Cardamom Cultivation in Knuckles Conservation Forest: Environmental and Socio-economic Perspective

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FOREWORD

Cardamom cultivation in Knuckles Conservation Forest (KCF) dates back to several decades. Initially it started as a legal venture, however due to lucrative financial returns it bestowed the cultivation continued to flourish despite the legal restrictions that later enforced upon it considering its environmental consequences. KCF, a natural world heritage site situated in Sri Lanka and is home to a number of endemic flora and fauna and considered to be a super biodiversity hot spot and important hydro catchment area. Though the cardamom cultivation has provided the peripheral villagers with monetary benefits the cultivation practices were found to be extremely destructive for this important ecosystem. Hence legal actions were taken against transgressors by the Forest Department on several occasions, a step which met with much resentment from the illegal cultivators of the peripheral villages as it had been one of their main income sources.

This study was conducted at the request of the Presidential Secretariat with the intention to identify environmental consequences of cardamom cultivation in KCF and socio-economic consequences on the peripheral villagers due to the ban of cardamom cultivation, for evolving a reasonable solution. The study has identified that the destruction to the environment is much more greater compared to the negative socio-economic consequences on peripheral villagers due to banning the cultivation as the environmental consequences are more serious in nature, thus can affect the whole nation at large. Therefore it is recommended to continue the ban on cardamom cultivation while providing alternative income sources to counter balance the income loss faced by vulnerable illegal cardamom farmers. I am pleased to state that the study has been the base for the national level policy decision to continue the ban on cardamom cultivation while providing alternative income sources for vulnerable illegal cardamom farmers.

Haputhanthri Dharmasena
Director

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EXECUTIVE SUMMARY

The Knuckles Conservation Forest (KCF) is one of the important tropical rain forests and world natural heritage sites situated in Sri Lanka. Since it provides a habitat for an exceptional number of endemic species of flora and fauna, the area is known as a super biodiversity hotspot and the location is also an important hydro catchment area which nurtures many rivers and irrigation schemes. Cardamom, an important shade loving export agricultural crop in Sri Lanka, grows well under the microclimatic conditions of high elevations of KCF.

Therefore in 1967, permits with validity of 20 years were issued to selected private individuals to cultivate cardamom in part of the Knuckles range called 'Kalupahana' area, under the supervision of the Forest Department. However, considering the consequences of cardamom cultivation on the forest ecosystem, permits were not renewed after 1987. Even though large scale cultivators have moved away, forest encroachers from peripheral villages continued the cultivation illegally. Meanwhile, another set of cultivators who have forcibly grabbed the abandoned cultivation lands owned by permit holders emerged. After declaring the Knuckles range as a conservation forest in the year 2000, cardamom cultivation in KCF was banned and legal actions were initiated on several occasions against illegal cultivators. However, people in the peripheral villages have raised objections to take legal actions citing the looming economic hardships due to loss of their livelihood.

Therefore, the study was conducted with the objectives of identifying the environmental consequences of cardamom cultivation in KCF and socio-economic consequences on cultivators due to banning of cardamom cultivation, to propose a win-win solution. For the study, primary data were collected using a household questionnaire survey representing 110 cardamom farmers of the Laggala-Pallegama DS Division, key informant interviews and observation methods. Secondary data were collected by reviewing the literature on previous studies.

According to the findings, cardamom cultivation alters the forest structure, canopy openness, composition of species, soil properties, watershed properties and natural regeneration and evolution processes of KCF, which cause numerous negative environmental consequences. Alterations in the properties of KCF cause undesirable modifications of ecosystem services, namely the reduction of water quality and quantity, depletion of genetic

resources, increased soil erosion, changes in hydrology impacting the downstream villages, ongoing development projects such as Moragahakanda and Kalu Ganga irrigation projects, climate and natural regeneration and evolution processes, losing the world heritage status and also negative implications on cardamom productivity and crop sustainability. Therefore under the current cultivation practices cardamom cultivations will not sustain in the long run.

Before banning the cardamom cultivation in the Kalupahana area, the primary source of income for the majority of famers was cardamom cultivation. Following the ban, the farmers have moved into alternative income sources. The mean household income has reduced significantly due to the shift and caused a number of socio-economic consequences.

As found, negative environmental consequences are more serious than the socio-economic consequences in the long term, which will affect not only peripheral villagers but also the downstream communities, national development projects and ultimately the entire country.

Therefore, it is recommended to continue the ban on cardamom cultivation in KCF. Natural regeneration should be allowed in cardamom planted forests without disturbing the forest. Continuous monitoring should be undertaken to observe the regeneration process and the FD should intervene where assisted natural regeneration is required. For the monitoring process FD can obtain the support of peripheral villagers, an act which will also help bridging the distance between the FD and the community, with the assurance of mutual benefits.

A deliberate, holistic and multi-dimensional approach should be adopted to recover the income loss of cultivators by creating alternative sustainable income sources. Due consideration is needed in terms of people's willingness, appropriateness to the area and long term sustainability of these methods. Therefore, it is recommended to provide suitable state-owned forests and village forests situated outside the KCF boundary to selected farmers under the guidance of local government authorities and FD for commercial export agricultural crop cultivation under agro forestry systems whilst providing initial financial and technical assistance in collaboration with the Department of Export Agriculture. (Eg: Pepper and cardamom cultivation). It is also recommended to provide financial and technical assistance for the identified people to develop self-employment activities by linking with the ongoing national development programmes.

Further, it is recommended to implement a long term plan to engage the villagers in the tourism industry, especially the young generation enabling them reap direct benefits of having a World Natural Heritage site in the area.

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ABBREVIATIONS

ARMD	Agricultural Resource Management Division
dbh	Diameter at Breast Height
DS	Divisional Secretariat
EWRMD	Environmental and Water Resource Management Division
FD	Forest Department
GN	Grama Niladhari Division
HARTI	Hector Kobbekaduwa Agrarian Research and Training Institute
IUCN	International Union for Conservation of Nature
KCF	Knuckles Conservation Forest
MEA	Millennium Ecosystem Assessment
UNESCO	United Nations Educational, Scientific, and Cultural Organization

CHAPTER ONE

Introduction

1.1 Background

The Knuckles Conservation Forest (KCF), a World Natural Heritage site situated in Sri Lanka consists mainly of montane and submontane forest types. It is located in Matale and Kandy districts stretching in the northwestern margin of the Central Highlands within the 900-1,900 m elevation range (Cooray, 1998; Samarawickrama et al., 2012). Since it has recumbent folds and peaks in the west of the massif which is similar to a tightened fist when viewed from certain locations, the name "Knuckles" was given to this forest range by early British surveyors. However, the Sinhalese traditionally call the area "*Dumbara Kanduwetiya*" which means misty mountains (Bandarathilake, 2005). The forest cover has an area of about 210 km^2 and acts as a barrier to the southwest and northeast monsoonal rains that has a direct impact on the rainfall precipitation of the country (Forest Department, 2009).

KCF is situated on the border of the wet and dry zones with unique geographical characteristics consisting of a number of sensitive ecosystems (Forest Department, 2009). Since it provides a habitat for an exceptional number of endemic species of flora and fauna, the area is known as a super biodiversity hotspot (UNESCO World Heritage Center, 2014). The location is also an important hydro catchment area, which provides water for many rivers and irrigation schemes. According to Badenoch (2009), Knuckles area accounts for 30 percent of watershed forest of the Mahaweli catchment. Recognizing the importance of this special ecosystem, in the year 1873 the area above 1,500 m elevation, the cloud forest, was declared as a conservation area by the British rulers (Fernando, 2010). In the year 2000, 17,500 ha of state-owned lands in the area which is above 1067 m elevation and the environmentally sensitive areas below that height range were declared as KCF by a Government Gazette Notification (No. 1130/22). In 2007 by government gazette notification number 1507/9 the private lands located within the conservation area were acquired to the KCF (Fernando, 2010). Considering their environmental, biological, hydrological and geological value and importance in 2010, central highlands of Sri Lanka were declared as a

"UNESCO Natural World Heritage Site" which covers KCF, Peak Wilderness Protected Area and the Horton Plains National Park.

Cardamom (*Elettaria cardamomum*) which is a perennial herbaceous plant is an important spice crop in Sri Lanka. The dried fruit or the capsule which contains a volatile oil is the tradable commodity of this plant. The whole cardamom, the grounded form and the extracted volatile oil are used in food industry, cosmetic industry and for medicinal purposes. Being the third most expensive spice in the world it has a huge potential to fetch high prices in the world market. By 2009 the total extent under cardamom cultivation was 2,794 ha in Sri Lanka. Production for the same year was 61 t where nearly 15 percent out of the total production was exported, which accounted for generation of Rs. 27.9 million of export earnings (Department of Export Agriculture, 2013).

Considering the cardamom crop ecology, it is a shade loving crop which requires nearly 60 percent shade for optimum productivity. Annual rainfall between 1500 mm – 2500 mm, temperature between 10-25 ^{0}C and well drained deep loamy and loamy clay soils with high organic matter content are the ideal climatic and soil conditions for optimum crop growth. Therefore, cardamom is generally grown under natural forest cover in hilly areas above 600 m elevation in the up and mid country. Matale, Kandy, Kagalle and Nuwara Eliya districts are the foremost cultivating areas. Matale, the major cultivating district accounts for 40 percent of the national cultivation extent (Department of Export Agriculture, 2013). The cool damp micro climate of the higher elevations of the KCF provides ideal conditions for growth of cardamom (Amarasinghe, 2010). The Knuckles range had accounted for 32 percent of the total national cardamom production (Bandarathilake, 2005).

1.2 Cardamom Cultivation in Knuckles Conservation Forest

Commencement of cardamom cultivation in KCF dates back to several centuries whilst commercial cultivation was started in 1805 (Fernando, 2010). Recognizing the high potential, in late 1960s the government encouraged farmers to cultivate cardamom in the Knuckles range. Therefore, in 1967, permits with a twenty year validity period were issued to selected private individuals to cultivate cardamom in part of the Knuckles range called 'Kalupahana' area under the supervision of the Forest Department (FD). In addition to these permit holders, cardamom

cultivation was also carried out by private land owners and the Estate Plantation Corporation in their lands located within the Knuckles range.

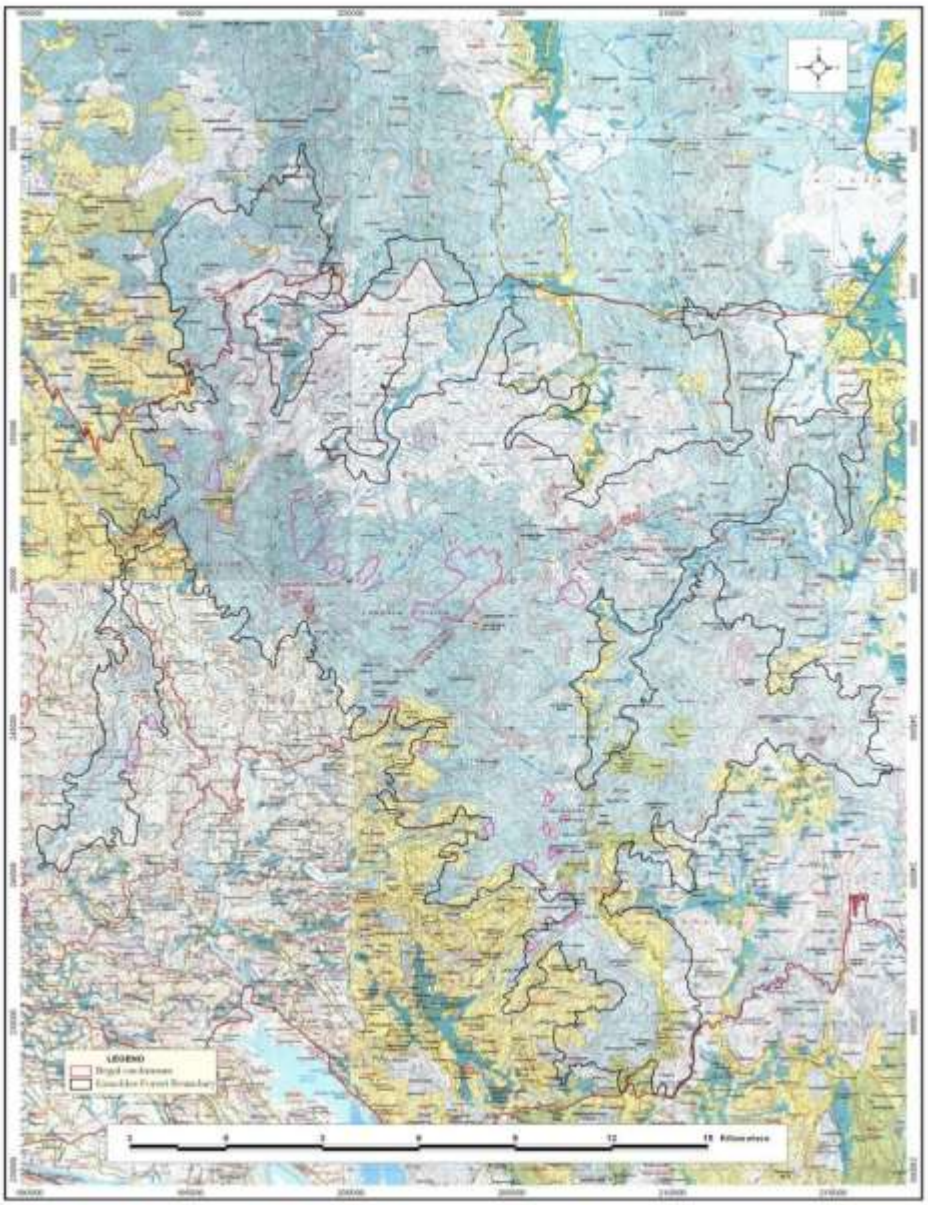
Moreover, recognizing the soaring returns, forest invasion by encroachers (illegal cardamom farmers) from peripheral villages has grown indiscriminately. Consequently, the area under cardamom cultivation expanded rapidly (Figure 1.1). Hence, though the initial approval was granted to cultivate cardamom in a 75 ha of land in KCF at present, the total area under cardamom has expanded to 2635 ha both in Matale and Kandy Districts (Fernando, 2010; Forest Department, 2009).

"Kalupahana" the focal area of the study is located in the middle of the KCF within the Matale district where the highest peak rises to 1, 629 m elevation (Cooray, 1998). Though it is difficult to find detailed factual information on the extents under cardamom, according to the Forest Department, nearly 210 ha of Kalupahana area is under planted[1] with cardamom (Figure 1.1). The main vegetation type found in the area is montane forest. These types of montane forests are the key types of vegetations in the catchments and watershed forests in the Knuckles range (Balasubramaniam, 1988).

1.3 Research Problem

For an optimum cardamom harvest, various crop management practices are needed, including clearing of shrubs and undergrowth, selective removal of canopy trees and pest and disease control. Harvested cardamom pods are processed in wooden barns built inside the forest. Forest trees are felled and used as firewood for cardamom curing. All the stated practices performed by the cultivators are considerable threats to the long term sustainability of this sensitive ecosystem. Cultivation and related activities would lead to thinning of forest biodiversity, slowdown the natural regeneration process, accelerate soil erosion and increase pollution of water resources (Reyes et al., 2006; Fernando, 2010; Dhakal et al., 2012).

[1]Plant or cultivate the ground around a tall plant with smaller plants



* The black line indicates the Knuckles boundary while the patches highlighted with the pink line demarcate the cardamom cultivated areas within KCF

Source: Forest Department

Figure 1.1: Cardamom Cultivated Areas in KCF

Considering the consequences of the cardamom cultivation on the forest ecosystem, once the permits expired in 1987, they were not renewed by the FD. Though the permit holders have vacated the cardamom fields, the forest encroachers from peripheral villages such as villages in the Laggala – Pallegama Divisional Secretariat area continued the cultivation illegally. In addition, another set of encroachers emerged as those who have forcibly grabbed abandoned cultivated lands owned by permit holders. According to the information from key informant interviews, majority of these people have political patronage. After declaring the Knuckles range as a conservation forest in 2000, 42 families of illegal cultivators who were residing in the Kalupahana area of KCF were moved out from the area and were relocated in alternative lands (Fernando, 2010).

Regardless of the efforts of relocating the illegal cultivators from the cardamom cultivation area by the FD, it has been found that, harvesting and processing of cardamom from existing cardamom cultivations by forest encroachers of peripheral villagers has been continuing illegally. Thus, conserving this vital ecosystem and safeguarding world heritage status has become a great challenge. One of the prerequisites stipulated by the UNESCO in granting the title of the World Natural Heritage Site to KCF was, removing the cardamom cultivations from the conservation forest. According to the officials of the FD, inability to remove cardamom cultivations from KCF is posing a danger of losing the title of "World Natural Heritage" for the Central Highlands of Sri Lanka. Therefore, the FD has resorted to legal action to eject the illegal cultivators in year 2003 and 2012 respectively. The ejectment orders were taken against 11 people in 2003. Another 49 people who were engaged in harvesting of cardamom were prosecuted in 2012 and FD is awaiting court orders for their ejectments.

