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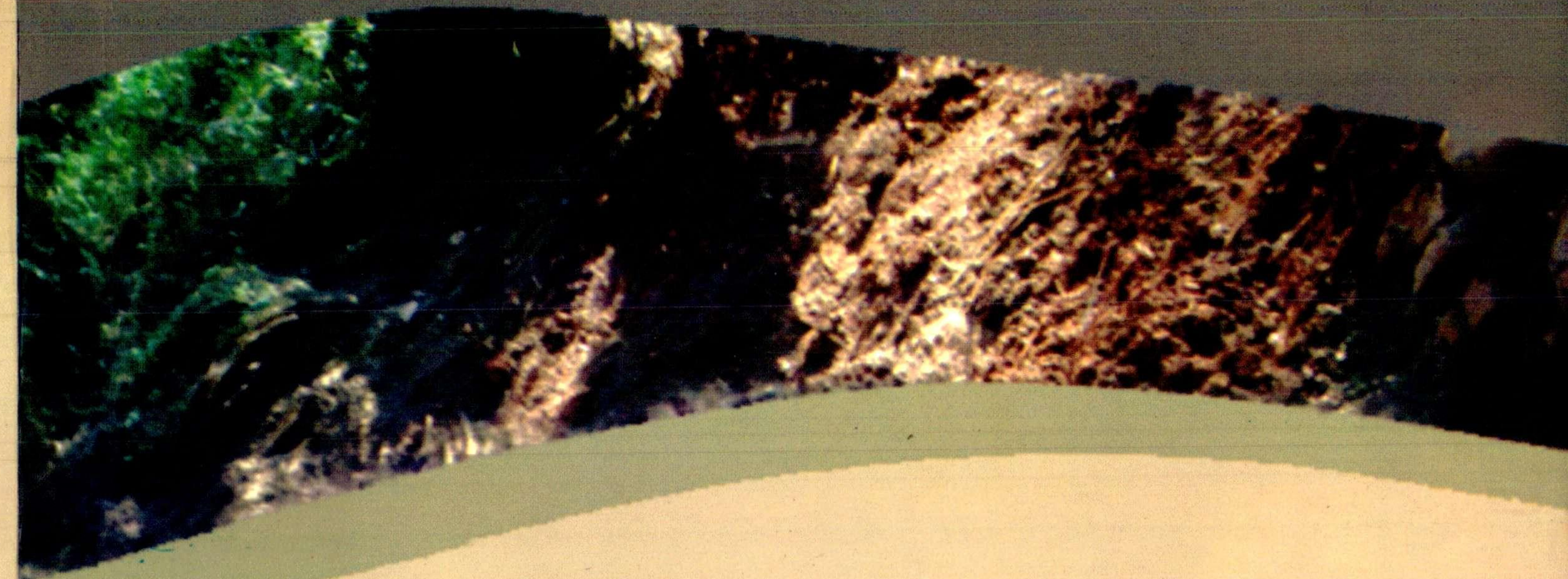

NATURAL RESOURCE MANAGEMENT PERSPECTIVES IN UPCOUNTRY VEGETABLE PRODUCTION: FARMERS' KNOWLEDGE, ATTITUDES AND RESPONSES

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Foreword

Agricultural activities throughout the world contribute to environmental degradation. Therefore, integration of environmental concerns into agriculture has been increasingly recognized. This research report is an outcome of a similar endeavour initiated in 2007 by the Environmental and Agricultural Resource Management Division of the Hector Kobbekaduwa Agrarian Research and Training Institute.

The study was established aiming at generating data and information pertaining to farmers' knowledge, attitudes and responses towards the management of natural resources and protecting the environment in the up-country vegetable farming systems. The principal question to be answered through this explorative study was 'why farmers are reluctant to employ eco-friendly farming techniques?'

The study attempted to assess the means of acquiring knowledge by the farming community about eco-friendly plant protection measures such as use of *neem* and integrated pest management and soil fertility management practices such as use of organic manure, soil test based fertilisation and organic farming. In spite of the fact that the lack of adequate knowledge has refrained farmers from using these technologies, the knowledgeable farmers are too disinclined to venture into their use for many reasons. The application of eco-friendly plant protection measures are largely constrained due to inadequate knowledge and shortage of raw materials. Misconceptions too prevail on the certainty of results. Scarcity, the high cost transportation and the issue of conversion period are the major hindrance for the use of organic manure. A host of constraints hamper the practice of organic farming and soil test based straight fertilisation. Having studied these aspects, the study suggests innovative ways to collectively address the inter-related issues of sustainable resource management and eco-system restoration, so as to internalize the environmental costs of up-country vegetable production.

I believe that this report will serve as an important reference material for development decision making in both agriculture and environment sectors in Sri Lanka.

L.P. Rupasena
Actg. Director/HARTI

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We also like to extend our sincere appreciation to our external reviewer Dr. H.B. Nayakkorala (former Director of the Natural Resource Management Centre) for the excellent feed back which helped us to improve the content of the report. The comments and suggestions provided by Mr. J.K.M.D. Chandrasiri, Head, Agricultural Policy and Project Evaluation Division and Dr. L.P. Rupasena, Deputy Director (Research) of HARTI are highly appreciated. We extend a note of thanks to Mr. V.K. Nanayakkara, former Director, HARTI for his observations. We also like to thank Mr. N. Thalagune, Editor, HARTI for the editorial assistance. Finally, our appreciation goes to Mr. S. Rameshwaran, Acting Head/Publication Unit of HARTI for proof reading the final report and to the printing staff of HARTI for the printing of the report.

Authors

Abbreviations

AEZ	:	Agro Ecological Zone
ARPA	:	Agricultural Research and Production Assistant
ASC	:	Agrarian Service Centre
ASOCON	:	Asian Soil Conservation Network Coordination Unit
CIC	:	Colombo Industries Chemicals
COP	:	Cost of Production
DBM	:	Diamond Back Moth
DL	:	Low-country Dry Zone
DOA	:	Department of Agriculture
DS	:	Divisional Secretariat
EA1P	:	Environmental Action 1 Project
ERP	:	Eppawala Rock Phosphate
EZ	:	Eco-zone
FAO	:	Food and Agriculture Organisation
FIVIMS	:	Food Insecurity and Vulnerability Information Mapping System
FMP	:	Fused Magnesium Phosphate
FYM	:	Farm Yard Manure
GND	:	Grama Niladhari Division
GO	:	Government Organisation
HARTI	:	Hector Kobbekaduwa Agrarian Research and Training Institute
HORDI	:	Horticultural Research and Development Institute
IL	:	Low-country Intermediate Zone
IM	:	Mid-country Intermediate Zone
IPNM	:	Integrated Plant Nutrient Management
IPM	:	Integrated Pest Management
IRDP	:	Integrated Rural Development Project
IU	:	Up-country Intermediate Zone
IWMI	:	International Water Management Institute
NEAP	:	National Environmental Action Plan
NGO	:	Non-government Organisation
NPK	:	Nitrogen, Phosphorous, Potassium
NRM	:	Natural Resource Management
OP	:	Open Pollinated
PM	:	Poultry Manure
REAP	:	Regional Economic Advancement Project
RMT	:	Rapid Multiplication Technique
SALT	:	Sloping Agricultural Land Technology
SPNI	:	Soil Plant Nutrient Interrelationships
TPS	:	True Potato Seed
TSHDA	:	Tea Small Holding Development Authority
TSP	:	Triple Super Phosphate
UNDP	:	United Nations Development Programme
UNEP	:	United Nations Environment Programme
UPVEGSYS	:	Up-country Vegetable Farming Systems
UWMP	:	Upper Watershed Management Project
WM	:	Mid-country Wet Zone
WU	:	Up-country Wet Zone

Executive Summary

The production of up-country vegetables in Sri Lanka has increased ten fold in the 21st century. Year round production of up-country vegetables with increased utilisation of agro-chemicals has had impacts on the triple compartments of the environment; land, air and water. Over time different resource management options have been suggested and diverse strategies have been adopted to conserve the natural resource base of the UPVEGSYS. Given this context, the main objective of this study was to assess the farmers' knowledge, attitudes and responses towards both the environmental problems associated with the up-country vegetable production and the eco-friendly farming techniques for the management of the natural resource base within the farming systems.

The study area covered the four districts with the largest extents of up-country vegetables; Badulla, Nuwara Eliya, Kandy and Matale. A sample of 223 farmers was chosen from 14 distinct agro ecological zones. The collection of data employed several methods; review of literature, discussions with key stakeholders and informants in the up-country vegetable farming system, questionnaire surveys and focus group discussions. Of the 14 Agro-ecological zones within the four selected districts, only six categories referred to as eco-zones (EZs) were considered during the data analysis.

The study findings show that the up-country vegetables are largely grown in the Badulla and Nuwara Eliya districts with the Kandy and Matale districts being the next two prominent districts. The ever spreading cultivation has extended to the areas of six districts surrounding the hill country. Currently, over 40,000 ha are grown with up-country vegetables within a diverse range of agro-ecological zones but only 14 zones predominate. The largest share of up-country vegetables is grown in the IU (42 percent) and WU (33 percent).

The literature review surfaces three major environmental impacts namely fertiliser pollution, pesticide pollution and land degradation due to soil erosion. The expansion of the area under such vegetables has links to its sustainability too. Build up of nutrients on the soils and water bodies (eutrophication) due to excessive fertilisation attributed to longer use of fertiliser mixtures and soil acidity are the problems of inorganic fertilisation. Use of highly hazardous and restricted pesticides and build up of resistance in pest are the pesticide related issues known for long. Soil erosion in steep lands uncovered for the up-country vegetable production with lack of inadequate conservation measures is alarming.

Efforts have been made to build farmers' awareness on the said environmental impacts. Overall, 59 percent of the sample farming community has never been exposed to extension programmes. The rest have been exposed to programmes on general agricultural knowledge, new technology and information and skill development largely through training programmes, lectures and seminars. Attempts to provide practical orientation through field days and demonstrations appear minimal. The level of farmers' knowledge on the said environmental impacts varies across locations. The number of knowledgeable farmers is comparatively higher in the Badulla district than other districts but more farmers in WU, WM and IU are knowledgeable on eco-zone basis.

Farmers' knowledge on selected eco-friendly plant protection methods, *neem* and IPM are far below than that of chemical methods. Adoption of such measures is lower than their knowledge levels. It is evident from the study that a number of reasons restrict the application of eco-friendly plant protection measures. Further, a variety of organic manure and straight fertilisers are used in the UPVEGSYS but the wider use of them is restricted due to many reasons as has been highlighted in the report. Organic farming is well-known to the majority of the vegetable growers, but a host of constraints hamper the practice of organic farming.

The study concludes that, in response to concerns on sustainability grown over time several efforts have been made to address key environmental issues though there has been a failure to maintaining the true sustainability in the farming systems. The knowledge of the farming community on eco-friendly cultural methods shows a spatial variation. Changes made by project-based interventions in terms of knowledge and attitudes of the farming community in certain locations are significant. However the adequacy of applying such eco-friendly practices which were mostly incentive based is unsatisfactory after the project period. Evidence suggests that the contents of the extension programmes are in right direction but there exists inequity in access to them and the programmes lack sufficient practical orientation. Overall, the farmers have a satisfactory level of knowledge about eco-friendly farming techniques though their application is constrained due to a number of factors distinctive to each method.

The study suggests a range of recommendations; strengthening and meaningful utilisation of data gathered at the grass-roots level to provide trade offs to farmers for sustainable utilisation of land with eco-friendly practices in compliance with agro-ecological variations, incentives to promote low input agriculture in the up-country vegetable production, research into developing more economically and environmentally viable cropping systems and land management technologies affordable to farmers who utilise fragile land categories in the UPVEGSYS covering a number of important aspects; avoid shortcomings of soil test based fertilisation, ensure increased mobility of straight fertilisers and provide simple guidelines to optimisation of chemical fertiliser use for up-country vegetables; strengthening of knowledge and technology dissemination process through making changes in extension curriculum, teaching methods and extent of investment; efficient utilisation of the potential of agricultural research and production assistants to promote sustainable agriculture at the grass-roots level that should comply with productivity, profitability and sustainability and strengthening policy spheres by incorporating environmental issues that are inadequately emerged at policy level.

List of Contents

List of Tables

List of Figures

Appendixes

Chapter One

Introduction

1.1. Background

The vegetable cultivation is an integral part of the smallholder sector in the up-country regions of Sri Lanka. Dispersed largely within the upper watersheds, it is characterised by year round production of vegetables in erodible landscapes with the increasing utilisation of agro-chemicals. Thus, it is becoming more and more perceptible that this system of cultivation is having severe consequences on the triple compartments of the environment; land, air and water.

The scientific literature discloses how diverse agricultural practices adopted in this vegetable farming system cause adverse environmental impacts. In particular, the erosive cultural practices adopted in the production of potato and vegetables have led to land degradation due to soil erosion, particularly in the hilly areas (UNEP, 2001). The pollution of land and water, loss of biodiversity as well as onsite and offsite effects of soil erosion has both temporal and spatial impacts. The fact that soil erosion leads to a decrease in the productivity of agricultural crops is a concern today and is found to be understood by the farmers to a certain extent. But, the farmers' knowledge on other environmental effects and impacts (externalities) such as agro-chemical pollution and its cost on agriculture is less understood. Inherently non quantifiable, these externalities have received little consideration at the decision making forum, thus not being addressed in sectoral policies too.

A variety of resource management options have been suggested to this diverse farming system. The UNEP (2001) emphasises the need for formulation of a strategy to wean rural people away from land-based employment, particularly in the critical watersheds in the central highlands. In contrast, the production of up-country vegetables has grown ten fold since 1970 and has become an important means of livelihood to the up-country communities in the 21st century. This confirms that people weaning from vegetable cultivation is an impractical alternative for protection of the environment in the up-country regions.

