ICIMOD Manual 2017/3

ICIMOD

FOR MOUNTAINS AND PEOPLE

Package of Practices
for Promoting Climate Resilient Cardamom Value Chains in Nepal

THE MOUNTAIN INSTITUTE
CONSERVATION. CULTURE. COMMUNITY.

About ICIMOD

The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalisation and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

About The Mountain Institute India

The Mountain Institute India is registered as a charitable trust in Government of India, New Delhi. The Mountain Institute entered in Sikkim way back in 1996 which was later on registered as TMI India in 2006. It is a part of the TMI that is committed to work to conserve the world's high priority mountain ecosystems, improve the livelihoods of mountain people, and increase awareness for mountain issues through research, advocacy, education, and outreach. Currently, it is involved in community-based conservation programs in the Eastern Himalayan region, partnering with local people to strengthen their communities and to conserve natural resources and cultural heritage. TMI India has conceived three broad programmes viz., (1) Ecosystem services, (2) Biodiversity and Environmental Change, and (3) Livelihoods of Mountain Communities and their Cultures. As a mountain based organization, TMI India with the local and indigenous communities seeks to develop and provide innovative solutions, in cooperation with a numerous regional, international, national, and local partners, which foster action and change for overcoming mountain people's economic, social, and physical vulnerability.

About ECDF

The Environment Conservation and Development Forum (ECDF) is a district based nonprofit established in 1996 to initiate actions for ecological balance, to contribute to peace building, to conserve natural resources, and to improve livelihood of deprived communities through increasing accessibility to basic services. ECDF has more than a decade of experience in social mobilization for community empowerment, capacity building of community-based organizations, community development, rural infrastructure development, environment conservation, and & biodiversity promotion. ECDF programs cover 50 communities and benefit more than 21,000 people.

Presently, ECDF works with the Rural Livelihoods and Climate Change Adaptation in the Himalayas program (Himalica/ICIMOD), Suaahara-II (USAID/HKI), the Water & Sanitation program (RWSSP-Fund Board), the Local Governance & Community Development Program (LGCDP/DDC), and the Reducing Carbon Emissions through Promoting Improved Cooking Stove (REDP/DDC).

ICIMOD gratefully acknowledges the support of its core donors: the Governments of Afghanistan, Australia, Austria, Bangladesh, Bhutan, China, India, Myanmar, Nepal, Norway, Pakistan, Switzerland, and the United Kingdom.

ICIMOD Manual 2017/3

Package of Practices

for Promoting Climate Resilient Cardamom Value Chains in Nepal

Authors

Ghanashyam Sharma[1]
Surendra Raj Joshi[2]
Min Bahadur Gurung[2]
Harish Chandra Chilwal[3]

[1] The Mountain Institute India
[2] International Centre for Integrated Mountain Development (ICIMOD)
[3] Environment Conservation and Development Forum (ECDF)

International Centre for Integrated Mountain Development, Kathmandu, February 2017

Published by
International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal

ISBN 978 92 9115 469 2 (printed)
978 92 9115 470 8 (electronic)
LCCN 2017–322004

Production team
Shradha Ghale (Consultant editor)
Christopher Butler (Editor)
Dharma R Maharjan (Layout and design)
Asha Kaji Thaku (Editorial assistant)

Photos: Pp12 and 13 (t) - Harish Chilwal; rest - Ghanashyam Sharma

Printed and bound in Nepal by
Hill Side Press (P) Ltd., Kathmandu, Nepal

This publication is available in electronic form at www.icimod.org/himaldoc

Citation: Sharma, G., Joshi, S.R., Gurung, M.B., Chilwal, H.C. (2017) *Package of practices for promoting climate resilient cardamom value chains in Nepal.* ICIMOD Manual 2017/3. Kathmandu: ICIMOD

Contents

Foreword

Large cardamom (*Amomum subulatum*) is an important high-value cash crop and a major source of livelihood for a large number of people in eastern hill districts of Nepal. Large cardamom farming is being expanded to around 41 districts in Nepal. As per the official records of Trade and Expert Promotion Center (TEPC), the crop is cultivated in 12,453 hectares, producing a total of 5,103 metric tons of cardamom annually. It is not surprising that large cardamom is the top contributor of trade revenue among agriculture-based exportable commodities, and this trend has increased by 52 per cent as compared to 2014/15. However, over the years, the production and productivity of large cardamom has declined due to climate change and other factors. Climate change events such as drought, incidence of diseases and pests, erratic rainfall patterns, long dry spells, unpredictable hailstorms or snowfall have altered traditional management practices as well as the crop cycle. For example, the flowering and harvesting season of cardamom has altered due to the effects of rising temperature. The rate of disease or pest infection has been increasing. Thus, cardamom farming system is now demanding more labour and increased investment in the form of water management, quality planting material, soil nutrient management, shade management, and integrated pest and disease management practices across the cardamom farming areas in Nepal.

Increasing demand for large cardamom in the global market has greatly motivated Nepali farmers for an immediate revival of cardamom plantations, which have seen declining productivity since 2009/10. Farmers have become more serious about exploring sustainable climate-resilient production practices. One of the important interventions of Himalica, a pilot programme of ICIMOD, is to develop a package of practices (POP) in large cardamom farming which can be promoted along with training and demonstration strategies for improving cardamom production systems. This POP includes climate-resilient practices and technologies to support local implementing partners including non-governmental organizations, vocational training institutions, research and academic institutions, and community-based organizations to apply such practices on a wider scale.

I highly appreciate the contribution of the authors who have packaged good practices based on a review of available literature and primary information collected from the field, observations and interactions with large cardamom farmers of Sikkim, the Kalimpong region of West Bengal and Taplejung district of Nepal. I am sure this POP is going to be a valuable resource for the revival of old cardamom plantations and establishment of new ones, which will ultimately lead to the well-being of marginal farmers through minimizing risks and reducing poverty.

David Molden
Director General
ICIMOD

Acknowledgements

The authors would like to express their sincere thanks to the large number of cardamom farmers of Hee-Gaon and other cardamom growing areas of Sikkim, Gumba-Dara in the Kalimpong region of West Bengal and the farmers of Furumbu and Sikaincha Village Development Committees of Taplejung District in eastern Nepal for their invaluable effort to manage large cardamom-based farming systems. Their inputs provided the basis for developing climate-smart package of practices that will help revive cardamom cultivation in eastern Nepal. We are grateful for the financial support received from the European Union to undertake this study.

We also like to extend our gratitude to Messrs. Chandra Prakash Bhattarai, Diwas Bhandari and Chandra Bahadur Kalikote from the Environment Conservation and Development Forum, Taplejung, Nepal and Bishnu K Chhetri, Secretary, Krishak Kalyan Sangsthan, Kalimpong, West Bengal, India for facilitating the field visits and providing technical inputs to develop this package of practices for cardamom farming. The authors are immensely grateful to Erling Valdemar Holmgren, then Programme Coordinator of Himalica, Dhrupad Choudhury, Regional Programme Manager for Adapting to Change, Eklabya Sharma, Director of Programme Operations, and David Molden, Director General of ICIMOD, for recognizing the need to improve, revive and scale up cardamom farming in eastern Nepal and for agreeing to document climate-smart package of practices for cardamom farming. The authors are also thankful to Sanjeev Bhuchar, Uma Partap, Madhav Dhakal, Anu Joshi Shrestha, Ghulam Ali, Nakul Chettri, Rucha Ghate, and Chanda Gurung of ICIMOD for providing valuable feedback on the report.

We greatly appreciate the efforts of the editorial and publication team at ICIMOD – Christopher Butler, Anja Rasmussen, Ujol Sherchan, Dharma Ratna Maharjan, and Asha Kaji Thaku – for bringing this publication in its final form. We are also thankful to Laxmi Dutt Bhatta of ICIMOD for proving an internal review of this paper and offering helpful suggestions to make it more comprehensive and context specific. Finally, we thank Golam Rasul, Livelihoods Theme Leader, for his valuable feedback on the report. The first author acknowledges The Mountain Institute India for providing time and facilities to carry out field surveys. This document is prepared under the Support to Rural Livelihoods and Climate Change Adaptation in the Himalaya (Himalica) Programme (ASIE/2012/292-464) funded by the European Union.

Acronyms and Abbreviations

AESA	Agro-Eco System Analysis
cm	Centimetre
ECDF	Environment Conservation and Development Forum
EM	Effective Microorganism
ft	feet
FYM	Farm Yard Manure
GESI	Gender Equality and Social Inclusion
GoN	Government of Nepal
ha	hectare
ICIMOD	International Centre for Integrated Mountain Development
ICRI	Indian Cardamom Research Institute
kg	Kilogramme
m	Metre
ml	Millilitre
mm	Millimetre
MT	Metric Tons
NAPA	National Adaptation Programme of Actions
NERAMAC	North Eastern Regional Agricultural Marketing Corporation
NSCDP	National Spice Crop Development Programme
PoP	Package of Practices
R&D	Research and Development
SALT	Sloping Agriculture Land Technology
TMI India	The Mountain Institute India
SMS	Short Message Service
VDC	Village Development Committee
WWF	World Wildlife Fund

Executive Summary

This Package of Practices (POP) was prepared with the goal of promoting climate-resilient cardamom value chain in Nepal. The intervention is carried out under the 'Support to Rural Livelihoods and Climate Change Adaptation in the Himalaya – Himalica', a demand-driven programme funded by the European Union and managed by ICIMOD. The Environment Conservation and Development Forum (ECDF) has joined hands with ICIMOD to implement the pilot project in Taplejung, with the objective of improving the resilience of mountain women and men in selected clusters through designing and implementing context/target community specific interventions on cardamom value chain and its associated sub-chains. The overall objective of Himalica is to reduce poverty among mountain men and women and children by unlocking new livelihood opportunities and promoting more equitable approaches for livelihood improvement and resilient communities. The pilot projects are designed around three broad areas: 1) improved management of resources (ensure the sustainability of the production system), 2) income diversification (adding value by upgrading products, processes, linkages, and diversification of products), and 3) institutional strengthening (with a focus on gender, social inclusion and governance). In line with the overall concept and strategy of Himalica pilots, one important intervention is to develop a POP with a list of technologies/practices which are to be promoted along with training and demonstration strategies for improving cardamom production systems in Taplejung district as a whole and to showcase demonstrated effects in selected pilot villages. The POP provides detailed information on practices and technologies to support local implementing partners including non-governmental organizations, vocational training institutions, research and academic institutions and community-based organizations to implement pilot activities aimed at making value chain climate resilient.

Large cardamom has been a major source of cash income for majority of farmers in Taplejung district. Over the years the production and productivity of large cardamom has declined in eastern Nepal in general and Taplejung in particular. Climate change events such as drought, incidence of diseases and pests, erratic and unseasonal rainfall patterns, long dry spells during winter season, unpredictable hailstorms or snowfall have altered traditional management practices as well as the crop cycle. There is growing concern over the changing climatic conditions. Rising temperatures have led to early flowering or early harvesting of cardamom. Severe frostbite is a serious problem for large cardamom and no preventive measures are available. The rate of disease or pest infection has been increasing. Infection of rhizome rot disease has increased with increase in the number of leaf eating caterpillar, aphids, stem borer and thrives that destroy the cardamom crop and reduce productivity. The incidence of *Chirkey* or *Foorkey* disease is still a major problem and several local varieties are susceptible to these diseases. Thus, the system now demands more labour and investment in the form of irrigation, quality planting material, soil nutrient management, shade management, manure application and integrated pest and disease management across the growing areas in Nepal.

The increasing demand for large cardamom in the local to global market has greatly motivated farmers in eastern Nepal, particularly in Taplejung, Panchthar, Sankhuwasabha and Ilam districts, for an immediate revival of cardamom production systems, which have been unproductive in recent years. The growing market demand has also encouraged farmers to bring more suitable farmland under large cardamom farming, thus ensuring the sustainability of the production system. In Sikkim and Kalimpong of West Bengal in India, farmers are engaged in innovative climate-smart agricultural practices to revive cardamom and increase production and productivity while also integrating suitable intercropping. Many climate-smart agricultural practices can be integrated into a single farming system and provide multiple benefits that can improve rural livelihoods and ensure the well-being of mountain men and women.

This POP is based on a series of field studies, observations and interactions conducted in the large cardamom farming areas of Sikkim, Kalimpong region of West Bengal and Taplejung district of Nepal. A large amount of available literature was reviewed to validate the information.

This POP is going to be a key guiding material for pilot demonstration in Taplejung to revive the old cardamom plantations while also establishing new plantations in the farmers' fields using adequate agro-techniques and local knowledge-based practices. It is expected that the revival of large cardamom-based farming will help rebuild sustainable agro-ecosystems and ensure the well-being of marginal farmers and contribute to poverty alleviation.

1 Introduction

A Brief Description of Large Cardamom in Nepal

Traditional cultivation practices of large cardamom serve as an example for harnessing a local mountain niche that is sympatric to agro-climatic ranges between 400 and 2,300 m elevations. This unique traditional farming system ensures ecological and economical sustainability based on indigenously-evolved agroforestry management practices and contributes to the well-being of mountain marginal farmers.

Nepal is the largest producer of large cardamom in the world; more than 95% of the produce is marketed to India, the largest exporter of large cardamom. Large cardamom is cultivated in around 41 districts of Nepal, among which Taplejung is the largest producer (total area: 3,915 ha; productive area: 2,952 ha; total production: 1,802 MT), followed by Sankhuwasabha (total area: 3,240 ha; productive area: 2,635 ha; total production: 940 MT), and Panchthar (total area: 1,620 ha; productive area: 1,506 ha; total production: 671 MT) (Government of Nepal [GoN], 2013). However, the total production and productivity of cardamom in Taplejung district has remained static. Majority of the plantations are old and infested with diseases and pests despite extensive expansion initiatives. This situation is also attributed to poor management practices, lack of quality materials, and lack of proper package of practices for the farmers.

Recent Trend of Large Cardamom Farming

The increasing demand for large cardamom in the local to global market has greatly motivated farmers in eastern Nepal, particularly in Taplejung, Panchthar, Sankhuwasabha and Ilam districts, for an immediate revival of cardamom plantation, which has been completely unproductive due to a variety of factors including climate change (Chapagain, 2011). This has also encouraged farmers to bring more land under cardamom farming, and made them more serious about exploring sustainable production practices. At the same time there are very interesting examples of climate-smart farming practices in cardamom growing areas of Sikkim and Kalimpong of West Bengal in India, where farmers have innovated to revive cardamom and increase production and productivity while also integrating suitable intercropping of other agricultural crops (Sharma et al., 2016). Many climate-smart agricultural practices can be integrated into a single farming system and provide multiple benefits that can improve the livelihoods and incomes of marginal mountain farmers.