Cardamom cultivation in Kalupahana area was an important income source for people in the peripheral villages of Laggala-Pallegama Divisional Secretariat (DS) area of the KCF. People involved in the cardamom cultivation can be mainly identified as owners of cultivations and labourers. Since they have lost their livelihood and a major income source, the cardamom cultivators obstructed the FD in carrying out the ejectment orders. Therefore, the ejectment of people has emerged a controversial issue in the social, economic and political context. Due to the sensitive nature of this matter, in 2012 a short-term political intervention was carried out allowing the cultivators to perform harvesting activities. However, according to the Forest Conservation Ordinance, agricultural

activities are not allowed within a Conservation Forest. Therefore, the decision of whether to continue cardamom cultivation or to continue banning of cardamom cultivation was on hold for a while until a firm decision was made by government authorities.

The study was initiated on the request by the Presidential Secretariat to find a sustainable solution to the problem of cardamom cultivation in the KFC.

Hence this study was conducted to identify the environmental consequences on the KCF caused by cardamom cultivation in the Kalupahana area and the impacts of prohibiting cardamom cultivation on the socio-economic and livelihood conditions of the encroachers of Laggala-Pallegama DS area in order to propose a win-win solution for both parties.

1.4 Objectives of the Study

1.4.1 General Objective

To identify the environmental consequences of cardamom cultivation in KCF and the socio-economic consequences on cultivators due to prohibition of cardamom cultivation in the KCF.

1.4.2 Specific Objectives

1. To find out the environmental consequences of cardamom cultivations in the KCF with special reference to Kalupahana area.
2. To identify the socio-economic consequences of encroachers of peripheral villages in Laggala-Pallegama DS area due to prevention of cardamom cultivation in the KCF.
3. To provide recommendations to minimize the negative environmental impacts and enhance socio-economic conditions of the encroachers.

CHAPTER TWO

Description of Study Area and Methodology

2.1 Sample Selection

Cardamom cultivators in the Kalupahana area were mainly residing in the periphery of the KCF within the Laggala-Pallegama DS area. The population of cultivators was 201 based on the statistics of Laggala-Pallegama DS office. For the study, Ranamure, Narangamuwa, Miniranketiya, Laggala-Pallegama, Karadamulla, Halminiya and Atanwala Grama Niladhari (GN) divisions constituting more than 95 percent of the cultivators residing within these GN divisions were selected. A household questionnaire survey was conducted on a sample of 110 cultivators both landowners and labourers who were randomly selected.

2.2 Data Collection

1) **Environmental Consequences (To achieve study objectives one and three**):

Environmental consequences of cardamom cultivation were identified based on secondary and primary data. Data from previous studies, experts' opinions, a household questionnaire survey and visual observations were used to collect data on cultivation practices, changes in forest structure and functioning parameters. Secondary data and key informant interviews with the subject specialists, such as forest ecologists were employed to identify the possible consequences of the cardamom cultivation on the forest ecosystem.

Data and information were collected based on three major parameters as follows;

i. Impact on the Biodiversity

A comparison of cardamom cultivated forest with adjacent natural forest in view of vegetation densities, canopy openness, tree species composition, presence of pioneer tree species, richness of species and species diversity was done by means of secondary data from previous studies. Information on activities affecting the flora and fauna during crop

management practices such as pest and disease management, weed management and cardamom processing was collected through a household questionnaire survey.

Key informant interviews and the literature review were conducted using a checklist to identify the effect of changes in above factors on the forest structure, species composition, nutrient recycling, watershed properties, soil erosion, natural regeneration and evolution processes together with suggestions to mitigate negative impacts.

ii. Impact on Soil

Topography of cultivated lands, comparison of cardamom cultivated forest and adjacent natural forest with regard to concentration of total N (Nitrogen), P (Phosphorous) and exchangeable K (Potassium), soil pH, soil organic matter content and exchangeable Ca (Calcium) and Mg (Magnesium) contents was done through secondary data. Type of impact on the soil by crop management practices such as agrochemical application, weed management and canopy opening was identified using the household questionnaire survey.

How the changes of above factors affect the forest structure, species composition, nutrient recycling, watershed properties, soil erosion and natural regeneration and evolution processes with the suggestions to mitigate negative impacts was identified using key informant interviews and the literature review.

iii. Impact on World Heritage Title

UNESCO guidelines and conditions stipulated to maintain the title of world heritage site and the extent to which the site has fallen short of those due to illegal activities were studied through key informant interviews, focus group discussions and a household questionnaire survey. Consequences of non-adherence to the guidelines, lost benefits to the country and community by losing the world natural heritage status, were identified using key informant interviews and the literature review.

The following key informants/agencies were interviewed to gather above information.

No	Type of Key Informant	No. of Interviews
1	Forest Ecology Specialists (Three University Academics, One Forestry Researcher)	4
2	Forest Department (Conservator General of Forests, Deputy Conservator of Forests, District Forest Officer-Matale, Range Forest Officers of Laggala- Pallegama, Illukkumbura and Deanston, Regional Deputy Conservator of Forests (Central and Uva Regions)	7
3	IUCN (Country Representative)	1
4	Sri Lanka National Commission for UNESCO (Secretary General)	1
5	Community Leaders (School Principals of Narangamuwa and Ranamure Villages, Chief Priests of Narangamuwa and Ranamure Temples, Representative from Cardamom Cultivators Association, Chairman of Laggala-Pallegama Pradeshiya Sabha)	5
6	Government Officials (Divisional Secretary Laggala–Pallegama, Grama Niladhari (Laggala-Pallegama)	2
7	Moragahakanda and Kalu Ganga Irrigation Project (Director- Environment and Watershed Management Division)	1
8	Personnel from Tourism Sector (Manager, Sir Johns Bungalow, Illukkubbura)	1
9	Non-Governmental Organizations (*Dumbara Surakinno*)	2
	Total	**24**

2) Socio-Economic Impact on Cultivators (To achieve objectives two and three):

The necessary information was collected using primary data collecting techniques.

1. Household Questionnaire Survey

A household questionnaire survey was carried out to gather information from cardamom cultivators including land owners and labourers. The data were collected based on the following parameters;

i. **Demographic and Socio-Economic Conditions** – Area of residence, household size, ethnicity, gender, age, educational level, employment status, land ownership, primary and secondary sources of income, total household income, major markets, access to roads, receipt of government welfare supports, other institutional supports and memberships in community based organizations.

ii. **Data on Cardamom Cultivation**- Type of involvement in cardamom cultivations (Eg: As a land owner or a labourer), labour availability at household level, duration of cardamom cultivation, land extent, number of harvesting seasons, types and methods of crop management practices, inputs used during cultivation, investment per season on cardamom cultivation, assets owned other than land (Eg: barns) in the cultivation site, selling price of unit quantity of cardamom, harvesting quantity per year, number of harvesting seasons per year, method of selling, labour wage rate in cardamom cultivations, number of labour day requirement per year, level of awareness created by the FD on the importance of protecting forest, knowledge of cultivators on the legal status of continuing cardamom cultivations, compensations granted by the government or any other institute for the lost cultivation, suggestions to mitigate the issues created by the action taken by FD of alternative income sources and potentials and constraints to engage in other income generating activities.

2. Key Informant Interviews

Key informant interviews were carried out with relevant government officers and community leaders of the study area to identify pros and cons of prohibiting cardamom cultivations in the protected area, availability of alternative income sources for the cardamom cultivators, problems and constraints associated with alternative livelihood options and to propose suggestions to mitigate them.

2.3 Data Analysis

1. The Environmental Impact

The impact on the Knuckles Conservation Forest by cultivation of cardamom was analyzed logically based on the literature review and discussions with key informants.

2. Socio-Economic Impact

The cultivators' income levels before and after their removal from the cultivation area was compared using a mean comparison.

To find the ultimate collective outcome, the findings of both environmental and socio-economic consequences were analyzed by applying the findings to the Millennium Ecosystem Assessment Conceptual Framework which is discussed in detail in the following section by adopting ecosystem approach to KCF. (Millennium Ecosystem Assessment, 2005).

2.4 Millennium Ecosystem Assessment Framework in the Context of KCF Ecosystem

People always depend on the services provided by the biosphere[2] and its ecosystems. An ecosystem is a dynamic complex of plant, animal and micro-organism communities and a non-living environment interacting as a functional unit. Therefore, human beings are a part of ecosystems. Though the mankind can cushion the environment related events by technology and culture, ultimately they are fully dependent on the environmental services[3] (Millennium Ecosystem Assessment, 2005).

The KCF is also an ecosystem where plants, animals, microorganisms and other living organisms are interacting among themselves and with the non-living environment such as soil, climate, water and light in which they are

[2]Biosphere is the all living entities on earth.

[3]Ecosystem services are the benefits that humans acquire from the ecosystems.

living. Generally, forest ecosystems are dominated by trees and they are enormously important as protective shelters for global biodiversity, biogeochemical cycles[4] and foundation of ecosystem services essential for the human well-being (Millennium Ecosystem Assessment, 2005). Since the people are an integral part of the forest ecosystem any impact on the forest will affect the well-being of the humans. Therefore, the consequences of cardamom cultivation in KCF will in turn have implications on the well-being of the people. On the other hand, consequences of banning cardamom cultivation in the KCF will have diverse impacts on the well-being of the people. Therefore, it is reasonable to consider beneficial and harmful implications of an action to evaluate a specific action which is true in the case of the cardamom cultivation issue as well (Pasca, 1976).

Hence in order to identify both beneficial and harmful consequences of the KCF by cardamom cultivation and socio-economic situation of peripheral villagers by banning the cardamom cultivation, it is important to identify the dynamic interaction existing between people and the KCF. The Framework of Millennium Ecosystem Assessment (MEA) can be taken as a popular and globally accepted measure for this.

2.5 Conceptual Framework for MEA

The conceptual framework for MEA has put the human well-being as the fundamental focus of the assessment while identifying biodiversity and the ecosystems as having an essential value. The framework considers that people make decisions related to ecosystems based on the considerations on human well-being and the essential value of the ecosystem and its biodiversity. The assumptions of the MEA are:

- There are dynamic interactions between people and other parts of ecosystems

[4]Biogeochemical cycle is the flow of chemical elements and compounds between living organisms and the physical environment. Chemicals absorbed or ingested by organisms are passed through the food chain and returned to the soil, air, and water by mechanisms such as respiration, excretion, and decomposition.

- Changing human conditions serve as both direct and indirect drivers of change in ecosystems
- The changes in the ecosystems will cause changes in human well-being
- In addition, there are many other independent factors in the environment, which change the human condition and natural forces that are influencing ecosystems

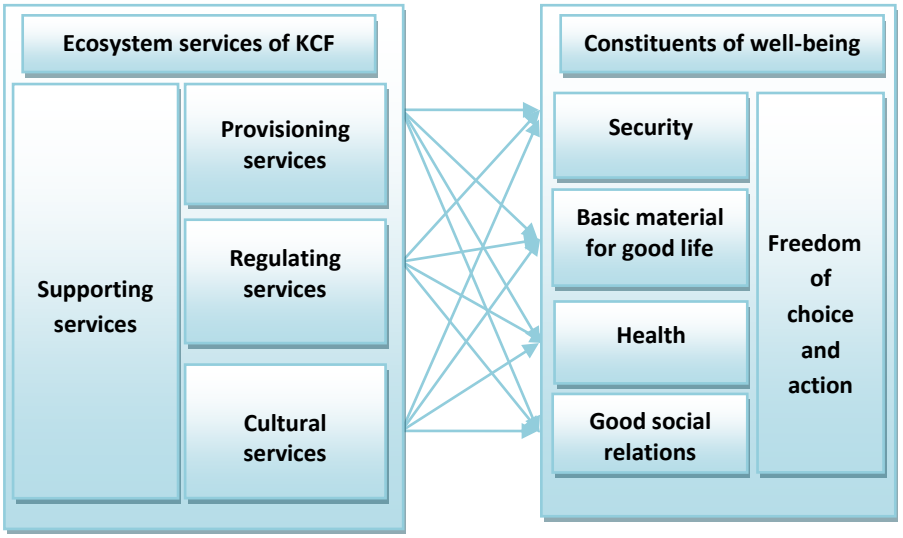
The MEA mainly focuses on the linkages between ecosystem services and human well-being. The assessment further suggests that multi scale approach (both spatial and temporal scales) should be used to assess the interactions between people and the ecosystem since it better reflects the multi scale nature of decision making. It also allows the examination of the driving forces that might be outside the region. Further, it helps examine the degree of differences of the impact of ecosystem changes and policy responses between inter and intra regions.

The MEA has classified ecosystem services mainly into four categories as provisioning services, regulating services, cultural services and supporting services.

- Provisioning services include the products people acquire from the ecosystem such as food, fresh water, and genetic resources.
- Regulating services include the benefits acquired by people from regulation of ecosystem processes such as air quality maintenance, climate regulation, soil erosion control and water purification.
- Cultural services include the non-material benefits people obtained from the ecosystems, such as recreation and aesthetic experiences.
- Supporting services include those that are necessary for the production of all other ecosystem services, such as primary production, soil formation and production of oxygen.

According to the MEA, human well-being includes multiple components including basic material for a good life, freedom for choice and action, health, good social relations and security. The MEA further states that, human interventions in ecosystems can increase the benefits to the human society. However, recent evidence shows that growing human impacts on the ecosystems have increased spatial and temporal consequences of ecosystem changes which are harmful to humans.

The Figure 2.1 illustrates the foremost ecosystem services obtained from the KCF and how the stated ecosystem services have linked with human well-being. The adjustments to the direct drivers of change will alter the ecosystem services provided by the KCF as exemplified in Figure 2.2.



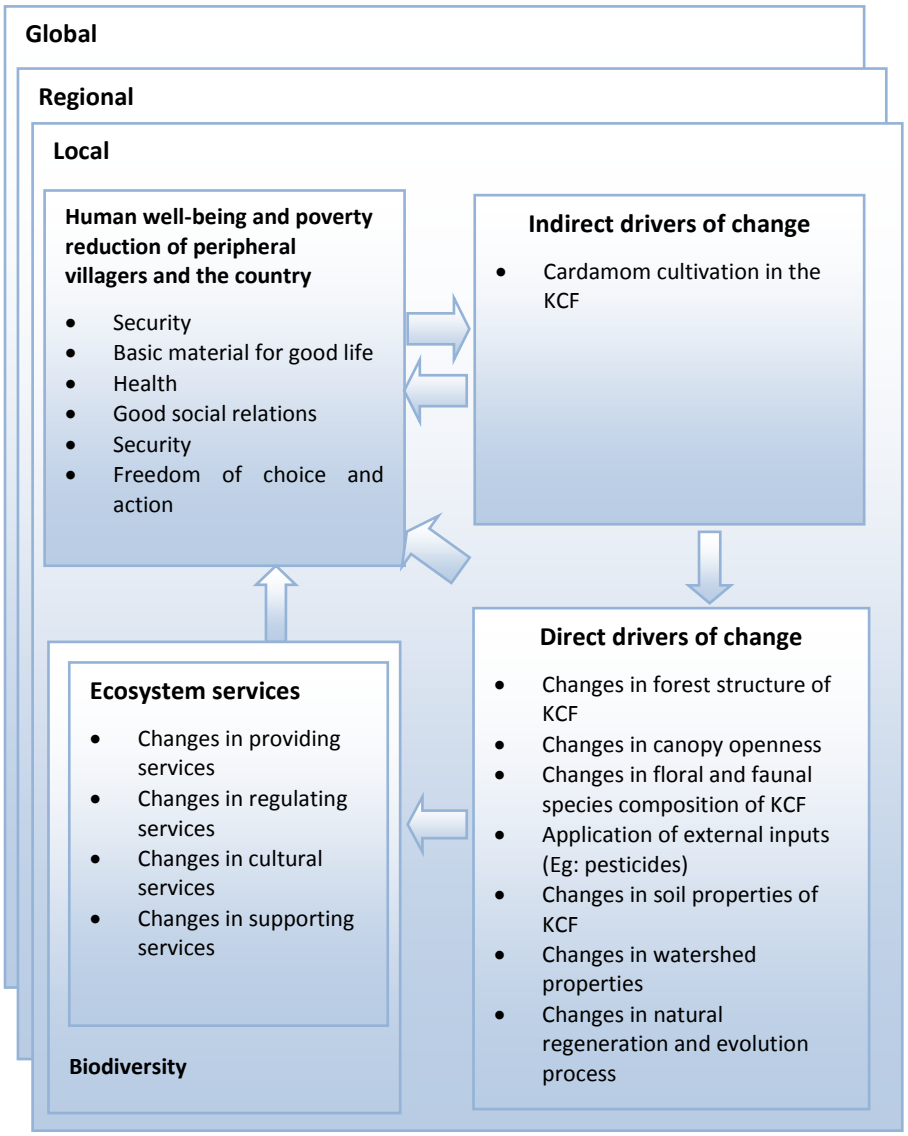
Source: Adopted from Millennium Ecosystem Assessment, 2005

Figure 2.1: Linkages between Ecosystem Services and Human Well-being of KCF

2.6 Conceptual Framework for Assessment of KCF Ecosystem

The Figure 2.2 illustrates the conceptual framework for assessment of consequences of cardamom cultivation in KCF ecosystem.

As the diagram depicts the study has identified that the cardamom cultivation in KCF, which is the main indirect driver of change concerned, has led to different direct drivers of change such as changes in forest structure, functions, soil and watershed properties. These direct drivers of change create changes in the services provided by KCF ecosystem. The resultant changes in the ecosystems services will impact on the socio-economic conditions of people which will ultimately have an impact on the human well-being both in short and long terms.



Source: Adopted from Millennium Ecosystem Assessment, 2005

Figure 2.2: Framework for the Assessment of Environmental and Socio-economic Consequences of Cardamom Cultivation in Knuckles Conservation Forest

CHAPTER THREE

Cultivation and Curing Practices of Cardamom in Knuckles Conservation Forest

The chapter discusses agronomic and postharvest handling practices adopted by farmers during cultivating and curing of cardamom and the resultant consequences on the forest in detail.