In the meantime, Samarathunga and Chandrasekara (2002) have suggested a design-based-per-hectare subsidy in the form of in-kind assistance with provision of information through research and extension as the most appropriate economic instrument for protection of the natural resource base utilised for the production of up-country vegetables. Attempts were made to overcome the said adverse environmental impacts through farmer education and training on soil conservation, integrated plant nutrient management (IPNM) and the provision of incentives for adopting these practices (chapter 2).Vast investments have also been made through specially designed projects and programmes. However, these efforts made to manage the key natural resource management problems in the up-country vegetable farming systems by various organisations (both government and non-government) have only been partially understood and assessed.

Despite this, the up-country vegetable production in the districts of Nuwara Eliya, Badulla, Kandy and Matale (study locations) has been gradually increasing (chapter 3; figure 3.1). From the trend of expansion, one could conclude that the up-country vegetable cultivation might be occurring at the severe expense of the environment. Nevertheless, how have farmers learnt this phenomenon? The following is a list of researchable aspects that would come into ones' mind.

- Did farmers learn about the key environmental/natural resource management (NRM) concerns in the up-country vegetable production?
- Do they recognise the relative prevalence of the above concerns and their magnitude?
- What are the interventions (projects and programmes) made by the various institutions (GOs and NGOs) to popularise eco-friendly farming techniques specially during the last decade?
- To what extent, the above interventions have succeeded and been integrated into the vegetable farming systems?
- What are the appropriate interventions and replicable eco-friendly farming technologies/packages adopted by farmers in the area?
- What are the major drawbacks of eco-friendly farming techniques so far introduced?
- What changes are required in the research and extension process?
- What adjustments and incentives (social, economic or policy related) would lead to optimal resource management (sustenance) in the up-country vegetable production?

Therefore, an investigation into the above aspects appear to be an important lesson to learn and generate information useful in recognising policy options that would ensure environmental and economic sustainability of the up-country vegetable production systems.

1.2. Objectives of the Study

The main objective of the study is to assess farmers' knowledge, attitudes and responses towards both the environmental problems associated with the up-country vegetable production and eco-friendly farming techniques for the management of the natural resource base of the up-country vegetable farming systems.

1.3. Specific Research Objectives

1. Identification of key natural resource management (NRM) problems in the up-country vegetable production through literature review,
2. Assessment of farmers' knowledge about the identified NRM problems and their relative significance in their farming systems,
3. Brief review of stakeholder contribution to the introduction of eco-friendly farming techniques over the last decade,
4. Assessment of the farmers' knowledge, attitudes and responses towards adopting eco-friendly farming techniques during vegetable production, and
5. Provision of appropriate recommendations in relation to research and extension efforts towards popularisation of conservation oriented farming techniques.

1.4. Study Methods

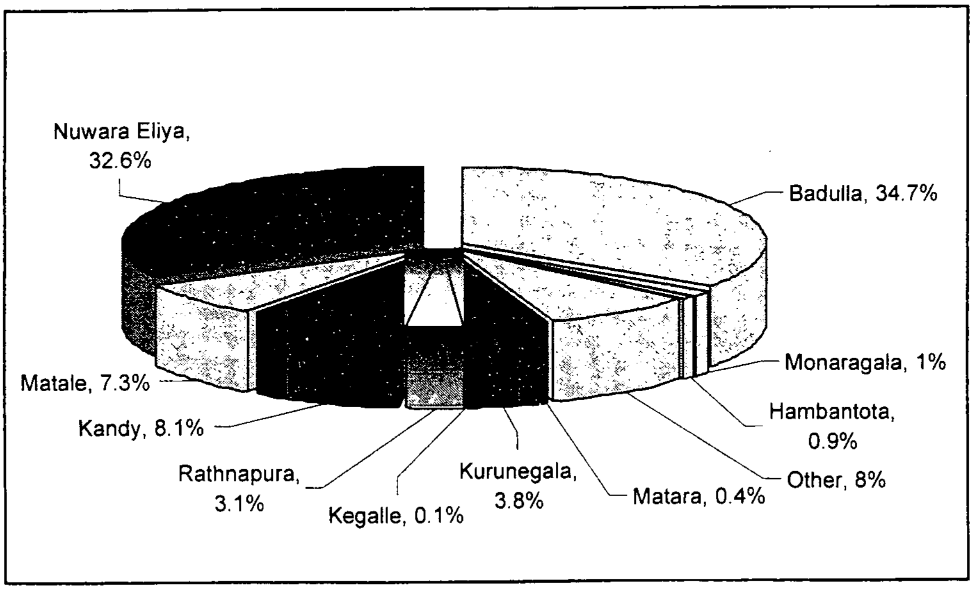
There were two major aspects of the study, namely 'Up-country Vegetable Farming Systems' (UPVEGSYS) and eco-friendly farming techniques or 'conservation farming techniques'. The Department of Agriculture (2007) has categorised vegetables including bean, carrot, radish, cabbage and cauliflower, knol khol, beet root, tomato, leeks, lettuce and capsicum as up-country vegetables. At GN level data is not available for cauliflower and lettuce. Further, potato is not included under up-country vegetables though it is a major crop in up-country farming system. However, there is a lack of spatial demarcation of the area producing these vegetables to date. Therefore, the areas of the up-country districts producing above mentioned vegetables and potatoes (exept cauliflower and lettuce). Accordingly, the ten crops, refered to as upcountry vegetables in this report are considered UPVEGSYS in this exercise.

Conservation farming is a system which meets farmers' required level of production within the socio-economic circumstances, while maintaining the quality of environment (ASOCON, 1991). It is defined as a broad system of land and water use which aims at achieving sustained agricultural production, while minimising the use of high cost of inputs i.e. energy, machinery, fertilisers, pesticides, weedicides (Commonwealth Secretariat and Government of Sri Lanka, 1983). The whole or appropriate mix or individual techniques in this study are referred to as conservation farming techniques or eco-friendly farming that help optimise resource use on sustained basis in accordance with the aforesaid definition.

1.4.1 Study Location and Sample Selection

In the absence of a clear demarcation of the spatial variation of UPVEGSYS district level data for 2006, appendix 1 provides a basis and a guideline towards the choice of the study locations. Figure 1.1 depicts the percentage distribution of the land extent for up-country vegetables in 2006.

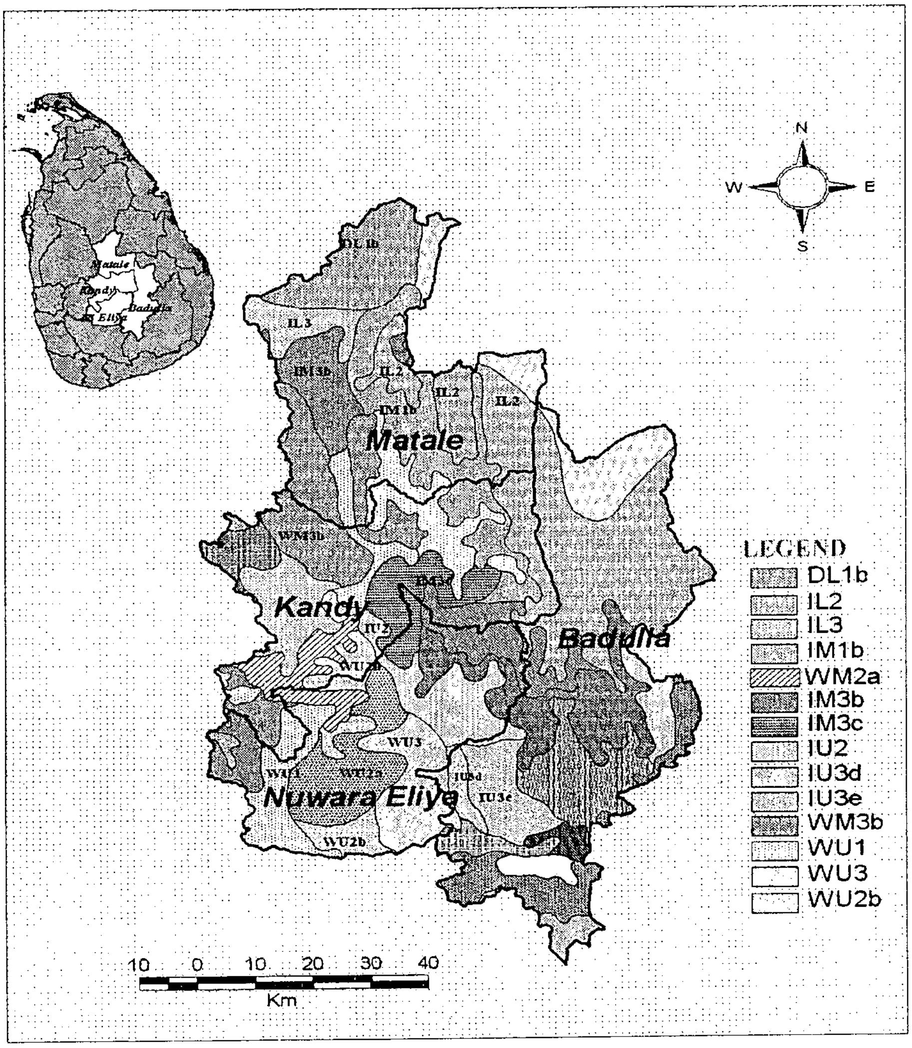
Figure 1.1: Percentage Distribution of the Land Extent for Up-country Vegetables by Districts (2006 Data)



As shown in figure 1.1, the largest extents of ten up-country vegetables are found in the Badulla district (34.7 percent) followed by the Nuwara Eliya district (32.6 percent), Kandy district (8.1 percent) and Matale district (7.3 percent). In each of these districts, almost all of the divisional secretariats (DSs) cultivate at least one of the ten selected vegetables (Department of Census and Statistics, unpublished data). While the other districts cultivate a number of up-country vegetables, the extent is around 8 percent. The four main districts cultivating up-country vegetables are located in the central hill country, which denotes an expanding extent of land under up-country vegetable cultivation (chapter 3; figure 3.6).

The study area covered the four districts of Badulla, Nuwara Eliya, Kandy and Matale. These four districts comprise 32 agro-ecological zones (AEZs) and out of which only 14 dominate with regard to the production of ten selected up-country vegetables at DS and ASC levels, and therefore they are within the purview of the study for sample selection (figure 1.2).

Figure 1.2: Agro-ecological Zones within Study Locations



Source: HARTI FIVIMS Secretariat, 2008

The selection of sample farmers covered 37 Grama Niladhri Divisions (GNDs) in 16 Agrarian Services Centres (ASCs) from 13 DSs of the four districts in the 14 AEZs as presented in table 1.1. Appendix II provides a more detailed outlook of the study locations by districts, Divisional Secretariats and Agrarian Services Centres.

Table 1.1: Distribution of Sample by Study Locations

Districts	Agro-ecological Zones	Divisional Secretariats	Agrarian Services Centres	*Grama Niladhari* Divisions	Number of Househods
Matale	5	5	5	16	78 (35%)
Nuwara Eliya	4	3	4	9	50 (22%)
Badulla	2	1	3	6	43 (19%)
Kandy	4	4	4	7	52 (23%)
Total	14	13	16	37	223 (100%)

Source: Survey Data, 2008

However, a broader categorisation of the study areas was to make the analysis less complicated. Thus, out of the 14 AEZs, only six categories referred to as eco-zones (EZs) were considered in the data analysis, namely the low-country dry zone (DL), low-country intermediate zone (IL), mid-country intermediate zone (IM), mid-country wet zone (WM), up-country intermediate zone (IU), and up-country wet zone (WU), where only rainfall and altitude parameters were taken into account (figure 1.3). Appendix III indicates the distribution of farm households by both AEZ and EZ categories.

The respective Divisional Officer of the ASC assisted in the selection of villages from each ASC and the villages were selected based on the intensity and the variety of up-country vegetables cultivated. Thus, 37 villages (appendix II) were selected and the respective Agricultural Research and Production Assistant (ARPA) of the village provided the farmer lists in view of the selection of farmers for the field survey. A total number of 223 farmers were selected and interviewed for collection of detailed data and information through a structured questionnaire. The distribution of farmers in selected agroecological zones is presented in figure 1.4 and in appendix III. Figure 1.5 graphically presents the study locations by districts, DSs, ASCs, AEZs and villages.

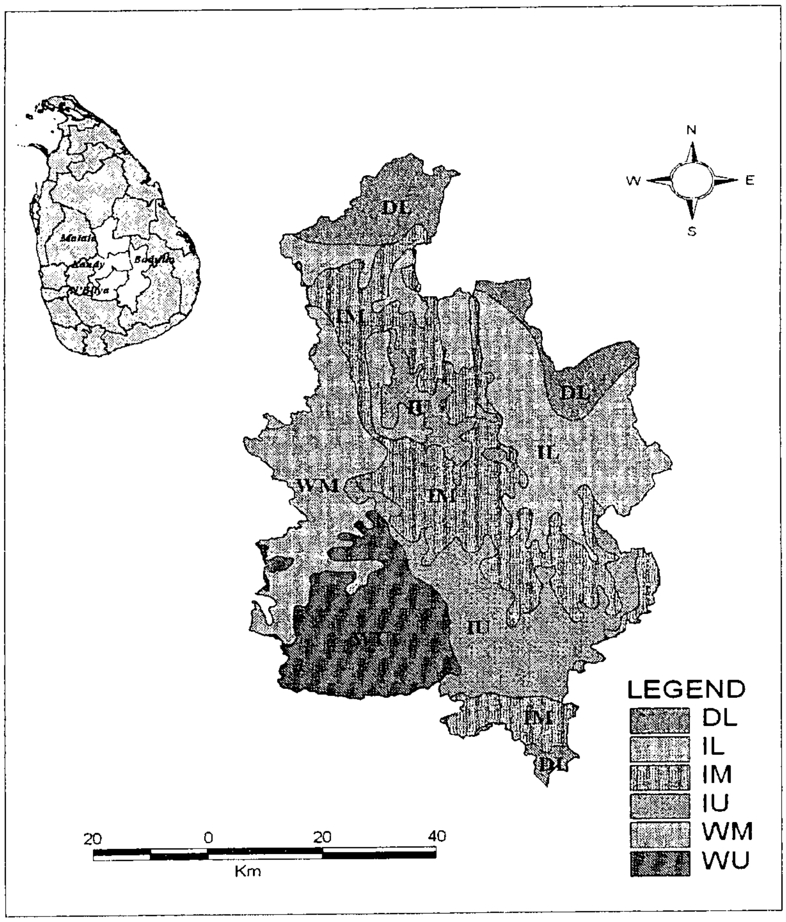
1.4.2. Data Collection Methods

Several study approaches were employed in order to collect the data and information required for the study. Included were; (a) review of literature, (b) an explorative survey by conducting discussions with the groups and individuals of key stakeholders and informants in the up-country vegetable farming system, and (c) questionnaire surveys.

