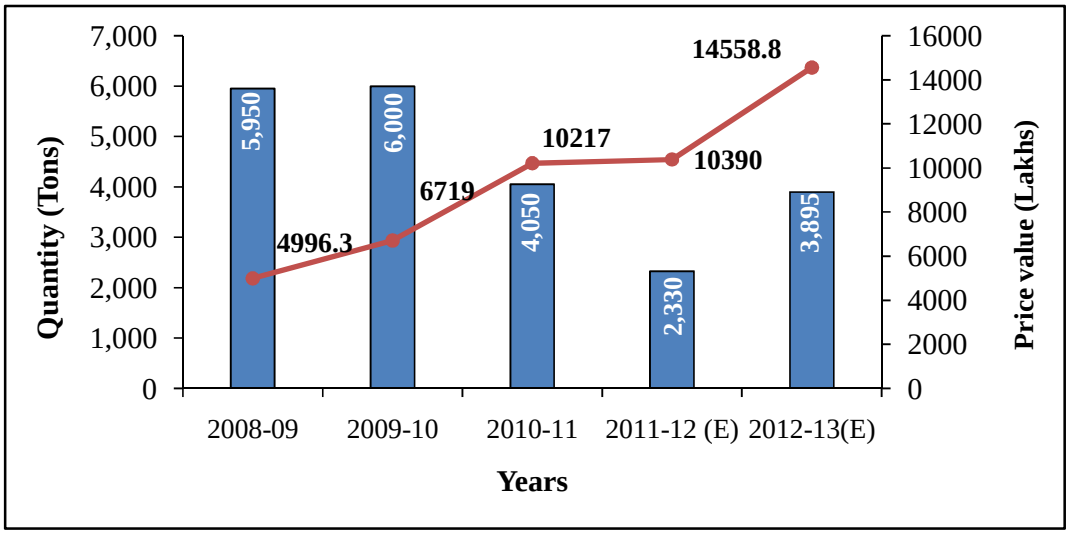

FIGURE 7: Import statistics and expending on large cardamom during 2008-09 to 2012-12
Source: Spice Board, India (http://www.indianspices.com/html/import.htm)

Economics of Large cardamom

Analysis of export and import statistics over the last five year showed that the agronomic yield is by and large not sufficient to meet the domestic demand. The trends on import quantity and expending revealed that in actual the country is expending more on import than the earnings. In year 2008-09, the country actually spent 3496.24 lakhs more than the total export earnings of that year which subsequently reached to 7728.81 lakhs in 2012-13 over the last five years (Fig. 8). Apparently, trend on increasing difference between import expending and export earnings showed the growing domestic demand. However, it may be attributed to the current Foreign Trade Policy that allows duty free imports under the Advance Authorization Scheme for value addition and re-export.