3.1 Agronomic Practices in Cardamom Cultivation

The table 3.1 shows the degree of adoption of different agronomic practices by the cultivators.

Table 3.1: Agronomic Practices Adopted by Farmers

Agronomic practice	Number of Cultivators (N=110)	Percentage of Cultivators
Land preparation	106	97
Fertilizer application	1	1
Weed management	68	62
Chemical pest and disease management	8	7
Wild animal damage management	86	79
Soil conservation practices	101	93
Light management	63	58
Undergrowth management	98	90

Source: Author's Survey Data, 2013

About 97 percent of cultivators have declared they had prepared the land before stand establishment and in the beginning of each cultivation season. The table 3.2 shows the types of instruments used by farmers in land preparation. Before establishing cardamom plantation, a general practice of cultivator was slashing the undergrowth of the selected forest area. The cultivators have removed all the small trees up to the arm sized girth. Then the cleared area was planted with new cardamom plants in the

holes dug using the hoe, wooden rod or knife while maintaining equal distance between plants. In the existing cultivation, the removal of emerging small tree seedlings takes place seasonally and during cleaning of the cardamom plants by removing all the dead leaves and branches. The collected plant debris in the cleaning process is applied to the ground in between cardamom rows. The cultivators have affirmed that this practice helps prevent the weed growth and acts as an organic mulch to control soil erosion and as a source of soil nutrient.

Almost all the farmers stated that, they do not apply external fertilizer since the forest soils which are rich in organic matter, thus provide a good yield. However, several famers were in the view that, fertility of the cardamom lands is depleting due to continuous cultivation and therefore, external application of fertilizer will be required in the future.

As the table 3.1 describes, 62 percent of the cultivators are carrying out weed management practices including mechanical weeding (using the hoe, knife and etc), manual weeding and mulching. They treat all the tree seedlings emerging in the cardamom cultivated areas of the forest as weeds. Mechanical and manual weeding practices are the most harmful to the soil. About nine percent of the cultivators stated they are applying mulch to minimize weed growth. About 40 percent of the farmers stated that they do not follow a weed control measure since after addition of plant debris and uprooted weeds to the soil during the initial land preparation, weed growth was minimal.

In management of pests, 92 percent of the cultivators have not controlled the pests, while the remaining farmers have applied pesticides for pest control. A rapid invasion of thrips was observed across all the cardamom plantations in the area. This has caused a drastic reduction in cardamom yield both in quantity and quality. According to the Department of Export Agriculture, there are no control measures for thrips attack, other than destroying heavily infested plants and applying pesticides. Several farmers have used Thiamethoxam 21.6 percent insecticide which is the recommended pesticide by the Department of Export Agriculture to control this pest. Considering the importance of KCF as an important watershed forest, this indicates the critical sign of instigation of pesticide usage in KCF which will lead to contamination of the headwaters with pesticides.

Table 3.2: Types of Agronomic Practices Performed by Cultivators

	Crop Management Practice	Method of Practice	No of Cultivators (N=110)	Percentage of Cultivators
1	Instruments used for land preparation	Hoe	74	69
		Knife	56	52
		Wooden stick	16	15
		Spade	5	5
		Manual	3	3
		Other	3	3
2	Fertilizer management	Not using fertilizer	108	99
		Organic fertilizer	1	1
3	Weed management	Hand weeding	35	32
		Mechanical weeding	39	36
		Mulching	10	9
		Not controlling weeds	40	37
4	Pest management	Pesticide application	8	7
		Not controlling pests	100	92
5	Management of damages caused by wild animals	Gun firing	5	5
		Setting traps	1	1
		Chasing out from the cultivations	10	9
		Noise (hooting , firecrackers)	84	77
		Not controlling	16	15
		Camp fires	4	4
		Other	5	5
6	Soil and moisture conservation	Terracing	81	74
		Mulching	47	43
		Not using conservation measures	6	6
		Other	1	1
7	Solar radiation management	Removing small trees	42	39
		Removing large tree branches	10	9
		Removing large trees	4	4
		Planting new trees	14	13
		Not controlling	41	38
		Other	6	6

Source: Author's Survey Data, 2013

Protecting the crop from wild animals such as monkeys, Sri Lankan palm civet and wild boars is one of the important tasks during crop management. Farmers used various techniques to repel wild animals. The majority of the cultivators (77 percent) had used various noises such as hooting and firecrackers. Five percent of the cultivators stated that they have used gun fire to scare away the wild animals while some farmers had set traps to kill and control them. However, it should be noted that, farmers were evasive in answering these questions as they were well aware that the activities they practiced in controlling wild animals were not legally and morally acceptable. Nevertheless, the responses implied that the consequences of the adopted practices in the natural habitat were detrimental to the existence of wild animals and the faunal diversity.

Most of the cardamom lands were located in sloppy lands (Gunawardane, 2003) and 74 percent of the cultivators mentioned that, they had used terraces to reduce soil erosion while another 43 percent noted they had used mulching to prevent soil erosion.

To increase sunlight penetration, 39 percent of the cultivators stated they have removed the small trees in the cultivation land to permit sunlight to reach cardamom plants while 8 percent of the cultivators said they did nothing to manage the shade. Around 9 percent of the farmers have mentioned they have cut the branches of large trees while 4 percent of the cultivators admitted that they have felled the large trees (table 3.2) to allow sunlight fall onto cardamom plants. Thirteen percent of the cultivators mentioned they have planted new fast growing trees such as *Macaranga indica* (Kanda) in places where more shade is required. It is apparent that cutting down the trees and branches and planting new tree species damage the biodiversity of the forest while it alters the forest structure and species composition.

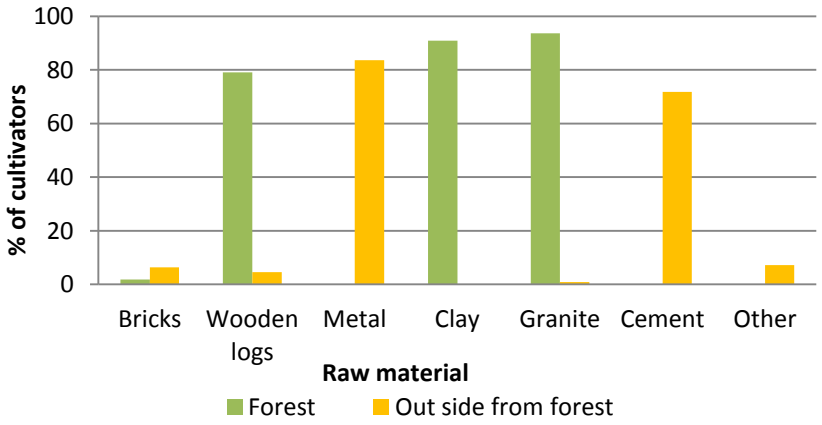
3.2 Curing of Cardamom

All the cultivators have cured cardamom pods within the forest using cardamom barns built inside the forest. Figure 3.1 illustrates the methods of acquiring raw materials for cardamom barn preparation. As the figure shows several raw materials such as bricks, wooden logs, metal, clay, granite and cement that were used for barn preparation. Out of these, logs, clay and granite were acquired from the forest itself.

Source: Author's Survey Data, 2013

Figure 3.1: Acquisition of Raw Materials for Cardamom Curing

Firewood acquired from the forest is the only source of fuel to cure raw cardamom pods. According to the survey findings, 76 percent of cultivators had acquired wood from dead or fallen trees whereas 29 percent of cultivators had acquired wood by cutting the forest trees (Figure 3.2).



Source: Author's Survey Data, 2013

Figure 3.2: A Tree Felled for Firewood to Cure Cardamom in Upper Reaches of Kalupahana Area. (Emergence of pioneer tree *Macaranga indica* can be observed in the photo as a result of increased light levels due to canopy opening)

Therefore, it is evident that the barn preparation and cardamom curing process cause huge destruction to the forest which in turn will have an impact on the forest biodiversity, forest structure, species composition and the soil properties.

CHAPTER FOUR

Environmental Consequences of Cardamom Cultivation in Knuckles Conservation Forest

4.1 Legal Framework for Conservation Forests and Usage of Forest Resources

Based on the Forest Conservation Ordinance, Sri Lankan forests are divided into three major groups;

1. Conservation forests
2. Reserved forests
3. Village forests
4. Other state-owned forests

Management actions and activities allowed within these different forest categories vary as given in the Ordinance.

According to the Forest Conservation Ordinance, the forests with following characteristics are declared as conservation forests by special gazette notifications.

- Consisting of unique ecosystems
- Availability of genetic resources
- Provide a habitat for rare and endemic species of flora, fauna, micro organisms and threatened species
- The areas need to be conserved in order to achieve ecological balance in the area by preventing salinization or drying up of rivers, ensuring adequate rainfall, preventing landslides and fires hazardous to human.

As per above guidelines, the Knuckles range was declared as a conservation forest on 10th April 2000 by an extraordinary a gazette notification.

According to the Forest (Amendment) Act, No 65 of 2009 “No person shall be permitted to enter a conservation forest other than under the authority of a permit issued by the Conservator General of Forests or a person authorized by him on that behalf for the purpose of:

a) Engaging in scientific research within a conservation forest
b) Observing the fauna and flora in a conservation forest
c) Implementation of the activities prescribed in the management plan

Subject to the provisions of above, any other activity carried out shall be guilty of an offence".

4.2 Climatic Variation and Vegetation Types in KCF

KCF is climatically very significant since a range of climates present in the island are reproduced within this small land area ranging from the extremely wet to nearly dry. Two main characteristic features have been identified to describe this climatic variation as,

- The Knuckles massif[5] is a detached block of Central Highlands, which is isolated from the main highlands by the Mahaweli River (De Rosayro, 1958; Cooray, 1998).
- The sudden ascend approximately from the sea level into an elevation of nearly 1800 m (De Rosayro, 1958).

Therefore, the impact of topography[6] in controlling the climate is more significant in KCF (De Rosayro, 1958). Variation in the topography along with rainfall, temperature, relative humidity and wind factors and the interactions between these factors have caused site specific climatic conditions in different areas of the KCF, which show a huge variation across different sites. According to De Rosayro (1958), three major forest formation types can be found in KCF namely,

1. Lowland tropical wet semi-evergreen forests (<900 m)
2. Sub montane tropical wet semi evergreen forests (>900 m <1400 m)
3. Montane tropical wet evergreen forests (>1400 m)

[5] A large mountain mass or compact group of connected mountains forming an independent portion of a range

[6] The arrangement of the natural and artificial physical features of an area

The above groups can be further divided into sub categories as shown in table 4.1. Among all the forest formation types, montane tropical wet evergreen forest is the most important forest type in ecological terms.

4.3 Vegetation Types in Kalupahana Area and Its Hydrological Importance

Kalupahana area is located in the middle of KCF within an elevation range of about 700-1600 m. The area mainly consists of sub montane and montane forests types. Among these, montane tropical wet evergreen which is the most important forest formation type includes sub categories of montane wet evergreen forest (dry), montane wet evergreen forest (wet), Low forest, elfin forest and pigmy forests. Generally montane forests are important due to their unique characteristics of biodiversity, endemism and services they provide (Gunawardane, 2003).

The motane forests are vital considering their hydrological role in the water stripping function as explained below. This is a unique characteristic of these forests that makes it different from other forest types. Since these forests are found in high elevations, they are distinguished by constant and recurrent cloud cover often at the canopy level. According to De Rosayro (1958), it was observed that the tree trunks, branches and the grounds of the forest are abundant with epiphytes, mosses and lichens even in the drier phase of KCF, mainly due to high moisture availability. Leaves and branches of tree crowns and trunks, rich with epiphytes, mosses and lichens intercept wind driven cloud moisture, which will drip onto the ground through leaves and tree trunks. Consequently, this natural process adds additional moisture to the ground throughout the year.

Figure 4.1: Tree Trunks Covered with Mosses Epiphytes and Lichens in High Elevations of KCF

Figure 4.2: Water Stripping Function of Moss Covered Tree Trunk in High Elevations of KCF (dripping of water droplets can be seen in the photograph)

Therefore compared to other forest types montane cloud forests areas yield a higher water volume and stable stream flow even during water scarce periods as it receives water from both rainfall precipitation and intercepted water from cloud moisture (Bruijnzeel, 2001). The annual fog interception from KCF is 84,277,000 m^3 (Forest Department, 1997). According to Bandarathilake (n.d), tributaries starting from montane areas of over 1070 m mainly in the wet montane areas of KCF are perennial

while the streams starting from lower elevations are seasonal. Hence montane forest areas in KCF are extremely important as watershed areas and in providing regular and controlled supply of water to the people living in downstream and soil erosion controlled by sustaining the ground cover (Aldrich et al.1997).

Table 4.1: Classification of Vegetation Types of the KCF

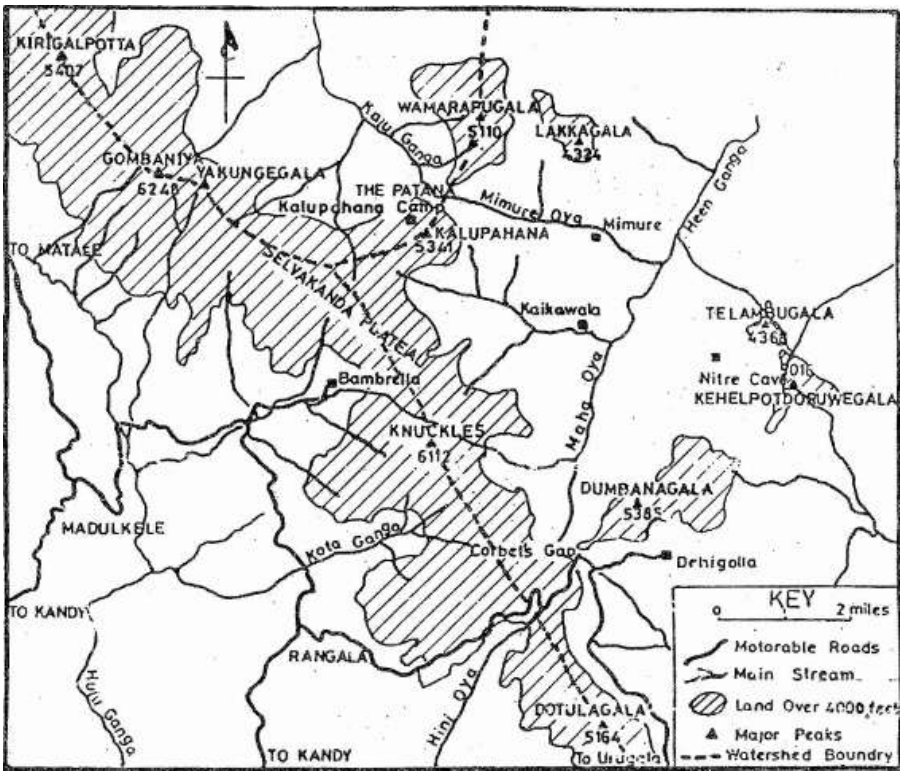
Formation type	Sub category
1) Lowland tropical wet semi-evergreen forest	a) Tropical wet semi-evergreen forest, Climax
	b) Low jungle
	c) Riparian forest
2) Sub-montane tropical wet semi-evergreen forest	a) Sub montane semi-evergreen forest-Wet
	b) Sub montane semi-evergreen forest- Dry
	c) Sub montane grassland (*patana*)
	d) Sub montane savanna
	e) Sub montane scrub forest
3) Montane tropical wet evergreen forest	a) Montane wet evergreen forest-Dry
	b) Montane wet evergreen forest-Wet
	c) Low forest
	d) Elfin forest-Elfin woodland or mossy forest
	e) Pigmy forest
	f) Montane (*patana*) grassland
	g) Bamboo brake
	h) Palm brake

Source: De Rosayro, 1958

4.4 Importance of Knuckles Conservation Forest as a Catchment Area

KCF serves as one of the important watershed areas of Sri Lanka. Western slopes of the forest receive heavy rains from the south west monsoon while north-east monsoonal rain provides water to the entire forest area. Weerawardhena and Russell (2012) stated that, KCF gives rise to more than 500 streams which serve as the tributaries for a number of rivers. According to Bandarathilake (n. d.), KCF acts as the second highest rainfall

area for the Mahaweli Basin. The major perennial streams originating from Knuckles can be identified as Kalu Ganga, Heen Ganga, Hulu Ganga, Hasalaka Oya, Theligamu Oya, Meemure Oya and Kaikawala Oya (Figure 4.3). Out of these Kalu Ganga, Heen Ganga and Hulu Ganga are important tributaries which provide perennial waters to Mahaweli river and its reservoirs. According to Cooray (1998), the total drainage system of KCF flows into Mahaweli river since many of its tributaries start from the Knuckles range.



Source: Bandarathilake (n.d.)

Figure 4.3: Tributaries and Major Catchment Areas Originating from KCF

Heen Ganga, Hasalaka Oya and Maha Oya, which drain into the eastern side, provide water to Lower Mahaweli river system (Weerewardhena & Russell, 2012). Maha Oya and headwaters of Meemure Oya are the tributaries of Heen Ganga. Hulu Ganga which drains into the southwest side provides water to the Upper Mahaweli river. Kalu Ganga and Theligamu Oya drains into the north eastern side of the Amban Ganga river

system (Weerewardhena & Russell, 2012). Out of this Kalu Ganga is the chief headwater stream of Amban Ganga which is one of the major tributaries of Mahaweli river. Halamini Oya and Karamana Oya are the major tributaries of Kalu Ganga. According to Bandarathilake (n.d.), Kalu Ganga originates from the western slope of Kalupahana and Meemure Oya originates from the eastern slope of Kalupahana ridge.