The cardamom growers of Nepal over the years have innovated, tested and practiced climate-smart agriculture. Reviving and expanding the cultivation of high-value crop-based production systems and maintaining agro-biodiversity is crucial for achieving future food security and climate change goals. Large cardamom is facing the impact of climate change; the impact can be seen in the reduction of productivity, production stability and incomes of the marginal farmers. It is important to revive large cardamom-based integrated farming through climate-smart innovations and practices for agricultural sustainability. There are five elements of climate smartness for improving large cardamom farming. They are:

- *Weather-smart practices*, which include alteration of planting time and the planting of recommended local varieties that are resilient to extreme weather conditions, assessment of rainfall requirements, snowfall and frostbite in cardamom and measures to cope with these problems.
- *Soil/nutrient-smart practices*, which include production and application of manures, compost production, green manure, inter-crops, weeding, etc. to maintain soil health/organic matter
- *Knowledge-smart practices*, which focus on strengthening linkages and making information available to value chain actors on - soil type, slopes/aspects, disease and pest management, market price, demand-supply, and business development services
- *Water-smart practices*, which focus on effective and efficient use of water at different stages of value chain, highlighting technologies that farmers should apply to ensure water availability – irrigation, mulching, shade, etc.
- *Energy-smart practices*, particularly for harvesting/post-harvest management

In addition to the above-mentioned practices, the interventions should focus on inclusive growth and benefit sharing, ensuring that the technologies and practices will not put more labour burden on women.

Challenges Facing Large Cardamom in Eastern Nepal

In recent years, cardamom value chain actors, particularly farmers, have been facing a number of challenges due to the changing climate as well as feminization of agriculture, continuation of the old cardamom agroforestry system and marketing phenomena. The important challenges are described below:

Impact of climate change

Climate change events such as drought, incidence of disease and pest, hailstorms, snowfall and their impacts on large cardamom agroforestry have been a matter of great concern for the growers in Nepal and India. These factors are mainly responsible for the decline in crop production and plantation area in several districts of Nepal, including Taplejung (Sharma, 2013; Partap et al., 2014; Rijal, 2012; Chapagain, 2011). Focused group discussion and interaction with individual expert farmers revealed that climatic conditions are changing; rising temperatures have led to the incidence of new diseases and pests across the growing areas. In Panchthar, the rate of disease infection has increased by 35%, and a growing population of leaf eating caterpillar, aphids, stem borer and thrives are destroying the cardamom crop, thereby reducing productivity (Rijal, 2012).The effects of climate change have significantly altered the management pattern and crop cycle (Sharma, 2013). The system now demands more labour and investment in the form of irrigation, quality planting material, manuring and integrated pest and disease management across the growing areas of Nepal.

In the high-altitude areas, mainly above 1,700 m elevation, frost bite is a major constraint during winter season as it causes severe crop damage. Frost also causes damage to the large cardamom leaves, which eventually dry out. Frostbite is followed by occasional snowfall events that are harmful for the cardamom bushes. However, farmers say that a uniform and low level of snowfall is beneficial for large cardamom, one, for supporting the moisture level of soil, and two, for providing a wet microclimatic environment for the plant growth.

Old cardamom agroforestry system

There is no rotation length of alder-cardamom agroforestry in the traditional practice, and many old stands have now become less productive. The standing alder trees and other shade trees have become highly nutrient exhaustive. There is lack of practices such as proper tree density management and gap filling or phasing out of excess shade trees in the farm as the plantation grows older. Under traditional farming, irrigation facilities and irrigation practices are not available, thus soil moisture requirement is not met, especially in the lean season. Soil replenishment and maintenance of soil fertility through application of manures or mulching is generally not practiced in old farms. In several old plantations, soil has turned compact, hindering cardamom root growth, resulting in exposure of cardamom bush approximately 3 to 6 inches above the ground. Similarly, cardamom rhizome parts of the bushes have gradually elevated from the ground due to soil erosion and the phasing out of fruit bearing tillers. Such bushes barely hold adequate soil nutrients for root growth and eventually become less productive. Disease infestation has been rampant in almost all the farms and farmers have not started clearing out the infected plants from the farms.

Lack of good farm management practices

The main factors behind the declining productivity of large cardamom are the lack of proper manure application, lack of soil fertility maintenance, and lack of irrigation facilities to retain soil moisture. Other factors include the lack of certified and good planting materials, and the lack of location-specific adaptive varieties as per the agro-ecological range, as well as the lack of major disease- and drought tolerant/resistant varieties, lack of pest and disease management and control measures, and insufficient priority given to postharvest handling and processing technologies. There is also a serious lack of proper extension services and proven agro-practices, lack of linkages, coordination and cooperation among the institutions related to cardamom, lack of adequate financial support to farmers, and lack of policy related to cardamom research for improving production and market. All these factors have contributed to the decline in overall production and productivity (Chaudhary & Vista, 2015).

Objective and Structure of Package of Practices (POP) for Large Cardamom

The main objectives of this POP are:

- To collect the best examples of climate-smart practices relevant to cardamom-based farming
- To suggest good practices and innovations related to the establishment of new plantations and revival of old farms, improve production systems, pre-harvest and post-harvest technologies, and management of diseases and pests to help cardamom farmers in Taplejung district of Nepal to revive cardamom-based farming
- To pilot the package of selected practices under the Farmer Field School approach and help cardamom farmers to make critical and informed decisions that render their farming profitable and sustainable

This POP is divided into five sections. The first section introduces the background and objectives of the study and outlines the constraints and opportunities for large cardamom cultivation in eastern Nepal. The second presents study findings collected from the literature review and good practices in cardamom cultivation gathered during field interactions with progressive cardamom farmers from Sikkim state, and Kalimpong region of West Bengal state of India and Taplejung district of eastern Nepal.

The third section presents climate-smart technologies and practices that can be integrated with cardamom cultivation for diversification of livelihood options, which is important for reducing climate risks and achieving sustainable and inclusive growth among programme beneficiaries. The fourth section highlights the key extension methods and services that can help scale up the findings and disseminate them widely. The final section summarizes the key conclusions of the study and makes recommendations to strengthen the sustainable management of old cardamom stands based on the constraints and opportunities identified.

2. Climate Resilient Cardamom Value Chain Development Practices

Crop Management in Different Stages of Growth

Large cardamom is generally a sciophyte, i.e., a shade-loving plant. It is also grown under hill shade or sparse shade conditions. Recently, as farmers have been receiving a lot of encouragement to cultivate this crop due to its high market value, they have started cultivating it in a wide range of terrain, from humid subtropical belts at 400 m elevation to warm temperate agro-climatic belts up to 2,300 m elevation. Until 10–15 years ago, the agro-ecological range for these cultivars was 600 to 2,100 m elevations (Sharma et al., 2000). Large cardamom is being grown in natural forest areas in steep hills that receive well-distributed rainfall for around 250 days with a total of about 3,000–4,000 mm per year.

Given their increasing knowledge and skill, cardamom farmers have been able to increase the habitat range of this crop. It is growing in lower altitudes, receiving around 1,700-2,500 mm rainfall per annum, preferably under hill shade moist conditions. In the higher altitudes, farmers grow the crop in high rainfall conditions (2,500-4,000 mm per annum). The crop exhibits slow growth during the dry season and can withstand up to 1°C. The plant is highly susceptible to frostbite. According to a cardamom grower "Low intensity snowfall does not necessarily hamper the production potential but prolonged exposure to sunlight will dry out the leaves."

Box 1: **How important is it for farmers to know the growth cycle of cardamom?**

Farmers need to understand and learn about plant growth, growth management and seasonal variation in the growth of cardamom crop. New buds begin to appear by the time of harvesting. Harvesting and use of knives requires a skilled hand to protect the new buds that will bear the fruit next year. Plant growth generally remains dormant during winter if the understory ambient air moisture and soil moisture level is low. Flower bud differentiation occurs in August in lower altitudes and in October in higher altitudes. Initiation of flower buds occurs before winter at lower elevations but further development takes place only after the lapse of the cold period in early March. On the other hand, at higher elevations, flower-bud initiation and development occurs soon after harvest, which pushes back flowering at least 2–3 months compared to plants grown at lower elevations.

Selection of local cultivars along the altitude

Some cardamom farmers have been able to breed different cultivars of large cardamom through trial and error. This has given rise to an increasing number of new varieties that can adapt to an agro-climatic range of 400 to 2,300 m elevations. Local cultivars such as *Bhalangey*, *Sawney*, *Ramsai*, and *Ramla* are cultivated widely in two states of India namely, Sikkim and West Bengal (Kalimpong region), and in Taplejung district of Nepal. Other varieties such as *Seremna* are restricted to Hee-Gaon in West Sikkim. *Dzongu-Golsai* is cultivated in Dzongu area of North Sikkim. Apart from these, *Chibeysai*, *Dammersai* and *Salakpurey* are cultivated in different areas of eastern Nepal. This suggests that cardamom growers should be able to select varieties with the following traits:

- High adaptability in the given altitude where it is grown
- High production potential (big size capsules, large number of seeds in capsules, more number of capsules in spikes, variety that gives 2 to 3 spikes in each fruit bearing tiller)
- Disease tolerant/resistant variety
- Variety that can be grown in low soil moisture conditions

General information on each of the varieties is given below. The farmer friends are advised to select the local variety best suited to the land and microclimatic condition of their farms.

Seremna

This variety was developed around 25 years ago by Lt. Sukram Subba, a cardamom grower in Hee-Gaon, West Sikkim (Figure 1). *Seremna* is a Limbu word, which means 'drooping leaves'. The variety is named thus because its leaves twist slightly downwards from the middle of the leaf lamina. *Seremna* grows exceptionally well in the low

(above 1,200 m) and mid altitudes of up to 1,800 m. This cultivar is well known for its high yield potential and tolerance to diseases and pests except the stem borer. Production of *Seremna* variety can be continued for up to 12–15 years. Regular management with manure and irrigation can help prolong the plantation life up to 20 years. The plant can be identified by their green tillers and leaves. The plant height normally ranges from 1.5 to 2.0 m. The productive tillers bear 2–3 spikes, and each spike bears around 10–15 capsules, each of which contains around 65–75 seeds. Farmer friends whose farms are situated at the elevation range 1,200–1,800 m are advised to select this variety.

Bharlangey

Farmers in high-altitude areas of Taplejung are advised to select *Bharlagey* that grows well in middle and high altitude agro-climatic zones (>1,500 m up to 2,200 m). It has an elongated capsule that is larger than that of all other varieties, and therefore has an exceptionally high yield performance. As a result there is a high market demand for this variety (Figure 2). It resembles *Ramasi* with its narrow leaves with margins. Plant height is also exceptionally high: up to 2.4 m. Fruit bearing tillers and spike ratio is relatively high in this cultivar. The bold capsules hold around 50–75 seeds. Flowering at middle altitudes starts in May while at high altitudes it starts from June to late July. Harvesting starts in late September at mid elevations and continues till November at high altitudes.

Chibeysai

Farmers in mid altitudes (1,300–1,800 m) can select *Chibeysai*, a local variety suited to these elevations. The production potential of this variety is very high (Figure 3). A single fruit-bearing tiller bears 2–4 spikes, each bearing around 10–12 capsules. This variety also has a very high market potential.

Figure 1: *Seremna* variety

Figure 2: *Bharlangey* variety

Figure 3: *Chibeysai* in Furumbu VDC, Udaya Dahal in his farm

Figure 4: Dzongu-Golsai in Dzongu, North Sikkim

Dzongu-Golsai

This variety of cardamom is adaptive to low elevations (below 1,000 m). It is grown mainly in Dzongu area of North Sikkim, but since it is tolerant to diseases, it has recently spread to other cardamom growing areas in Sikkim state, and Kalimpong region of West Bengal state of India. The tillers are green in colour, the leaves are narrow and erect (Figure 4). It has big and bold capsules with 50–70 seeds. Flowering starts in May and the capsules are ready to be harvested by September. Farmers in lower altitude areas of Taplejung can select this variety for their farms.

Ramsai

Ramsai is cultivated in elevations ranging from 1,200 to 1,600 m (Figure 5). It can also be cultivated on steep slopes. The plant has narrow leaves with a large number of maroonish tillers. Plant height ranges from 1.5–2 m. Flowering starts in May and harvest takes place in September-October. This cultivar has smaller capsules compared to other varieties; each capsule bears around 25–40 seeds. Farmers can select this variety if other cultivars are not performing well in their farms.

Ramla

The plant is similar to *Ramsai* with the same height and vigour (Figure 6). The leaves are broad and slightly elongated. Tillers are similar to *Ramsai*. Capsules are dark pinkish in colour with around

30–40 seeds. Cultivation of this variety is restricted to a few high-altitude areas of Sikkim state, Kalimpong region of West Bengal state of India, and Taplejung district of Nepal.

Flowering starts with the onset of monsoon and the capsules are ready for harvest in late October. Farmers are advised not to select this variety in the initial phase of revival. They can select this variety only if other varieties do not perform well in their farms.

Sawney

This cultivar of cardamom was widely grown at lower elevations (900-1,500 m) in all the cardamom growing areas of Sikkim and Kalimpong in India and the Taplejung district of eastern Nepal. Plants are 1.5–2 m tall and robust in nature (Figure 7). Leaves are ovate and broad with maroonish tillers. Capsules are relatively small compared to *Bharlangey* and contain only 35–50 seeds each. Flowering starts with the onset of rains, in late March to May, and harvest time falls in September through October. This variety is highly susceptible to diseases and pests. Farmers should select this variety only if they are able to manage pests and diseases.

Figure 5: *Ramsai* variety

Figure 6: *Ramla* variety

Figure 7: *Sawney* variety under the alder trees

Selection of planting material

Selection of planting material is another important aspect of establishing productive large cardamom plantations (Figure 8). Planting material should be selected from disease free lines or disease tolerant varieties based on the suitability of the cultivars at different altitudes.

Planting material developed from seeds is free from virus infections, so farmer friends can develop saplings from seeds. Farmers need to know that plant productivity and agronomic yield per plant is attributed to clump growth, plant height, the number of spikes per tiller, the number of productive tillers per clump, the number of capsules per spike and the size of capsules (i.e., capsule with a considerable number of seeds in it). Thus, elite clumps should be identified from a disease tolerant productive variety. Farmers can choose *Seremna*, *Bharlangey*, *Chibeysai*, or *Dzongu-Golsai* depending upon the suitability of a given variety to their farms and raise those seedlings in proper seed nursery management conditions.