(a) Literature Survey

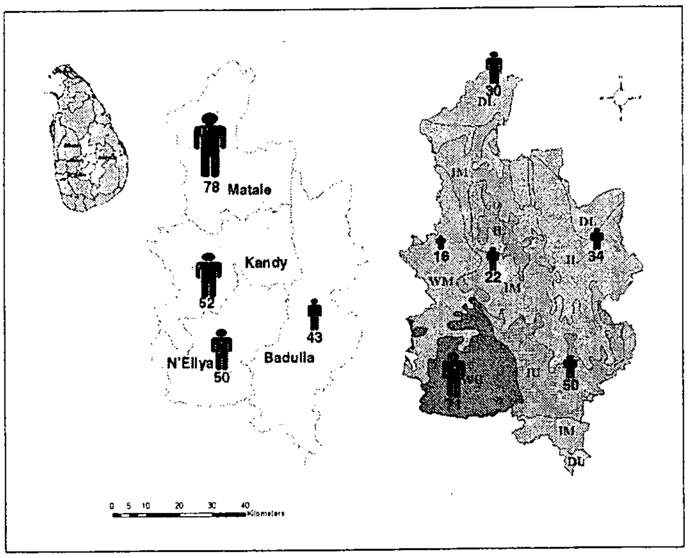
The literature survey included the review of research outputs and personal experience gathered by scientists in the area of resource use and management in the up-country vegetable farming systems through personal contacts and the review of published and unpublished information sources.

Figure 1.3: Location of Eco-zones within Study Districts



Source: FIVIMS Secretariat of HARTI, 2008

Figure 1.4: Distribution of Sample by Districts and Eco-Zones



Source: Survey Data, 2008

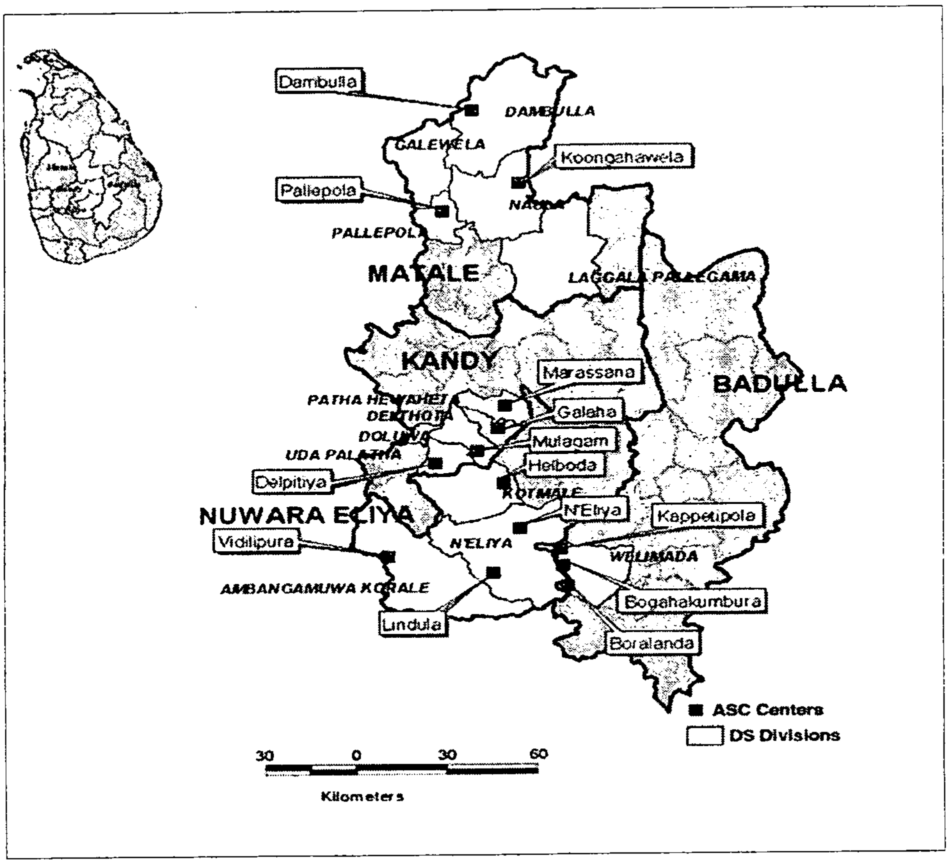
(b) Explorative Survey

An explorative survey was conducted to identify various stakeholders and their contribution (projects and programmes) to the up-country vegetable farming systems. It was based on discussions with key personnel in the field of agriculture in the selected districts and the related data and information obtained from the respective District Secretariats. This attempt comprised collection of secondary data and information pertaining to eco-friendly farming interventions by various partners, especially during the past decade. Attention was also paid to gather information on the interventions by both the government and the non-government organisations in helping and motivating farmers towards adopting eco-friendly farming techniques.

(c) Questionnaire Survey

A structured questionnaire survey was carried out to gather information on several aspects of the sample of the farming community. This enabled to gather data and information on current knowledge and response towards adopting eco-friendly farming techniques by the farming community. In addition to collection of data and information on socio-economic features of the sample population, special attention was paid to gather data on three major environmental impacts, namely land degradation, fertiliser pollution and pesticide pollution and eco-friendly farming techniques.

Figure 1.5: Study Locations by Districts, Divisional Secretariats, Agrarian Services Centres



Source: Survey Data, 2008

1.4.3. Analysis

The data analysis was carried on the basis of both district and eco-zone categories and was limited to simple descriptive analysis.

1.5. Report

The report is organised into six chapters. Followed by the introductory chapter, the second chapter records the literature review in relation to key environmental concerns in UPVEGSYS, the research and extension efforts towards its sustainability through a variety of interventions by partner organisations. The third chapter describes the physical distribution of UPVEGSYS and the fourth chapter is an attempt to provide a description of the sample of the farming community based on the four major up-country vegetable growing districts. This includes statistics pertaining to both socio-economic and production aspects of the sample of the farming community. The fifth chapter is devoted to discussing the study findings. It begins with an effort on raising farmers' knowledge and their responses towards the same, with particular reference to three major environmental concerns in UPVEGSYS; soil degradation, pesticide pollution and fertiliser pollution. Conclusions and recommendations are given in the final chapter.

Chapter Two

Literature Survey

2.1. Introduction

In line with the first objective of the study, i.e. the identification of the key natural resource management (NRM) issues in UPVEGSYS, this chapter presents the review of literature. It appears that a wealth of information is found in the literature which has intensively discussed the environmental effects and impacts on the production of up-country vegetables. Information can also be gathered which emphasises the shift towards a precision system of agriculture which protects the environment -- has been seen as essential. Hence, the major concern of this conceptual review was to bring to light the natural resource management issues and conservation options suggested to UPVEGSYS. Finally, it covers conservation options in terms of policies and programmes so far executed in UPVEGSYS.

2.2. Natural Resource Management Issues in UPVEGSYS and Conservation Options

This section attempts to reveal, how the expansion of UPVEGSYS links to its sustainability. Any sustainable land use system should meet the following broad tests.

- Maintain soil pH and physical structure
- Ensure a constant level of soil organic matter
- Replenish soil nutrients that are removed
- Avoid build up of toxic contaminants
- Maintain a desirable level of flora and fauna (Panabokke, 1996).

Keeping these fundamentals in mind, the review of literature on sustainability concerns and the natural resource management issues of UPVEGSYS was organised under three major themes; land degradation, pesticide pollution and fertiliser pollution. Both sustainability issues and conservation options were searched under each sub theme.

2.2.1. Land Degradation and Conservation Options

Land degradation, temporary or permanent lowering of the productive capacity of land (UNEP, 2001) is the oldest known environmental issue in the country, which is also a major challenge to food production. For a long time, land degradation has been a serious concern in Sri Lanka and it is the main degradation process that takes place in agricultural lands in this country (Nayakakorale, 1998). Evidence shows that a number of factors have contributed to land degradation, among which the expansion of human settlements, plantation agriculture and non-plantation agriculture have become prominent from time to time since the 19th century. The prominent means of land degradation is soil erosion. In the 21st century, the problem of soil erosion within UPVEGSYS has led to severe calamities, for instance, the minor landslips in Kotmale which appear to be due to indiscriminate breaking of steep slopes for the cultivation of manioc and other un-irrigated crops, principally annual crops.

The need for soil conservation was emphasised through the Act No. 25 of 1951 (Department of Agriculture, 1952). Since then, a number of remedial measures have been taken towards controlling soil erosion, but the severity of the issue has grown as evident by the studies.

In the current context, the land degradation due to soil erosion has been recognised as the most prominent environmental concern -- the magnitude of which shows a regional variation. Data indicate that soil erosion amounts to 412, 1026 and 147 tones/ha/year in the up-country, mid-country and low-country respectively (UNEP, 2001). The up-country vegetables are largely grown within the up-country and mid-country. The situation is further aggravated due to lack of adopting satisfactory soil conservation measures. Krishnarajah (1984) and Stocking (1992) reported very high losses of soil from vegetable growing lands, resulting in silting of major reservoirs such as Kotmale, Polgolla, Victoria, Randenigala and Rantambe (Chandrapala *et al.,* 2003).

Soil erosion is a complex phenomenon occurring naturally and aggravating anthropogenically and a number of models appear to be useful to assess the erosion hazard. As cited by Munasinghe *et al.,* (2001), these include screening and planning models; e.g. Universal Soil Loss Equation by Wishmeier and Smith (1978), and complex models; e.g. hydrological assessment models, CREAMS model by Knisel (1980), and ANSWERS by Beasely *et al.*, (1980).

Recognising the limitations of previous attempts, Bandara and Somasiri (1991) have constructed a map showing different classes of erosion hazard, and their geographical distribution. This study shows the distribution of erosion hazard areas in the Kandy and Nuwara Eliya districts where about 249,700 ha (69 percent) of land is vulnerable to high erosion hazard.

A recent attempt to construct a potential soil erosion map in the districts which grow up-country vegetables by Munasinghe *et al.,* (2001), provides more useful information for soil conservation planning at provincial level. The map indicates five potential soil erosion categories, namely low, moderate, high, very high and extremely high and shows that all five potential erosion classes occur in the Nuwara Eliya district, a major up-country vegetable growing district.

According to Munasinghe *et al.,* (2001), soil erosion potential of a particular area can be changed considerably through changing its land use. In the light of above, numerous measures are suggested including;

(a) Need for maintaining a permanent vegetative cover as of natural forest in the areas towards the south-western part of the Nuwara Eliya district,
(b) Conservation under a permanent vegetative cover coupled with intensive soil conservation measures (best-suited natural vegetation or an agro-forestry system) in the areas surrounding Hanguranketha and Rikillagaskada (extremely high erosion hazard areas),
(c) Vigorous soil conservation measures, both mechanical and agronomic, in vegetable cultivating areas,
(d) Motivate the farmers to replace annual crops with permanent type of land uses in the lands under sparsely used croplands in very high erosion hazard areas where annuals are mostly grown, and

(e) Strict conservation measures such as practice of annual cropping only on bench terraces along with other conservation measures in high erosion hazard areas.

Kendaragama *et al.,* (2000), noticed that reluctance of farmers in vegetable growing areas with limited resources to adopt mechanical soil conservation measures due to lack of initial investment and thus have the necessity to popularise alternative measures of soil and water conservation practices. According to Lal (1989), the contour hedgerows is an effective agronomic practice in controlling soil erosion by creating an effective barrier to soil movement on the upslope boundary as terraces. Chandrapala *et al.,* (2003), experimented to evaluate the effects of selected agronomic measures, namely; contour furrowing, mulching and their combinations in association with *Artemisia vulgaris* (wild Chrysanthemum) hedgerows on soil erosion, run off and crop yields. Thus, over time the land degradation due to soil erosion has been well understood and options are suggested.

It is evident from the given discussion that efforts have been continued to search for conservation options to the problem of land degradation. Therefore, it is noteworthy to learn about how farmers respond to this issue, while producing up-country vegetables. The outcome of a similar assessment is presented in a subsequent chapter.