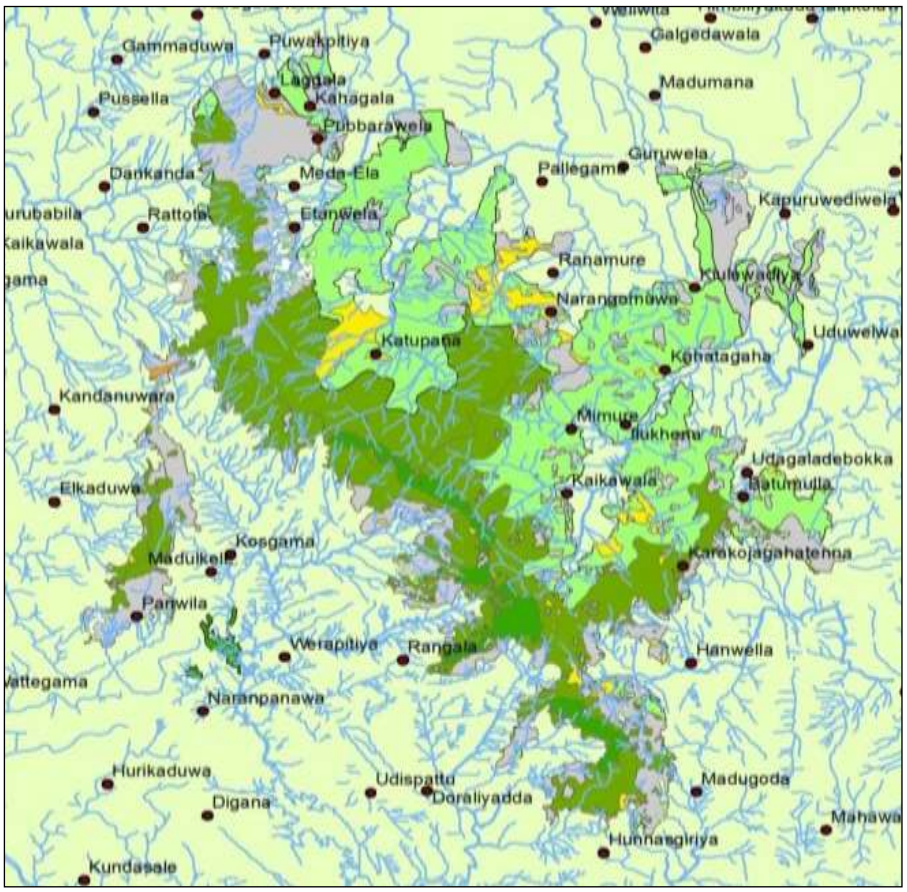
KCF acts as the watershed area to Victoria, Randenigala and Rantambe reservoirs providing 30 percent of its water requirement (Weerewardhena & Russell, 2012). The main water source for the newly constructed Moragahakanda reservoir comes from Theligamu Oya and Amban Ganga, while Kalu Ganga is the main water source for the Kalu Ganga reservoir. Therefore, KCF represents about 80 percent of the watershed area for Kalu Ganga and Moragahakanda irrigation schemes (Forest Department, 2009).

Moragahakanda - Kalu Ganga Development Project is a huge multipurpose irrigation project with a total investment of Rs 61,321.7 million. The major objective of the project is to increase the water availability to Mahaweli systems, H, 1/H, M/H, G, D1 and D2. The expected benefits of the project are summarized as follows,

1) To develop 68,000 ha of cultivable land, including 3000 ha of new land. The cropping intensity is expected to increase from 1.55 to 1.85 and additional 80,000 t of agricultural produce is expected to supply to the domestic market. The number of beneficiary farmers will be about 87,000.
2) To ensure domestic and industrial water supply of Matale, Anuradhapura, Polonnaruwa and Trincomalee districts.
3) To generate 20 MW hydropower.
4) To produce 4,500 t of inland fish annually.

However, changes in land use patterns would bring changes in the hydrological process resulting in a considerable decline in dry season flow (Zadroga, 1981; Brown et al., 1996). According to Bruijnzeel (1990), replacement of tropical forests by any agricultural activity would bring profound changes in the hydrology of the area. When the understory is removed and trees and branches of trees of upper canopy levels are continuously cut down for crop management and curing practices of cardamom the total leaf surface area of the forest is reduced. Therefore, the amount of moisture intercepted from the fog/clouds and the rainfall declines. Though cardamom plants are present in the understory,

compared to forest trees their moisture interception and uptake of water from the root system are comparatively lower as forest trees have generally larger total leaf area and deeper root system.



Graphic courtesy: Suranjan Fernando

Figure 4.4: Total Drainage System and Bordering Peripheral Villages in the KCF

The most crucial factor is that, the majority of cardamom cultivation areas are situated in the montane forest region of Kalupahana area due to favorable climatic conditions. Therefore, alterations in hydrological processes of the forest such as reduction of dry season stream flow, will not only impact on the forest itself but also on the villages situated in the downstream (Figure 4.4) and the reservoirs and human settlements which are mainly dependent on this watershed area. Therefore, the impacts on

the watershed area would reduce the water availability in the reservoirs and increase the risk and uncertainty in achieving the expected targets from the huge investment made while reducing the reservoir capacities due to increased siltation rates.

4.5 Floral and Faunal Diversity of KCF

As mentioned in the section 4.2, the Knuckles range is an isolated block of Central Highlands which is separated from main highlands by the Mahaweli river or the Dumbara valley. Despite the fact that Knuckles massif and the main highlands have a common geological origin, Knuckles massif has been isolated for thousands of years from low-lying Kandy Plateau[7]. Therefore, the biota[8] in KCF shows many similarities with the biota of main highlands while exhibiting various differences as a result of the elongated isolation period (Government of the Democratic Socialist Republic of Sri Lanka, 2008).

Therefore, this small land area is home to numerous plants and animals, including very rare endemic species, sometimes confined only to KCF in the whole world. Table 4.2 shows the details on flowering plants, including woody plants and orchids found in KCF (Gunawardane, 2002 and Government of the Democratic Socialist Republic of Sri Lanka, 2008).

Table 4.2: Plant Species Found in KCF

Type of plant	No of species	Endemic species	Percentage of endemic species	Percentage nationally threatened
Flowering plants	1033	160	15	11
Woody plants	450	151	34	
Orchids	83	35	42	55

Source: Government of the Democratic Socialist Republic of Sri Lanka, 2008

[7] An elevated, comparatively level expanse of land

[8] The animal and plant life of a particular region, habitat, or geological period

According to Fernando (2010), though KCF represents less than 0.5 percent of the total land of the country, the area constitutes about 1/3 of total flowering plant species of the country. There are 1033 of flowering plants belonging to 141 flowering plant families out of which 160 are endemic (Bambaradeniya & Ekanayake, 2003).

Table 4.3: Faunal Diversity among Vertebrates in KCF

Fauna group	No of families	No of genera	No of species	No of endemic species	Percentage of endemic species	No of globally threatened species
Mammals	20	33	41	8	20	9
Birds	46	121	160	19	12	5
Reptiles	14	48	85	43	51	2
Amphibians	4	14	28	18	64	10
Fresh water fishes	8	15	24	11	46	2
Total	92	231	338	99	29	28

Source: Government of the Democratic Socialist Republic of Sri Lanka, 2008

The variation in climate and elevation and topography also has resulted in outstanding faunal diversity in the Knuckles range. According to the Forest Department (1997), of 281 forests in Sri Lanka, KCF is the richest in terms of faunal taxa. Table 4.3 shows the level of diversity of vertebrates in KCF.

Among the freshwater fishes, *Garraphillipsi* and *Puntius srilankensis* are exclusively confined to KCF. *Puntius martenstyni* is a globally threatened endemic fish species found in KCF. It has high habitat specificity and confined to the northern part of the KCF and can be seen only in the headwaters or the rivers located within the forest (Government of the Democratic Socialist Republic of Sri Lanka, 2008).

Among non-vertebrates, *Ceylonthelphusa sanguinea, Ceylonthelphusa callista, Ceylonthelphusa cavatrix, Ceylonthelphusa durelli and Ceylonthelphusa diva* are five freshwater crab species belonging to endemic genus *Ceylonthelphusa* that is confined to KCF (Government of the Democratic Socialist Republic of Sri Lanka, 2008).

As stated in Chapter 3 felling of trees, clearing of undergrowth during crop management and curing practices do a clear destruction to the floral diversity of KCF. Planting of fast growing pioneer tree species alters the forest structure and diversity. Further, these alterations in the forest along with crop management practices such as controlling of damages caused by wild animals and pesticide application affect the faunal species diversity in the forest ecosystem. Increased canopy openness impacts on the lower layers of forest structure. Pesticide application pollute the headwaters whilst increased erosion alters the soil chemical properties, turbidity of water which would ultimately impact on the soil and water borne organisms leading to extinction of rare organisms. Therefore, finally the natural regeneration and evolution process of the forest would be altered.

4.6 Deviation of Forest Structure and Canopy Openness after Cardamom Cultivation

4.6.1 Deviation in Mean Tree Density

Dhakal et al (2012) has conducted a study to find out the effects of cultivating cardamom on forest structure, tree species composition and soil properties of KCF. The table 4.4 shows the major findings of the study. The findings indicate that, the mean tree density of trees ≥ 5cm dbh (Diameter at Breast Height) was 49 percent lower in cardamom planted forest compared to that of natural forest. As discussed in Chapter Three, this was mainly due to the removal of trees during cardamom stand establishment and agronomic practices during stand management. This is further proven by the study conducted by Gunawardane (2003) in KCF, which states that sub canopy layer was absent in cardamom cultivated forests.

However, considering the size class distribution of trees, the stem densities were not consistent across all size classes. The natural forest consisted of higher small stem density while cardamom planted forest consisted of higher large stem density. Therefore, the mean basal area[9] was 13 percent

[9] Tree basal area is the cross-sectional area (over the bark) at breast height (1.3 m above the ground) measured in $m^{2.}$ This can be used to estimate tree volumes and stand competition.

higher in cardamom planted forest compared to natural forest (Dhakal et al., 2012). One possible reason for abundance of large trees in cardamom planted forest is due to the less competition with the availability of more space, after the removal of small trees (Parthasarathy, 1999). Competition among the trees could be reduced further due to removal of large trees in nearby forest patches to obtain firewood to construct cardamom barns and cardamom processing (Dhakal et al., 2012).

Mean densities of saplings and tree seedlings were three and two-fold lower in cardamom planted forest than natural forest. As revealed in Chapter Three, this was caused by the continuous removal of saplings and seedlings during crop management practices. Gunawardane (2003) found that, although cardamom cultivation was banned since year 2000, farmers in 72 percent blocks of cardamom lands situated in the KCF were still practicing weeding and low slashing by 2003. He further states that, forest regeneration was observed in a very small extent (8 percent) of cardamom lands.

Table 4.4: Mean Stem Density (≥ 5 cm dbh), Basal Area (trees ≥ 5 cm dbh), Sapling (<5 cm dbh and ≤1.5m tall), Tree Seedling Density (< 1.5 m tall), Canopy Openness, Soil Properties and Species Richness in Cardamom Plantations and Natural Forests. (Statistical significance of the difference between cardamom planted forest and natural forest is displayed in the form of t and p values which was derived from generalized liner mixed models with forest type)

Variables		Forest Type				
		Cardamom cultivated forest	Natural forest	df	t	p
Forest Structure	Stem density (ha^{-1})	620±46	1500±119	59	7.40	0.00
	Basal area (ha^{-1})	30.8±3.2	23.6±1.98	59	-2.44	0.02
	Sapling density (ha^{-1})	1086±126	2723±308	59	5.05	0.00
	Tree seeding density(ha^{-1}x 1000)	23.1±2.68	50.5±3.60	59	6.12	0.00
	Canopy openness (%)	35.2±1.64	19.3±0.55	59	-9.36	0.00
Soil properties	Soil organic matter (%)	7.90±0.35	9.27±0.85	59	1.66	0.10
	Soil pH	5.00±0.14	5.40±0.13	59	2.33	0.02
	Soil N (mg g^{-1})	3.55±0.13	4.46±0.26	59	3.39	0.00
	Soil P (mg g^{-1})	6.24±0.50	3.69±0.34	59	-4.13	0.00
	Soil K (mg g^{-1})	0.09±0.01	0.06±0.00	59	-2.54	0.01
	Soil Ca (mg g^{-1})	0.57±0.06	0.55±0.04	59	-0.33	0.74
	Soil Mg (mg g^{-1})	7.02±0.83	6.70±0.64	59	-0.27	0.78
Community Structure	Species richness per plot	9.43±0.48	10.0±0.56	59	2.49	0.02
	Cardamom density (ha^{-1})	6098±498	121±51	30	1365	0.00

Source: Dhakal et al., 2012

4.6.2 Deviation in Canopy Openness

The mean canopy openness was 29 percent higher in cardamom planted forest than in natural forest (Dhakal et al., 2012). According to Gunawardane (2003), 11 percent of the cardamom blocks were found with open canopy cover. As stated in Chapter Three, selective removal of trees from the cardamom plantation during crop management, barn preparation and firewood acquisition has increased the solar radiation falling on the forest floor (Figure 4.5). As per the observations during the field visit to KCF, felled rare and endemic tree species were found to be used as firewood for cardamom barns. As mentioned by Dhakal et al (2012), the study team also observed presence of pioneer tree species (Eg: *Macaranga indica* (Common name - Kanda)) and invasive weed plant species (Eg: *Chromalaena ordata* (Common name - Podisinghomaran)) in cardamom cultivated forest, which were emerging in open canopy areas after trees were felled for firewood (Figure 4.6).

Figure 4.5: An Open Canopy Area Due to Felling of Trees in Kalupahana

This implies that the situation had been conducive to develop light demanding pioneer tree species for a longer period. The enhanced emergence of pioneer tree seedlings ultimately impacts on the structure of the forest community across all size classes. Dhakal et al (2012) further suggests that, dominating pioneer tree species such as *Macaranga indica* having a relatively open canopy structure will lead to a self replacement as a result of change in the below canopy light environments.

Figure 4.6: Emergence of Light Demanding Pioneer Trees of *Chromalaena odorata* in an Open Canopy Area of Kalupahana

4.6.3 Deviation of Tree Community Structure

As stated earlier, Dhakal et al (2012) states the tree stand in cardamom cultivated forest consists of a high density of early successional pioneer tree species such as *Macaranga indica, Symplocos cochinchinensis*, *Chromalaena odorata* and *Maesa indica.* The main reason for this change in species composition might be due to the disturbance to the forest during stand establishment, maintenance of cardamom plantations, especially due to the increased light transmission on the forest floor and due to tree felling during barn preparation and cardamom curing.

The species richness[10] was higher in cardamom plantations compared to natural forest. Dhakal et al (2012) suggests that in short term disturbance to canopy cover by removal of trees would induce the emergence of pioneer tree species which are low or absent in natural forest.

[10] Species richness is the diversity of species in a community measured as the number of species compared with the number of individuals in the community. It is given by: d = (S − 1)/logN, where d is the richness index, S is the number of species, and N is the number of individuals.

4.7 Impact of Changes in Soil Parameters

The Land Commission (1987) highlights the importance of the forests in relation to soil and water management as follows;

1) Enrich the soil through forest litter. For example, by creating organic matter enriched with humus and encouraging microbial activity
2) Enhance the infiltration of rainfall and reduce the surface runoff and
3) Decrease the soil erosion

Intensive agricultural activities cause negative impacts on the properties of the forest soils which ultimately affect the soil processes such as nutrient recycling and water regulation. Table 4.4 describes how the soil properties have deviated in cardamom cultivated forest compared to natural forest. The mean total P and exchangeable K concentrations were 41 percent and 26 percent higher respectively in the top soils of cardamom plantations. However, lower pH and 12 percent lower mean total N concentrations were recorded in cardamom cultivated forest compared to adjacent natural forest. The exchangeable Ca and Mg did not differ in the both types of soils (Dhakal et al., 2012). The lower N concentration might be a result of mineralization of organic matter, loss of soil N through leaching and de-nitrification due to amplified soil disturbance by agronomic and barn preparation practices and canopy openness (Dhakal et al., 2012).

A study conducted by the Institute of Fundamental Studies on soil properties of cardamom planted forest and natural forest of KCF has found that, the 'A' horizon of natural forest is well preserved and covered with mulch. The maximum depth of 'A' horizon found was 30-35 cm in natural forest. However, the 'A' horizon depth of cardamom planted forest was relatively lower ranging between 15-25 cm (Madduma Bandara, 1991). According to Gunawardane (2003), nine percent of the cardamom plantations were situated in stream reservations. Therefore, changes in soil properties have a number of negative externalities on downstream water resources and villages.

The rate of infiltration of soil depends on the physical characteristics of the soil which is determined by the availability of litter layer, elevated organic matter levels and improved soil structure. However, with cardamom cultivation, the under growth of the forest is removed, the canopy

openness is increased and the soil organic matter content is reduced (Table 4.4). Changes caused in the soil properties lead to physical loss of soil, land degradation, reduced or absent dry weather stream flow, changes in micro-climate, and undesirable off site effects such as reservoir siltation (Wijewansa, 1988). Year around stream flow is important for reservoirs' performance, especially downstream reservoirs of Mahaweli system viz; Victoria, Randenigala, Rantambe and newly constructed Moragahakanda (Wijewansa, 1988; Forest Department, 2009).