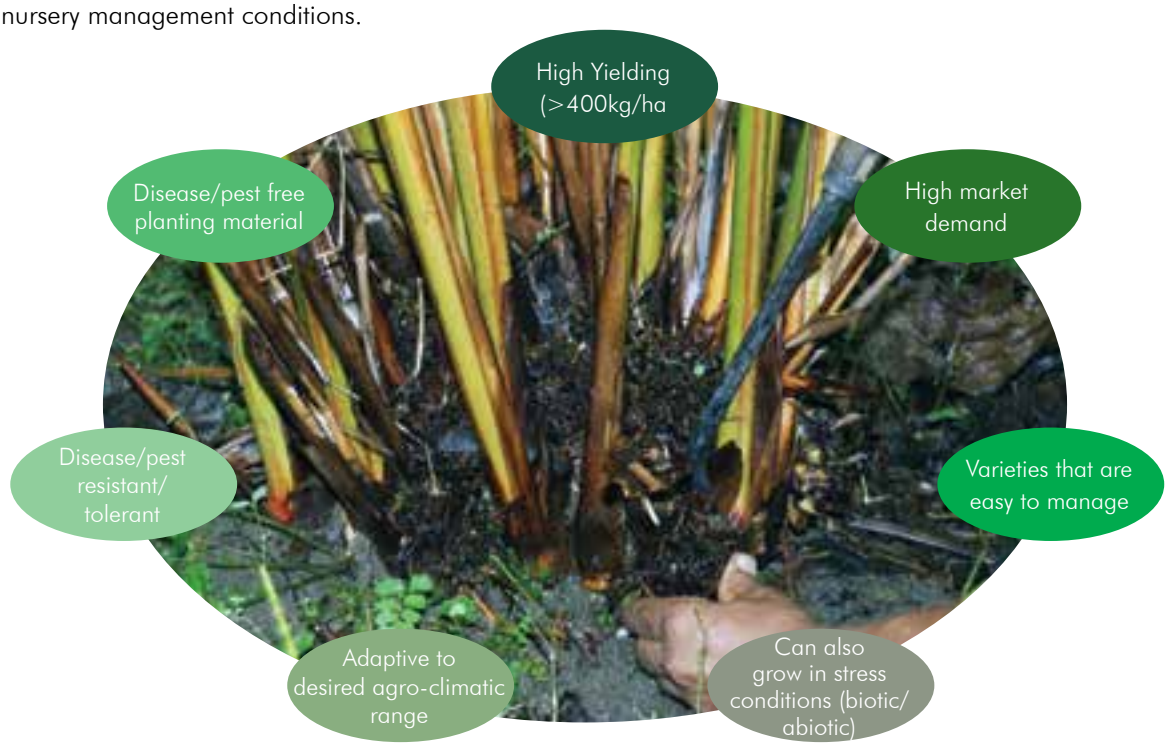


Figure 8: Selection criteria of planting material

Propagation of large cardamom

Propagation through seeds

Farmer friends are advised to establish seed beds during December for sowing large cardamom seeds. Expert farmers should visit the farm and select big and well-matured capsules from the well-fruited spikes for seed extraction. The seeds are washed with water or sometimes mixed with sand and rubbed together to remove mucilage. They are then dried in the sun for a few days and sown in the primary nursery.

The Indian Cardamom Research Institute in Gangtok, Sikkim has recommended another method under which the seeds are treated with 25% nitric acid after the mucilage is removed (25 ml of concentrated nitric acid is mixed with 75 ml of water to make 25% nitric acid). Farmers can apply this method for seed treatment. Seeds can be immersed in the solution and stirred for 10 minutes. Seeds are then thoroughly washed in running water to remove the acid. Germination starts within 4–5 months of sowing. Until then farmers should take care of the seed bed with proper irrigation. Farmers can also establish sheds over the seed beds to protect them from excess rain, hail or sunlight. Farmer friends can refer to the pictures showing the nursery cycle (Figure 9).

Establishment of primary nursery

Farmers are advised to develop seed beds of around 15–25 cm height and around 1 m width and of a convenient length in December. Seed sowing should be carried out in February (*Phagun*) as soon as winter ends and the soil starts becoming warm (Figure 10). Seed beds can be prepared in the fertile field. Well-decomposed livestock

Figure 9: Process for nursery development of large cardamom (selection of best capsules to primary nursery development)

Figure 10: Development of secondary nursery, the sapling transplanted from a seed nursery

manure is mixed with soil on the seed beds and the soil surface is made to fine tilt. Based on the length of the seed bed, seeds are sown in lines 5–10 cm apart across the bed. The seeds are then covered with a thin layer of soil. The seed beds are covered with ferns, dry weeds, or rice straw or small twigs of *siris* tree. *Siris* leaves make the best mulching biomass as they decompose fast and supplies nutrients such as nitrogen and phosphorus. Farmers should periodically water the seed bed to keep it moist. Sprouting begins by the month of June (*Asar*).

In the second year of nursery establishment, once the new saplings attain the 34-leaf stage, they are transplanted to new seed beds at a spacing of 1 x 1 ft. The new seed beds are supplied with good quality manure and managed through regular irrigation during winter. From the third year, saplings can be sold or transplanted to establish new plantations. Some plants such as Titepati (*Artemisia vulgaris*), soybean or legumes are grown to provide partial shade to the saplings.

Establishment of secondary nursery

Farmers can also establish a secondary nursery by making seed beds of considerable length depending upon the availability of land. Well-decomposed manure is mixed with soil and the saplings supplied from the primary nursery are transplanted. Saplings are planted in a row at 1 x 1 m spacing in May. By the second year of transplantation, the new saplings are ready for field planting. Nursery should be established away from the old orchards to avoid the occurrence or transmission of pests and diseases.

Farmers should consistently raise a nursery of shade trees and plant in spots where the canopy cover is opening up and direct sunlight falls on the ground at least for a few hours a day but not throughout the day.

Propagation through suckers

Selection of planting material is very important for developing a productive orchard. The suckers should be selected from high-yielding, disease-free plants (yielding around 600–800 kg per ha for 3–4 years). Mature tillers with 2–3 immature tillers or vegetative buds can be used for planting in the new fields. Such tillers start bearing fruit within two years of planting (Figure 11).

Figure 11: New planting material for sell at Hee-Gaon, West Sikkim, India

Selection of land and recovery of plantation stands

Assessment of soils

Cardamom farmers need to have sound knowledge of soil selection in their farms before planning to establish a cardamom plantation. Large cardamom grows well in forest loamy soil that is brownish-yellow to dark-brown in colour, at a soil depth of 15 cm to a few inches. Cardamom can be grown in sandy soil, sandy loam, silty loam or clay.

Previous studies have shown that in alder-cardamom agroforestry systems that are up to 15 years old, the soils have a high total nitrogen content (0.20–0.55% at 0–30 cm soil depth), organic carbon (2.14–5.62% at 0–30 cm soil depth), soil organic matter (3.70–8.96%at 0–30 cm soil depth) and total phosphorus (87.07–101.79 mg 100-1 soil at 0–30 cm soil depth) and available phosphorus (4.03–9.09 mg 100-1 soil at 0–30 cm soil depth) (Sharma et al., 2009c). Thus, yield performance of cardamom is high until this stand age with proper management. Farmers have to harvest alder trees after this stand age and utilize the stand for growing other cereals, pulses and vegetables for 3 to 4 years and replant cardamom thereafter.

Most of the soils in the large alder-cardamom plantations are acidic in nature with pH ranging from 4.64–5.32 until the stand age of 15 years. Research results have shown that soil in alder-cardamom agroforestry becomes increasingly acidic in the maturing stands after the 15-year stand age. Soil becomes more acidic (3.8–4.5) in increasing alder-cardamom agroforestry after the 15-year stand age. On steep slopes, most of the soil nutrients are lost due to overland runoff, especially in monsoon. Farmer friends should develop terraces or check walls of considerable sizes to prevent soil erosion.

Slopes and aspect of land

Farmers should understand the aspect while selecting sites for cardamom plantations. North-west and south-west aspects are appropriate. Aspects that receive sunlight throughout the day are not preferable. It is important for the farmers to know that large cardamom does not perform well if the site receives sunlight throughout the day as it reduces air and soil moisture, causes severe leaf burn and spoils crop performance. It grows well on gentle to medium slopes, or even on flat lands with proper drainage that prevents water logging. Experiences of cardamom farmers have revealed that re-planting in the same old orchard with old-growth trees does not result in good production. Farmers are advised to select farm lands (*khet*, *bari*, *orbhasmey*) that are otherwise not productive for high-value cash crops (Figure 12).

Figure 12: New farmlands are good for developing new cardamom plantations or nurseries

Reclaiming the old plantation sites

In several areas of Taplejung, farmers have old large cardamom plantation stands with trees that are standing without understory cardamom. In those stands, existing cardamom trees have been completely abandoned as there are low productive cardamom bushes under tall and mature trees. Such stands have a very low soil nutrient level. In contrast, the standing trees take up a high level of nutrients and do not contribute litter to the stand floor. In such a situation, the farmers can harvest the trees and the stand can be used for agriculture (maize, potato, ginger, fodder grass, beans, peas, soybean, etc.) for around 2–3 years (Figures 13 and 14). The farmers can establish terraces to reduce soil erosion and stand runoff during monsoon and to start planting important shade species with multiple functions (appropriate shade, litter, fodder, timber, and nitrogen supply through fixation). From the third year onwards, a new batch of large cardamom can be planted and intercropped with several agricultural crops with nitrogen fixing species. Farmers are advised to establish cattle sheds within the cardamom fields for production of manure. Mulching, supply of nutrients from the *Goth* (cattle shed) for proper soil fertility management can improve productivity and performance of the crop.

Figure 13: Some farmers in Sikaicha, Taplejung have started to phase out the standing alder trees

Plantation of large cardamom

Planting time

Suitable planting time for large cardamom starts from the beginning of monsoon, i.e., middle of May-June (*Baisakh-Jeth*) when the soil has enough soil moisture. Timely planting of the suckers will make them grow faster. If a sucker with 2–3 new buds is planted in May-June, it will bear fruit in the second year. Planting of cardamom seedlings before or after the monsoon will eventually lower the survival rate of the suckers, and even if they survive, the growth rate will be very low compared to those planted during monsoon.

Figure 14: New plantation development of large cardamom

Field preparation for planting

Farmers are advised to clear the field selected for new plantation. The field is ploughed, and small pits of 30 x 30 cm are prepared on the contours at a space of around 1.5 x 1.5 m from the pit. Closer spacing of 1.45 x 1.45 m is advised for *Seremna* or *Bharlangey*. Farmers are advised to prepare the field during March-April (*Phagun-Chait*) and fill the planting pits with manure and mulch. Planting is usually done soon after the onset of monsoon (May through June). Saplings (suckers) are planted on the pits up to the collar region. Farmers should avoid deep planting; they should also avoid tightening the soil in the pits by stepping over it. The new plants should be supported by staking them to avoid logging under heavy rain or wind. Mulching can be done around the plant base.

Farmer friends are advised to initially intercrop large cardamom saplings with other crops such as *Kerau* (field-peas), *Rahari dal* (kidney bean), *Mas dal* (Black gram), *bakulla* (Broad bean), *Masyam dal* (rice bean), *bodi* (cow pea), *bhatmas* (soybean), *aduwa* (ginger), Chilli, etc (Figures 15 and 16). Farmers are also advised to keep the spacing in plantation small (1 m x 1 m) in the initial phase so that they can harvest the planting material in the second and third year and sell them; with this, correct spacing will be maintained with age.

Field management

Farmers should know five things that are crucial for plantation management:

- shade and plant canopy cover management
- insect/pests and disease management

Figure 15: Intercropping with field pea during plantation phase

Figure 16: Intercropping with ginger and rice-bean

- phytosanitation, irrigation and manure management
- inter-culture operations, soil fertility maintenance, and
- protection from cattle grazing, from wild animals or from frost or snow.

The plantations should be managed with proper mulching, application of manure, timely watering, and provision of required shade. Regular monitoring of crops for the occurrence of diseases and pests is compulsory. Farmers should find a suitable (shady place, or provide shade) for raising a nursery. Farmer friends should always maintain a small nursery in a plot of land so that they can fill the gaps in the plantation every year or sell the sapling to earn some money. A few hours of sunshine on the ground is also very important for plant growth.

Grazing farm animals in and around a large cardamom orchard is harmful for plant growth and production. Browsing and trampling by animals will reduce the performance of the plant. Farmers should plant adequate fodder trees in the orchards to meet the fodder requirement of their cattle rather than letting cattle graze in the orchard. Farmers should also guard their cardamom farms against wild animals such as monkeys, wild boars, civet cats, bear and deer.

Gap filling to enrich plantation

Gap filling is an important step to maintain an adequate number of cardamom bushes in the field. Diseased plants, old and unproductive plants, and bushes damaged by the elements or by wild animals should be uprooted or slashed without disturbing the adjoining bushes. Farmers should carry out gap filling in May-June wherever space is available. Planting material used for gap filling should be of a disease tolerant and highly productive variety. Similarly, gaps between the shade species or suitable associate species should also be filled by replanting the species.

Intercropping with large cardamom

Farmers are advised to inter crop large cardamom with useful plants of various species. Apart from planting shade trees, farmers are advised to grow beans, cowpea, finger millet, or other food crops or cash crops.

Frost and snowfall management

A simple method for reducing damage caused by frost and snowfall is delayed weeding, especially during winter months. Farmers are advised to keep the weeds intact in the field until the winter is over, especially in a newly established plantation (first, second or third year), to reduce frost bite. Weeding can be carried out soon after the snowfall season is over. Developing suitable shade-providing species, both trees and bushes, is another way to reduce crop damage. Another possible way to control frost and snowfall is to put up a shade made of twigs and leafy branches over the cardamom plants during winter months or to use agro-nets over the cardamom canopy (Figure 17).

Figure 17: Frost and snow control by raising associated legumes and other plants during winter

SALT/terracing

Sloping Agriculture Land Technology (SALT), a low input technology introduced in the Philippines, is one of the best options for improving slope lands into productive zones for growing cardamom in eastern Nepal. Sloppy wastelands or old cardamom plantation stands can be converted into terraces to improve the fertility and stability of agricultural soils. Farmers can be encouraged to use a combination of suitable species (both nitrogen fixing and non-nitrogen fixing) or other fast-growing, fast-coppicing and high-biomass leguminous trees or shrubs on their respective farms. Some preferred species include Ipil-ipil (*Leucaena leucocephala, L. diversifolia*), Kaliandra (*Calliandra calothyrsus*), Dhaincha (*Sesbania* sp.),

Bhatmase (*Flemingia macrophylla*), Ankhitarey (*Walsura trijuga*) and Bute-kanike (*Desmodium* spp.). These can be planted along with *Alnus nepalensis*, *Albizzia* spp., banana and other fodder trees or fruit trees.