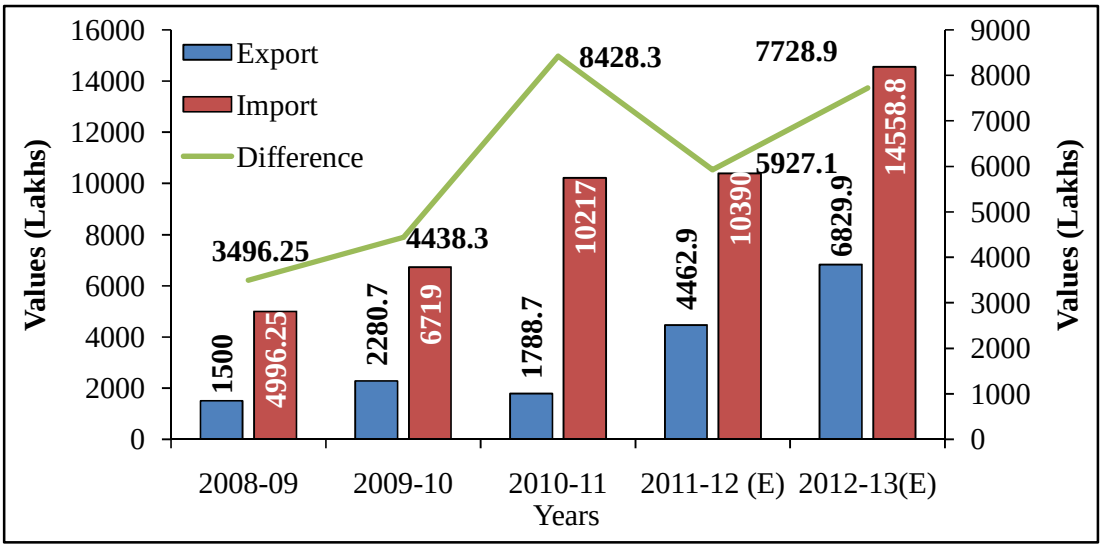

FIGURE: 8 Differences in value (in lakhs) between import expending and export earnings

Production constraints/factors impacting the cardamom farming

Under the changing scenario of intensive agricultural practices and landscape transitions traditionally managed agro-ecosystem across the globe have been severely affected in term of productivity. The systems have been impacted with the ongoing transformations that led them to homogenous in nature and less diverse. The changes and practices towards the expansion of agricultural area and productivity led to the many unforeseen implications on ecosystems functioning as well as livelihood of the people. In the process, the systems become weakened with diminished ecosystem resilience, making them more prone and vulnerable to disease and pest infestations. The major factors impacting the large cardamom farming include, old plantations (15,000ha, almost 50 %) that were established before 1980s and have not been producing more than 100 kg/ha capsules as compared to the new plantations producing 250-350 kg/ha), diversification of agricultural system, decline of pollinator abundance (diversity & density), *reduced flowering*, changing in climatic patterns *(increase in temperature and less rainfall)* and natural calamities (draught, hailstorms, snowfall in higher altitudes).

Change in land use for diversification of agricultural system

The ability of cardamom based agroforestry system to sustain and to meet the growing demands could be addressed with the optimization of land for availability of perennial cash flow. In the changing scenario of modern economic structures, farmers are shifting their reliance on traditional commodities and opting for improved means of income generation. It includes technology-driven changing farming practices and production of seasonal commodities, other spice crops like turmeric and bamboo plantation that ensures year round cash availability for diverse needs and growing demands of the people.

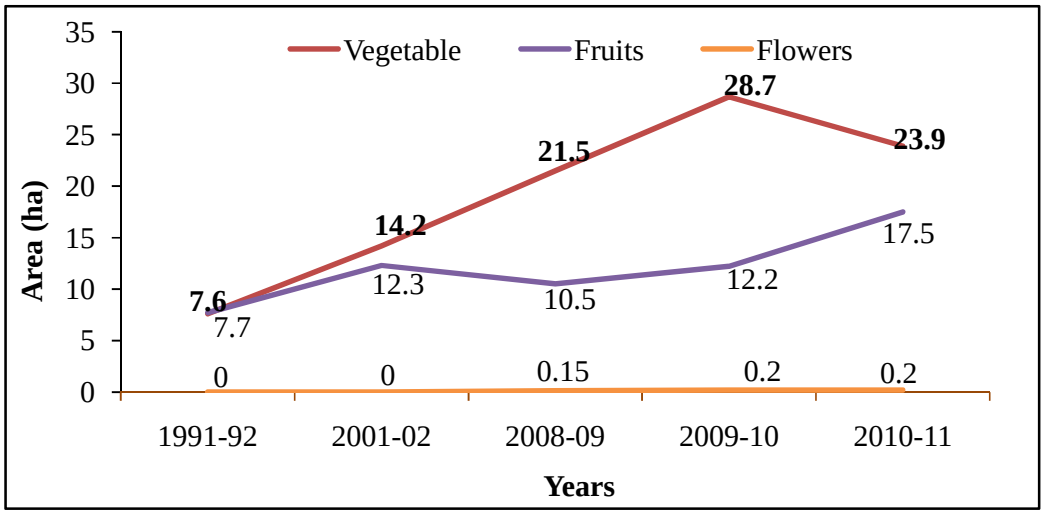

FIGURE: 9 Changing agricultural practices and increase in area of other cultivated crops