When cardamom plantations are established under forest cover, the deep rooted tree species are replaced with shallow rooted cardamom plants. Therefore, the stability of sloppy lands has negative effects due to the reduction of the mechanical contribution of roots to strengthen the soil. Gunawardane (2003) states that, 26 percent of the cardamom plantations are situated in steep terrains of > 50 percent slope. This cultivation activity could pose increased incidence of landslides causing accelerated reservoir siltation (Wijewansa, 1988). Removal of understory and cutting down of trees reduce the soil aggregate stability and water intake capacity due to lowering the level of organic matter content and the soil microbial activity would decline with time when the forest stand is disturbed. Especially when the forest soil surface gets exposed the declining rate would be accelerated (Lal, 1987).

Therefore, due consideration should be given to safeguard the protective role of the KCF in sustaining the ecological balance and also to ensure the economic viability of multipurpose irrigation schemes.

4.8 Central Highlands of Sri Lanka as a World Natural Heritage Site

To encourage the identification, protection and preservation of cultural and natural heritages around the world, which is considered to be having outstanding value to humanity, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has enacted an international treaty. This is called the Convention Concerning the Protection of the World Cultural and Natural Heritage. According to the treaty, the World Heritage Sites belong to all the people in the world irrespective of the territory (UNESCO World Heritage Center, 2014).

There are 981 sites in the World Heritage list which constitutes of both cultural and natural heritage sites regarded as having outstanding universal value. This consists of 759 cultural sites, 193 natural sites and 29

both cultural and natural mixed sites. Sri Lanka has two Natural World Heritage sites, namely Central Highlands of Sri Lanka and Singharaja Forest (UNESCO World Heritage Center, 2014).

The Central Highlands of Sri Lanka are located in the south-central part of the island. These includes;

1. KCF
2. Peak Wilderness Protected Area and
3. Horton Plains

4.8.1 Criteria for Selection

There are ten criteria adopted in the process of selecting a specific site for World Heritage Site. Any site included in the World Heritage List must have an outstanding universal value and should meet at least one out of ten selection criteria. The Central Highlands of Sri Lanka were declared as a World Natural Heritage in the year 2010 based on the UNESCO list of criterion ix and x, which are described as;

i. "To be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals;
ii. To contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation."(UNESCO World Heritage Center, 2014).

4.8.2 The Benefits of Having KCF as a World Natural Heritage Site

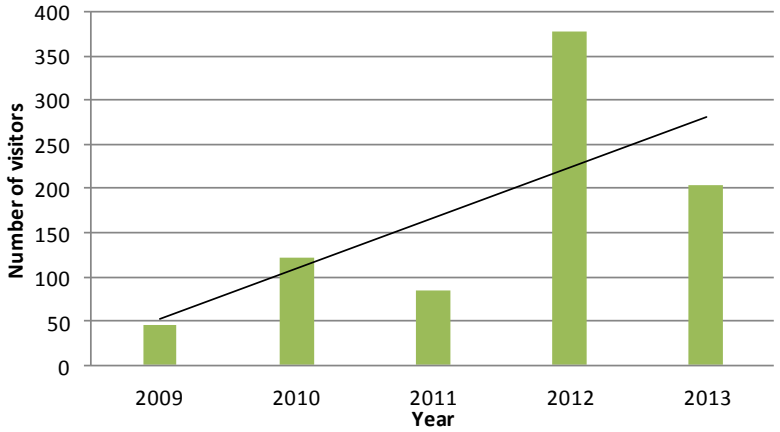
Declaration of KCF as a World Natural Heritage brings several benefits to Sri Lanka such as increased attraction as a tourist destination, funding assistance and financial support, world recognition and support for research and development. These benefits bring more foreign remittances to Sri Lanka.

For example, considering tourism the vision of the government towards becoming the "Wonder of Asia" and reaching the status of the upper middle income country, the tourism sector has been identified as one of the key sectors, which would generate foreign revenue. Sri Lanka is

planning to increase the number of tourists visiting the country up to 2.5 million by 2016, and has positioned that as a US$ 2-3 billion economic activity (Department of National Planning, 2010). Therefore, the country is making various efforts and strategic planning to make Sri Lanka a popular tourist destination in the world. For easy reference in terms of diversity the Sri Lanka Tourist Board has categorized the tourist attraction places into nine areas, namely, beaches, heritage, wildlife, scenic beauty, mind and body wellness, festivals, sports and adventures and essence. KCF which is among one of the World Natural Heritage sites in the world consists of many endemic flora and fauna, rich in scenic beauty, mountain cliffs, waterfalls, hence serves for most of these categories. Therefore, by being a World Natural Heritage site, KCF would help communicate the diversity of the country, thus helps attract more high-end tourists to the country.

Figure 4.7 shows the number of tourists visited KCF via Theligamu Oya entrance. The graph shows an increasing trend of visitors to the KCF especially after 2010, the year in which the Knuckles range was declared a conservation forest. According to the FD, all these tourists are from France and Germany.

However, it is essential to take into consideration that during the declaration process of World Heritage title for the Central Highlands of Sri Lanka, removal of cardamom cultivations was one of the conditions stipulated. Failure to adhere to the stipulated conditions will place the Central Highlands of Sri Lanka on the World Heritage red list and eventually will be removed from the list.



*

2013 figures indicate the data only up to July 2013

Source: Theligamu Oya Forest Office, Forest Department

Figure 4.7: Number of Tourists Visited Knuckles Conservation Forest via Theligamu Oya Entrance

Therefore, if such situation arises the above stated benefits will be reversed. As a result the country will lose the opportunity to market the country as a tourist destination and it will tarnish the image of the country for being unable to maintain a Natural Heritage title and in turn, funding assistance and financial support will also be withdrawn.

CHAPTER FIVE

Socio-economic Perspective of Peripheral Villagers

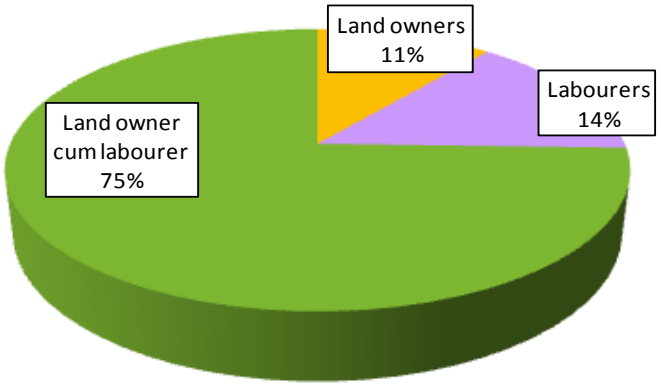
The following chapter discusses the demographic details of encroachers, the impact on livelihoods, income levels and the ensued difficulties by encroachers after banning of cardamom cultivation in KCF and the proposed solutions to overcome the problems.

5.1 Encroacher Categories

Based on the field survey, three major encroacher categories could be identified as,

1. Land owners - They have their own cardamom lands, but use hired labour for field operations.
2. Land owner cum labourers- Encroachers who have their own cardamom lands and are engaged in cultivation activities. They may also hire out their labour as paid laborers or exchange (*Aththam*) labourers.
3. Labourers- Encroachers, who do not have own cardamom lands, but work as paid labourers on daily wage basis or on contract basis.

Figure 5.1 shows the composition of different encroacher categories living in the Laggala –Pallegama DS division. The findings disclose that, out of the total encroachers, the majority were in the category of landowner cum labourer (75 percent). The total owner operators, including both depending on own labour and hired labour, account for 86 percent. This implies majority of the encroachers who were engaged in cardamom cultivation had their own cardamom lands. Only 14 percent of the sample was wage labourers in the cardamom cultivations.



Source: Author's Survey Data, 2013

Figure 5.1: Distribution of Cultivators

Table 5.1 shows the distribution of encroachers among the GN divisions. About three fourth of the total cultivators were living in Halminiya, Narangamuwa and Ranamure GN divisions. These three GN divisions are situated on the way towards Kalupahana. The Narangamuwa GN division is situated near the entry point of KCF. Therefore, a comparatively easy access to Kalupahana from theses villages can be identified as one of the possible reasons for the increased involvement of people in these GN divisions in cardamom cultivation. Consequently, these three GN divisions show the highest dependency on cardamom as the income source.

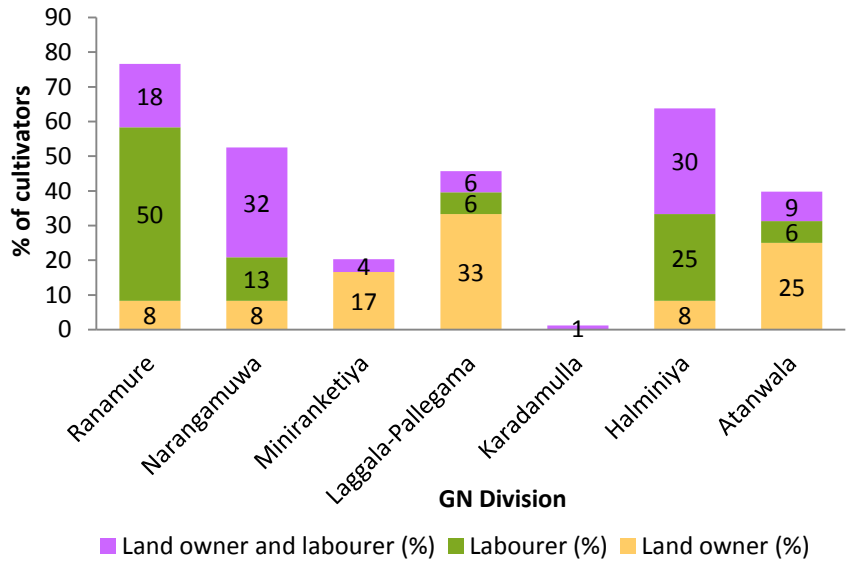
Table 5.1: Distribution of Cultivators among GN Divisions

No	GN division	Total number of cultivators	Percentage of cultivators
1	Ranamure	24	22
2	Narangamuwa	29	26
3	Miniranketiya	5	5
4	Laggala-Pallegama	10	9
5	Karadamulla	1	1
6	Halminiya	30	27
7	Atanwala	11	10
	Total	**110**	**100**

Source: Author's Survey Data, 2013

Figure 5.2 shows the distribution of different encroacher categories among GN divisions. The majority of owner operators lived in Narangamuwa GN division (32 percent). This was followed by Halminiya as 30 percent and Ranamure as 18 percent. However, the presence of exclusive land owners was relatively lower in these GN divisions (only 8 percent in each GN division). The cultivation fields were situated in Kalupahana area, about 10 -15 km away from the villages at an elevation about 1100 m and above. The cultivators have to reach the farming area by walking on narrow foot trails and climbing steep mountains. By walking and trekking experienced encroachers are able to reach the cultivations in about five hours. Due to these hardships, the general practice of the encroachers was to stay in the cultivations for a week or more before going back to the village. Food and other necessary items for the stay were carried with them from the village.

Therefore, most of the encroachers were engaged in cultivation activities in their own land and also in other lands as paid laborers or *Aththam* laborers. Hiring of labor has enabled them earn an extra income.



Source: Author's Survey Data, 2013

Figure 5.2: Cultivator Categories Based on GN Division

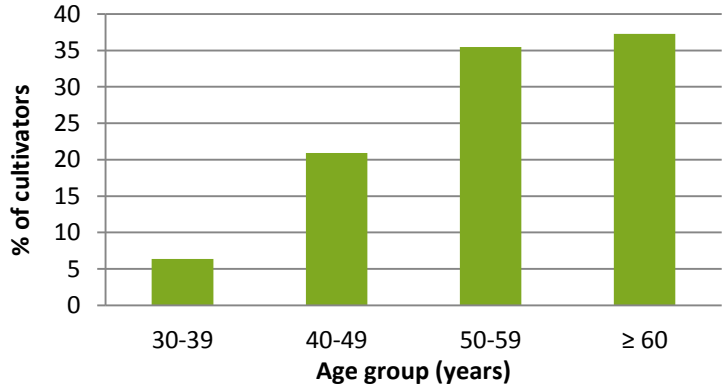
The majority of the cardamom land owners in the Laggala-Pallegama GN division, unlike Halminiya, Narangamuwa and Ranamure GN divisions,

depended on hired labour for the cultivation. The main reason is that compared to the other GN divisions in the same DS the Laggala-Pallegama GN division is situated in a more urbanized area, away from KCF, the majority of the encroachers in the area have the opportunity to engage in other income generating activities while managing the cardamom lands using hired labor with occasional short visits to the cultivation lands.

Majority of the sole laborers live in Ranamure GN division (50 percent), followed by Halminiya GN division (25 percent).

5.2 Age Distribution

The figure 5.3 shows the age distribution of encroachers. The majority of encroaches (72 percent) were in the age group of 50 years or above. Only 27 percent of the encroachers were less than 50 years. This indicates that the majority of encroachers are relatively aged and the involvement of young generation in cardamom cultivation is relatively low.



Source: Author's Survey Data, 2013

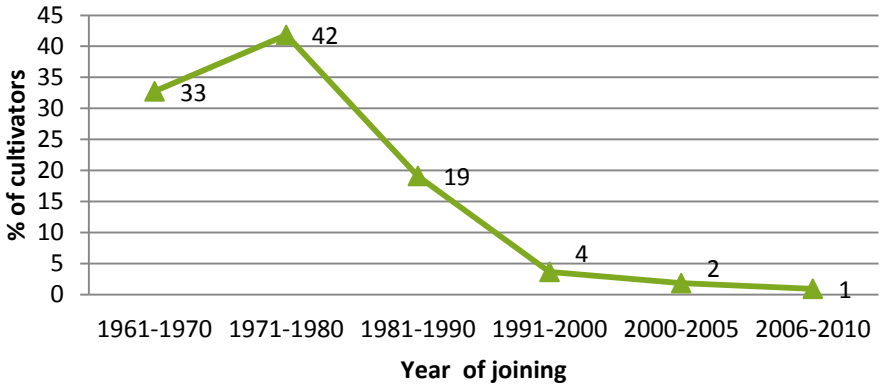
Figure 5.3: Age Distribution of Cultivators

Figure 5.4 shows the pattern of involvement of the encroachers in cardamom cultivation over the years. The encroachers have started to engage in cardamom cultivation after 1961. The very first set of encroachers (about 33 percent) was engaged in cardamom cultivation during the 1961-1970. The highest percentage of the encroachers (42 percent) joined the cardamom cultivation during the period of 1971-1980. Afterwards a gradual decrease could be observed in the joining pattern where only 19 percent of illegal cardamom farmers were engaged in the

cardamom cultivation in the period of 1981-1990. This has continued to decline till 2010 when none of the new cultivators entered the cardamom cultivation afterwards. Cardamom cultivation was first identified as a profitable venture in late 1960s. High returns earned by the farmers from the cardamom cultivation motivated peripheral villagers to encroach KCF and establish their own cultivations illegally. A number of villagers who were involved in hiring out their labor in large cardamom plantations also established their own cultivations while working for large-scale cardamom plantations. Though the legal permit holders left the cultivation after expiry of 20 year validity period of cultivation permits, several others have encroached these lands and declared ownership illegally. These encroachers also received the blessings of local politicians.

However, as per the information received from the field survey, the gradual decline of people entering cardamom cultivation was mainly due to:

- Reduction in the profitability due to decreasing crop productivity and drop in world cardamom prices.
- Less interest of new generation in cardamom cultivation.
- Banning of cardamom cultivation in the Knuckles range after being declared as a conservation forest.
- Emergence of new pest species in cardamom cultivations.

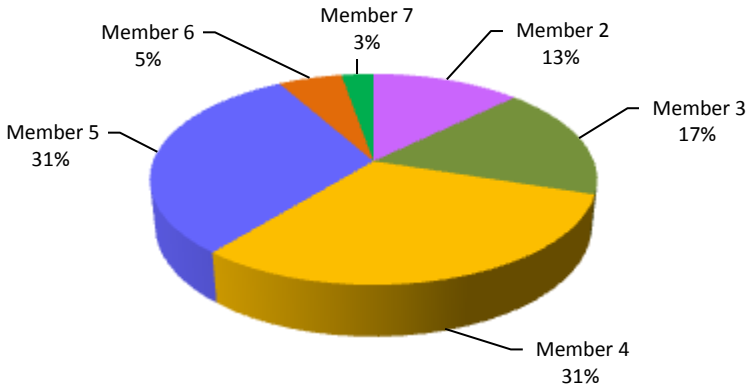


Source: Author's Survey Data, 2013

Figure 5.4: Joining Pattern of Encroachers in to Cardamom Cultivation

5.3 Family Size Distribution

Figure 5.5 shows the average family sizes of the households of encroachers. According to the figure, the majority (62 percent) have 4-5 members in the family. Average family size of encroachers was equal to 4.1 which is in line with national average household size (Department of Census and Statistics, 2011). In most of the families the parents had engaged in cardamom cultivation whilst the involvement of younger generation was found to be minimal.