Water Management

Harvesting of water

Water harvesting is an important element of stand management as it improves the soil moisture status of cardamom stands (Figure 18). Small water harvesting ponds can be created at suitable locations within the cardamom plantations to arrest rainwater during monsoon, which can be used during the dry season. Farmers can also develop such ponds to store water brought from nearby springs, streams and rivers. In dry areas where there is an extreme shortage of water, farmers can dig several pits throughout the plantation stands to store water during the rainy season and increase soil moisture.

Farmers can repair and rebuild the existing traditional irrigation system *kulo*, which comprise simple surface channels that divert water from streams (*kholso/kholo*). In the *kulo* system, a temporary headwall (usually built with river boulders) across a *kholso/kholo* (ravine) is constructed to store and divert the flow of water through a canal to the nearby cardamom field.

Farmer friends whose cardamom farms are located in dry areas can also develop water harvesting ponds at a suitable distance from the cardamom plantation using silpauline. The harvested water can be used for irrigation during the lean season.

Irrigation

Proper irrigation facilities are necessary for keeping cardamom crop healthy and productive. Irrigation by drip or sprinkler is the easiest way apart from bringing water from the nearby stream through channels. Irrigation by flooding and constant flow of water through the cardamom stands will leach away nutrients or wash away fertile soil, so this method should be avoided.

Farmers can adapt hose irrigation at the rate of 40–50 liters per plant at fortnightly intervals during the dry season. For sprinkler, irrigation equivalent to 35–45 mm of rain once a week is recommended depending on the soil thickness (Figures 19 and 20).

Figure 18: Water harvesting pond created above the plantation

Figure 19: Sprinkler irrigation

Figure 20: Locally made sprinkler for irrigation

In some plantation areas, farmers can dig numerous pits of varying sizes (1.5 ft x 1.5 ft x 1.5 ft) within the farms so as to harvest water during the rainy season or even in winter. Farmers can also bring water for irrigation from streams, springs or small rivers through gravity flow in pipes or through channels. For flood irrigation and for excess water flow during monsoon, a diversion channel should be developed in the farm for proper drainage so as to avoid soil erosion and nutrient loss. Regular irrigation during the lean season (at least once a week) will retain the moisture content of the soil and augment decomposition of litter through microbial action. Irrigation should be continued during prolonged drought period.

Shade Tree Management

Large cardamom is a shade-loving plant and requires high moisture and is usually cultivated in areas where mean annual rainfall varies between 1,500–3,500 mm (Sharma et al, 2007). Large cardamom thrives well in moist soil. Soil moisture is maintained by water diverted from seasonal springs on the upper slopes. The system is well suited to conserving soil, water and tree cover of the characteristically steep slopes of the region.

Interestingly, in the recent years farmers have been growing cardamom in open bari-land or khet-land without shade conditions or with very sparse trees. When it is grown in open conditions, farmers grow titepati (Artimesia vulgaris), bilaune (Maesaindica) or masyamdal (Vigna umbellata). Exposure to direct sunlight throughout the day is highly detrimental to large cardamom. It causes sunburn to the leaves and drastically reduces the understory and soil moisture content. Proper management of shade and associated species is crucial for maintaining the crop for optimum productivity (Figures 21 and 22).

About 30 important tree species are used to provide shade to the cardamom plants. Alder (*Alnus nepalensis*), a nitrogen fixing and fast growing tree, is most commonly planted with cardamom. The quick decomposing leaf and twig litter of alder supply nutrients to cardamom plants. Based on a research report, about 155 kg per ha of nitrogen is added to the soil through fixation by alder root nodules in a 15-year old stand. The nitrogen added to

Figure 21: Titeypati used in cardamom farms

Figure 22: Different species of shade trees

the soil through fixation in root nodules of alder adds about 155 kg per ha to a 15-year old stand. Alder trees are also used for fuel wood and timber.

Several plant species can be used to provide shade for cardamom. The trees used to provide shade in the agroforestry system are also a major source of fuel, fodder and timber, especially as access to state-owned forests is restricted. Shade-providing plants commonly preferred by farmers are: Rato Siris (*Albiziastipulata*), Kurkure Siris/Kalo Siris (*Albizzia odoratissima*), Harde Siris (*Albizzia lebbeck*), Seto Siris (*Albizzia procera*), Badahar (*Artocarpus lakoocha*), Rukh Katahar (*Artocarpus heterophyllus*), Pipli (*Exbucklandea populnea*), Kainjal (*Bischofia javanica*), Lekh Saur (*Betula alnoides*), Lapsi (*Choerospondias axillaris*), Lampatey (*Duabanga gradiflora*), Faledo (*Erythrina arborescens*), Argeli (*Edgeworthia gardneri*), Bhadrakse (*Elaeocarpus lanceafolius*), Rudrakshya (*Elaeocarpus sphaericus*), Auley Faledo (*Erythrina stricta*), Auley Mahuwa (*Engelhardtia acerifolia*), Lekhbohori (*Ehretia wallichianiana*), Dudhilo (*Ficus nemoralis*), Dumri (*Ficus recemosa*), Rai Khanyu (*Ficus semicordata* var. *monata*), Chyuri (*Diploknema butyracea*), Lapchekaulo (*Machilus edulis*), Kera (*Musa paradisiaca*), Saur (*Betula alnoides*), Musure katus (*Castanopsis tribuloides*), Panisaai (*Terminalia myriocarpa*), Other important fruit plants thatcan be grown as shade species are Okhar (*Juglans regia*), Phamphal (*Persea americana*), Aarubakhada (*Prunus domestica*), Aaru (*Prunus persica*), Ambak (*Psidium guajava*), Amaro (*Spondias pinnata*), Timmur (*Zanthoxylum rhetsa*), Suntola (*Citrus reticulata*), Mel (*Docynia indica*),etc. Shade tree management is critical in large cardamom agroforestry system, and it is therefore advised that the old trees be removed and young plants be allowed to grow in a cyclic order.

Box 2: Why is it important to replant shade trees?

A number of studies have recommended revival and re-establishment of large cardamom in a phase-wise manner to bring about the sustainability of farming. Sharma et al., (2009b) reported that the alder trees add 58–155 kg ha-1 of nitrogen through fixation in 5–40 year old stands with the highest amount of nitrogen fixation in 10–15year old stands. Majority of cardamom orchards in Taplejung are mature (20 to more than 40 years) alder trees. The alder tree provides excellent shade, supplies a good amount of litter from twigs and leaves and nitrogen from the root nodules to understory cardamom when they are young. After 15 to 20 years of stand age, the alder trees mature and take up more nutrients to maintain their physiology, instead of supplying nutrients to the stand (Sharma et al., 2002b, 2007, 2009c). Therefore, Sharma et al. (2009a) & Awasthe et al. (2011) have recommended phase-wise replanting of both large cardamom and alder/Albizia with other preferred mix-tree species to ensure a sustainable performance of the large cardamom farming system.

Soil Nutrients/Land Management

Manure production and application

Cardamom farmers should maintain livestock in their farms to get constant supply of manure as cardamom requires a considerable amount of manure. Cardamom growers should keep their cattle within the cardamom farm, preferably at the top of the plantation site. This will reduce the amount of labour required to transfer the manure during the time of application. Such an arrangement will benefit plantations close to the cattle sheds and enhance their productivity.

Around 10–15 kg (or a little more depending on the size of the cardamom bushes) of manure should be applied around the cardamom bush (Figure 23). The cardamom bush has to be covered with the crop residue immediately after harvest so that the plant will get enough nutrients to grow during the lean period. Minor tillage or soil digging in and around the cardamom bushes should be avoided, as this will damage the growing roots under the soil. Well-decomposed manure devoid of white grubs should be made ready at the time of manure application. The next batch of manure can be applied right before the flowering season immediately after weeding. Slashed weeds can be used as mulching material to cover

Figure 23: Application of manure after harvesting

manure around the base of the cardamom bushes. The plants should not be disturbed during the flowering season. Frequent visits inside the cardamom bushes during flowering will also disturb the pollinator species.

Bio-composting or Vermi-composting

Farmer friends are advised to develop bio-composting pits at different locations in their farms. Unwanted weeds, twigs and leaves of trees can be composted in the pits with some cow dung. Farmer friends are also advised to make a few vermi-composting pits in their farms (Figure 24). There are a few agencies that provide training and supply worms for vermi-composting. In several cardamom areas of Sikkim and Kalimpong, composts prepared by

सेन्टर अफ एक्सिलेन्स ..... नाजीताम कृषि फार्म

कम्पोस्ट बनाउने विभिन्न विधिहरूको विवरण (एक झलक)

क्र.सं.	विधिको नाम	पिटको आकार	पिट संख्या	तयार हुने अवधि	उत्पादन क्षमता (प्रति पिट)	प्रयोग गरिने सामान
१.	माडेप कम्पोस्ट	१२.५.३	३०	४ महिना	२० क्विन्टल	गोबर, बायोमास, माटो, पानी
२.	वर्मी कल्चर	६.३.२	१२	६० दिन	२ किलो	गोबर, गँइयौला, पानी
३.	वर्मी कम्पोस्ट	१०.५.२	२४	३ महिना	१० क्विन्टल	गोबर, बायोमास, गँइयौला, पानी
४.	वर्मी वास	२.२.२	१	१ हप्ता	१ लि. प्रति दिन	पानीको घडा, गँइयौला, पानी र गोबर
५.	सी. पी. पी.	१५.१	१६	३ महिना	५० किलोग्राम	दुधालु गाईको गोबर, बेसल्ट पाउडर, (जिप्सम), अण्डाको छिल्का, बि. डी. प्रिपरेशन
६.	बि. डी. कम्पोस्ट	१०.४.३.	१	३ महिना	१० क्विन्टल	बि. डी. प्रिपरेशन, गोबर, बायोमास, पानी
७.	ई. एम. कम्पोस्ट	१०.४.३.	१	३ महिना	१० क्विन्टल	बायोमास, गोबर, ई. एम. पानी
८.	तरल किट-नाशक	२०० लि.	१५	७-१० दिन सम्म	२०० लिटर	गहुँत, गाईको गोबर, नीम, बकाइनो, धतुरा, पानी

Figure 24: Vermi-compost pits, and preparation of composts used for large cardamom in Nazitam Government Agriculture Farm in Sang-Martam, East Sikkim, India

the use of earthworms are used as manure in cardamom farms. Vermi-composting supplements the production of livestock manure in areas where farmers own a limited number of livestock but need additional manure for their cardamom farms.

Farmer friends are also advised to make bio-composting pits in suitable locations of the cardamom farm. They can collect different kinds of weeds, climbers, twigs and leaves or leaf litter from the nearby forest or agro-forest and mix them with cow/buffalo dung to prepare compost. Exotic weed such as Kalikhar (*Eupatorium adenophorum*) is ideal for bio-composting.

Green manuring

Farmers are advised to initiate green manuring mainly by growing legumes and other N_2-fixing or non-N_2-fixing species. Depending on the altitude, they can grow *Sanaei* (sun hemp, *Crotolaria juncea*), *Dhaincha* (*Sesbania* spp.), *Ipilipil* (*Leucaena leucocephala*), *Khair* (*Acacia catechu*), *Uttis* (*Alnus nepalensis*), *Siris* (*Albizia* spp.), *Kalikhar* (*Ageratina adenophora*) and other such species to increase soil fertility in cardamom plantations along the terrace edges (Figure 25). Green manures are grown *in situ* or obtained from trees and bushes around the fields. As per the suitability and availability of such nitrogen fixing species, farmers in Taplejung can apply green manuring to maintain soil fertility and to increase the soil organic matter in the cardamom farms.

Use of Jholmal as bio-fertilizer and bio-pesticide

Jholmal is a homemade bio-fertilizer and bio-pesticide made of locally available materials – animal urine, water, micro-organisms, farmyard manure and plants. It is prepared by mixing and fermenting the ingredients in a defined ratio (Agrawal et al., 2016). Use of jholmal is a traditional practice among local communities. It helps improve crop yields, lowers the costs for farmers and helps reduce the use of harmful chemicals. It controls insect pests and protects crops against fungal and vector borne diseases, thus improving plant health.

Figure 25: Green manuring in large cardamom stands

Development of soil base and mulching

Fields with deep, well-drained soils with loamy texture and pH 5.0-5.5 are best suited for cardamom plantations. Soil rich in organic matter and inter-planting of nitrogen fixing species such as *Alnus nepalensis*, *Albizia* spp. or some legumes will enrich the soil base with nitrogen and phosphorus. Compost manure or vermi-compost or farmyard manures can be used for soil fertility maintenance. If the field is not terraced, the farmers can slightly terrace the land by cutting the upper half and placing it on the lower half, followed by mulching of easily degradable organic matter. Dried twigs, leaf litter and weeds can be used as mulching materials.

Figure 26: Weed growing and weed management in cardamom farms

Weed management

Weeding and clearing the litter over the cardamom clumps before flowering helps maintain plant growth. Tree leaf litter or weeds will damage cardamom flowers. Weeding should also be carried out before harvesting (Figure 26).

It is important to control weeds in the plantation to allow the cardamom to use available soil moisture and nutrients to the maximum. At least two rounds of weeding are required for effective control of weed – once before flowering and once before harvesting. Weeding can be done manually by hand or by using a sickle depending on the intensity of weed growth. Weeds can be slashed from around the plant base or from the space between the bushes. Dried shoots and other materials removed during weeding can be used as mulch around the plant base to conserve moisture during winter until the onset of monsoon. Mulching will also prevent weed growth around the plant base. Uprooting weeds around or between the plant bushes is not advisable, as it will disturb the formative roots.

Different types of weeds grow in the large cardamom plantation. Many of them can come into use at different times of year. Farmer friends should know that certain weeds are both beneficial and harmful to cardamom. Weeding should be carried out before the flowering season so that weeds do not disturb the growth of flowers. Weeding should also be carried out during the fruiting stage so that weeds do not cause damage to the capsule bearing spikes.

In high-altitude areas where winter frost is a problem, the weeds are kept intact so that they will protect the cardamom plant from frostbite. Soon after winter, weeds should be removed and used as mulching material.