People are also involving themselves in other professions like shop-keeping, hotels/restaurants, jobs mainly in private sectors and village tourism to add to their family income. Consequently, the traditional alder-cardamom

based farms have also undergone noticeable changes over the last twenty areas with reduction in area for cardamom cultivation. In 1991-92, the area under cultivation for vegetable and fruits in Sikkim were 7600 ha with production of 46100 MT and 7700 ha with production of 18800 MT, respectively, that has in 2010-11 substantially increased to 23900 ha with production of 120900 MT for vegetables and 17500 ha with production of 25800 MT for fruits. More recently in addition, the floriculture practices (mainly, Cut flower production) have also been adopted by the farmers as an income diversification mean. In 2008-09 the area under flower cultivation was 150 ha with 66 lakhs no. of cut flowers production that has been increased to 200 ha area under cultivation with 230 lakhs no. of cut flowers production in 2010-11, contributing 0.33 % of the total Cut flower production in the country[5].

Areas under large cardamom production have been steadily declining impacting the overall all production of large cardamom. It was observed despite the increasing profit turnovers over the decades. The increased area for cultivation of vegetable, fruits, flowers and bamboo plantation also contributed quite significantly for the ongoing land use transition across the region (Fig. 9).

Pollination constraints in large cardamom

Large cardamom is bisexual and essentially a cross-pollinated (allogamous) crop due to its heterostylic (pin-type) nature of flowers. The anthesis took place early in the morning (5–6 hr) and anther dehisces longitudinally just before anthesis, and heavy pollen mass is visible along the two dehiscing sutures in freshly opened flower. The flowers last only for a day and senescence starts around 14 to 18 hr and yellowish colour of corolla fades either in same day (18 hr) or next day. The variation in senescence and fading were varied with the altitude while anthesis was unaffected [6,7] .

The insect visitors of large cardamom were bumble bees (*Bombus braviceps* Smith and *B. haemorrhoidalis*) honey bee (*Apis cerena*), fruit fly (*Bactocera* sp.) and skipper (*Udaspes folus*). However, as far as the pollination efficiency is concerned only bumble bees were considered pollinators while others were regarded as pollen robbers. Under open field condition 65.5% pollination was recorded and attributed to visits of bumble bee without interventions of social bees. The shape and orientation of the stigma have a role to prevent autogamy. It however, does not prevent geitonogamy as bumble bee visits several other flowers of the same clump for pollen as well as nectar [8]. The pollination syndrome of large cardamom can be considered specialized as the flowers are well adapted to pollination by bumble bee. Optimum foraging activity of bumble bees was maximum recorded during 5.00– 6.00 a.m. on clear days whereas, it became less or even nil on rainy days.

On the other hand *Apis cerana*, which is considered as efficient pollinators of number of crops could not be able to effect pollination as it rarely come in contact with stigma during pollen foraging and most of the pollen were deposited on the non-receptive stigma hairs. The act of pollen robbery by visiting insects, especially, *A. cerana* brought out competition for the resources and often deprived the plant of pollen availability for pollination by bumble bees.