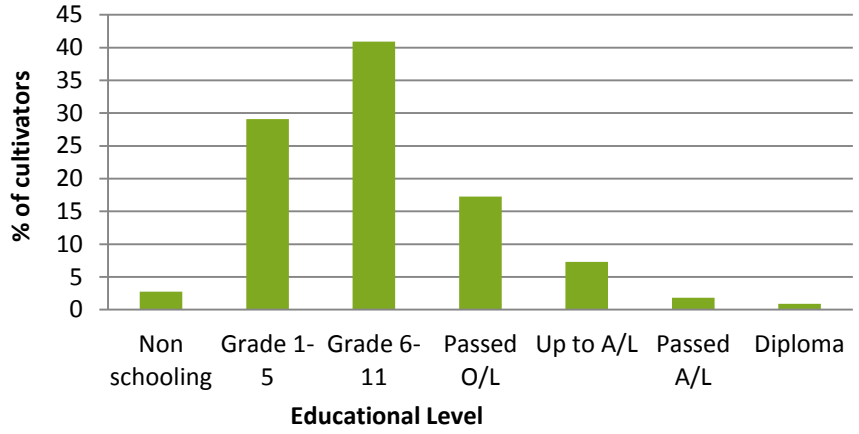


Source: Author's Survey Data, 2013

Figure 5.5: Family Size Distribution among Cardamom Cultivator Households

5.4 Educational Level of Encroachers

Findings on the educational levels of encroachers illustrate that (Figure 5.6) the majority of them (41 percent) belonged to the category of those who had received secondary education (Grade 6-11) followed by the category of those who received primary education (Grade 1-5) consisting of 29 percent. This shows that, the majority of the encroachers had received primary education, however, have not completed senior secondary (O/L) education (Education Guide Sri Lanka, 2010). Therefore, it is evident that the education level among encroachers was fairly low. According to household questionnaire survey findings, in late 1960-1990s the cardamom cultivation was identified as a very profitable venture. Therefore, the then younger generation had drop out of school to join cardamom cultivation due to lucrative profits it fetched.



Source: Author's Survey Data, 2013

Figure 5.6: Educational Level of Cardamom Cultivators

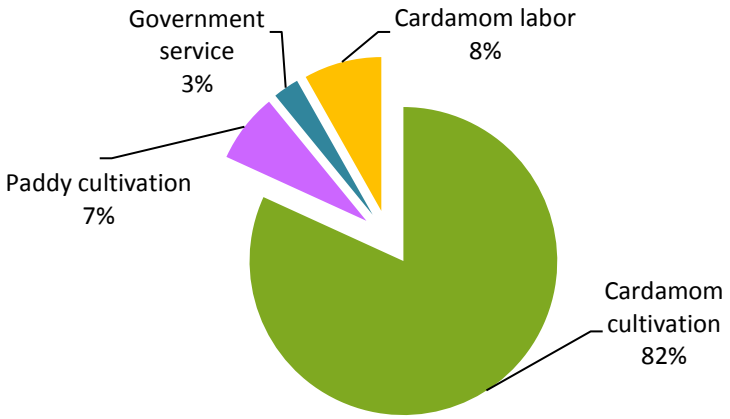
However, when considering the educational level of household members, it is higher among the younger generation. In the age group of 20-29, 14 percent have passed A/L, 3 percent were diploma holders whilst 10 percent were degree holders. In the age group of 30-39, 13 percent have passed A/L, 2 percent were diploma holders whereas 3 percent were degree holders. This indicates that the educational level of second generation of the encroachers has increased. One of the reasons for this situation is the income generated from cardamom cultivation has helped them provide a better education to the children. In addition, the presence of few young people among encroachers can be interpreted as a mark of reversed interest in cardamom cultivation due to the increase in the educational level.

5.5 Primary Income Sources of Encroachers Before and After Banning Cardamom Cultivation

The figure 5.7 explains the primary income source of illegal cardamom farmers before banning cardamom cultivation in KCF. Findings disclose cardamom cultivation was the major livelihood activity for 90 percent of the encroachers. Out of that, 82 percent were land owners while the other 8 percent were laborers. Only 7 percent depended on paddy cultivation as the main income source whilst keeping cardamom cultivation as a secondary income source. This implies that the banning of cardamom

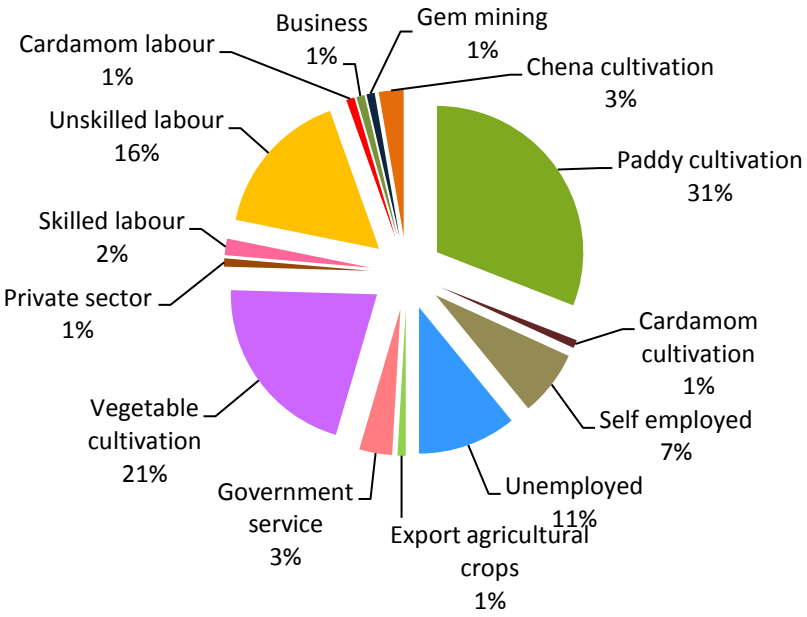
cultivation has directly affected the major income source of 90 percent of the households.

The figure 5.8 shows the primary income source of illegal cardamom farmers after banning cardamom. The findings elucidate that, people have moved towards various alternative income generating activities, mainly into agriculture based activities after banning of cardamom cultivation. The majority of the encroachers have shifted into paddy cultivation (31 percent) whereas 21 percent have moved into vegetable cultivation. A small fraction of the encroachers was still engaged in illegal cardamom cultivation. Along with paddy, vegetable, chena and export agricultural crop cultivation, the agriculture sector has become the new leading income source for 57 percent of cultivators. Nearly 18 percent of the encroachers are engaged as skilled and unskilled laborers, especially in the Moragahakanda and Kalu Ganga Irrigation Projects. However, one of the significant observations was, most of the chosen income sources were not sustainable as they are project based temporary employment opportunities.



Source: Author's Survey Data, 2013

Figure 5.7: Primary Income Sources of Households before Banning Cardamom Cultivation



Source: Author's Survey Data, 2013

Figure 5.8: Primary Income Sources of Households after Banning Cardamom

5.6 Household Income Levels of Encroachers

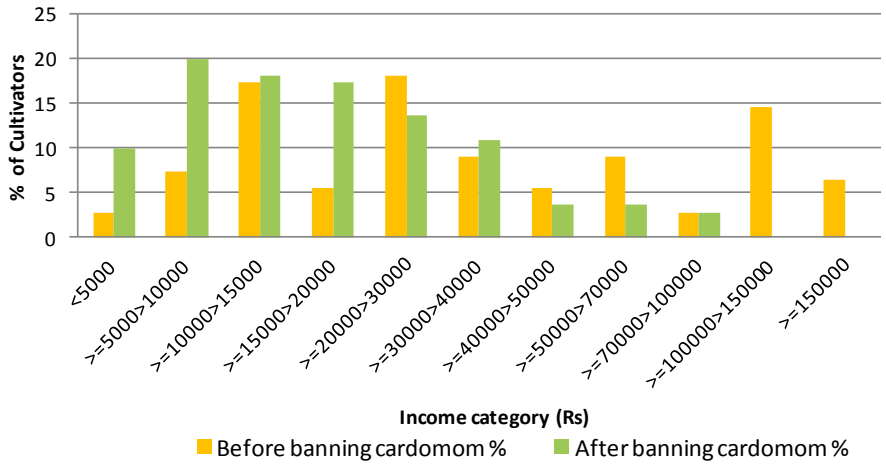
Income statistics of most recent National Household Income and Expenditure Survey (NHIES) (2019/10) are presented in table 5.2. According to the table, the mean income level of the Matale district is less than the mean income level of the country and of the rural sector. This implies that Matale is a relatively poor district where mean income level is comparatively low.

Table 5.2: Household Income Statistics

Category	Income level (Rs/month)
Sri Lankan mean household income	36,451
Mean income level for rural sector	35,228
Mean income level for Matale district	30,013
Median income level for Matale district	18,606

Source: Department of Census and Statistics, 2011

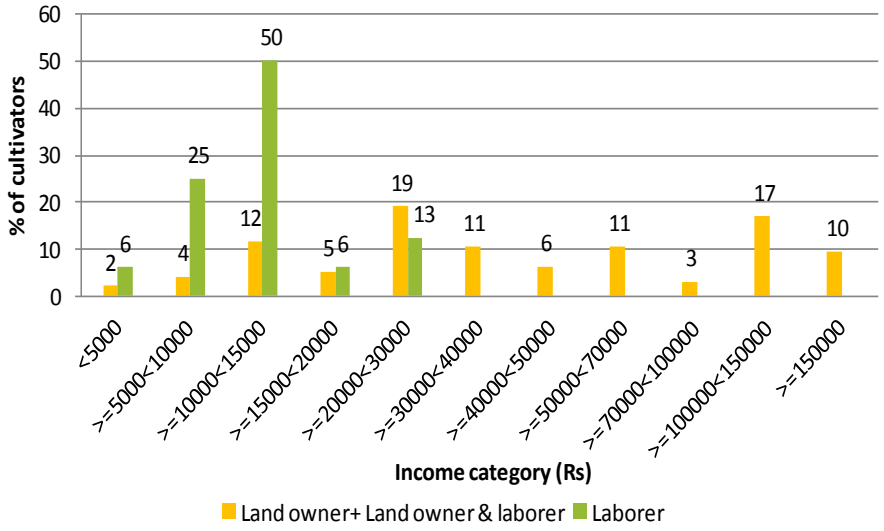
The figure 5.9 shows the survey findings on the distribution of income level before and after banning cardamom cultivation of the households in the study area. The Mean income of encroachers before banning cardamom cultivation was Rs.48,638 per month. The majority of the cultivators had received an income of Rs.20,000-30,000 per month and the median income was Rs.25,600 per month. Compared to the mean income level of households in the Matale district (Table 5.2), before banning cardamom cultivation the mean income level of the encroachers was significantly higher ($p < 0.001$). This denotes before banning cardamom cultivation in KCF, the encroachers were in a better income position.



Source: Author's Survey Data, 2013

Figure 5.9: Household Income Levels Before and After Banning Cardamom Cultivation (For all Cultivators)

Figure 5.10 shows the income level of encroachers before banning cardamom for land owners and laborers separately. The mean income level of land owners was Rs.54,771 per month while for laborers it was Rs.11,021 per month. There is a significant difference between mean income levels of land owners and laborers ($p = 0.003$). The maximum income earned by laborers was Rs.20,000 per month, whereas land owners, including those providing and non-providing own labor for cultivation have earned a maximum income of Rs.334,791 per month. Therefore, compared to laborers, land owners have earned a significantly higher level of income.

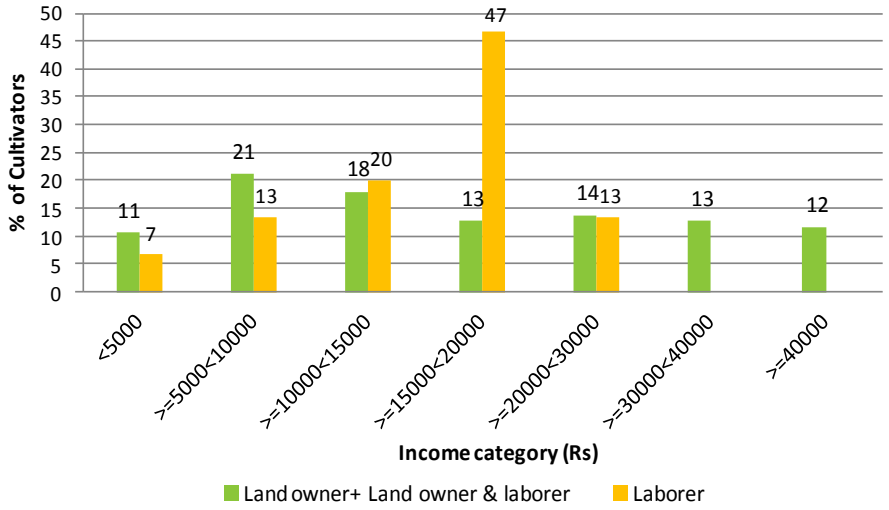


Source: Author's Survey Data, 2013

Figure 5.10: Household Income Levels of Encroachers before Banning Cardamom (For Land Owners and Labourers Separately)

The income levels of land owners and laborers after banning cardamom cultivation are shown in Figure 5.11. The mean income of land owners after banning cardamom cultivation was Rs.18,197 per month, whereas for laborers it was Rs.15,067 per month. Though, the mean income of landowners is still greater than laborers, there is no significant difference between the two means. However, it is noteworthy to mention that, the mean income of landowners has reduced significantly from the value of Rs.54,771 per month to Rs.18,197 per month. The mean income level of laborers has increased to Rs.15,067 per month from Rs.11,021 per month compared to the situation before imposing the ban, though it does not show a significant difference. This signifies that banning cardamom cultivation has a noticeable negative impact on the income level of cultivators. Since many laborers have found employment under Kaluganaga and Moragahakanda irrigation projects as skilled and unskilled laborers, their mean income level has increased. However, they might experience difficulties in finding employment when the irrigation project comes to an end. The income disparity was wider for landowners compared to laborers since majority of them have moved towards agriculture based employment activities. Compared to the mean income of

the Matale district, the income of landowners and laborers after banning cardamom cultivation was significantly lower.



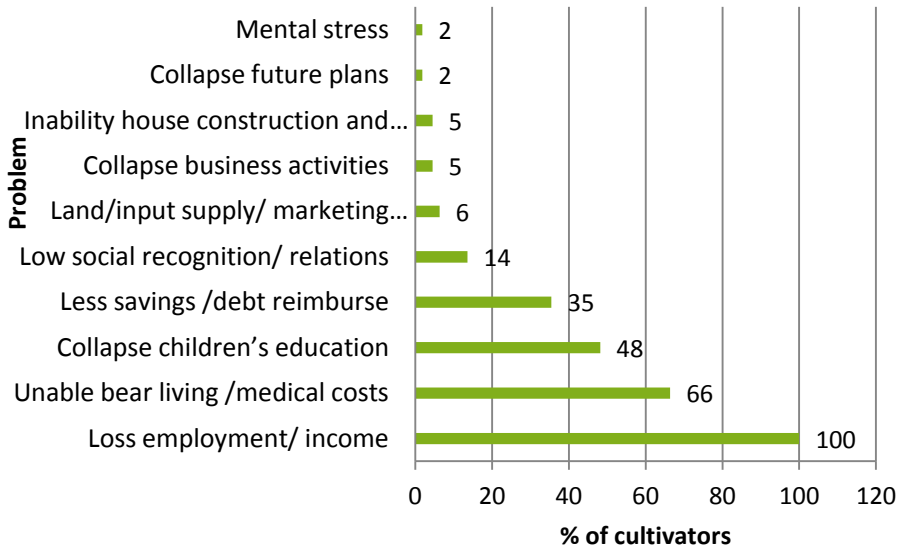
Source: Author's Survey Data, 2013

Figure 5.11: Household Income Levels of Encroachers After Banning Cardamom Cultivation

5.7 Problems Faced by Encroachers after Banning Cardamom Cultivation

The figure 5.12 shows the difficulties faced by illegal cardamom farmers after banning cardamom cultivation. All of the encroachers have stated that, they have lost their livelihood and faced a loss of income. Since cardamom cultivation had been the major livelihood for 90 percent of the cultivator households (Figure 5.7) this is undoubtedly noticeable. As discussed in section 3.6, the mean income levels before and after banning cardamom cultivation showed an income difference of Rs.30,880 per month which is a significant reduction.

About 66 percent of the encroachers have mentioned that, reduction in household income has caused difficulties in managing living and medical expenses after banning cardamom cultivation. Bearing medical expenses was a serious concern for the majority of ageing encroachers who had to spend a fairly high amount on various illnesses.



Source: Author's Survey Data, 2013

Figure 5.12: Problems Faced by Encroachers after Banning Cardamom Cultivation

About 48 percent of illegal cardamom farmers have faced difficulties in meeting the expenses of their children's education. Children of some households were boarded in the nearby town of Matale for schooling. Children in several households were receiving higher education in Colombo and many households had to spend money on supplementary private tuition classes of the children. About 35 percent of the households affirmed that, it has been difficult to repay the debts and loan interests and save for the future.

The income drop has affected the social status of the people (14 percent) in the community. This was mainly due to reduced engagement with social activities as a result of lack of money to spend on the activities and therefore weakened social relationships.

About 6 percent of the encroachers who had moved towards agriculture based alternative income sources had faced various issues such as land tenure, lack of water and marketing of agricultural produce.