2.2.2. Fertiliser Pollution and Conservation Options

The literature review on fertiliser pollution and conservation options in the up-country vegetable production is organised under four sub themes. Firstly, it presents the need and importance of fertilisation of up-country vegetables under the theme 'soil-plant nutrient inter-relationships' (SPNIs). Having understood these SPNIs, the review of literature presents scientific knowledge acquired over time on optimal fertilisation of up-country vegetables and status of soil fertility management in practice. Then, the discussion focuses on what economic losses are and how environmental pollution is brought about through fertilisation and finally the alternatives suggested to fertility management to avoid economic losses and environmental pollution in UPVEGSYS.

a. Soil-Plant Nutrient Inter-relationships

Literature reveals that, SPNIs in farming systems -- growing vegetables and potato show remarkable differences compared to farming systems used for other crops. These differences are attributed to a range of reasons. Most of the vegetables are annuals with shorter lifetime from one to six months. Vegetables produce high biomass within a short period of time and unlike other annuals they are harvested succulent, while the crop is still in a physiologically active state, for example vegetables belonging to the families, namely cucurbitacea, malvaceae and solanaceae. Large amounts of vegetative material are removed as edible portion during harvest of certain vegetables (Wijesundara, 1990). Generally, the vegetables are high P and K feeders owing to their high biomass production (Wijewardena, 2000). Being a leafy vegetable, cabbage requires a good supply of N to provide high yield (Wijewardena, 1998). Vegetables are shallow rooted and have to obtain their nutrient requirement from a small volume of soil (Wijewardena, 2000). According to Wijewardena (1994 and 1995), the vital contribution of phosphorus supply for the plants is many fold as it affects the growth, every transformation activity of various enzymes, seed formation including root development and crop maturity. This stresses the need for applying a relatively large quantity of P during the short time from the soil or from added fertiliser for adequate growth.

In particular, potato has been described as a "hungry crop" (Kathirgamathyah and Ceasar, 1964). According to De Vaz and Thenabadu (1972), potato plant is referred to as a gross feeder as it removes large quantities of nutrients from soil. Short vegetative period and the limited root system of the crop (Al-Abbas *et al.,* 1966) are attributed to fairly high requirement of phosphorus by the potato crop. Potato removes from the soil much more potassium than the quantity applied as fertiliser (Wijesundara, 1990). Vegetable growing soils in the up-country areas are inherently low in soil fertility (Wijewardena *et. al.,* 1996) especially due to the high demand for nutrients by the present cultivars. Accordingly, the vegetables should substantially receive relatively a large supply of P within a short time from the soil or added fertiliser to achieve high yields (Wijewardena, 1994 & 1995). Therefore, fertilisation is an essential component in any vegetable crop production system.

b. Scientific Knowledge and Status of Fertility Management in UPVEGSYS

There was no systematised information on the fertiliser requirements of up-country vegetables at the inception of their cultivation (Kandiah and Rodrigo, 1954, Kathirgamathaiyah, 1965). Kandiah and Rodrigo (1954) had initiated conducting of manurial experiments on fertiliser requirements for potato and other vegetables at Rahangala.

Evidence shows that the problem of over-fertilisation has been in existence for several decades receiving the attention of the researchers. De Vaz and Thenabadu (1972) conducted fertiliser trials during 1969 and 1970 *Yala* seasons for potato with the variety of Arka and found that there was only a little effect on increasing yields of potato by applying fertilisers in excess of those recommended by the Department of Agriculture (DOA).

In addition to these quantitative studies, the scientists have focused on other aspects of fertilisation associated with potato cultivation and have come up with significant findings i.e. close relationship between the rate of nutrient removal by potato crop and the tuber growth (De Vaz *et al.*, 1972); effects of different methods of placement of fertiliser on P uptake Al-Abbas *et al.,* (1966); comparative results between furrow application and broadcasting of the fertilisers (Caesar and Ganesan, 1992) Al-Abbas *et al.,* (1966); relationships of P uptake with lime application and placement of N, supply of Ca and Mg from dolomite and coral lime (Al-Abbas *et al.*, 1966).

Evidence shows that the manurial trails have been performed on up-country vegetables other than potato. According to Kathirgamathaiyah (1965) cabbage and bean are the commonly cultivated up-country vegetables on which he conducted experiments as to micro nutrient requirements of these vegetables. Wijesundara (1990) found that the total quantity of nutrients removed was very high in potato, cabbage, tomato, bean and carrot.

A study by Wijewardena, (1993) has revealed how K and Mg fertilisers increase yields in vegetable crops, steady depletion of them with continuous cropping and need for including Mg in the fertiliser recommendations for vegetables in the up-country region. This study also emphasises the need for applying at least 100 kg K_2O/ha and 30 kg Mg/ha to maintain the level of K and Mg on the soil.

Among plant nutrients, phosphorus is considered the most limiting plant nutrient in Ultisol (Wijewardena, 1995). Studies by Wijewardena (1994 and 1995) on P fertilisation on sequentially cultivated tomato, pole bean, cabbage and potato showed responses up to 100 kg/ha. He concluded that the application of 100 kg P/ha to vegetable crops is necessary to maintain a reasonable P level under vegetable cultivation in the Ultisol.

The effect of long-life fertilisers which gradually absorb into the soil and can be continuously available to crops such as fused magnesium phosphate (FMP) -- have been conducted in the up-country intermediate zone and found as effective as triple super phosphate (TSP) as a source of P for vegetables and it is a suitable replacement for TSP (Wijewardena, 1997).

Two field experiments conducted in the up-country intermediate zone establish the fact that the application of N at the rate of 100 kg/ha is sufficient for both pole bean and cabbage cultivation (Wijewardena, 1998). He also found that the application of poultry manure at 10 t/ha significantly increased the yield of tomato (30.1 t/ha) over no-manure application (10.2 t/ha). The application of chemical fertiliser also significantly increased the yield of tomato (22.7 t/ha) over no-chemical fertiliser application (18.8 t/ha) (Wijewardena, 1998).

DOA has recommended the application of 2 t/ha of liming materials, but farmers apply 650 kg/ha per year (Wijewardeana, 1999; Kendaragama *et al.*, 2001).

In accordance with DOA recommendations in 1998, the rice crop utilises the residual of phosphorous and potassium applied to vegetables grown on paddy lands and receives nitrogen only (Wijewardena, 2001).

The use of high rates of NPK fertilisers as well as organic fertilisers is a unique feature of vegetable farming in the up-country region in the current context (Wijewardena, 1995a; Wijewardena, 1996). Farmers apply almost two-three times higher than that of the DOA recommended rate of NPK fertilisers (Wijewardena, 2001). Generally, the vegetables are high P and K feeders, and therefore poultry manure in combination with chemical fertilisers had been recommended to potato and vegetable crops (Wijewardena, 1999). Use of fertiliser mixtures and liming materials are also common practices among farmers in this region. With all the knowledge, DOA has revised the fertiliser recommendations in 2007.

c. Economic Losses and Environmental Pollution due to Fertilisation in UPVEGSYS

Evidence shows that chemical fertilisation has resulted in nutrient imbalances of the soils of the UPVEGSYS areas; residual soil phosphorous build up on vegetable growing lands (Wijewardena and Amarasiri, 1990, Jeevanthan *et al.*, 1995, and Dissanayake, 1999); high accumulation of soil potassium (Wijewardena, 1993, Wijewardena, 1994 and 1995); accumulation of P and K rather than the depletion in vegetable growing lands in the up-country intermediate zone (Rezania *et al.*, 1989), steady depletion of K and Mg with continuous cropping in control plots (Wijewardena, 1996).

Chemical fertilisation in UPVEGSYS is associated with a number of adverse consequences. Excessive fertilisation is reported in intensively vegetable growing areas of the up-country intermediate zone (Wijewardena, 1993) and the up-country wet zone (Jeevanthan *et al.*, 1995; Dissanayake, 1999). Results of the soil analytical data indicate that the high-soiled P and K accumulations in vegetable fields, could be due to over-fertilisation by farmers in the region (Wijewardena, 2000), in particular due to the use of fertiliser mixtures (Wijewardena, 2001). As a result, the productivity of the soils in this region tends to be in decline (Maraiker *et. al.,* 1996, Wijewardena, 2000). Kendaragama *et al.,* (2001) reports the effect of the continuation of P accumulation on the productivity of valuable vegetable cropland in the Nuwara Eliya district. Excessive fertilisation could create numerous negative interactions between nutrients and contamination of drinking water (Wijewardena, *et al.,* 1996b). The authors also report the availability of substantial amounts of some plant nutrients such as K, Ca, and Mg in drinking well-water in the Nuwara Eliya district and Ca and Mg in the Badulla district.

Literature also reveals the adverse consequences resulting due to excessive application of lime on vegetable growing lands. Dissanayake (1999, cited in Kendaragama *et al.,* 2001) indicates that lime application causes higher pH on vegetable growing soils and thereby contributing to reduce organic matter content. In particular, a higher rate of dolomite (2 t/ha) is not beneficial for potato cultivation in the up-country (Wijewardena, 2001).

Organic fertilisation could also lead to adverse impacts. Wijewardena and Guneratne (2004) reported increase in heavy metal contents to toxic levels due to continuous and heavy application of organic manure on soil. Wijewardena (1998) observed that there are detrimental effects of the application of poultry manure over 10 t/ha on the yield of tomato.

All these environmental considerations have economic considerations too. According to Wijewardene (1996), excessive use of both NPK fertilisers and organic fertilisers was continuously reported to have increased cost of production and heavy drain of foreign exchange for fertilisers. In line with these, several alternatives have also been suggested as briefly given in the next section.

d. Alternatives for Fertility Management to Avoid Economic Losses and Environmental Pollution in UPVEGSYS

Having learnt the environmental impacts of excessive fertilisation, the researchers have emphasised the need for soil test based K and P fertiliser recommendations to avoid P build up and to safeguard the nutrient balance since long (Ponnamperuma, 1958; Dissanayake, 1999; Wijewardana, 1999; Kendaragama *et al.,* 2001). Introduction of the straight fertilisers in 1990 by the DOA is a greater achievement in this regard. A number of other alternatives have been suggested. Poultry manure is one such alternative and Wijewardena and Amarasiri (1990) stressed the importance of locally available materials such as poultry manure as an alternative for heavy drain of foreign exchange for fertilisers. Poultry manure is also an economical approach to correct the soil acidity and to increase the vegetable yield in Ultisols (Wijewardena, 2001). It increases the pH, P, K, Ca, Mg, Zn and Mn on the soil for having intermediate fertilising properties (Giardini *et al.*, 1992) and reduce P and K fertiliser application rates by 50 percent to reduce P and K build-up on the soil by applying 10 t/ha poultry manure (Wijewardena, 2000). Broiler litter is a suitable replacement for scarce cattle manure and poultry manure (Wijewardena, 2000).

Eppawala rock phosphate is another alternative method at 100 kg/ha to get high yield from up-country vegetables such as potato, cabbage, pole bean and tomato for P fertilisation (Wijewardena and Amarasiri, 1990). Wijewardena in 1995 stressed the importance of P fertilisation on long-term basis to avoid P build up and fused magnesium, phosphate

(FMP) was recommended as a suitable replacement for TSP which causes increased accumulation of P on the soil (Wijewardena, 1999).

Liming is one of the alternatives for acidity problem on the up-country growing soils. Wijewardena (2001) has recommended the application of 1t of dolomite/ha and 25 kg S/ha for the potato grown on the sites with low pH value of 4.9. He also recommends burnt lime as a more effective liming material than dolomite and poultry manure. The minimum recommended rate of poultry manure is at the rate of 2 t/ha per crop in Ultisols (Wijewardena, 2001).

The problem of heavy metal accumulation occurs due to use of organic manure. Hence, Wijewardena and Guneratne (2004) emphasise the need for application of recommended rates of animal manure for crops to avoid build-up of heavy metals. Researchers also have stressed the importance of residue recycling as a means of returning a major portion of nutrients removed back to soil.

Hence, it is learnt from the given background that it is worthwhile to study the farmers' knowledge on these recommendations and their practice at the grass-roots level and the results of the assessment of which is presented in the subsequent chapters.

2.2.3. Pesticide Pollution and Conservation Options

The literature review on pesticide pollution and conservation options in the up-country vegetable production is organised under three sub themes. Firstly, it presents how plant protection needs arise in UPVEGSYS under favourable weather conditions conducive for the occurrence of pest and diseases. Secondly, it focuses on economic and environmental costs and benefits of pesticide use during the up-country vegetable production. Finally, it presents alternatives suggested to avoid economic losses and environmental pollution due to pesticide use in UPVEGSYS.

a. Plant Protection Needs in UPVEGSYS

Wet weather coupled with wind and mist -- prevalent during the major part of the year in the up-country areas of Sri Lanka -- provides perfect conditions for the spread of pest and diseases causing heavy yield losses to vegetable farmers. The following text verifies the researchers' learning experiences of plant-pest relationships prevalent in UPVEGSYS.

Studies by Manikavasagar (1953) corroborate first reporting of potato tuber moth in 1951, after a large-scale intensified production of potato commenced during the early 1950s which led to studies on pests and diseases. This study provides evidence on the use of toxic pesticides such as DDT sprays on the field and DDT dusts in the stores for the control of tuber moth. According to Fernando and Manickavasagar (1957), potato tuber moth has been identified as the major pest of potato during the 1950s.

Late blight is one of the harmful diseases in potato. A series of studies found to be searching late blight control methods and have emphasised; the necessity for precautionary spray control (Department of Agriculture, 1963); planting of tolerant varieties (Caesar and Ganesan, 1963); necessity for fungicidal spraying (Babu *et al.*, 1999).

Bacterial wilt is another major disease affecting potato which is widespread all over the up-country region and the yield loss due to bacterial wilt varied from 5-25 percent, thus incurring heavy financial losses to the farmers. As cited in Nugaliyadda, *et al.*, (2001) from Wijesekara, 1997, leaf minor was first reported in Sri Lanka from the Nuwara Eliya region in 1996. It can cause 100 percent yield loss by facilitating the entry of *Phytopthora infestans* (Babu *et al.*, undated). Leaf minor is known to attack ten different plant families including up-country vegetables such as beet, carrot, cabbage, leeks and potato. Potato cyst nematode is another serious pest of potato in Sri Lanka which causes yield losses as great as 80 percent on heavily infested soils (Nugaliyadda and Perera, 1999).