Disease Management

Emergence of diseases in Eastern Nepal

Viral diseases *Chirkey* (mosaic streak) and *Foorkey* (bushy dwarf) and the fungus disease that causes rhizome rot have existed in Nepal for many years (SNV, 2008). In plants infected by *Foorkey* disease, the stems are shorter, the spikes become stunted, crop production declines rapidly and the whole bushes die within 2 to 3 years (National Spice Crop Development Programme [NSCDP], 2009). Similarly, in plants infected by *Chirkey*, brownish spots appear all over the leaves and the entire leaves gradually become brown and dry (NSCDP, 2009). Both the *Chirkey* and *Foorkey* are viral diseases; aphid is the most important vector for its transmission (NSCDP, 2009). These diseases occur more frequently in lower altitudes than in higher and cooler areas. During 2005-2008, the disease infection rate was 70% in Ilam, 35% in Panchthar and 25% in Sankhuwasabha (SNV, 2008). The disease infection started from the lower altitudes on the southern belt and gradually moved to higher altitudes including different cardamom growing areas of Taplejung. In Sankhuwasabha district, some lower belts of Barabise, Matshapokhari, Diding were more severely infected compared to VDCs such as Num, Makalu and Pawakhola on the higher belt. Extensive field survey and field observation across the elevation range revealed that the infection initially started in the lower altitudes and gradually moved to the higher altitudes. The infestation of aphids also started from lower elevation to the higher elevations. This could be attributed to a gradual rise in temperature, erratic or non-uniform rainfall pattern and prolonged dry periods over the years.

Management of *Chirkey* disease

According to the Spices Board (2015), this disease is transmitted by corn aphid (*Rophalosiphum maidis*), which is one of the prevalent insect vectors. The disease spreads within the plantation and to adjacent plantations through contaminated field implements (mostly a knife used for fruit harvesting, or a sickle used for weeding cardamom) and aphids (see Table 1 for details).

Table 1: **Observation and management aspect of *Chirkey* disease**

Field observation	Symptoms and management
Identification of the symptoms at different times of the year	Mosaic appearance on leaves Leaves become pale yellow
Causal agent and transmission	*Chirkey* virus is the causal agent, mostly transmitted through sap and aphid. Farm implements such as knife, or other farm implements used during farm operations (gap filling, weeding, slashing, trimming of fruit bearing tillers before harvesting) can carry the sap of the infected plants to the healthy plants.
Infected plants survival	The infected plants dry out and die within 1–1.5 years while others continue to survive with a rapidly declining yield, followed by drastic reduction in the growth of new shoots from the base.
Disease transmission	ICRI Sikkim has reported that the disease does not transmit through seeds and seedlings raised from healthy plants that are not infected by *Chirkey* disease. Thus such seedlings are disease free.
Disease resistance or tolerance varieties	A number of field experiments and observations have been carried out, but no disease-resistant cultivars have been found or developed through breeding or any other scientific techniques.
Disease management	Farmers should regularly monitor the disease throughout the year, uproot the infected plant (dry and burn it or bury it under the soil in a different location), irrigate the plants during dry months, and use manure to enhance soil fertility. No scientific management techniques have been devised to manage this disease.

Farmers should notice the appearance of the disease, which is characterized by the appearance of a mosaic on young, newly emerged leaves (Figure 27). Discrete pale green to yellow longitudinal stripes running parallel to each other can be seen on the leaves when observed closely. Gradually it spreads to the mature leaves and the entire bush or the plantation will be infected. As a result of the disease, photosynthetic activity of the leaf area reduces dramatically while infection continues to reduce flowering thereby low fruit yield.

Management of *Foorkey* disease

Generally this disease can be identified in bushes with a large number of thin, stunted shoots coming out from the rhizome part (Table 2). The leaves become small, pale green and slightly curled (Figure 28). Over time it can be seen that these thin shoots do not grow while the remaining tillers gradually become pale yellow, drastically reducing the flowering and fruiting. Several inflorescences eventually become stunted and do not flower. In some cases the spikes remain fruitless, or if there are any capsules, seed formation does not take place.

Figure 28: Foorkey disease in large cardamom

Figure 27: Chirkey disease in cardamom leaf

Table 2: **Observation and management of *Foorkey* disease.**

Field observation	Symptoms and management
Identification of the symptoms at different times of year	Stunted and bushy growth appears at the rhizome part; newly emerging tillers with small pale green leaves; sometimes also produces broad, pan-like leaves.
Causal agent and transmission	It is caused by virus; primary spread takes place through infected planting materials. Transmission of disease is through aphids that primarily appear in banana.
Infected plant survival	If the infected part is regularly removed including the roots and rhizomes, the plant can survive for a year or more and bear some fruits. In several plantations it is observed that infected plants die during the growing season, mostly during winter.
Disease transmission	ICRI Tadong has reported that the disease does not transmit through seeds and seedlings raised from healthy plants that are not infected by *Foorkey* disease. Thus such seedlings are disease free.
Disease resistance or tolerance varieties	A number of field experiments and observations have been carried out by ICRI Sikkim. As of now no disease-resistant cultivars have been found or developed through breeding or any other scientific techniques.
Disease management	Management options include regular monitoring of the disease throughout the year, uprooting of the infected plant (dry and burn or bury under the soil in a different location), irrigation during dry months followed by the use of manure to enhance soil fertility. No scientific management techniques have been devised to manage this disease. Farmers are advised to destroy all the collateral host plants of the aphids in and near the plantation.

The Spices Board (2015) has reported that this disease is transmitted through virus, and unlike *Chirkey* disease, it is not transmitted mechanically through sap. As per the report, this disease is transmitted through a vector banana black aphid (*Pentalonia nigronervosa* and *Micromyzus kalimpongensis*). The virus is persistent and can survive inside the aphid for a long time after acquisition feeding on infected plants. The virus is also transmitted through infected rhizomes of the split suckers from one plantation to another.

Fungal blight

Over the last 10–15 years, fungal blight (*Colletotrichum gloeoporiodes*) has severely damaged cardamom plantations, leading to reductions in plantation area and productivity (Table 3). Fungal blight is completely dependent on the first rains, mostly pre-monsoon showers of April-May, and progresses rapidly during the peak monsoon. As the disease progresses, the leaves dry out giving a burnt appearance and finally the infected clumps and the entire plantation dries up. The rhizomes of the infected plants have to be examined periodically for lesions with air space in the middle. The spikes of the diseased clump appear more elongated compared to the spikes of a healthy clump and lack fruit setting.

Phoma leaf spot disease

This disease is caused by *Phoma hedericola*. The disease appears in the entire leaf area showing water soaked lesions. The spots appear round in shape over the leaf lamina; the spotslater coalesce and become yellowish and eventually dry out. The disease appears mostly during winter and advances during the rainy season. This disease has been spreading fast in the cardamom seedling nurseries of Arunachal Pradesh and in many plantations in Sikkim, India. The disease spreads fast during continuous rain, causing severe damage to cardamom bushes. The only available option for managing this disease is to separate the infected plant parts and dry and burn them. Other recommended management practices are sanitation, phyto-sanitation and application of bio-agents.

Leaf streak disease

This disease is caused by *Pestalotiopsis royenae*. It appears throughout the year and causes considerable damage to the leaves of the cardamom plant (Figure 29). The most susceptible variety of cardamom is *golsai*. In a diseased plant, numerous translucent streaks are formed along the veins of young leaves. Emerging folded leaves get

Table 3: **Observation and management of fungal blight**

Field observation	Symptoms and management
Identification of the symptoms at different times of year	Water soaked lesions appear either at the leaf margin or tips or any other point on the leaves, which rapidly enlarge, coalesce and cover a major portion of the leaf lamina, and finally the leaves appear blighted. In some cases the leaf lamina becomes yellowish and the blight spreads further. The leaf sheath covering the pseudo-stem appears blackish brown in colour and this colouring eventually spreads to rhizomes and subsequently turn into greyish or blackish patches with brown margins. After this the pseudo-stem becomes brittle and breaks in the middle or at the collar regions, and in some cases, the pseudo-stem becomes narcotic.
Causal agent and transmission	Caused by a fungal blight *Colletotrichum gloeoporiodes*
Infected plant survival	The survival rate of the infected plant is almost nil; therefore infected plants or clumps should be removed.
Disease transmission	No disease tolerant or resistant variety has been developed either by the farmers or by scientific research institutions.
Disease resistant or tolerant varieties	Field based observations and experiments are being carried out at research centres such as ICRI Sikkim.
Disease management	As a management practice, the fruit bearing tiller after harvest, or leaves of the infected plants should be composted in a pit away from the plantation. The pathogens are killed during the decomposition process. ICRI Sikkim has also suggested the use of EM (Effective Microorganism) solution or cow dung slurry for easy composting. Chop down the infected plants, uproot, dry and burn.

infected first. ICRI Sikkim has recommended three rounds of 0.2% copper oxychlode or 1% Bordeaux mixture at 15-dayintervalstocontrol the disease.

Molds

Molds (fungal infection) have been a persistent problem for cardamom. Several species of black-coloured fungi or mould grow on honey dew excreted by aphids feeding on trees. They release sooty, gray-black, velvety, often crust-like materials. Molds covers the leaf of large cardamom, and in severe cases, the black growth might even block the sunlight and interfere with photosynthesis. Mold growth can slow down respiration by physically closing the stomata. Lack of rainfall promotes the accumulation of sooty materials; plants affected by sooty mould wilt faster than unaffected plants. As a management practice, farmers can irrigate the field on a regular basis and destroy mould wherever it appears on the plant. Farmers are also advised to examine aphids in the associate plants and destroy them.

Clump rot

Various agents cause clump rot in cardamom, and the most common is fungus, such as *Pythium* sp., *Cephalosporium* sp. and *Rhizoctomia* sp. Clump rot is generally observed during summer and during winter until the onset of monsoon. The infected plants show yellowing of the leaves and wilting of the rhizome and

Figure 29: Leaf streak disease in Nuk-Danda, Kalimpong, West Bengal in Hariyo alainchi

Figure 30: Rhizome rot is a major problem in large cardamom

stem parts. The infected plant should be removed, dried and burnt to prevent the spread of disease. Rhizome rot has been an increasing problem in the cardamom farms across its growing elevations resulting into sharp decline of productivity and plantation area (Figure 30).

Pests of Cardamom and Their Management

Leaf caterpillar

The leaf caterpillar (*Artona chorista*) initially feeds on the chlorophyll content of the leaf lamina from under the surface. The infested portion of the leaf appears like white paper. As the infestation advances, the leaf undergoes defoliation, leaving the midrib intact. The incidence of this disease has been noticed during the onset of monsoon (May-June) and also during October through March (Table 4). Thus this disease appears in both the dry season and pre-monsoon season. The only option for managing this disease is to inspect the infested plant and kill the caterpillars (Figure 31). Farmers are advised to sprinkle bio-pesticides (cow urine with tobacco leaf juice) on the infected plants.

Shoot fly

Large cardamom plants are also susceptible to shoot fly (*Merochlorops dimorphus*). These flies damage emerging shoots. As the infestation progresses, the tip of the young shoot becomes brown and later the whole shoot dries up. Thus, new leaves do not come out in an infested shoot. This pest infestation has been observed throughout the year. Severe infestation can be seen during the rainy season when new tillers start growing. To manage this fly, farmers should inspect the infested plants and separate them and kill the flies (Table 4).

Stem borer

The larvae of the stem borer (*Glyphipteris* sp.) bore into the pseudo-stem above the collar region and feed on the central part of the pseudo-stem, causing dead heart. Minutely frass materials (excreta) can be seen outside the holes of the pseudo-stem. Stem borer incidence is observed mostly during March through November. *Seremna* is susceptible to stem borer. Farmers are advised to monitor the infected plant and destroy the stem borer at different times so as to stop its life cycle (Table 4).

Figure 31: **Various stages of leaf caterpillar in Seremna**

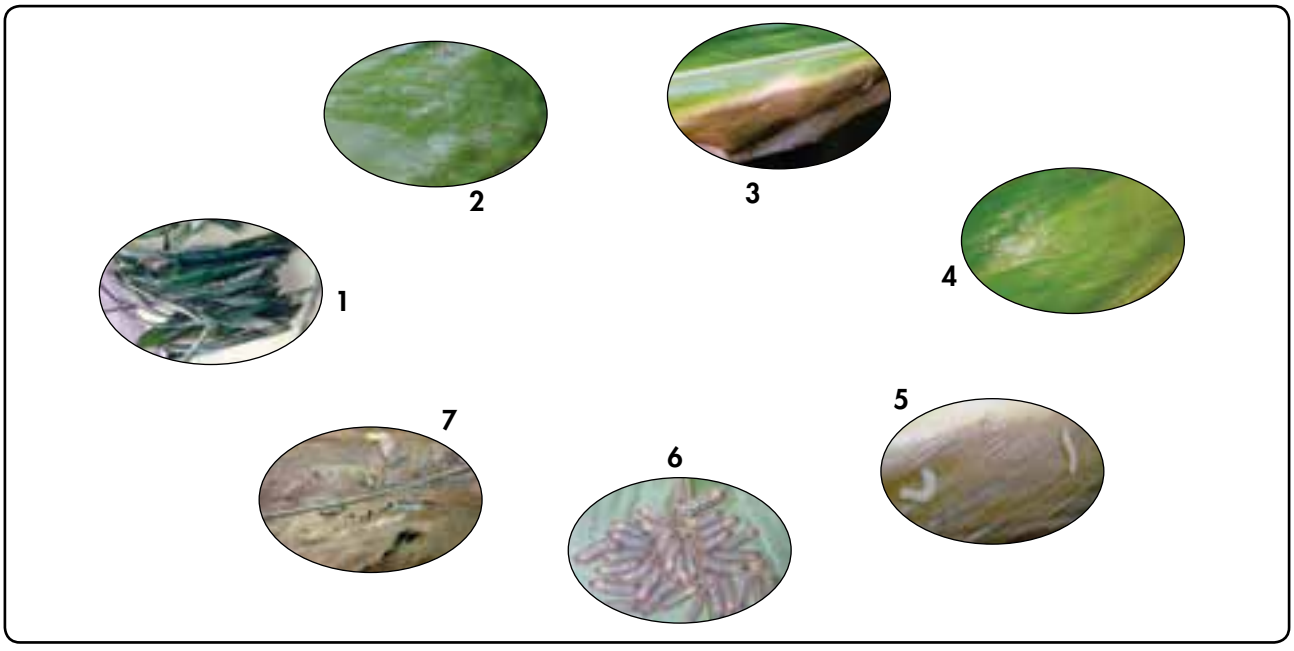


Table 4: **Some important pests and their management.**

Pests	Symptoms	Management
Leaf caterpillar (*Artona chorista*)	Initially feeds on chlorophyll content of leaf lamina from under the surface; infested portion appears like a white paper. Defoliation of the leaf takes place as the infestation advances.	The only way to manage this disease is to inspect the infested plant and kill the caterpillars. Farmers are advised to sprinkle bio-pesticides (cow urine with tobacco leaf juice) on the infected plants.
Shoot fly (*Merochlorops dimorphus*)	These flies damage the emerging shoots. As the infestation progresses, the tip of the young shoot becomes brown and later the whole shoot dries up. New leaves do not come out in an infested shoot.	The way to manage this fly is to inspect the infested plants and separate them and then kill the flies.
Stem borer (*Glyphipteris* sp.)	Bore into the pseudo-stem above the collar region and feed on the central part of the pseudo-stem, causing dead heart. Upon close observation, minutely frass materials (fine powdery excreta or fragile perforated pseudo-stem produced by the activity of boring insects) can be seen outside the holes of the pseudo-stem.	Farmers are advised to monitor the infected plant and destroy the stem borer at different times so as to stop its life cycle. The infected portion of the plant should be separated and disposed in a different location.
White grubs (*Holotrichus* sp.)	Damage the base of the pseudo-stem and the rhizome part. The infested plants look yellow after its activity starts during May-October when it feeds on the rhizome part.	To manage white grubs, farmers need to monitor the plant and kill the insect.
Aphids (*Mollitrichosiphum* spp.)	Aphids appear all along the newly emerging shoots and completely cover them.	Farmers should regularly irrigate the plant and destroy the aphids wherever they appear on the plant.
Capsule borer	The holes in the capsules are prominently seen in the infested capsule and a lot of infested capsules rot and decay. The pupation of the larvae develops in the capsule and comes out from the hole after maturity.	As a management practice, farmers are advised to clear the leaves, twigs, or weeds that appear over the fruit-bearing bushes so as to prevent different types of insects from infecting the spikes.