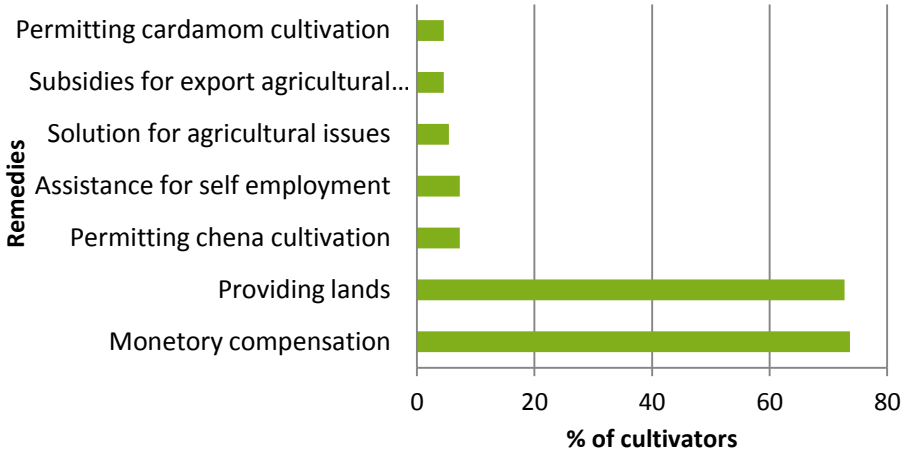
5.8 Encroachers' Suggestions to Overcome the Problems Emerged After Banning Cardamom Cultivation

The figure 5.13 illustrates the proposed remedies of the encroachers for the problems aroused after banning the cardamom cultivation. About 74 percent of the encroachers stated that, they prefer to have a monetary compensation of Rs.100,000 per acre for the lost cardamom lands. They have affirmed that, monetary compensation would help them develop alternative income sources.

Seventy three percent of the encroachers have declared they preferred to have a plot of land to cultivate pepper which is a promising export agricultural crop at the moment. As shown in figure 5.14, 90 percent of the encroachers have already planted pepper in their home gardens. As per the encroachers, pepper is well adapted to the climatic conditions of the area. Further, they have declared there is a considerable demand for pepper which fetches a good price.

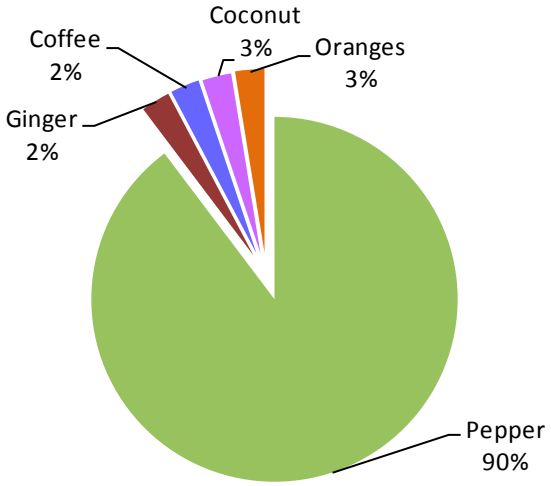
Seven percent of the encroachers have requested for financial and skill assistance to develop self-employment such as masonry, eco-tourism, spice making, and book binding as alternative income sources. They needed financial assistance to develop and expand the ongoing self-employment activities.

Solutions to the problems associated with agricultural activities were requested by 5 percent of encroachers. Since the Laggala-Pallegama DS division is situated in close proximity to the Wasgamuwa National Park, elephant attacks have become an emerging problem in the area. Some cultivators have demanded for irrigation water since there is no irrigation water supply to the area to carry out cultivation activities throughout the year. Several farmers have requested to establish a proper marketing mechanism in the area. After banning cardamom 21 percent of encroachers have moved towards vegetable cultivation. The majority of farmers stated they have faced difficulties when marketing the yield. Since the DS division is situated in a rural area transportation is very costly. The closest wholesale vegetable collection center is the Dambulla Dedicated Economic Center (DDEC). However, for GN divisions such as Atanwala there is no motorable road system.



Source: Author's Survey Data, 2013

Figure 5.13: Remedies Proposed by Encroachers



Source: Author's Survey Data, 2013

Figure 5.14: Perennial Crop Cultivation Pattern among Encroachers

5.9 Cost of Banning Cardamom in KCF

Banning of cardamom cultivation will incur a cost due to loss of cardamom production. The following calculation shows the total value of cardamom produced in Kalupahana area. According to calculation shown in Part I by

banning cardamom cultivation, Rs 110 million worth of cardamom production would be lost to the country.

Part 1

Average dry cardamom yield per year	=123kg/ac
Total cardamom land area in Kalupahana (Forest Department, 2010)	=520 ac (210ha)
Total cardamom production from Kalupahana area per year	= 123 kg/ac x 520 ac = 63,960 kg
Farmgate price of a kilo of cardamom (Department of Export Agriculture, 2013)	= Rs 1730.00
Hence Total value of cardamom produced in Kalupahana	= 63,960xRs.1,730.00 = **Rs 110, 650,800.00**

Part 2

Considering export earnings by cardamom the following calculation shows the amount that the country will lose at various levels of export quantities.

Average Rupee value for 1 kg of exported cardamom	= Rs 3094.00
Total foreign revenue loss to the country	
If total cardamom production from Kalupahana Exported	= 63,960kg x Rs3094/kg = **Rs 197, 892, 240.00**
If 75% of cardamom production is exported	=63,960kg x Rs3094/kg x 75% = **Rs 148, 419, 180. 00**
If 50% of cardamom production is exported	=Rs63960kg x Rs3094/kgx50% = **Rs 98, 946, 120.00**
If 25% of cardamom production is exported	= 63,960kg x Rs3094/kg x 25% = **Rs 49,473,060.00**
If 10% of cardamom production is exported	= 63,960kg x Rs3094/kg x 10% = **Rs 19,789,224.00**
If 5% of cardamom production is exported	= 63,960kg x Rs 3094/kg x 5% = **Rs 9,894,612.00**

The Part II shows the loss of foreign revenue at various cardamom volume levels of exportation. It shows that if the full quantity is exported the income would be Rs 198 million. If 5 percent is exported Rs 9 million would be earned. Due to the drop in cultivation, the country would incur a loss of the above given amount.

CHAPTER SIX

Environmental and Socio-economic Consequences of Cardamom Cultivation in KCF in the Context of Millennium Ecosystem Assessment Framework

The overall outcome of the details discussed in the chapters three, four and five are discussed in this chapter in the context of Millennium Ecosystem Assessment.

6.1 Indirect and Direct Drivers of Change

As elaborated in Chapter Three the cardamom cultivation in the KCF is considered the foremost indirect driver of change.

As discussed in Chapter Four the cardamom cultivation in KCF which is the concerned indirect driver of change makes a range of alterations in the KCF ecosystem and they are the direct drivers of change to the services provided by the KCF ecosystem which is depicted in Figure 6.1.

Continuous cardamom cultivation in KCF would transform the forest structure with the reduced number of saplings and seedlings and increased canopy openness. In addition, increased occurrence of early successional tree species is the other impact.

Simultaneously, agronomic and curing practices adopted by cardamom cultivators have the ability to alter the floral and faunal diversity of the KCF. The cardamom stands establishment, weed management, solar radiation management, cardamom barn preparation and curing of cardamom pods would lead to felling of forest trees and the introduction of new tree species. This leads to reduction of floral biodiversity by removal of vital tree species and modify the biodiversity by introduction of early successional and invasive tree species. Destroying and/or modifying of natural habitats, wild animal damage management and pest management practices tend to reduce the faunal diversity of the KCF.

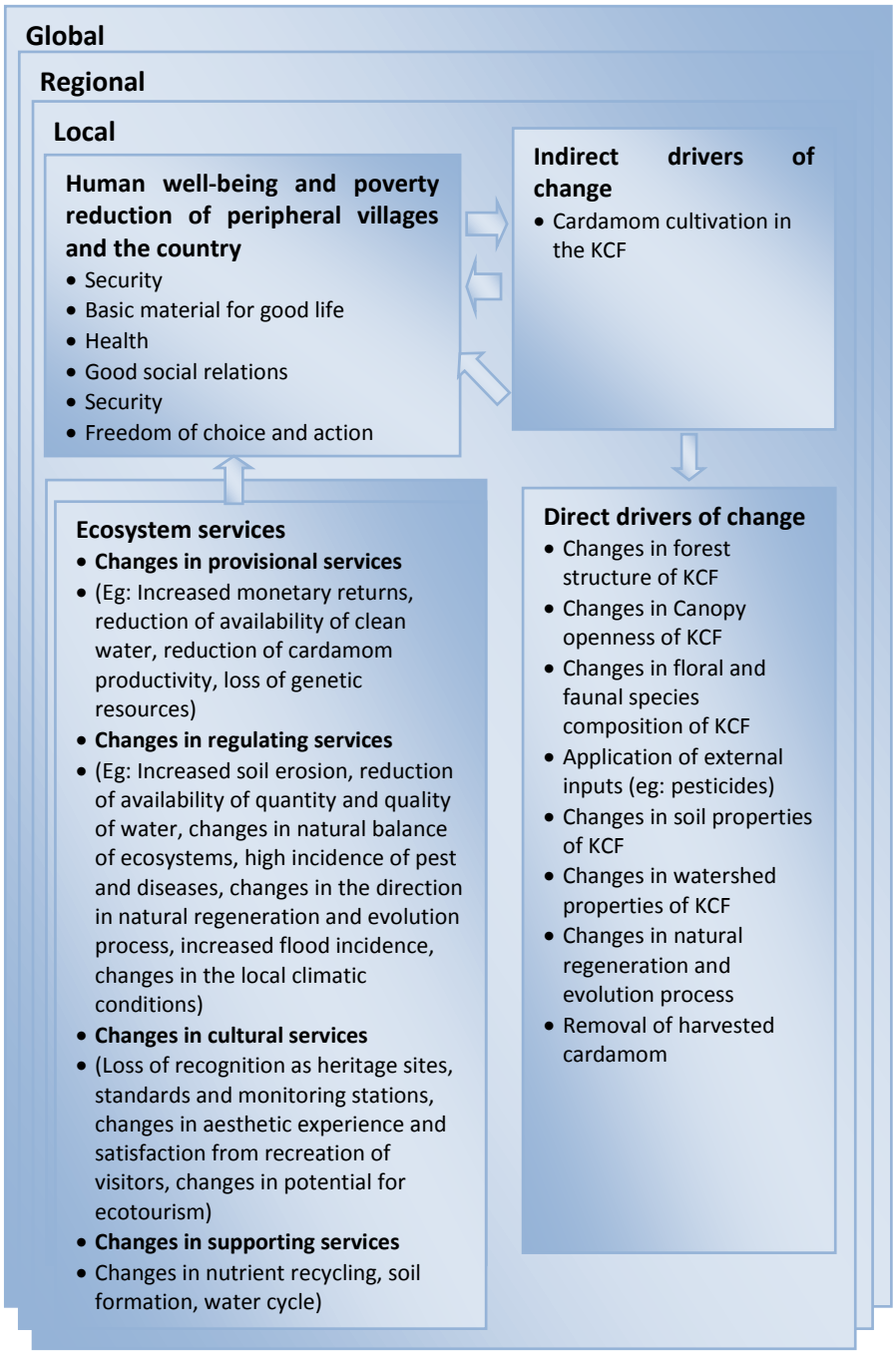


Figure 6.1: Framework for the assessment of environmental and socio-economic consequences of cardamom cultivation in Knuckles Conservation Forest

Continuous removal of the harvest from the forest system, increased canopy openness, constant mechanical disturbance to the soil, the indiscriminate undergrowth removal are undesirable practices that alter the chemical, physical and biological properties of the soil of the forest ecosystem.

The increased canopy openness leads to increased light penetration in lower layers of the forest structure, directing towards reducing the relative humidity at higher altitudes (Reyes *et al*., 2006) and increasing the air temperature due to direct exposure to the sun. Consequently, the growth of epiphytes mosses and lichens and capturing process of wind driven cloud moisture are also affected. Reduced organic matter content would reduce the permeability and the water holding capacity of the soil causing increased runoff. Ultimately the hydrological cycle of the KCF would be affected.

The alterations in the forest structure, canopy openness, species composition, nutrient recycling and soil properties and watershed properties have an impact on the natural evolution and regeneration process of the forest. The changes in the forest structure, canopy openness and species composition would lead to the emergence of a different seed bank creating a different species composition which is primarily in abundance with early successional tree species. Regeneration of indigenous tree species could be mired by fast growing exotic plants (Reyes et al., 2006). In long term, continuous removal of seedlings and saplings will lead to absence of regenerating forest stand. With non-existence of replacement stand, the canopy openness will increase further, leading to increased light levels on to cardamom plants. In the long run, as the cardamom is a shade loving crop, the increased light levels would affect the growth of cardamom plants and therefore cardamom plants would disappear from the area.

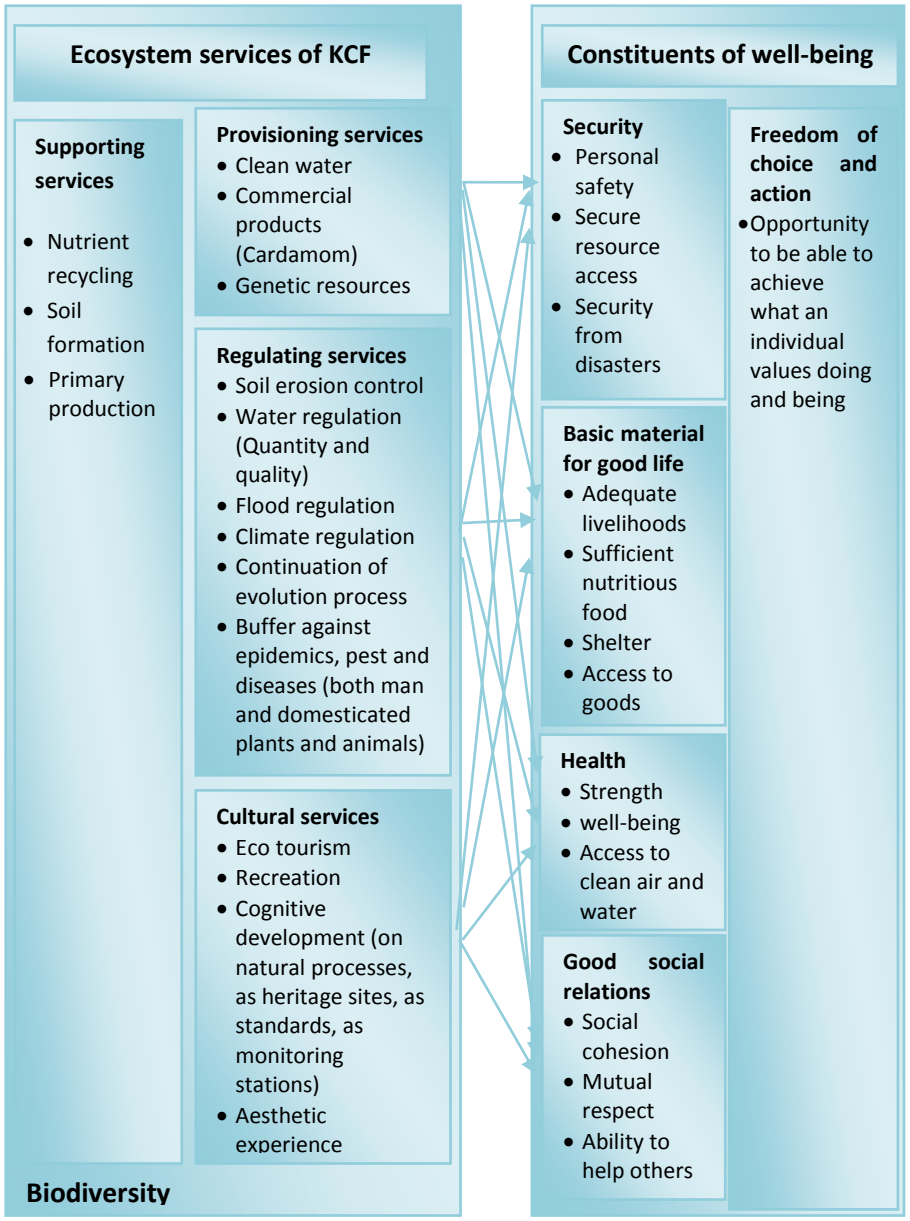


Figure 6.2: Linkages between Ecosystem Services and Human Well-being of KCF

6.2 Changes in Ecosystem Services of KCF by Continuing Cardamom Cultivation

The figure 6.1 illustrates the foremost ecosystem services obtained from the KCF. The adjustments to the direct drivers of change will alter the ecosystem services provided by the KCF as exemplified in figure 6.2.

- **Provisioning services**- There are several key services obtained by the KCF. Supply of adequate clean water to peripheral villages and to downstream communities for drinking, agriculture, hydro power generation and fisheries activities are the top most services. Supply of cardamom and genetic resources are the other important services provided. Continuation of cardamom cultivation gives financial benefits to peripheral villages, but the quality of water supplied to peripheral villages and downstream communities would be reduced if the upstream waters get polluted due to pesticides applied to cardamom lands. Loss of biodiversity by cardamom cultivation has an impact on genetic diversity.