Cabbage, a widely grown vegetable crop on the up-country region is affected by a wide range of insect pests, among those semi-loopers and diamond black moth (DBM) are considered major pests (Rathnasinghe, 1991). The DBM was found to be the dominant species of the cabbage caterpillar complex on the high lands of Sri Lanka (Fernando, 1964 and 1965). Jesudasan and Yogarathnam (1984), reported that the seasonal fluctuation of DBM incidence in the upland areas of Sri Lanka roughly following three arbitrary growing seasons. Bean rust disease was found to be particularly severe, and hence economically important, in the Welimada, Bandarawela, Badulla and Padiyapelella areas (Wimalajeewa and Thavam, 1973).

The economic importance of the late blight disease of potato (*Phytopthera infestans*) in Sri Lanka has been discussed in several papers (Peiris and Silva, 1954; Abeygunawardene and Peiris, 1958; Abeygunawardene, 1960; Abeygunawardene and Balasooriya, 1961; Caesar and Ganesan, 1963; Senevirathne, 1970; Wimalajeewa, *et al.*, 1974; Babu *et al.*, 1999). The necessity of chemical measures rather than resistant varieties as means of controlling late blight has been indicated by all these authors.

Nevertheless, the evidence shows that a series of experiments have been conducted on the identification of late blight resistant potato varieties. Followed by this, several resistant potato varieties have been released; 'Krushi' and 'Sita' in the early 80s; 'Hillstar', 'Lakshmi' and 'Manke' in 1999; and commenced CIP line screening (Babu *et al.*, 2005).

Studies have also been carried out to find non-chemical methods of pest control in up-country vegetables: parasitoids activity (Jesudasan and Yogarathnam, 1984); effect of poultry manure (PM) on root knot nematodes (*Meloidogyne spp.*) in tomato (Wahundeniya, 1991); efficacy of *neem* derivatives and chemical insecticides for controlling leaf eating caterpillars in cabbage; natural enemy complex of leaf minor and their effectiveness on the management of the pest.

Accordingly, it appears that research on plant protection has been concentrated on various aspects such as screening for resistant varieties, use of alternative materials, control through pesticides, identification of causal factors for pest abundance, and integrated pest control methods.

b. Economic Losses and Environmental Pollution due to Pesticide Use in UPVEGSYS

Under normal weather conditions then prevalent in the Nuwara Eliya district, the use of the standard dosage recommended by the fungicide manufacturer was found to be adequate and very satisfactory to the control of late blight (Wimalajeewa and Thavam, 1974). The author also reports that the majority of the cultivators use fungicides indiscriminately and without any understanding of the basis for their usage; therefore such measures invariably result in heavy and unnecessary expenditure, thus increasing the cost of production. This was the situation several decades ago.

In the current context, wind, mist and wet weather conditions that prevail during most of the year in the central hills of Sri Lanka -- compel the farmers to resort to frequent spraying of fungicides -- to prevent heavy yield losses from late blight which is managed through frequent applications of both protective and curative fungicides (Babu *et al.*, 2005). Commercial varieties require 12-15 spraying rounds per season; whereas only 2-3 prophylactic spraying rounds are sufficient for the total control of late blight (Babu *et al.*, 1999). Control of disease is possible by spraying copper fungicides; weekly spraying is better than fortnightly applications. The spray treatment not only covered the cost of treatment, but produced considerable increased yields.

Chemical method appears to be the best method for pest control in other crops as well. According to Wimalajeewa and Thavam (1973) the most promising method under local conditions for the control of bean rust was the use of chemicals; several insecticides such as methamidophos, quinalphos, monocrotophos and profenofos have been recommended for the control of caterpillars (Bandara and Kudagamage, 1989); even today the farmers have to resort to frequent, sometimes daily, spraying of agro-chemicals to protect their crop from leaf minor (Babu *et al.*, 1999).

Evidence shows that there has been new outbreaks of pest and diseases leading to pesticides related problems due to intensification of vegetable production in the up-country vegetable farming areas; the gravity of the issues is also well understood since long; as reported by Mervin D de Silva (1960) "*highly toxic insecticides are being used, for the control of cabbage pests, than for those of any other economic crop. Excessive treatment aggravates the problem of residues, hazards to persons, livestock and wildlife subjected to contamination of drift. And toxic insecticides on food are injurious to human beings, but the precise nature of the harm done is yet unknown. In Ceylon, the problem of residues on crops is even more serious, in that, at present there is no legislation in force to supervise and control the use of insecticides*".

Recent studies also surface the gravity of the issues; the control of cabbage caterpillars with highly hazardous and categorised under restricted insecticides-- some of which are incapable of giving economic control due to build up of resistance in the pests compelling the farmers to use higher dosages at frequent intervals (Bandara and Kudagamage, 1989). Overuse of insecticides in cabbage indiscriminately without taking adequate precautions and giving adequate consideration to recommended pre-harvest intervals resulting in environmental pollution and harmful insecticide levels to human beings (Rathnasinghe, 1991). Given the context, the scientists have proposed several alternatives to the aforesaid issues as given below.

c. Alternatives to Avoid Economic Losses and Environmental Pollution due to Pesticide Use in UPVEGSYS

Literature is evident on a variety of alternatives to avoid economic losses and environmental pollution in UPVEGSYS. Wimalajeewa and Thavam (1973) recommended long crop rotations for controlling bean rust. Jesudasan and Yogarathnam (1984) have shown the importance of selective use of pesticides for DBM in favour of the natural enemies, since parasitoids activity causes about 65 percent reduction in DBM larval numbers during major peak incidence. According to Wahundeniya (1991), it is needed to apply high rates of poultry manure (10 t/ha) continuously to control root knot nematodes in tomato while increasing the yield. Wahundeniya in 1993 found the means of controlling leaf eating caterpillars of cabbage by insect growth regulators such as chlorfluzauron. Kelaniyangoda, *et al*., (1996 and 1997) experimented on component technologies to manage bacterial wilt in rooted potato cuttings in net houses. Nugaliyadda and Perera (1999) emphasised the need to introduce resistant varieties to control nematodes. Nugaliyadda *et al.* (2001), experimented on the use of azadiractine as an integrated component of the pest management system. Babu, *et al.* (2005), stressed the importance of introducing more late blight resistant varieties, which will also bring down the cost of fungicides and their spraying and efficient and effective pest detection methods in place of serological and molecular methods while importing seeds and planting materials.

Accordingly, the eco-friendly means of plant protection too can be summarised as; introduction of resistant varieties, application of efficient and effective pest detection methods at the importation of planting materials, biological control methods such as growth regulators and natural pesticides. The results of the assessment of farmers' knowledge and adoption of these eco-friendly plant protection methods are presented in the subsequent chapters of this report.

2.3 Initiatives for Conservation Farming in UPVEGSYS

2.3.1 Government Policies

Soil erosion is the most prominent means of land degradation in UPVEGSYS. Various studies point to the diverse factors which affect erosion both directly and indirectly from the cultivation of crops such as potato and vegetables in hilly terrain, insecure tenure arrangements, cultivation of large extents of plantation crops and development projects. From as early as 1873, an order was issued that land of 5,000 feet above sea level was not to be alienated (DOA, 1952). The issue of soil erosion has been a concern for which a number of laws and regulations have been enacted by successive governments. The enactment of the soil conservation act in 1951 was brought about with the notion "the care of the land is a pre-requisite to survival". With this in mind, numerous policy initiatives, strategies and plans were formulated to combat land degradation at the national level.

Legislation was passed by governments to safeguard the environment through various acts and ordinances. These were enacted in the Land Development Ordinance (1935), State Land Ordinance (1947), Water Resource Provision Act (1964), the Land Grants (Special Provision Act - 1979), the Agrarian Services Act (1979), the Mahaweli Authority of Sri Lanka Act (1979) and the National Environment Act (1980).

A soil conservation unit was set up in 1951 at the DOA with the sole purpose of mitigating soil erosion. Increasing population gave rise to demand for land which gradually accelerated the soil erosion in the hill country. The soil conservation act provides for the declaration of erodible areas, restrictions on land use practices on private lands and acquisition of sensitive lands for conservation purposes. With the passage of time, it was seen that this act was not providing the required attention, and was amended in 1996 with the focus shifting to prevention of soil erosion.

The Second Constitution of the Republic of Sri Lanka included clauses, where the state was responsible to protect and preserve the environment for its countrymen and that it is the duty of every Sri Lankan to protect nature and conserve its riches. A national policy framework incorporating the sectors of agriculture, land and forestry spelt out the need to manage the scarce natural resource for the present generation and all future generations. The National Land Use Policy (1996) of which -- the specific objective was -- the utilisation of land based on capability of the land and the needs of the community.

The national conservation strategy of 1988 was formulated with the need to decelerate environmental degradation. A policy for conservation and the improvement in the natural resource base was the main theme of the policy. In 1990, an environmental action plan (EAP) was formulated with the recommendation of a national conservation strategy. The importance of soil conservation led to the National Environment Action Plan (NEAP) of 1990, a more comprehensive plan produced with the amalgamation of the EAP and Sri Lanka's national report. The Third National Environmental Action Plan was prepared for 1998-2001. Along with the national level programmes, a large number of projects with foreign assistance were started.

2.3.2 Projects

- Re-forestation and Watershed Management Project (1980)
  The main aim of this project was to increase and build the institutional capacity of the Forest Department and protect the watershed areas in the hill country regions and boost the natural resource and commercial resource base.
- Community Forestry Project (1982)
  Funded by the Asian Development Bank, this project sought to supplement the fuel wood and increase planting of edible food trees and supply of construction timber.
- Integrated Rural Development Programmes (IRDP) (1982)
  It was only during the latter part of the IRDP programmes that the issues of land were taken into consideration. Various programmes under IRDP projects especially in the districts of Badulla, Nuwara Eliya and Matale addressed the issues of land degradation in critical areas so as to improve income and living standards of the communities. The IRDP programmes dealt mainly with methods to minimise soil erosion, through both biological and mechanical means.
- Land Use Policy Planning Project (1983)
  Two projects under this scheme from 1983 to1994 were launched. The first project initiated land use planning process at the national level which was extended to the district level.
- Upper Mahaweli Watershed Management Project (1987)
  This was a project for a period of 9 years. At the beginning from 1987 to 1996, it was implemented by the Mahaweli Authority of Sri Lanka where the main activity was the promotion of sloping agricultural land technology (SALT) to ensure ecologically acceptable management of natural resources in the catchment areas of the Mahaweli river basin. Other activities included the promotion of *vetiver* grass as a conservation method and promotion of mixed farming and livestock. In certain areas, the *vetiver* and SALT techniques were adopted by a large number of farmers during the project period. But with the completion of the project, the hedgerows were not maintained as there is a lack of monitoring and at present only a very few of the farmers are maintaining any of the SALT. One

impact of the project was the distribution of planting material to a large number of users and the creating of an interest for the use of *vetiver* grass among a large percentage of farmers.

- Forest Land Use Mapping Project (1989)
  This was a project under which mapping was done for the upper Mahaweli catchment area which could be used for land use planning.
- Landslide Hazard Mapping Project (1990)
  This project was to regulate the haphazard development of infrastructure in the districts of Badulla and Nuwara Eliya.
- Shared Control of Natural Resources Project (1992)
  This was funded by the USA and implemented by International Water Management Institute (IWMI) for a period of five years. Main activity was to increase user control over land and water through institutional mechanism for sharing and integrate conservation.
- Environmental Action 1 Project (1995)
  This is a World Bank funded project with an institutional strengthening component for communities through participatory methods and to demonstrate environmental activities. It includes a land management component with suitable technologies to minimise land degradation in the wet zone of the Central Province representing ten micro catchments.
- Upper Watershed Management Project (1997)
  Main focus of this project was to improve and protect forest cover and conserve soil and water in upper watershed areas by empowering people and strengthening institutions to manage the natural resources. The project covered nine Divisional Secretariats of the Ratnapura, Nuwara Eliya and Badulla districts. The component of promotion of conservation oriented farming systems addressed issues related to environmentally unsound farming systems and practices through the promotion of appropriate vegetative (covering 4,000 ha) and mechanical soil erosion control measures. Interventions were on-farm and off-farm soil conservation, hydrological and soil erosion monitoring activities, improving economic conditions of people, and strengthening stakeholder capacity. Conservation methods used were SALT, *vetiver* grass (*Chcysopogon zizanioides*), planting of contour strips, gully plugs, brushwood, stone terraces and other useful methods. To aid the conservation methods used, it was also designed to get support from agricultural extension through the training of beneficiaries in land management, minimum tillage, crop selection, use of organic manure and compost, integrated pest management (IPM) and crop diversification.

The desired impact of these conservation methods shows that reversed slope terraces are more effective than the SALT system or stone terracing or other mechanical methods due to the slope steepness, farm size and the type of crops grown. But, a large percentage of the project beneficiaries prefer mechanical conservation techniques, as they feel that there is less competition from the crops with mechanical conservation. Annual maintenance is very essential and in certain areas -- where this has not occurred -- the money spent on the conservation technique has been wasted. Project beneficiaries have shown income benefits from the use of conservation techniques by having lower cost of production and yield increase. The use of IPM has not been widespread, but the beneficiaries realise the adverse impact of the use of agro-chemicals on their health and the environment. Another aspect is that the training given to the beneficiaries for maintenance of the conservation oriented farming system is inadequate though there was a large component of farmer training. Sustainability -- after project completion -- requires well-orchestrated effort by the government and the people in the region.