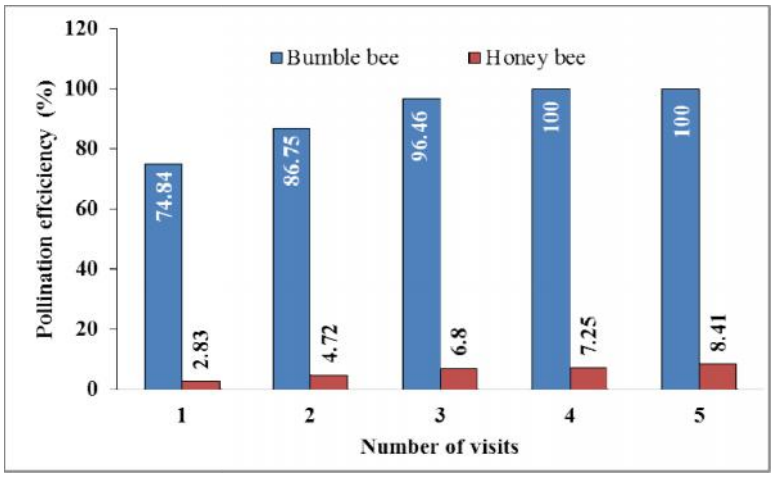

FIGURE: 10 Relative differences in pollination efficiency in per visit of Bumble bee and Honey bee

Data on pollination efficiency (Fig. 10) of large cardamom showed remarkable difference of efficacy between bumble bee and honey bee. In case of bumble bees, one visit resulted in 74.84% of pollination and that increased gradually with increasing visits and optimum pollination (100%) achieved with a total four visits, while honey bee affected only 8.41% of pollination even after five visits [7].

Pollination syndrome

The highly specialized mode of pollination in large cardamom (Bumble bees as pollinators) makes the crop highly vulnerable as large most of the plants remained un-pollinated due to lower pollinator density. The diversity of pollinator guilds hardly impacts the pollination efficiency in large cardamom rather hampers the process by competing for the same resources [8].

Low knowledgebase on pollination

In addition, knowledgebase on pollination aspects is quite low among the rural farming communities. It has been observed that only 30-40% of rural population (respondents***)*** were aware about the pollinators and pollination process. The diversity of pollinators known to farmers was *bumble bee, honey bee, stingless bee and Trigona sp.* Some pollination friendly activities around their farms like *flowering boundaries and multipurpose tree plantation* were also noticed, that was deliberately adopted for some additional income and for the purpose of

shade to the large cardamom plantations, respectively. In addition, traditional bee keeping practices in log hives were also recorded in rural households with an average of one bee hive/ household. Significant decline in pollination services and resource dearth for pollinators could also be visualized with an analysis on comparative account of present and past record of honey production in the region. In past *'the honey production/ per household was recorded between 80-450 kg and was sold @ 100/kg, whereas the present records revealed a substantial decline in production with 40 to 50 kg of honey production/household with the selling price of 750 /kg'*. It showed either the disinterest of farmers towards bee keeping or more possibly decline in viable bee populations due to intensive land use practices that generally restrict the abundance of pollinator in the region.

Pests and diseases

Pest and disease are other the causes which are impacting the yield. Among the insect pests that leaf caterpillar (*Artona chorista* Jordon) and stem borer (*Glyphipterix* sp.) are the important pests infecting the leaves and stems respectively. Infestation of white grubs (*Anomala* sp.) and Aphids are some other limiting factors. Aphids are considered rather more infectious than others as they facilitate the spreading of viral diseases *viz*., *Chirke* and *Foorkey*. The spread of fungal disease *Colletotrichum* blight that appears at the advent of pre-monsoon showers (April-May) and progresses rapidly during the rainy season (June-August) impacts the area to be necrotic and dry, also caused severe plantation loss since last 10 years[9]. Likewise the viral diseases *Chirke* and *Foorkey* since early eighties have drastically reduced the production (60%) and plantation area (almost 50 %) of large cardamom[10].

Management constraints

The area under large cardamom is continuously declining due to problems related to crop management in the region, It includes lack of awareness, improper infrastructure, lack of incentives mechanism for replantation, impediments in gap filling of older plantation, inadequacies in dissemination of Research & Development activities and scientific backups in terms of improved varieties (disease resistant and High Yielding Varieties), pollination and post harvesting innovations. The progressive shift of reliance from traditional commodities to other farm produce and adoption of new income means in other professions were also causing serious setbacks to cardamom farming in the region.