White grub

White grubs (*Holotrichus* sp) are polyphagous (able to feed on various kinds of food) and cause damage to the base of the pseudo-stem and the rhizome part. The larvae are fat, whitish or cream-coloured grubs, and generally about 38 mm long when fully grown (Table 4). The newly hatched grubs emerge during June-August and continue to develop till October/November. During this period, the feeding grubs spread 6 inches into the soil but may move deeper if the soil gets very dry. The larvae feed on plant roots and organic matter in the soil. The infested plants look yellow after its activity during May-October when it feeds on the rhizome part. White grubs can also be seen during winter. Manual collection of adult beetles during the emergence period is an effective method of managing the pest.

Aphids

Aphids grow on several crops such as beans, leafy vegetables, flowers, banana, citrus plants, and also on Himalayan alder. Both adult aphids and nymphs cause damage to cardamom crop by transmitting the viral disease. Incidence is severe during the summer season at lower altitudes (<1,000 m). In several cardamom growing areas, aphid infection has been noticed during winter and pre-monsoon season. Lack of rainfall would promote the growth of aphids. Incidence of aphids also increases the incidence of mould. The increasing temperature along the advancing altitudes as recorded in recent years might have been favourable for the growth of aphids, leading to wide spread incidence of viral diseases such as *Chirkey* and *Foorkey* on cardamom plantations. Farmers should regularly irrigate the plant and destroy the aphids wherever they appear on the plant or on the associated plants.

Figure 32: Capsules infested by stem borer

Capsule borer

Damage of capsules due to borer attack is a serious problem for cardamom. When capsules are maturing, the larvae of the borer enter the fresh capsules and damage or eat the seeds (Figure 32). The holes are visible in the infested capsule and a lot of infested capsules rot and decay (Table 4). The pupation of the larvae takes place in the capsule and the adult emerges from the hole after maturity. As a management practice, the farmers are advised to clear the leaves, twigs, or weeds that appear over the fruit-bearing bushes so as to prevent different types of insects from infecting the spikes.

Other pests

Different fruit-eating animals like monkey, mouse, *dumsi*, *kala*, squirrel, etc. damage the large cardamom fruits and buds. Climatic variation, prolonged dry periods and erratic rainfall pattern have increased the incidences of several pests over the years. Such climatic conditions favour the spread of pests, making the plant susceptible to other diseases and pests or environmental stress conditions. The infected plants or plant parts should be destroyed; otherwise they serve as breeding ground for pests. To manage pests and diseases, the farmers have to give adequate time for phyto-sanitation and maintain optimum plant population per unit area. They are also advised to guard the farm from wild animals.

Planting insect repelling or attracting species

Some species have antagonist behaviour while others attract unwanted insects that either feed on the nectar or collect pollens. Growing aromatic plants such as marigold or other flower plants can act as a biological control measure against insects that are harmful to cardamom (Figure 33). In cardamom plantations and around them, crop rotation or sequence is designed to present a non-host crop to pests/insects. The rotations are likely to substantially suppress the pests/insects harmful to the cardamom crop.

Alternative methods of pest management

Figure 33: Planting marigold in the cardamom plantation, a climate-smart practice

Pest management in a large cardamom field is important for plant growth, vigour and productivity. Farmers have to raise flowering plants / compatible cash crops along the field border. Shorter plants should be grown closer to main crops and taller plants closer to the border to attract natural enemies and to avoid immigrating pest populations. In several cardamom growing areas, farmers grow flowering plants on the internal bunds inside the field so as to attract the pests that would otherwise infest the cardamom plant. In addition, farmers should retain some important weeds such as *Tridaxpro cumbens*, *Ageratum* sp., *Alternanthera* sp. etc. growing in the cardamom plantation as they serve as nectar sources for insects and pests. They can also select plants that serve as appropriate companions; these could be trap-crops and pest-repellent crops. Flowering plants enhance biodiversity; the number of parasitoids and predators (natural enemies) will also increase due to the availability of nectar, pollen and insects. The major predators include a wide variety of spiders, ladybird beetles, long horned grasshoppers, earwigs, etc.

Understanding prey or predator insects in the field

Some insects may be harmful to the crops. However, majority of our farmer friends are not aware of insects that are beneficial to the crops. Predators are mostly farmers' friends as they feed on pests which would otherwise require careful observation in the field. The growing concept of 'insect zoo' can enhance farmers' ability to identify beneficial and harmful insects. In an insect zoo, unfamiliar or unknown predators in the field are collected in plastic containers and brought to a place where farmers can observe and study them with the help of scientists. The predator can be placed inside a plastic bottle together with parts of the plant and some known insect pests. The activities of the insects in the bottle can be observed for a certain period to determine whether the test insect is a pest (feeds on plant) or a predator (feeds on other insects). Regular observation of such insects and pests will help farmers to identify pests and predators. This will reduce the pests and save the predators in the large cardamom fields. Lace wing bug (*Stephanitis typica*) is one of the insects that feed on aphids. If infestation of aphid is high on cardamom, lace wing bug can be introduced to control aphids.

Field-based ecological engineering for pest management

Field-based ecological engineering is a simple method of pest management, control of soil borne and other diseases. Farmer friends are advised to apply this method to increase the beneficial microbial population and enhance soil fertility.

The following activities are suggested:

- Crop rotations with leguminous plants which enhance the nitrogen content, within the plantations or along the terrace edges.
- Farmers should keep the soils covered year-round with living vegetation and/or crop residue by mulching to reduce moisture loss.
- Farmers can add organic matter such as farmyard manure (FYM), vermi-compost, or crop residue, which enhance below-ground biodiversity of beneficial microbes and insects.
- Farmers should provide a balanced dose of nutrients using manures (bio-composts/vermi-composts) or bio-fertilizers based on soil test report, if such resources are available through proper extension services.
- Farmers have to learn about the application of *Trichoderma harzianum/viride* and *Pseudomonas fluorescens* for the treatment of seed/seedling/planting materials in the nurseries and field application through R&D institutions. This is being carried out in cardamom farms in Kalimpong, India with support from the Spices Board, a government institution working on large cardamom.

To attract natural enemies, farmers can grow flowering plants/compatible cash crops along the field border. Shorter plants should be aligned towards the main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population (Table 5). There are several natural enemies in the cardamom field which could play a very significant role in controlling foliar insect pests. The diversity of natural enemy significantly contributes in the management of insect pests both below and above ground. They require food in the form of pollen and nectar; shelter, overwintering sites and moderate microclimate, etc.; and alternate hosts when primary hosts are not present.

Table 5: **Field observation for management of cardamom crop in the field**

Attributes	Field observations
Plant	Observe the plant height, number of aerial tillers, crop stage, deficiency symptoms, etc.
Pests	Observe and count the pests on different parts of the plant.
Natural enemies	Observe and count the parasitoids and predators.
Diseases	Observe the leaves and stems and identify any visible disease symptoms and severity.
Rats	Count the number of plants affected by rats.
Weeds	Observe the weeds in the field and their intensity.
Water	Observe the water situation of the field.
Weather	Observe the weather condition.

Crop management strategies for farmers

Around 3–4 skilled and knowledgeable farmers from groups of large cardamom growers can visit the cardamom field (newly established and the old plantations elsewhere). They can walk across the field and choose a small plot (5 m x 5 m) or around 15–20 bushes. They have to minutely observe each of these plants and record their observations:

While walking in the field, farmers should manually collect insects in plastic bags. Use a sweep net to collect additional insects.

- Collect plant parts with disease symptoms. Find a shady place to sit as a group in a small circle for drawing and discussion.
- Each group will first locally identify the pests, defenders and diseases collected.
- Each group will then analyse the field situation in detail and present their observations and analysis in a drawing (the AESA drawing).
- Each drawing will show a plant representing the field situation. The weather condition, water level, disease symptoms, etc. will be shown in the drawing. Pest insects will be drawn on one side. Defenders (beneficial insects) will be drawn on the other side. Number each insect. Indicate the plant part where the pests and defenders were found. Try to show the interaction between pests and defenders.
- Each group will discuss the situation and make a recommendation for crop management.
- The small groups will then merge and a member of each group will present their analysis to all participants.
- The facilitator will facilitate the discussion by asking guiding questions and make sure that all participants (including shy or illiterate persons) are actively involved in this process. Formulate a common conclusion. The whole group should support the decision on what type of management practice is required in the AESA plot.
- Make sure that the required activities (based on the decision) will be carried out.
- Keep the drawing for comparison purposes in the following weeks.

Harvesting and Post-Harvest Processing

Harvesting

Farmer friends should learn the correct method of using the knife (*Chhuri*) to harvest the ripe capsule-bearing spikes attached to tillers. During the ripened stage, the spike-bearing tillers and new tillers are arranged very compactly, so using a double-edged knife might trim down the new shoots of the new tillers that will bear fruit next year (Figures 34 and 35). Farmers also suggested that if the bush has grown profusely with a large number of tillers, they have to be judicious while thinning it so that the fruit-bearing tillers will find enough space for fruiting next year. Therefore, training and skilled labour is crucial for managing tiller density and for harvesting cardamom.

Prior to harvesting, farmer friends are advised to examine the capsules in the spikes to check the stage of seed maturity (until they turn black). Harvesting can begin once the capsules look maroon and fully matured. Cardamom maturity starts from the lower elevations to higher. Therefore, cardamom in the lower elevations should be harvested from September end till the end of October or the first week of November depending on the time of maturity.

Figure 34: Use of knife during harvesting

Figure 35: Different types of knives used for harvesting

Post-harvest curing of cardamom

Soon after the harvest of spikes, farmer friends are advised to stock up the produce in a dry, shady area and separate the capsules from the spikes. Fresh capsules should be dried to retain their colour. Stocking of capsules for more than two days should be avoided so as to protect them from mould or other fungal infection.

Over the last 10–15 years many research and development institutions have devised or improvised different curing kilns (*bhatti*) to improve the quality of capsules and reduce the consumption of firewood. As a final step for obtaining best quality product, the maroon capsules and essential oil content should be retained. Therefore, curing is the most crucial step in large cardamom processing.

The quality of capsule largely depends on the curing conditions and methods. Farmers are advised to stock up hard fuel-wood a year prior to the drying of cardamom. Cardamom should be dried using dry woods. Steady flames that do not produce smoke will be highly beneficial. It is very important to monitor the fire during drying otherwise the capsules will lose their colour and turn dark, which will eventually fetch a low market price (Figure 36).

Figure 36: Large cardamom harvesting and curing process

Post curing grading

Grading the capsules after curing is important for fetching better market prices. Grading can be done by removing the tails called the *kainchi-cut*, or those with the tails *non-kainchi-cut* or segregating the capsules into *thulo-danu* and *sanu-danu*. Different cultivars have different sized capsules. *Golsai* and *Bhalangey* varieties have big capsules and grading them can bring the best market price.

For grading, farmer friends can immediately lightly mesh the capsules by reshuffling them to remove the unwanted outer part and dust. In the next step, *thulo-danu* and *sanu-danu* can be segregated manually or using locally made bamboo sieves. Adoption of improper postharvest handling, storage and processing techniques will lower the quality of the capsule and thus the product will not fetch premium market price.