2.3.3 Programmes in Study Locations

The DOA has its own programmes and has done studies on soil fertility management, plant protection and soil conservation despite their involvement under numerous projects throughout the years. Whilst it comprises several institutions, the key partners worked in UPVEGSYS are Horticultural Research and Development Institute (HORDI), Plant Protection Centre, Natural Resources Management Centre, and Fertiliser Unit. Other important contributions of these institutions include dissemination of information to the farming community and maintain data bases for use by clients. Hadabima Authority is another organisation working in this area which comes under the Ministry of Agriculture.

A brief description of programmes conducted by local organisations in study locations are given below.

- *Arunalu* Community Development Centre in the Matale district. This organisation has worked with farmers in the Naula DS Division (Hapugayaya GND). The project was funded by the UNDP (2005-2006) and worked with 25 farmers. Soil conservation techniques were carried out after training the farmers. This organisation is also involved in preventing soil erosion on the Nalanda oya by helping farmers to plant trees along the watershed of the oya.
- *Laksetha Sahana Seva Sanvidanaya* in the Kandy district. This organisation has been involved in four GN divisions of Doragamuwa, Migamawatta, Migama and Watagedra of the Pathadumbara DS division. With UNDP funding in 2003/2004, a total of 80 farmers were trained and given grants to carry out various conservation techniques on their farms. The extent of land for the 20 farmers covered 125 acres. Presently, this organisation is working with Sustainable Agriculture Development Research Institute providing training to farmers on the preparation of compost.
- *Gramiya Sanvidhana Sangamaya* in the Matale district. The project commenced in 1996 in ten GN divisions in the Naula DS and completed in 2006/2007 reaching 1,210 farmers. Both training and funds were provided to farmers. For each conservation method utilised by the farmers 60 percent was to be contributed through labour, while the balance of 40 percent was given in cash.

These NGOs have been mainly involved in raising environmental awareness of land degradation among the farmers in the area. In the Matale district, the number of farmers reached by the *Arunalu* Community Development Centre and *Gramiya Sanvidana Sangamaya* has been 1,235 in total. Their main activity has been trying the soil conservation techniques of SALT and planting contour strips and mechanical conservation methods. The initial step of these NGOs has been the training of farmers with the technique suitable to their individual farms and then offering the part of financial assistance as done by the *Gramiya Sanvidana Snagamaya*. Since most of the NGOs depend on funding and the keenness of the organisation itself, their impact on a large-scale is limited and not sustainable in the long-run.

2.4 Summary

The continuation of UPVEGSYS and its expansion have links to its sustainability. The literature surfaces three major environmental impacts arising in view of up-country vegetable production, namely land degradation due to soil erosion, pesticide pollution and fertiliser pollution.

The land degradation due to soil erosion, the oldest known environmental problem in the country, is a major environmental issue in the mid-country and up-country where UPVEGSYS is largely spread. It is a phenomenon well researched from measuring erosion hazards to suggesting remedial measures both physical and agronomic.

As evident from the literature survey, almost all the up-country vegetables are gross feeders of nutrients and thus optimum fertilisation is essential. Farmers have learnt these complex soil-plant-nutrient inter-relationships largely by experience. This causes excessive fertilisation leading to environmental and health related issues and substantial economic losses to farmers. One of the problems of inorganic fertilisation is building up of nutrients on the soils and water bodies (eutrophication) due to excessive fertilisation attributed to longer use of fertiliser mixtures. Soil acidity is another serious environmental problem. Drastic increase in the commercial up-country vegetable production -- may aggravate all theses issues. Though the scientists are successful in searching viable alternatives for these environmental, economic and health issues, the farmers continue to practise excessive fertilisation at a greater environmental and economic cost. This emphasises the need for simple and practical directives on optimum fertilisation.

There is also evidence that could be adduced to support the economic and environmental consequences arising due to pest control in the up-country vegetable production. Wet weather coupled with wind and mist prevailing during the greater part of the year provides perfect condition for the spread of pest and diseases in UPVEGSYS. Hence, the farmers have to rely on more highly hazardous and restricted pesticides indiscriminately leading to build-up of resistance in pest compelling farmers to use higher dosages at frequent intervals. This has created the problems of residual and toxic impacts on both human and eco-systems. But, the degree of the damage to the human and the environment is less understood. Research on plant protection aspects has concentrated on screening of resistant varieties, use of alternative materials, control through pesticides, identification of causal factors for pest abundance and their control, and IPM. But, the necessity of chemical methods is strongly emphasised. This compels to conclude that there has been an overemphasis on the control of insect pests by chemicals, thereby discouraging other pest control methods, in particular biological control methods.

Further, there has been a growing concern with regard to environmental impacts of the up-country vegetable production. This is reflected in the various efforts undertaken by the government in enacting various policies, strategies and plans. Steps taken to avoid adverse impacts through the enforcement of the comprehensive environmental laws have met with a certain success but, there is still a need to integrate issues such as promotion of conservation activities and management of natural resources during agricultural activities. Accordingly, it can be understood that over time environmental degradation has been on the increase and the efforts to decelerate the degradation process have also been in line, though the adequacy of them is questionable. Hence, a greater mobilisation and awareness building among the people to move towards sustainable agriculture is a pre-requisite.

Chapter Three

Physical Distribution of Up-country Vegetable Farming Systems

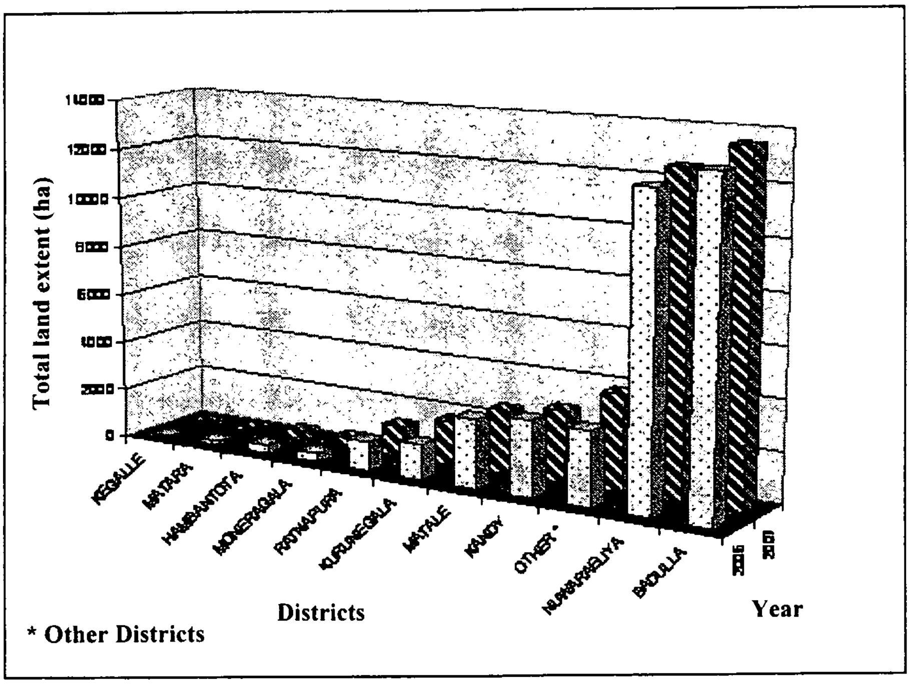
3.1 Introduction

It is vital to learn about spatial variation of UPVEGSYS, the area producing ten vegetables categorised under up-country vegetables; bean, carrot, radish, cabbage, knol khol, beet root, potato, tomato, leeks and capsicum. This chapter presents the outcome of the attempt made to demarcate the physical distribution of UPVEGSYS based on the data gathered at the GND level for the selected ten crops.

3.2. Physical Distribution of UPVEGSYS on District Basis

Figure 3.1 is evident that there is a wider spatial variation of the production of up-country vegetables. Further, it is apparent from figure 3.1 that the up-country vegetables are largely produced in ten districts, namely Nuwara Eliya, Badulla, Kurunegala, Matale, Kandy, Ratnapura, Moneragala, Hambantota, Kegalle and Matara. However, the Puttalam, Anuradhapura and Jaffna districts also produce up-country vegetables but they are included in the category of 'other' in figure 3.1.

Figure 3.1: Extent of Land under Up-country Vegetables in 2006 and 2007



Source: Department of Census and Statistics, 2007

According to the data presented in appendix 1, the total land extent of the up-country vegetables cultivated in 2006 was 37,354 ha, of which the key up-country vegetable producing districts were Nuwara Eliya and Badulla districts. They produced 32.6 and 34.7 percents respectively of the total annual extent of the up-country vegetables produced. The Kandy and Matale districts produced 8.1 and 7.3 percents respectively. The other prominent districts were Kurunegala, (4.46 percent) Ratnapura (3.17 percent), Moneragala (1.02 percent), Hambantota (0.88 percent), Kegalle (0.18 percent) and Matara (0.34 percent). The cultivated land extent of these ten districts amounted to 92 percent and the remaining 8 percent was cultivated in the districts such as Puttalam, Anuradhapura and Jaffna.

3.3. Physical Distribution of UPVEGSYS on Agro-ecological Zone Basis

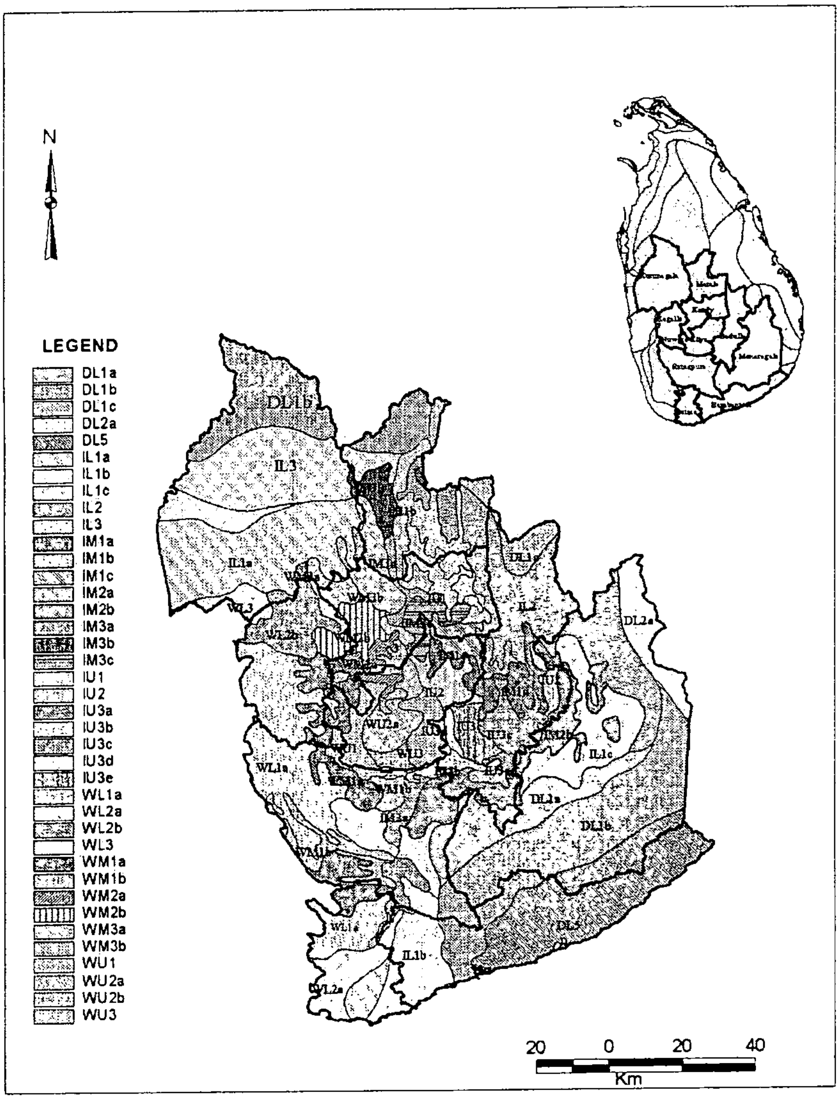
The up-country vegetable growing areas of the ten districts lie within a diverse range of agro-ecological zones as shown in figure 3.2. The environmental conditions in the hill areas are conducive for production. Pushkarnath (1960) admires this condition that a few countries in the world enjoy such advantages, as are bestowed by nature on the upland of Ceylon, for successive cropping of potatoes in the hill areas.

As discussed in chapter 1, the 14 AEZs predominate over up-country vegetable production and the analysis was done following the six eco-zone categories. A further description of eco-zones and their extent of the up-country vegetable production are detailed below.

3.3.1 Up-country Intermediate Zone (IU)

The largest part of UPVEGSYS lies in the up-country intermediate zone (IU) on agro-ecological basis, whereas the Badulla district falls on district basis. Soils in the up-country vegetable growing areas of the IU are mainly Reddish Brown Latasolic soils and Mountain Regosols. However, the soils of the rice-based cropping systems in this region are Immature Brown Loams (Soil Science Society of Sri Lanka, 2005). The IU zone is located on the windward side of the north-eastern monsoon and it experiences maximum rainfall during the months of November, December and January. The months from May to September are dry and very windy throughout the IU zone, because they fall within the rain shadow of the south-western monsoon (Panabokke, 1996). Mountainous, hilly and rolling topography is characteristic of the IU zone (Department of Agriculture, 2003). The IU zone of Sri Lanka which lies 900 m above sea level consists of seven agro-ecological zones, namely IU 1, IU 2, IU 3a, IU 3b, IU 3c, IU 3d, and IU 3e.