- **Regulating services**- The major regulating services obtained from KCF include reduced soil erosion, water regulation, flood regulation, climatic regulation, buffers against epidemics and continuation of natural regeneration and evolution processes. However, continuation of cardamom cultivation has a negative impact on all above regulatory services. Removal of sub canopy and undergrowth, removal of mechanical cover of the soil by replacement of deep rooted forest trees with shallow rooted cardamom plants would cause increased soil erosion, reduction of soil infiltration capacity and soli stability, physical loss of soil, land degradation, landslides, accelerated reservoir siltation reducing the reservoir capacities and reduced dry season stream flow reducing the water availability to reservoirs and human settlements. Reduced permeability and water holding capacity and increased canopy openness result in increased flood incidence. Negative impacts on water stripping function and soil permeability has an impact on the hydrological role of the KCF which would result in reduced water supply to the areas under the Knuckles watershed area especially reducing water availability for agriculture, aquaculture and the multipurpose irrigation projects such as Mahaweli project and Moragahakanda and Kalu Ganga

irrigation project. The changes in the relative humidity, temperature, solar radiation would alter the micro-climatic conditions of the area. Breakdown of the natural balance of the ecosystem due to disturbances, additions and removals to and from the KCF ecosystem induces epidemic occurrences such as the prevailing thrips attack. The changes in the forest structure, soil properties species composition are able to modify the natural regeneration and evolution process of the KCF.

- **Cultural services** – Providing increased opportunities for eco tourism, recreation, cognitive development such as prospects for scientific research activities, set as standards to measure climatic changes and act as monitoring stations for regional and global changes in environmental conditions, global recognition as a World Natural Heritage site and aesthetic experience are the major cultural services provided by the KCF. However, the persistence of cardamom cultivation alters the scenic and environmental value of the KCF by changing the biodiversity of the forest, stream flows of rivers and waterfalls by transformed hydrological cycles. There is a risk of losing the World Natural Heritage title for not adhering to the conditions stipulated in the declaration. Subsequently, inability to maintain the World Natural Heritage title would affect the reputation of the country. Further, all above factors may reduce the tourist attraction in the area.

6.3 Impact on Human Well-being and Poverty Reduction

The changes in the above ecosystem services affect the human well-being and poverty reduction of the peripheral villages and the country.

- **Security-** Changes in provisioning and regulatory services will affect the security level of people. Reduction of availability of good quality water for drinking, agriculture and aquaculture, increased floods, soil erosion and landslides and increased epidemic incidence in agricultural crops would reduce personal safety, secure access to resources and protection from disasters.

- **Access to basic material for a quality life-** This is highly related to provisioning and regulatory services. The basic material for high quality life includes adequate livelihoods, nutritional security, good

shelter and access to essential goods and services. Permitting cardamom cultivation in the KCF opens up avenues for the people to engage in their usual livelihood activity. Availability of a sustainable income source would assure the people to access sufficient nutritious food, shelter and essential goods.

However, generation of a sustainable income source from cardamom cultivation is questionable as;

- Cardamom will not be a sustainable crop in the KCF with the current crop management practices done by cultivators in the long term.
- The prevailing heavy thrips invasion has reduced the quantity and quality of the cardamom yield.
- Productivity reduction due to reduction in soil fertility and age of the stands.

Therefore, as per the available literature and the research findings, the continuous cultivation of cardamom has long term negative impacts compared to short term benefits acquired by a small group of people and the cultivation would alter the valuable regulatory services provided by the nature.

However, banning of cardamom cultivation has a negative impact on the access to basic material for a good life of the cultivators due to loss of their livelihood. Therefore, it is required to develop sustainable alternative income sources for the peripheral villagers to earn the lost income.

- **Health-** Health conditions are mainly related to the provisioning services. As discussed earlier, allowing of cardamom cultivation causes pollution of headwaters by pesticides and other agronomic practices which have an impact on the downstream communities. Further, the recreational and aesthetic experience will have positive implications on the human health. The impact on the human health due to loss of recreation is a loss to both local and world communities since KCF is a tourist destination of both local and foreign tourists.

- **Good social relations-** This includes social cohesion, mutual respect and the ability to help others. As found in the survey, the reduced income levels of peripheral villagers by banning

cardamom cultivation have affected the social relations and mutual respect among the community members. Therefore, it is again important to identify reliable income sources for the peripheral villagers to increase their income levels.

- **Freedom of choice and action-** This implies the opportunity to achieve what an individual values doing and being. It is observable that the banning of cardamom cultivation limits the freedom of peripheral villagers to exercise their freewill to choose what they want as an income source. Apparently they are trading off their way of life for several other ecosystem services. However, it is noteworthy that the negative impact on the ecosystem services will be visible in long term. Most of them are irreversible and would incur a huge cost if needed to manage. Further, even cardamom cultivation is allowed as it is not sustainable in long run ultimately both the cultivation and the forest would be destroyed.

CHAPTER SEVEN

Findings, Conclusions and Recommendations

7.1 Major Findings

1. Cardamom cultivation practices done by encroachers: Major inputs used were new cardamom plants and agrochemicals. During crop establishment and seasonal land clearing, saplings and seedlings were removed from the cultivation area. None of the encroachers were using herbicides for weed controlling. Chemical fertilizer application was not practiced yet however, would be required if the cultivation continues since productivity is decreasing. Chemical pesticide usage has been initiated (7 percent of encroachers) as a thrips controlling measure, a need to curtail a pest spreading through the cultivations. Some of the methods used to control wild animal attacks such as gun firing and setting traps can cause harmful effects on fauna of KCF. Some of the encroachers have used terracing (74 percent) and mulching (43 percent) to control soil erosion. To control the sunlight falling on cardamom plants, removing of small trees (39 percent), removing of branches of large trees (9 percent) and removing of large trees (4 percent) were practiced by encroachers. All the encroachers have cured cardamom within the forest. Raw materials such as logs, clay and granite were acquired from the forest. All the encroachers have used firewood to cure cardamom. Twenty nine percent of encroachers have obtained firewood by felling trees while 76 percent have acquired it from the fallen trees. However, the actual figures might differ from the above figures since these illegal cardamom farmers did not divulge details of cultivation practices which have a negative impact on the forest flora and fauna.

2. A legal framework for use of conservation forests: No person can enter conservation forests for any purpose other than to carry out scientific research, to observe flora and fauna or to implement a prescribed management plan. Any other activity carried out will be unlawful.

3. Climatic variation and vegetation types found in KCF: All varieties of climatic types found in Sri Lanka are reproduced within KCF. Three major forest formation types were found in the area namely lowland tropical wet semi evergreen forests, sub montane tropical wet semi

evergreen forests and montane tropical wet evergreen forests. These were again sub divided into 17 categories. Among these montane tropical wet evergreen forests are the ecologically most important.

4. Vegetation type in Kalupahana area: The major forest formation type is montane tropical wet evergreen. Hydrological importance and characteristic bio diversity are important services provided by them. The trees in these forests are rich in epiphytes mosses and lichens. The area is mostly covered with clouds due to higher altitude. Therefore, the trees will intercept wind driven cloud moisture and will add additional water to the ground throughout the year. Hence, these forests are important for the continuous water supply to downstream villages. Consequently, any alteration to the forest by cardamom cultivation will change the hydrological role of the area and thus, affect the downstream villages.

5. Floral and faunal diversity of KCF: Due to the common geological origin similar to the Central Highlands the biota of the area is showing many similarities while exhibiting various differences. There are 1033 flowering plant species out of which 15 percent is endemic. There are 450 woody plant species of which 34 percent is endemic. Out of that, 71 species are globally threatened. There are 83 orchid species of which 42 percent is endemic and 55 species are nationally threatened. With regard to faunal diversity there are 92 families of vertebrates belonging to 231 genera. The total number of species found was 338 out of which 29 percent is endemic. Twenty eight species are globally threatened.

6. Deviation of forest structure and canopy openness following cardamom cultivation: Mean tree density of saplings seedlings and trees ≥ 5cm dbh was lower in cardamom cultivated forest compared to natural forest. The major causes for this were removal of trees during cardamom stand establishment weed control solar radiation control, barn construction and acquiring firewood for cardamom curing. The mean canopy openness was 29 percent higher in cardamom planted forest compared to natural forest due to selective removal of trees to allow solar radiation falling on cardamom plants. Increased light levels have promoted growth of light demanding pioneer tree species. This will ultimately impact on the structure and species composition of the forest community across all size classes.

7. Impact of cardamom cultivation on soil properties: Mineralization of organic matter, leaching losses, de-nitrification amplified by continuous soil disturbances, increased canopy openness and reduced mechanical support to soil by replacing deep rooted forest trees with shallow rooted cardamom plants have resulted in altered soil properties such as reduced Nitrogen concentration and reduced depth of A horizon. This will lead to deviation of desired functions of forest soils such as physical loss of soil, land degradation, loss and depletion of forest cover, reduced or absent dry weather stream flow, local climatic changes and undesirable off site effects such as reservoir siltation and increased incidence of landslides.

8. KCF as a catchment area for irrigation projects: The total drainage system of KCF flows into Mahaweli river as many of its tributaries start from the Knuckles range. KCF is the watershed area to Victoria, Randenigala, Rantambe and recently initiated Moragahakanda and Kaluganaga irrigation schemes.

9. KCF as a World Natural Heritage and impact of cardamom cultivation on the title: Being a World Natural Heritage site, KCF brings several benefits to the country such as tourism, funding assistance and financial support, world recognition and support for research and development. Inability to remove cardamom cultivations from KCF, which is one of the conditions in declaration of KCF as a World Natural Heritage site, will lead to losing of the title. If the title is removed it will bring negative impacts to the country in terms of a tourist destination, and it will blemish the country's image as being unable to maintain a natural heritage title thus funding assistance and financial support will be withdrawn.

10. Socio-economic features: Majority of encroachers were landowners who have worked in cardamom fields (74 percent). Two thirds of the encroachers live in Halminiya, Narangamuwa and Ranamure GN divisions. Seventy two percent of encroachers were above 50 years of age. Average family size was 4.1. Forty one percent of the encroachers have received education up to grade 6-11.

11. Employment of encroachers before and after banning cardamom cultivation: Cardamom cultivation was the primary source of income for 90 percent of the encroachers before the ban was imposed. Paddy cultivation was the primary source of income for 31 percent of

encroachers after banning the cultivation. Twenty one percent of cultivators have chosen vegetable cultivation while 16 percent have moved towards unskilled labour after imposing the ban on cardamom cultivation.

12. Household income level before and after banning cardamom cultivation: Before banning cardamom cultivation the mean income for total encroachers was Rs.48,638 per month. Before banning cardamom mean income for land owners was Rs.54,771 per month which has reduced to Rs.18,197 per month after banning the cardamom cultivation. This is a significant reduction in the income level. For labourers, the monthly mean income before the ban was Rs.11,021 per month which has increased to Rs.15,067 per month after banning. However, there is no significant difference between these two values.

13. Problems faced by encroachers after banning cardamom: The major difficulty faced by the encroachers was losing of livelihood activity and income. Sixty six percent of encroachers could not bear the living cost due to reduction in income level. Forty eight percent of encroachers faced difficulties in spending on children's education while 35 percent has faced problems in repaying loan and debts. For 14 percent of encroachers the loss of income from cardamom cultivation has affected their social recognition and relationships. The other major difficulties faced by encroachers after banning cardamom cultivation were agricultural input and marketing related issues, collapse of future plans, inability to carry out of housing construction and repair and mental stress due to income loss.

14. The remedies proposed by encroachers: Seventy four percent of encroachers preferred a monetary compensation of Rs.100,000 per acre. They stated it will help invest in alternative income sources. Seventy three percent of encroachers suggested providing land to the affected farmers for cultivation of pepper. The encroachers mentioned that this is a promising crop in the area. Seven percent of encroachers requested for assistance for self-employment which some of the farmers have already started. The other proposed remedies were providing solutions for problems related to agriculture such as wild animal damages, irrigation and marketing issues and assistance for cultivation of export agricultural crops. Five percent of cultivators proposed to allow cardamom cultivation again.

7.2 Conclusions

1. KCF accounts for a bountiful ecosystem services. Provision of clean water, commercial products such as cardamom and preserving genetic resources depict the major provisioning services. Soil erosion control, water regulation, flood regulation, climate regulation, continuation of natural regeneration and evolution process and buffer against epidemics describe major regulatory services. Ecotourism, aesthetic experience, recreation and supporting cognitive development by serving scientific research illustrate cultural services.

2. However, the research substantiates the fact that the cardamom cultivation alters the forest structure, canopy openness, species composition, soil properties, watershed properties and natural regeneration and evolution processes of KCF.

3. These changes will result in undesirable modifications of ecosystem services. For instance, reduction of water quality, depletion of genetic resources, increased soil erosion, changes in hydrological role, climate and natural regeneration and evolution processes will also negatively impact on cardamom productivity and crop sustainability.

4. Hence it is apparent that allowing cardamom cultivation in KCF is not a sustainable means of poverty alleviation since it will provide long term negative impacts over the short term positive impacts which in turn will affect the human well-being of peripheral village community including cultivators and others communities that receive ecosystem services.

5. Cardamom cultivation in Kalupahana area of the Knuckles Conservation Forest was the primary source of income for a majority of cardamom cultivators in the Laggla- Pallegama DS division before the ban. It has assisted them to earn a substantial income.

6. After banning cardamom cultivation they have moved towards various alternative income sources in both agricultural and non agricultural sectors where most were either short term or associated with an increased risk. The mean household income has reduced significantly to a level even lesser than national average.

7. Loss of livelihood activity and reduced income, inability to bear living cost, incapability to afford medical and educational expenses, failure to settle debts and loan installments, affecting of social recognition, stalled house construction and repair activities were the major problems encountered by cultivators after banning the cardamom cultivation.

8. Paying a monetary compensation, providing alternative lands for pepper cultivation, assisting in alternative income sources, providing solutions for the problems encountered in agricultural activities and allowing cardamom cultivation were the proposed key remedies by cultivators.

7.3 Recommendations

1. **Banning of cardamom cultivation should be continued in KCF**
   Since the long term environmental cost is greater than the socio-economic cost on the peripheral villagers, the ban on cardamom cultivation in KCF should continue. Natural regeneration should be allowed in cardamom planted forests without disturbing the forest. In Dothalugala area of KCF which is a cardamom cultivated area about 50 years ago, has successfully recovered to the status of a natural forest, after abandoning the cardamom cultivation. Therefore, cardamom plant cannot survive in the natural forest stand unless it is maintained. However, continuous monitoring should be undertaken to observe the regeneration process and the Forest Department should intervene where assisted natural regeneration is required.

2. **Collaborative monitoring process**
   For the monitoring process of forest regeneration FD can get the collaboration of peripheral villagers since Kalupahana area is situated in the middle of KCF and FD is lacking human resources to pay frequent visits to those areas. This will help bridge the gap between the FD and the community of the peripheral villagers, rewarding them with mutual benefits.

3. **A deliberate holistic, multi dimensional approach should be adopted to recover the income loss of encroachers by creating alternative sustainable income sources.**
   Due attention should be paid to people's willingness, compatibility to the area and long term sustainability of these methods.

4. **Provide suitable state owned forests and village forests which are situated outside the KCF boundary to selected farmers for export agricultural crop cultivation**

   For selected vulnerable encroachers state owned forests and village forests which are situated outside the Knuckles boundary should be given under the guidance of local government authorities and FD for commercial export agricultural crop cultivation under agro forestry systems, whilst providing initial financial and technical assistance with the collaboration of the Department of Export Agriculture. (Eg: For Pepper and cardamom cultivation).

5. **Assisting self-employment**

   Provide financial and technical assistance for the identified people to develop self- employment ventures by linking with ongoing national development programmes which will help them meet financial and training requirements.

6. **Assistance for agriculture based employers**

   The issues faced by people who have moved towards paddy and vegetable cultivations should be properly addressed. New crop varieties, technical know-how and ways to deal with marketing problems should be addressed with the assistance of Department of Agriculture. The emerging problem of elephant damages should be addressed as early as possible with the collaboration of FD, Department of Wildlife Conservation and local government authorities.

7. **Infrastructure development in the area of Laggala-Pallegama**

   Being a rural area with less developed infrastructure facilities in Laggala-Pallegama area people have limited exposure to the external world when they search for other employment opportunities. Especially the road and transport facilities are poor. For example to enter Atanwala village one has to walk about four kilometers by climbing steps as the village is not accessible in vehicles while for Narangamuwa vehicles can only access up to a certain extent of the village. Therefore these facilities should be improved.

8. **Awareness creation on the importance of KCF**

   FD with the collaboration of local government authorities should conduct awareness programmes for peripheral villagers to educate them about the importance of KCF for their own benefit and the

negative implications upon its destruction. The awareness programmes should have a two-way communication where FD can receive the feedback of the people while addressing the difficulties faced by people due to restricting them from using forest resources.

9. **Encourage farmers to underplant cardamom by providing plantation forests**

   Cardamom cultivation should be encouraged in forest plantations such as Pinus, Eucalyptus and Acacia on a long term lease basis and in home garden agro forestry systems in potential areas such as Thangappuwa and Kabaragala. Cardamom cultivation is already being practiced in those areas and there is a potential to obtain 40kg per acre per 45days of raw cardamom from the area. To promote this, initial financial and technological support should be provided under the guidance of FD and the Department of Export Agriculture. This will help recover the lost income resulted by banning the cardamom cultivation in Kalupahana area.

10. **Ecotourism**

    Ecotourism is becoming popular in the area by being a Natural World Heritage site. However, the direct benefits are most unlikely to reach the local communities. According to the study findings, there is a number of educated youth in the area even among the affected families. At present the people from the peripheral villages are working in eco-tourism activities as labourers or trackers. This requires to be changed and the educated youth found in the areas should be redirected more towards white collar jobs in the sector allowing them to obtain direct benefits of having a World Natural Heritage site in the area.

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