CONCLUSION

In the present scenario of increasing domestic demand and excessive expending on import of large cardamom, farming large cardamom of still holds the key to maintaining the viability of small and marginal farmers in the mountain region due to continuous price inflation. Contrary to other cash crops, it is quite inexpensive in terms of input cost, flourishes well under diverse agro-forestry regimes, thus, ecologically more viable also. As further expansion of land holdings size is almost impossible in the existing regulations, the potentiality for sustainable development of a marginal/fragile mountain lands needs serious evolution with the intensive management and corrective measures for optimization of land and delivery of goods.

RECOMMENDATIONS

An integrated approach incorporating the real-time issues of farming communities along with corrective measures to address the various constraints impacting the cultivation and production of large cultivation is urgently required. The approach should include intensive revival of old age plantations that could be adequately achieved through programmes like '*Special purpose Fund for Replantation and Rejuvenation of Cardamom Plantations'* sponsored by Spice board of India. Dissemination of R&D findings/ backups particularly on improved varieties (HYV as well as disease resistant), agro-climatic requirements of cultivars, pest & diseases, cost-benefit analysis on cardamom farming, pollination aspects and government and semi-government schemes for promotion of large cardamom should readily be available to farming communities with material and farmer friendly packages.

The approach for farming practices should also include scientific methods of gap filling and weeding, avoiding intervention of social bee (honey bee) during cardamom bloom, inclusion of pollination curriculum in farmer's oriented awareness programmes and most importantly ensuring year round availability of bumble bees through adoption of pollinator friendly activities, like erecting flower boundaries around the farms, multi-purpose tree plantation, leaving bumble bee habitats and suitable substrates undisturbed *etc*. [11].

For qualitative improvement of large cardamom and to minimize the output cost during post- harvest handling, promotion of environment friendly and low cost curing kiln (as developed by TERI) is also required and suggested. So far, value addition to the produce at site and forward and backward linkages to the system for obtaining good outputs have met with only limited success and also need to be strengthened.

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REFERENCES

[1]. McNeely, J. A. and Mainka, S.A. (2009) Conservation for a New Era, IUCN, Gland, Switzerland.

[2]. Sharma, G., Sharma, R., Sharma, E. (2009) Traditional knowledge systems in large cardamom farming: Biophysical and management diversity in Indian mountainous regions. *Indian J Tradit Know*. **81**, 17-22.

[3]. Sharma, R., Jianchu, X., Sharma, G. (2007) Traditional agroforestry in the eastern Himalayan region: Land management system supporting ecosystem services, *Trop Ecol.* **48**, 189-200.

[4]. Spices Board Statistics (2011) Spices Board. Kochi, India

[5]. National Horticulture Database (2011) (http://nhb .gov .in/ area-pro/database-2011.pdf).

[6]. Sinu, P.A. and Shivanna, K.R. (2007) Pollination biology of large cardamom (*Amomum subulatum*). *Curr Sci*., **93**, 548-552.

[7]. Kishore, K. H. Kalita, Rinchen, D., Pandey, B. and Denzongpa, R. (2012) Floral biology of large cardamom (*Amomum subulatum*), Indian J Agr. Sci. **82**, 578-582.

[8]. Palatty, A. S and Shivanna, K.R. (2007) Pollination biology of large cardamom (*Amomum subulatum*). Curr Sci. 93, 548-552.

[9]. Sharma, G. and Dhakal, T. D. (2004) Opportunities and Challenges of the Globally Important Traditional Agriculture Heritage Systems of the Sikkim Himalaya.

[10]. Sharma, G. and Rai, L.K. (2012) Climate change in Sikkim patterns, impacts and initiatives information and public relations department; in *Climate change and sustainability of agrodiversity in traditional farming of the Sikkim Himalaya*. Arrawatia, M. L. and S. Tambe (eds), pp. -193-218, Government of Sikkim, Gangtok.

[11]. Hatfeild, R., Jepsen, S., Mader, E., Black, S.H. and Shepherd, M. (2012) Conserving bumnbe bees: guidelines for creating and managing habitat for America's declining pollinators, The Xerces Society for Invertebrate Conservation, pp-32, Portland.