Figure 3.2: Agro-ecological Zones of Ten Districts Cultivating Up-countryVegetables



Source: FIVIMS Secretariat of HARTI, 2008

The rainfall factor of the AEZs favours the growth of perennial plantations including tea, natural forest, forest plantations and export agriculture crops except vegetables. The IU 1 receives the highest rainfall year round, where the 75 percent expectancy of annual rainfall is >2,400 mm. The 75 percent expectancy of the annual rainfall in the IU 2 and IU 3 zones are >2,100 mm and >1,900 mm respectively. In general, the rainfall received by the IU 3 zone is significantly lower. The IU 3 zone is divided into five AEZs, namely IU 3a, IU 3b, IU 3c, IU 3d, and IU 3e which receives rainfall at a reducing rate from >1900 mm to >1,400 mm and therefore the IU 2, IU 3c, IU 3d and IU 3e zones in the IU area zone -- provide favourable conditions -- to produce up-country vegetables (Department of Agriculture, 2003).

However, the extent and production data for the 2004/2005 *maha* and the 2004 *yala* (Department of Census and Statistics, unpublished) show that there is a certain percentage of the up-country vegetables cultivated in the remaining 3 AEZs, namely IU 1, IU 3a and

IU 3b. The IU 1 agro-ecological zone has land extents of some 50-97 ha and in the IU 3b in Pattiapola and Ohiya areas have land extents between 97 to 159 ha under the cultivation of up-country vegetables. Figure 3.3 shows 43 percent of the total area under up-country vegetables in the *yala* season and 42 percent of the total area in the *maha* season with an annual land extent of 42 percent in the IU areas.

3.3.2 Up-country Wet Zone (WU)

The large part of the up-country wet zone (WU) lies within the Nuwara Eliya district. The 75 percent expectancy of the annual rainfall of this area varies from >3100 mm to >1,800 mm in its four AEZs named as WU 1, WU 2a, WU 2b and WU 3 (Department of Agriculture, 2003). The same source indicates that only the WU 2b and WU 3 have vegetable producing land use systems. However, according to the 2004/2005 *maha* and the 2004 *yala* production data (Department of Census and Statistics, unpublished), some areas in the WU 1 such as Ambagamuwa DS Division and Vidulipura ASC also cultivate a significant land extent of vegetables amounting to 2.8 percent of the total land area under up-country vegetables in the Nuwara Eliya district. Data indicate that the WU is the second largest producer of up-country vegetables which amounts to 26 percent of the total land extent in the *yala* season, 39 percent of the total land extent in the *maha* season and 33 percent of the total annual land extent (figure 3.3).

3.3.3 Low-country Dry Zone (DL)

The low-country dry zone (DL) which lies below 300 msl consists of 11 AEZs and none has been recognised with vegetable producing land use systems by the Department of Agriculture (2003) in an effort to distinguishing agro-ecological regions of Sri Lanka. According to the data on the up-country vegetable production in 2004, the *yala* and *maha* of 2004/2005 (Department of Census and Statistics, unpublished), the Dambulla ASC of the Dambulla DS division (DL1b) and the Wilgamuwa DS division (DL 1c) of the Matale district -- produce up-country vegetables (figure 3.3). The Dambulla DS division cultivates over 50 ha of both cabbage and capsicum and smaller extents of bean, knol khol, radish, beetroot and carrot. The contribution from the DL area to both the seasonal and annual production of up-country vegetables amounts to one percent each.

3.3.4. Low-country Intermediate Zone (IL)

The low-country intermediate zone (IL) comprises five AEZs i.e. IL 1a, IL 1b, IL 1c, IL 2 and IL 3. The IL 1c and IL 1b are in the Moneragala, Ratnapura and Hambantota districts and the IL2 areas lie in the Matale district, while the IL 3 areas lie within the Matale and Kurunegala districts. These areas have neither been stated as producing vegetables by the Department of Agriculture (2003) nor classified as having mixed home gardens. However, the 2004/2005 *maha* and the 2004 *yala* data show that 18-44 ha are cultivated with up-country vegetables within the IL 3 and IL 2 zones. The total land extent under up-country vegetables in the IL area is only one percent both seasonally and annually (figure 3.3).

3.3.5 Mid-country Wet Zone (WM)

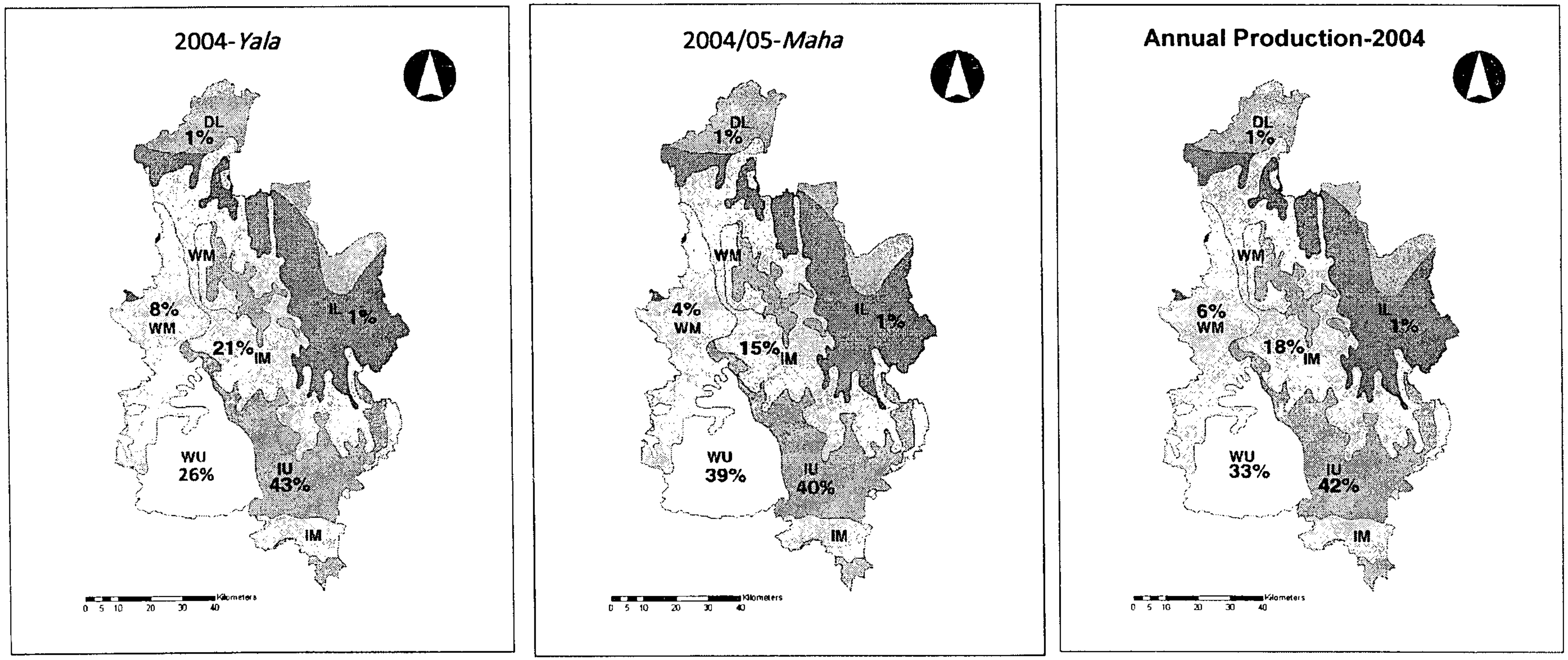
The mid-country lies between 300 to 900 msl and the mid-country wet zone (WM) consists of six agro-ecological zones; WM 1a, WM 1b, WM 2a, WM 2b, WM 3a, and WM 3b. According to the Department of Agriculture (2003) mixed home garden predominates in all AEZs except the WM 1a zone. The WM 1b is not within the four districts of the study. Data of the Department of Census and Statistics (unpublished) for 2004/2005 show that up-country vegetables are also grown in the rest of the agro-ecological zones of the WM area where the largest extents are found in the WM 2a and WM 3b zones. Doluwa and Udapalatha DS divisions of the WM 2a zone grow all up-country vegetables. The extent of the total land for up-country vegetables in the WM area amounts to 8 percent out of the total land extent in the *yala* season and four percent out of the total land extent in the *maha* season with an annual total land extent of 6 percent (figure 3.3).

3.3.6 Mid-country Intermediate Zone (IM)

The mid-country intermediate zone (IM) comprises eight agro-ecological zones found in the districts of Matale, Kandy, Badulla and Nuwara Eliya, namely the IM 1a, IM 1b, IM 1c IM 2a, IM 2b, IM 3a, IM 3b and IM 3c. According to the Department of Agriculture (2003), most of these AEZs except for the IM 1b and IM 3a zones grow up-country vegetables.

However, according to the data (Department of Census and Statistics, unpublished), these areas also produce up-country vegetables. Data also show that the IM area holds the third largest share of the land extent for up-country vegetables amounting to 21 percent of the total land extent in the *yala* season, 15 percent of the total land extent in the *maha* season with an 18 percent of the total annual land extent (figure 3.3).

Figure 3.3: Percentage Distribution of Up-country Vegetable Extents by Eco-zones

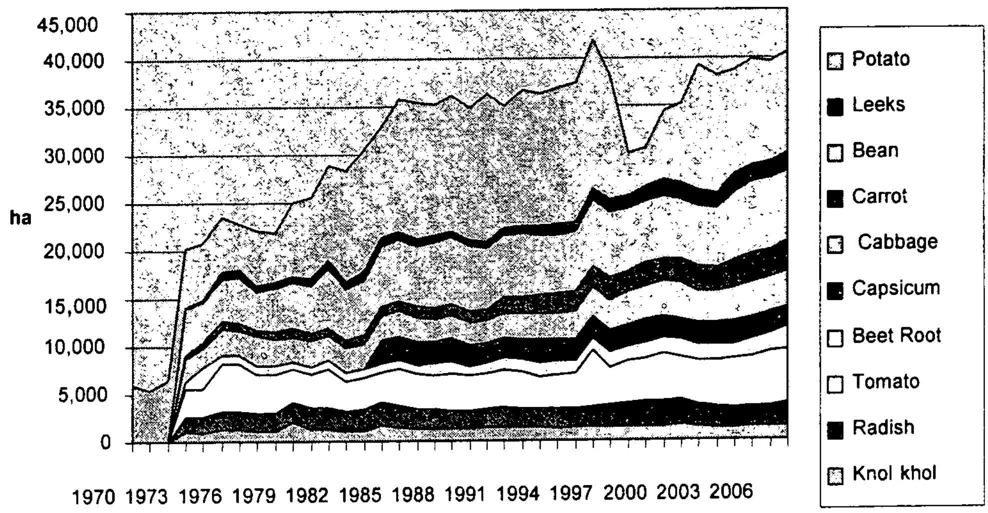


Source: Department of Census and Statistics-Unpublished

3.4. Expansion of UPVEGSYS

As it has been discussed at the beginning of this chapter, the up-country vegetable production is distributed in varying extents throughout the country. As shown in figure 3.4, there is a marked increase in the land extent under tomato, potato and bean except for other up-country vegetables which show a slight increase over time.

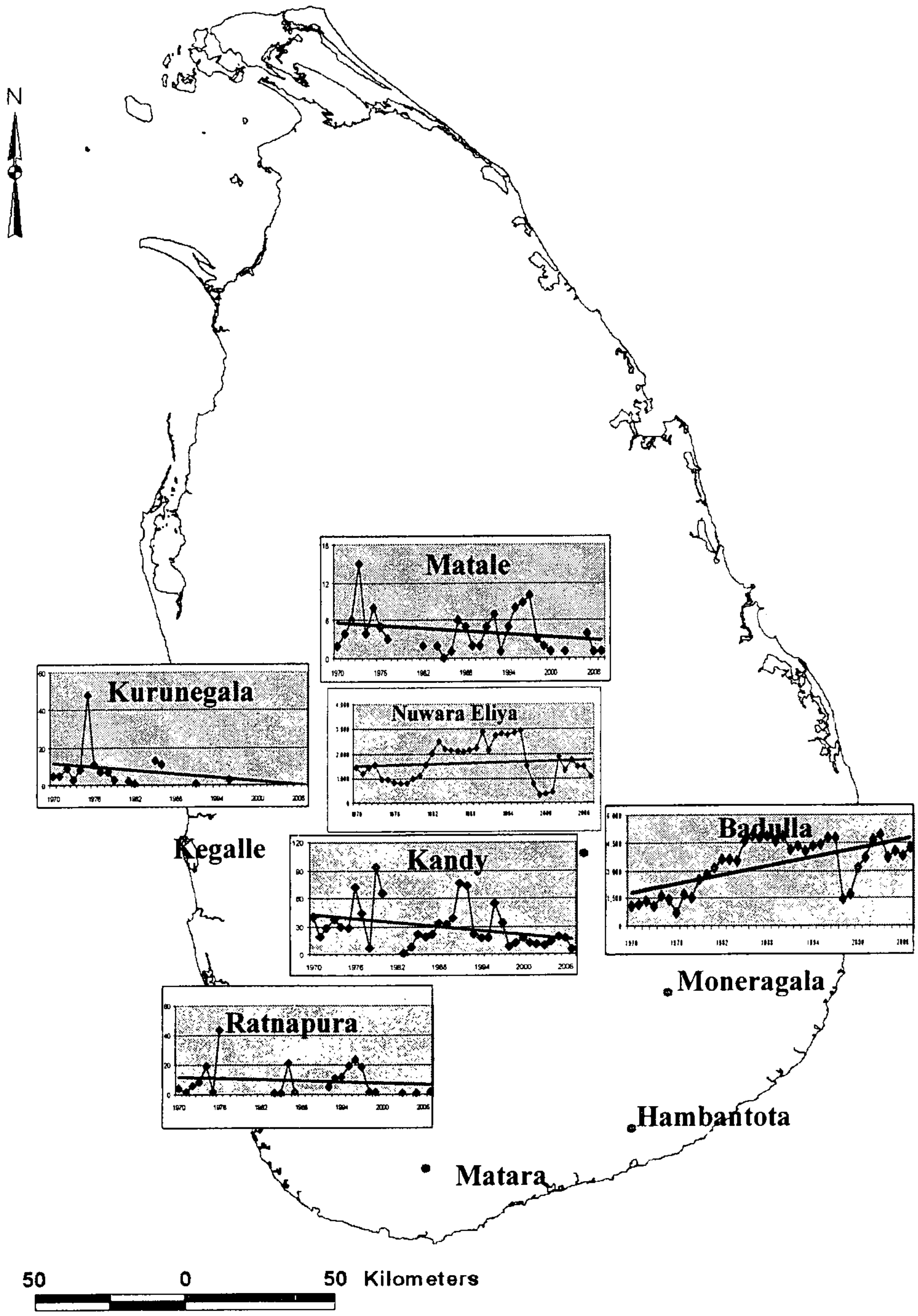
Figure 3.4: Variation in the Extent of Land in Up-country Vegetables



Source: Department of Census and Statistics, 2007

Figure 3.5 illustrates the data on variation in the extent of land used for potato in major growing districts from 1970 to 2007. Accordingly, the potato cultivation in the Badulla district has shown an increasing trend to date, whereas the Nuwara Eliya district shows a slight increase. The Matale and Kandy districts have shown both highs and lows and since 2000, the land extents under potato have been in the range of 10-20 ha. The Ratnapura district records a decline to nearly zero level; the cultivation seems to have been resumed from time to time -- instead of total give-up. Of the ten districts, the Kurunegala district has a small extent cultivated for a number of years. In the Matara district, potato is now grown intermittently except in 1975, when an extent of 89 ha was cultivated.