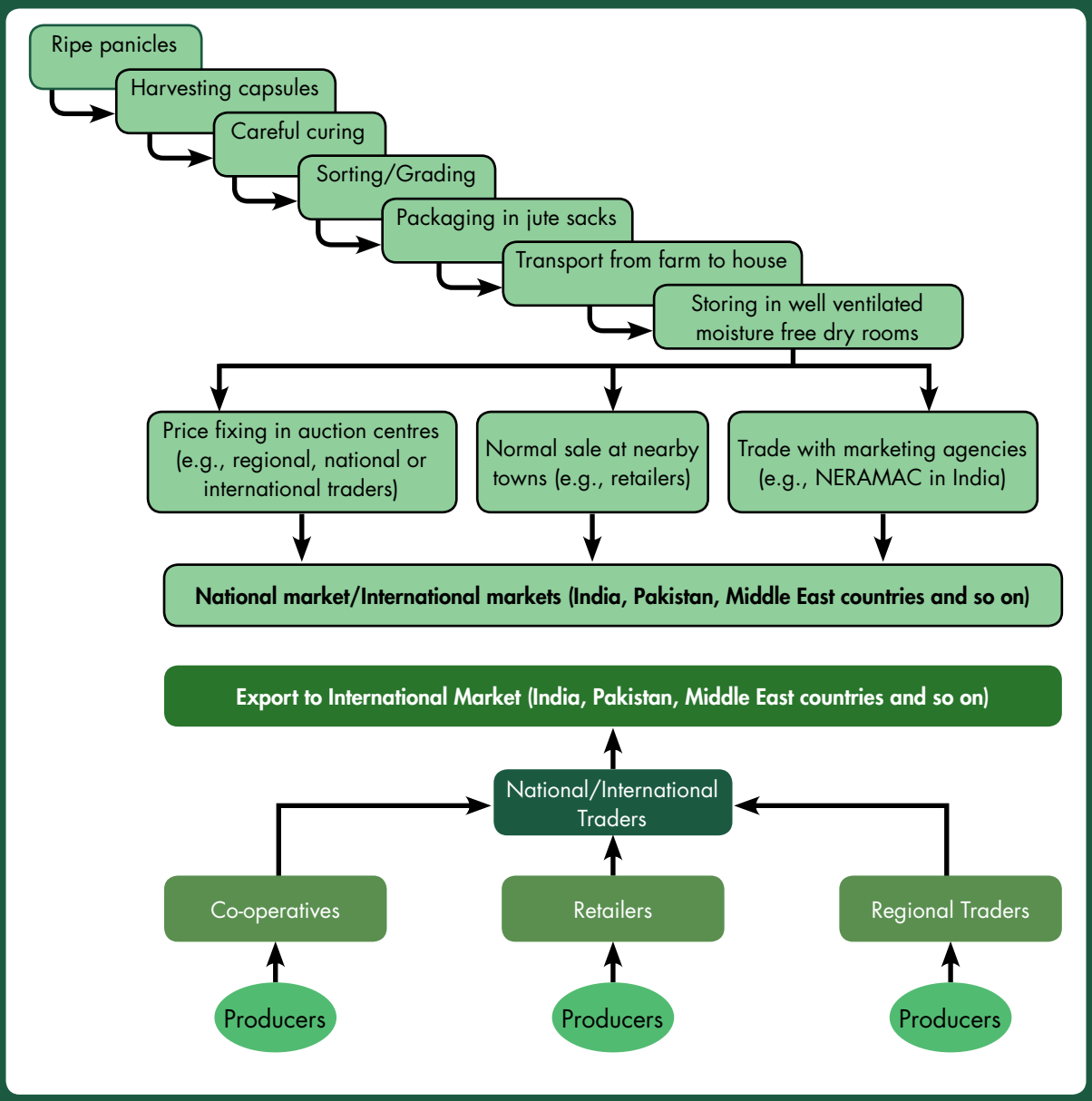
Some important things to be remembered after the curing of the cardamom capsules is cleaning, grading and preparation for market, packing house operations, packing and packaging materials, decay and insect control, temperature and relative humidity control, safe storage, safe transportation, and handling at destination.

Market Linkage and Demand-Supply of Cardamom

Farmers are required to understand the value chain of large cardamom marketing and trade (Figure 37).The North Eastern Regional Agricultural Marketing Corporation (NERAMAC) in India has set an example for fixing premium price with farmers. The NERAMAC organizes the auction of large cardamom at Singtam, East Sikkim, where the traders from Siliguri and elsewhere come to bid the best product directly with the cardamom farmers coming from different parts of Sikkim and Kalimpong. From 2015 onwards, daily market prices are sent via the SMS system to the registered mobile numbers so that the farmers understand the volatility of the market for their produce. In the first auction that took place in December 2015, per kg price of the best large cardamom capsule was USD 27.5 (USD 1 = Indian Rupees 60).

Based on the above example from India, farmers are advised to establish a network of cardamom growers and link up with the main local and regional traders to understand the market price.

Figure 37: Supply chain for large cardamom trade



Gender and Social Equity

This POP has been designed to initiate a participatory and gender inclusive approach towards the improvement and scaling up of large cardamom based farming in eastern Nepal, where roles of both men and women are central. Both men and women can take part in the value chain, starting from field preparation, nursery development, and selection of cultivars, weeding, irrigation, manuring, harvesting and marketing. For drying, men have more roles, especially for collection of fuel-wood. Women and men can equally participate in the marketing of cardamom. Both men and women would be able to make household decisions (Table 6).

Table 6: **Participation of women and men in different activities along the cardamom value chain**

Activities	Participation
Nursery development	Men plough the field while women are involved in soil preparation and manure application.
Selection of varieties	Both men and women of the household and/or neighbouring households discuss which variety is best for which plot of land allotted for cardamom plantation.
Plantation	Both men and women build pits, put manures, and engage in plantation activities.
Weeding/gap filling	Weeding is an important activity at different times of the year, and both men and women participate in it. Similarly, both men and women carry out gap filling by planting new saplings.
Harvesting	Harvesting is mostly done by men, though women farmers are also starting to get involved.
Post-harvest curing	Splitting hard woods is done mostly by men. Women help them to bring cardamom sacs to the curing centre. Both men and women participate in curing, reshuffling of drying cardamom, fire management during curing, etc.
Marketing	Household members discuss and make decisions regarding the sale of their produce. These days even children use mobile phones and receive market information from different towns and market centres. They can give their parents suggestions on good price fixing with traders.

Equal participation of men and women in cardamom farming and marketing will ensure that the earnings from cardamom trickle down to the women, meaning they have a say on how the earnings are to be spent. Their interest in continuing the work is thus likely to increase. This will lead to the success of large cardamom-based farming system, which equally demands women's labour.

It is interesting to note that in a climate-smart production system, gender roles and responsibilities have been informally divided so as to ensure optimum production and management. In general, women are more involved in nursery development, weeding, manuring, irrigation, harvesting, and post-harvest processing of large cardamom apart from their regular involvement in raising small livestock poultry, goats, sheep, ducks, etc. Men are involved in ploughing for nursery development, site selection, selection of cultivars, weeding, management of diseases/pests, harvesting, curing, transporting, storing, and marketing, etc. Women's contribution is higher in feeding, collecting fodder, cleaning sheds, and grazing of livestock while men are more involved in management such as disease treatment, milking, and buying and selling of animals and their products.
In places where mechanized farming facilities are not available, people engage in traditional farming, which is labour intensive. Both men and women have to work together depending on the nature of the work. Therefore, availability of labour and the involvement of farmers play a significant role in enhancing agricultural productivity and ensuring meaningful decision making.

Building on Traditional Knowledge

The sustainability of large cardamom-based farming system is based on the rich traditional ecological knowledge system, which has evolved over generations through trial and error methods and their continuous interaction with the environment. At certain points in time, cardamom farming faced major constraints such as disease and pest control, or prolonged dry periods, etc., which eventually lead to a dramatic decline in plantation area and production. In such extreme situations, farmers drew on their knowledge systems and came up with innovative ways to revive the crop in new locations. Farmer friends are advised to share and transfer the rich traditional ecological knowledge to other farmers and children so that the knowledge will survive overtime.

3. Diversification of Livelihood Options for Cardamom Farmers

Diversification of livelihood options is important for strengthening the resilience of cardamom farmers. The POP explores different options for diversifying farmer products, increasing their income and improving soil and water quality, reducing (wind) erosion and preventing damage due to diseases and pests. It emphasizes integration of trees, crops and livestock to ensure the sustainability of the production system on the one hand, and to improve processing, product diversification, branding on the other hand to increase benefits for the value chain actors. Some examples for diversification of livelihood options are as follows:

Figure 38: Pollination of cardamom by honeybees

Figure 39: Beekeeping, a traditional practice in Furumbu VDC, Taplejung district

Figure 40: Kiwi cultivation at Udai Dahal's farm in Yaphrek, Furumbu VDC 8, Taplejung district

Beekeeping for Pollination and Economic Services

It is very important for cardamom growers to understand the role of pollinator species and their services in increasing the productivity of large cardamom (Figure 38). Bumble bees and honey bees are major pollinators of large cardamom and we have to conserve them. Beekeeping is one of the ways to conserve pollinator (Figure 39). It is a potential income generating activity that farmer friends in the pilot sites can promote. Beekeeping has social, religious and spiritual, health and medicinal and environmental importance. It can enhance pollination in large cardamom while also bringing good incomes to the households.

Kiwi Cultivation as a Shade-Giving Vine Fruit

Kiwi (*Actinidia chinensis*) cultivation on sloping land in the mid-hill areas of Nepal can help prevent soil erosion and is a sustainable land management practice (Figure 40). This high-value crop promotes biodiversity and improves livelihoods by providing a source of cash income (http://www.icimod.org). Therefore, farmer friends can initiate kiwi cultivation along with cardamom plantation. Thiscouldbe a viable option for diversifying livelihood options for farmers.

Kiwi cultivation is already being practised in Furumbu VDC in Udai Dahal's farm near the cardamom field at Yaphrek. The farmers in the pilot sites can be provided planting materials to encourage them to grow kiwi. The unused terraces and edges of the cardamom farms or other open farmlands can be used for kiwi cultivation, which can bring considerable income to the farmers.

Production of Legumes and Other Potential Crops

Eastern Nepal has highly diverse climatic and environmental conditions, which allow cultivation of a dozen species of pulses. Farmer friends are advised to

grow legumes such as black gram, broad bean, chickpea, cowpea, field pea, grass pea, horse gram, lentil, mung bean, phaseolus bean, pigeon pea, rice bean, and soybean. Grain legumes are used in many forms for human consumption or can be sold in the market. A variety of leguminous plants can be intercropped. This has a dual function in the cardamom-based farming system and can help increase the soil nutrient base, bring cash income, or provide food.

Farmer friends are also encouraged to cultivate cereals and pseudo-cereals (e.g., rice, maize, wheat, sorghum, rye, millets, buckwheat, amaranth, chenopods, etc.), legumes (e.g., horse gram, beans, pulses, soybean, etc.), vegetables (e.g., leafy vegetables, mustard, niger, coriander, spices, cucurbits, cabbages, cauliflower, yams, etc.), fruits and nuts (e.g., banana around the house, jackfruit, figs, litchi, tamarind, guava, pineapple, peach, pear, plum, etc.), medicinal or aromatic plants, roots and tubers and multipurpose trees depending on land availability.

Mushroom Cultivation in Cardamom-based Farming

Farmer friends can also initiate mushroom cultivation to diversify livelihood options. Mushroom can be cultivated throughout the year under natural environmental conditions. It is important to bring cultivation technology and provide training to the interested farmers in the pilot sites of the project. Shitake mushroom, a low-cost, high-value mushroom, can be cultivated on cardamom forest floors without requiring any inputs (manure or investment).

Cardamom Nursery

To increase household income, farmer friends can develop a nursery for cardamom seeds or for split rhizomes. By the second year of nursery development, farmers will be able to sell a considerable number of planting materials (Figure 41). The mother seeds should be collected from disease resistant or tolerant varieties, which can adapt to the range of altitudes identified as suitable for new cardamom plantations. The demand for planting material is very high and current supply has not been able to meet the requirements for eastern Nepal. There are many opportunities to establish cardamom nurseries, both for selling the planting materials and for eventually converting the nurseries into a full-fledged productive stand. The market rate per sucker is increasing every year.

Figure 41: A cardamom nursery in Hee-Gaon, West Sikkim

4. Extension Methods and Services

Demonstration at Farmers' Field: 'Showing by Doing Approach'

It is a participatory approach that allows farmers to learn, share, test, demonstrate, and disseminate production technology of large cardamom in such a way that the adoption rate grows and delivers positive results (Figure 42). Fine-tuning production technology based on location-specific conditions and resources available with the farmers enhances the revival of the production system of large cardamom. The approach is a direct response to farmers' needs for integrated pest and disease management, soil fertility maintenance, improvement of farm techniques, and enhancement of the production level. The demonstration plots are to be established in strategic locations where farmers can gather easily for observation, analysis, discussion and debate. This allows new ecological concepts to be combined with local knowledge for improvement of the production system of large cardamom.

Shade Species Selection and Nursery Methods

Large cardamom is a shade-loving plant and grows well in 50–60% shade conditions. Selection of multifunctional shade species is important for optimum benefits both for enhancing the productivity of large cardamom and for other benefits. Farmers have to select shade species based on the ecological function of the species. Firstly, they have to select nitrogen-fixing species such as *Alnus nepalensis* or *Albizia*, which help enhance soil fertility by providing nutrient rich litter, nitrogen through fixation in root nodules and excellent shade. These species also supply a considerable amount of phosphorus to the soil. Secondly, farmers should select suitable fruit trees so that they can intercrop these species for additional income while providing required shade. Thirdly, they have to identify suitable fodder tree species that will provide dual benefits namely, shade for the plantation and fodder for animals. Finally, farmers can select some suitable timber species that can provide good shade and can be harvested for good timber at the time of agroforestry rotation.

Farmer friends are advised to establish nursery of various multipurpose shade species in their farms. They have to plant mixed species in the new cardamom plantations, keeping the plant-to-plant distance in mind so as to establish partial shade. Farmer friends can also plant such species in degraded lands or open agriculture lands to establish agroforestry, which can supply beneficial biomass afterwards.

Figure 42: Farmers discussing crop management techniques

Selection of species and timely collection of seeds is important. During February-March, seed beds can be prepared with appropriate manure mixed with soil over the beds. The seed beds need to be protected from the sun, hailstorms, or rain by providing appropriate shade. Bamboo splits (*Chim*), tree twigs, or grasses (*Khar*) can be used for this purpose. Farmers have to develop seed beds, and seed sowing can be done during March-April. Regular and skillful weeding, manuring and irrigation should be carried out. Once the saplings attain a height of around 2–2.5 ft, they should be transplanted to the cardamom farms. Newly planted saplings should be given a protection cover using bamboo splits for at least a year.

Facilitation for Data Recording and Peer Learning

Farmers should note down the data in a notebook and make a drawing on a chart to keep a record of the plant growth and behaviour (Tables 7 – 10). This will help them analyse their activities and draw conclusions.

Table 7: **Data to be recorded by the group of farmers.**

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plant growth (monthly)												
Height of plant												
Number of leaves												
Crop situation												
Plant health												
Pests, diseases, weeds												
Natural enemies												
Soil condition												
Irrigation												
Weather conditions												
Input costs												
Seeds												
Fertilizer												
Bio-pesticides												
Labour												
Harvest												
Yield (kg/acre or *ropani*)												
Price of produce (Rs./kg)												

Table 8: **Calendar events for cardamom crop cultivation**

Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Manure application												
Irrigation												
Weeding												
Gap filling (new suckers)												
Slashing fruit-bearing tillers												
Disease/pest monitoring												
Mulching												
Harvesting												
Drying												
Drainage to avoid water logging												
Land and soil management												
Fuel-wood stocking for drying												

Table 9: **Summary of suggestions for climate-smart practices**

Elements of climate resilient practices	Activities	Climate resilient practices
Weather smart practices	Selection of crop variety and crop management as per weather trends	Depending on weather trend and climate change scenario, selection of varieties (e.g., drought/frost tolerant) and management practices need to be adopted. For example, in high altitudes, weeds can be grown during winter to prevent frostbite from harming the new shoots that will fruit next year. Similarly, harvesting can be delayed by a few days if rainfall is predicted.
Soil/nutrient smart practices	Manure application	Based on soil testing results, appropriate dosages of manure/organic fertilizer should be applied to improve soil health. Some simple low-cost practices include: use of well-decomposed dung, and planting of leguminous trees or shrubs that can serve as live fences, hedge plants, insect repellents, such as Titepati (*Artemisia vulgaris*), Ankhitare (*Walsura trijuga*), Dhaincha (*Sesbania* sp.), Khirro (*Sapiumin signa*), Sanaei (*Crotolaria juncea*), ipilipil (*Leucena leucocephala*), Rahar dal (*Cajanas cajan*)
Soil/nutrient smart practices	Intercropping	Intercropping of nitrogen-fixing pulses or beans, or nitrogen-fixing fodder trees such as *siris* or *phaledo* can help enrich the soil nutrient base while also providing other benefits to the farmers.
	Shade trees	*Alnus nepalensis*, Albizia spp., and other preferred species
	Weeding	Weeding should be carried out before flowering and harvesting. Weeds can be used as mulch around the bushes.
Knowledge smart practices	Access to and use of information	ICT-based information on market price, supply volume, weather forecast and crop advisory services can help value chain actors to minimize risks (e.g., if the market value is low, farmers can store the produce in a moisture-free dry room until market price rises up).
	Communication/ dialogue among VC actors	It is important to work in a group/cooperative and engage in collective bargaining to improve the bargaining power of producers; frequent interaction between buyers and suppliers is important for understanding the specific requirements of the market and engage in fair business.
Water- smart practices	Irrigation	Sprinkler or drip irrigation can be carried out during dry periods at frequent intervals (at least twice a week)
	Mulching	Slashed pseudo-stem, weeds or leftover fodder residue mulched with dung can be used as mulching material. Mulching will provide additional nutrients to the plants after decomposition as well as protect the base of the bushes from frostbite or snow.
Energy-smart practices	Drying	Cardamom drying is the most important step in cardamom processing. Proper drying process is necessary for colour and oil retention. Energy-smart practices include promotion of the improved dryer that consumes less fuelwood and emits less carbon while saving labour, use of dry fuelwood of hard-wood (*kharodaura*) species such as *chilauney*, *phalanth*, book, or *katus* that will provide enough heat, and constant monitoring of fire flames and reshuffling (upside down) the capsules while drying to make the moisture content of the capsules uniform.

A participatory crop management approach is recommended. It is a simple method of field observation by a farmer or a group of farmers. After the field visit, farmers can sit together and discuss the following important observations:

- Discuss and write down the important observations you made at the large cardamom field.
- Which crop management aspects are of immediate importance at the time of your observation and in the coming seasons?
- Mention any pest or disease outbreak you observed or any disease or pest that needs immediate management attention.
- List down the beneficial insects and harmful pests.
- What changes have occurred in the field since your last visit? Discuss and write them down.
- Calculate and determine the ratio between the pests and the defenders in the field.
- Note down whether the crop is healthy or requires some inputs such as manure, irrigation, etc.

Table 10: **Cardamom planting calendar**

Activities	Year I	Year II	Year III
Land preparation	Dec-Feb	–	–
Pit digging and filling with composts/manure	Dec-Feb		
Planting of shed species	April-June	Gap filling, April-June	Gap filling if required
Planting of suckers	May-June	Gap filling May-June	Gap filling May-June
Intercropping of vegetables or other suitable crops	May-December	May-September	Intercropping can be done only on terrace rises and not between the cardamom bushes
Manure application	September-October	Oct-Nov after the use of a knife	Oct-Nov after harvest and April before flowering
Irrigation	Dry periods	Dry periods	Dry periods
Weeding	April, before flowering	Before flowering (April) and before harvesting (July-Aug)	Before flowering (April) and before harvesting (July-Aug)
Use of a knife	–	During harvesting time, August-October	During harvesting

Note: From fourth year onwards the farmers have to continue with what they do in the third year.

- Which insects and pests could you identify? Which ones could you not identify? Discuss who you should consult for identification.
- Discuss what management practices might be needed to improve the current situation of the crop?
- Discuss when such management practices could be carried out and who should be involved.
- Discuss how appropriate the shade trees or other associated species are, how can they be better managed so that cardamom as the main species is benefited?
- Record any problems that might emerge in the farmers' discussion in the near future or in the coming season, e.g., good or bad weather situations, emergence of pests or diseases, etc.
- Discuss the problems mentioned above and how they be prevented.
- And finally summarise your observations in two sections titled 'problems' and 'solutions' (actions to be taken to solve the problems) for better management of the cardamom plantation.

Network and Collaboration for Scientific Research on Pests and Diseases

Persistent disease and pests have contributed to the dramatic decline of the plantation area, production and productivity of large cardamom crop in Nepal. Over the years, cardamom farmers have gained a good understanding of diseases and pests and developed a number of strategies to keep ahead of fast-emerging biotic stresses. The traditional practices that farmers use can be highly effective, but the conditions are changing as climate variations speed up the evolution and emergence of new pest and disease variants.

It is important to carry out a detailed scientific study of different pests and diseases infesting large cardamom and other associated crops. Research and development (R&D) infrastructure on large cardamom has become a necessity, especially considering that large cardamom is now a source of national pride for Nepal. To begin with, the project implementing agency has to extend network and collaboration with research institutions such as Pakhribas Agriculture Research Centre or any institution with a well-established laboratory and other facilities to initiate screening of diseases and pests and to carry out advanced research on pest and disease eradication.

Soil Testing of the Cardamom Farms

Soil testing is an important farm management tool for recording the soil nutrient status and nutrient deficiency in cardamom plantations. A proper soil test will help ensure that the crop receives sufficient manure to meet its requirements while taking advantage of the nutrients already present in the soil. It will also help determine the pH of the soil. Soil analysis is a valuable tool for cardamom farm as it determines the inputs required for efficient and economic production.

The ECDF can coordinate with Pakhribas Agriculture Research Centre in Dhankuta or any other R&D agencies to carry out soil testing for the old cardamom farm as well as for the new plots identified for piloting. Based on scientific analysis, soil nutrient levels vary from year to year, and will frequently vary within fields, even on fields that seem to be uniform. It is therefore necessary to follow recommended steps developed by R&D institutions for soil sampling and testing to develop a sound soil fertility management program.

Co-operative Marketing System

In the large cardamom growing VDCs of Taplejung district, establishment of a cooperative system would be the best alternative strategy for involving farmers in the development process; it would also be an effective means to improve the socioeconomic situation of the marginalized communities. The cooperative marketing system can be established through enhancing people's participation, promoting market oriented production systems, increasing the bargaining power of the farmers, supplementing existing service delivery system, and providing credit and mobilizing savings. Establishing co-operative marketing in the pilot VDCs of Taplejung would shorten the marketing channel (producer – local traders/regional traders (wholesalers/middleman-retailer)/national traders/international traders – consumer) and enable farmers to bypass middlemen who take away a good share of the profits in the process.

The cooperative can create a sizable revolving fund that can be used to provide low-interest loans to the cooperative members when the need arises. This will allow cardamom farmers to establish a cardamom nursery, buy good quality planting materials, bear the cost of new plantation establishment, or initiate subsidiary livelihood options such as beekeeping.

Establishment of Crop Advisory and Market Information System

A cardamom web portal would be an effective tool for sharing and exchanging information on large cardamom with various stakeholders including the farmers. As a nodal agency working with the cardamom growers, the ECDF can establish a *cardamom webportal* that provides necessary information on cardamom, starting from the day-to-day activities, rainfall, weather events, diseases and pest management, best practices, marketing, etc. Interested cardamom farmers can register their mobile numbers on this web portal to develop a network of cardamom growers. The portal can be linked up with the Nepal Chamber of Commerce to obtain information on the fluctuating market price of cardamom on a daily basis; this information can be sent to the farmers via SMS on a daily basis. The ECDF and cardamom cooperatives, in collaboration or partnership with the Nepal Chamber of Commerce, could establish a cardamom auction centre in Taplejung by inviting regional or national traders or exporters. Farmers could directly bargain and negotiate the premium price for their produce at the auction centre.

5. Conclusions

Large cardamom-based farming is one of the most promising livelihood options for farmers. It can provide employment to marginal farmers, improve the economic well-being of the households, and restore ecological health, all of which form the basis for sustainable agriculture development in eastern Nepal. This POP will be useful to interested cardamom farmers as it describes the complete cycle of large cardamom agroforestry development, production, management and re-establishment.

Apart from farm-based management that demand low input from farmers (as described in this POP), a series of extension services such as soil testing, disease control techniques through application of bio-pesticides, irrigation facilities, post-harvest curing techniques, market linkage for ensuring premium prices, training and capacity building need to be made available to the farmers. Such services will not only facilitate and encourage farmers to enhance their livelihood through improved agricultural practices but also contribute to poverty eradication.

It is a matter of pride for Nepal that it is the largest producer of large cardamom in the eastern Himalayan region. Taplejung is the largest cardamom producer district in Nepal. Revival of climate-smart large cardamom farming in Taplejung will further enhance the production system and help scale it up to other districts. Large cardamom is one of the major agricultural cash crops and contributes significantly to national economy; therefore it urgently needs strategic policy interventions and extension services.

References

Agrawal, N.K., Marechal, J., Leikanger, I., Choudhury, D., Maden, U., Sellmyer, A., …. Maharjan, D.R. (2016). Preparation of Jholmal in RMV Pilot Sites – Up-scaling a local practice. Kathmandu: ICIMOD

Awasthe, R.Kk, Singh, K.K., and Tomar, J.H.S. (2011). 'Large cardamom (Amomum subulatum Roxb.) based agroforestry systems for production, resource conservation and livelihood security in the Sikkim Himalayas'. *Indian Journal of Soil Conservation* 39 (2): 155–160.

Chapagain, D. (2011). Report on Assessment of climate change impact on large cardamom and proposed adaptation measures in eastern hill of Nepal. Submitted to NAPA Project Team National Adaptation Programme of Action (NAPA) Project Office Ministry of Environment Singha Durbar, Kathmandu NEPAL; submitted by Dipesh Chapagain Research Grantee, Applied Research Grants for Climate Change Adaptation Clean Energy Nepal 108 Vinayak Marga, Kamaladi, Kathmandu, Nepal, Central Department of Environmental Science, Tribhuvan University pp 52.

Chaudhary, R. (2015). Vista Shree Prasad Edited, Proceedings of the Stakeholders Consultation Workshop on Large Cardamom Development in Nepal held in April 20, 2015, Commercial Crop Division, NARC, Khumaltar, Nepal.

Government of Nepal [GoN] (2013). Statistical information on Nepalese Agriculture 2012-13 (2069/070). Government of Nepal, Ministry of Agricultural Development, Agri-Business Promotion and Statistics Division Statistics Section Singha Durbar, Kathmandu Nepal pp 205.

National Spice Crop Development Programme. (2009). Annual Report of National Spice Crop Development Programme. National Spice Crop Development Programme, Government of Nepal, Ministry of Agriculture Development, Khumaltar, Kathmandu.

Partap, U., Sharma, G., Gurung, M.B., Chettri, N., and Sharma, E. (2014). Large cardamom farming in changing climatic and socioeconomic conditions in the Sikkim Himalayas. ICIMOD Working Paper 2014/2. Kathmandu: ICIMOD.

Rijal, S.P. (2014). Impact of climate change on large cardamom-based livelihoods in Panchthar District, Nepal. The Third Pole, 33-38 (www.nepjol.info/index.php/TTP/article/download/11544/9333 accessed in November 2015).

Sharma, R., Xu, J., and Sharma, G. (2007). 'Traditional agroforestry in the Eastern Himalayan region: Land management system supporting ecosystem services'. *Tropical Ecology* 48 (2): 189-200.

Sharma, G. (2013). Opportunities and challenges of large cardamom farming, beekeeping, and pollination system in Sikkim. Report submitted to International Centre for integrated Mountain Development, Kathmandu Nepal, pp 46.

Sharma, G., Partap, U., Dahal, D.R., Sharma, D.P., and Sharma, E. (2016b). Declining Large -Cardamom Production Systems in the Sikkim Himalayas: Climate Change Impacts, Agroeconomic Potential, and Revival Strategies. Mount Res Dev36 (3):286–298 http://dx.doi.org/ 10.1659/MRD-JOURNAL-D-14-00122.1.

Sharma, E., Sharma, R., Singh, K.K., and Sharma, G. (2000). 'A boon for mountain populations. Large cardamom farming in the Sikkim Himalaya'. *Mountain Research and Development* 20(2): 108–111.

Sharma, G., Sharma, E., Sharma, R., and Singh, K. K. (2002a). 'Performance of an age series of Alnus-cardamom plantations in the Sikkim Himalaya. Biomass, Productivity and Energetics'. *Annals of Botany* 89: 261-272, UK.

Sharma, G., Sharma, R., Sharma, E., and Singh, K. K. (2002b). 'Performance of an age series of Alnus-cardamom plantations in the Sikkim Himalaya. Nutrient Dynamics'. *Annals of Botany* 89: 273-282, UK.

Sharma, E., Sharma, R., Sharma, G., Rai, S.C., Sharma, P., and Chettri, N.(2008). 'Values and services of nitrogen-fixing alder based cardamom agroforestry systems in the eastern Himalaya'. In Snelder, D.J. and Lasco, R.D. (eds.) *Smallholder Tree Growing for Rural Development and Environmental Services: Lessons from Asia*. Springer Science publications + Business Media B.V 2008 pp 393-409 (in the Advances in Agroforestry Series).

Sharma, G., Sharma, R., and Sharma, E. (2009a). 'Impact of altitudinal gradients on energetics and efficiencies of N-fixation in alder–cardamom agroforestry systems of the eastern Himalayas'. *Ecological Research* 25:1-12, DOI 10.1007/s11284-009-0628-z, Japan.

Sharma, G., Sharma, R., and Sharma, E. (2009b). 'Impact of stand age on soil C, N and P dynamics in a 40-year chronosequence of alder-cardamom agroforestry of the Sikkim Himalaya'. *Pedobiologia* 52: 401-414. Elsevier GmbH. doi:10.1016/j.pedobi.2009.01.003, UK.

SNV, (2008). *Alleviating poverty through cardamom farming - an experience of SNV Nepal.* Kathmandu: SNV Nepal.

Spices Board (2015). *Large Cardamom Guide 2015*. SPICES BOARD Ministry of Commerce and Industry Government of India, Sugandha Bhavan, P.B. No. 2277, Palarivattom P.O., Kochi 682 025, Kerala.

Project funded by the European Union

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

ISBN 978 92 9115 469 2