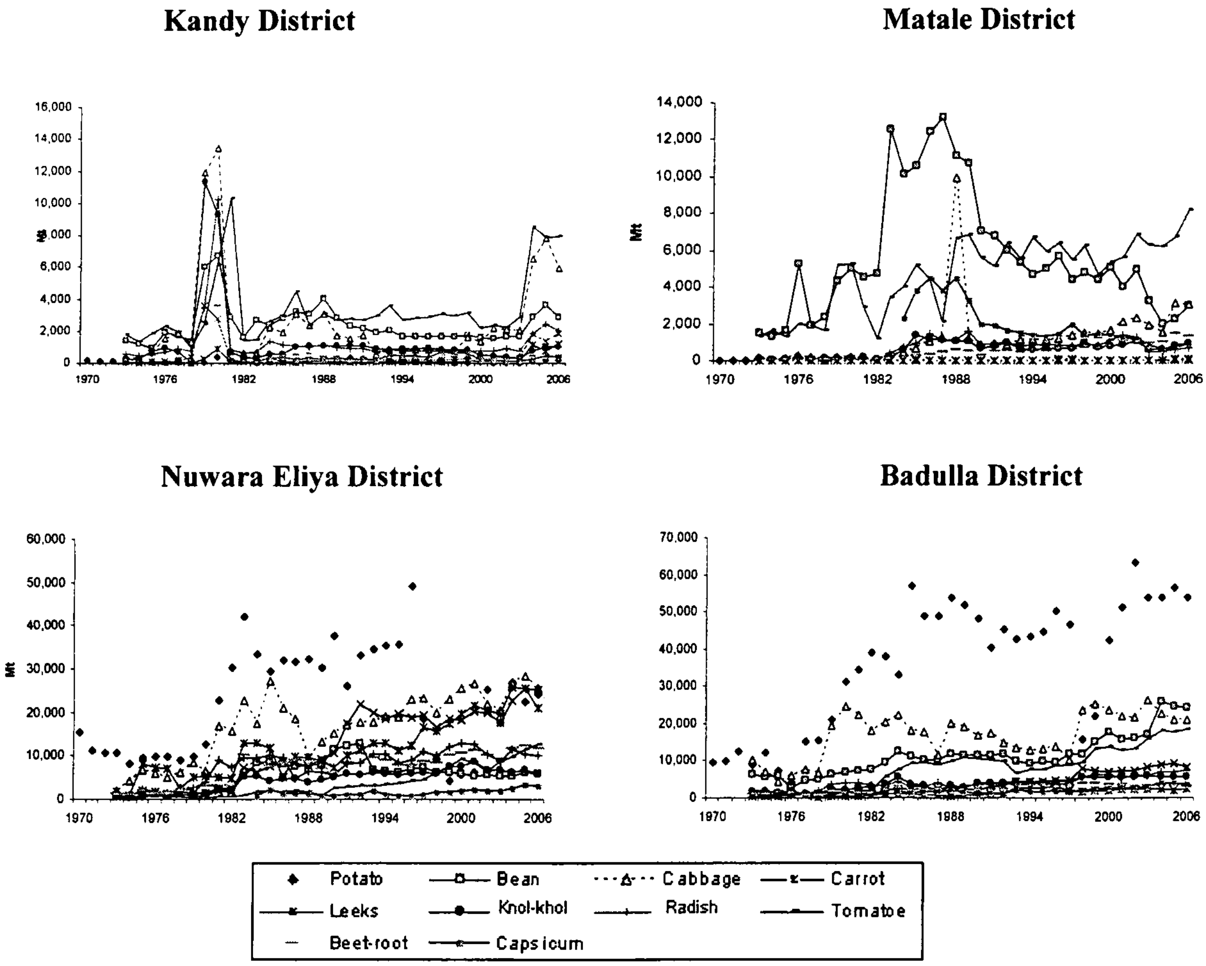
Figure 3.5: Variation in the Extent of Potato in Major Growing Districts since 1970



Source: Department of Census and Statistics, 2007

Outside the ten districts, the districts in the Northern and Eastern Provinces have also grown potato to some extent. The Jaffna district has had extents of land over 500 ha under potato cultivation till the early 1980s; which declined in 2000, the extents were as low as 100 ha. The other districts have grown less than 20 ha and even this has now been given up more or less. The Puttalam district has grown potato around 20 ha during the mid 1980s and 1990s which has gradually decreased and stopped production after 1997. Overall, the up-country vegetable production increased over time and variations across major growing districts are presented in figure 3.6.

Figure 3.6: Variation in the Production of Up-country Vegetables (1970-2007)



Source: Department of Census and Statistics, 2007

From figure 3.6 it is evident that the production of up-country vegetables has increased over time. Sources reveal that the potato has been a popular food in Sri Lanka. It has been imported freely to the country prior to 1967 and then a ban was imposed to increase the local production. The data also confirm the distinctive drive towards self-sufficiency in potato. With this, it has been expected to substitute the then extent of 40,000 tons of potato imports through triple cropping in 4,000 ac. and to be self-sufficient in both seed and consumption by the end of 1961 (Department of Agriculture, 1960). Thus, it appears that the then policy drive towards self-sufficiency has been consistent with the subsequent actions.

3.5 Summary

Physically UPVEGSYS is largely distributed in the Badulla and Nuwara Eliya districts with Kandy and Matale districts being the second most prominent districts. A certain amount is also produced in the other six districts surrounding the central hilly areas of the country. According to the 2006 data, the percentage distribution of the land extent amounts to: Badulla - 34.7 percent, Nuwara Eliya - 32.6 percent, Kandy - 8.1 percent, Matale - 7.3 percent, Kurunegala - 4.5 percent, Ratnapura - 3.1 percent, Moneragala - 1 percent, Hambantota - 0.8 percent, Kegalle - 0.1 percent, and Matara 0.3 percent. The extent of data constitutes 92 percent of the total up-country vegetable production in the year and the rest of 8 percent is produced in the Puttalam, Anuradhapura and Jaffna districts.

These ten districts lie within a diverse range of agro-ecological zones but only 14 zones predominate in terms of up-country vegetable production in the up-country intermediate zone (IU), up-country wet zone (WU), mid-country intermediate zone (IM), mid-country wet zone (WM), low-country dry zone (DL) and low-country intermediate zone (IL). According to the approximate calculations, the percentage distribution of the extent for up-country vegetables in these areas amounts to 42 in IU, 33 in WU, 18 in IM, 6 in WM, 1 in DL and 1 in IL.

Currently, over 40,000 ha are grown with up-country vegetables with the largest extent being under potato. The rest of the area occupies bean, tomato, cabbage, carrot, radish, capsicum, beet, leeks and knol-khol on a decreasing extent. The extent under other up-country vegetables has shown slight increases over time. According to the GN divisional level data on the up-country vegetable production (the 2004 *yala* and the 2004/05 *maha* the latest available data at the time of field survey- unpublished), the largest share of up-country vegetables is grown in the IU (42 percent) and WU (33 percent). Twenty four percent is grown in the mid-country together with IM (15 percent) and WM (four percent), while the rest of two percent of the land area is equally distributed in the DL and IL areas. Overall, it can be deduced that there has been an exceptional expansion of the up-country vegetable farming systems over time and space.

Chapter Four

Sample of the Farming Community

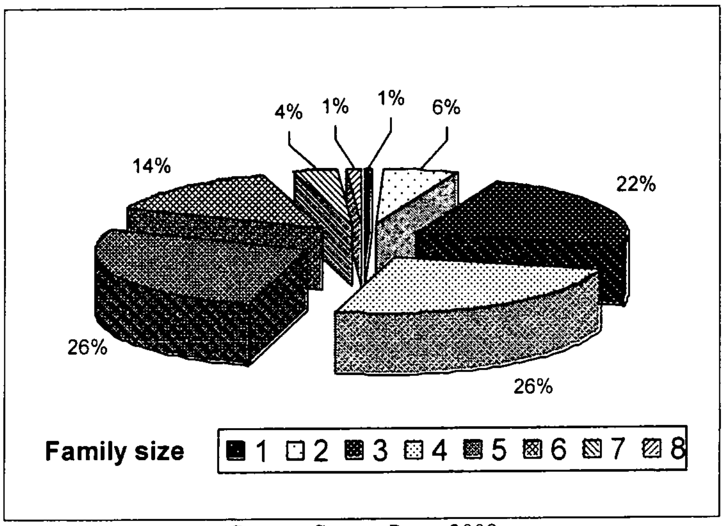
4.1. Introduction

The sample of the farming community has been chosen for this study from the four districts, namely Matale, Nuwara Eliya, Kandy and Badulla, where up-country vegetables are largely grown. Both socio-economic and production features of the sample are presented in this chapter.

4.2. Demographic Features

The sample survey consisted of 223 households with a total population of 972. The family size varied from one to eight members with the majority being four or five member families (figure 4.1). The average family size varied among districts; Matale 4.58, Nuwara Eliya 3.96, Badulla 3.98 and Kandy 4.73 with an overall average family size of 4.4.

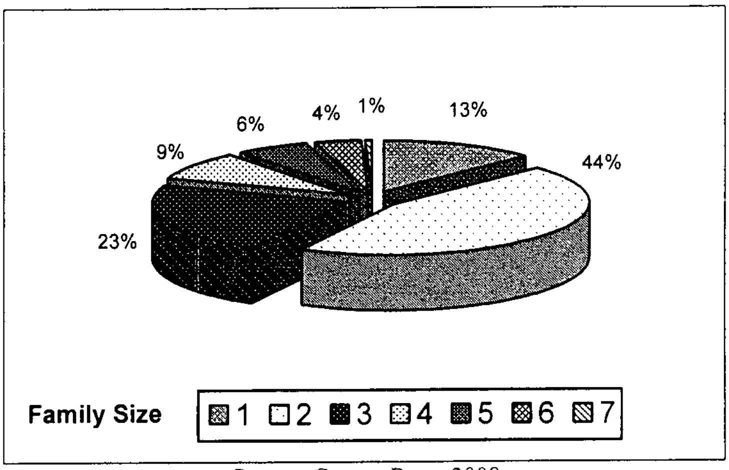
Figure 4.1: Sample Households by Family Size



Source: Survey Data, 2008

One of the livelihoods of the sample households was agriculture which comprised a range of activities like the cultivation of paddy and other field crops including up-country vegetables and tea and other minor export crops. Figure 4.1 indicates the data pertaining to the number of family members involved in the above agricultural activities in each family. Thus, it is apparent from figure 4.2 that agriculture is largely a family business which is run by two or more family members amounting to 87 percent families of the total number of sample households. Of the rest of the families (13 percent), the farmer is the sole operator of the farming land. Further, farming is a two-member task among the majority (49 percent) of the farm households. No clear variations are found across study locations.

Figure 4.2: Sample Households Involved in Agricultural Activities by Number of Members



Source: Survey Data, 2008

Of the households selected for the survey, the person who is largely involved in the up-country vegetable cultivation was interviewed for detailed data collection. Of the total number of farmers interviewed, 211 (97 percent) are heads of households and the rest included spouses, sons or mothers of the heads of households. The heads of households comprised 198 (94 percent) males and 13 (6 percent) females. Overall, the majority of farmers 204 are males (91 percent), while the rest are females. The distribution of the sample farmers by age category is presented in table 4.1.

Table 4.1: Distribution of Sample Farmers by Age Category

Age Category (years)	No. of Farmers	% of Farmers
30 and below	13	5.8
31 -40	48	21.5
41 -50	69	30.9
51-60	63	28.3
61-65	18	8.1
Above 65	12	5.4
Total	223	100

Source: Survey Data, 2008

The age structure of the sample community widely varies from 24 years to 85 years with the majority being between 30 to 60 years (table 4.1). All the farmers above 65 years are still the breadwinners of the selected farming families.

4.3. Education

Table 4.2 presents the education level of the sample householders as reported by 218 households. A limited number of them have never received secondary education, while a significant portion (18.2 percent) comprising all ages has received only primary education regardless of the districts.

Table 4.2: Level of Education of Sample Farmers

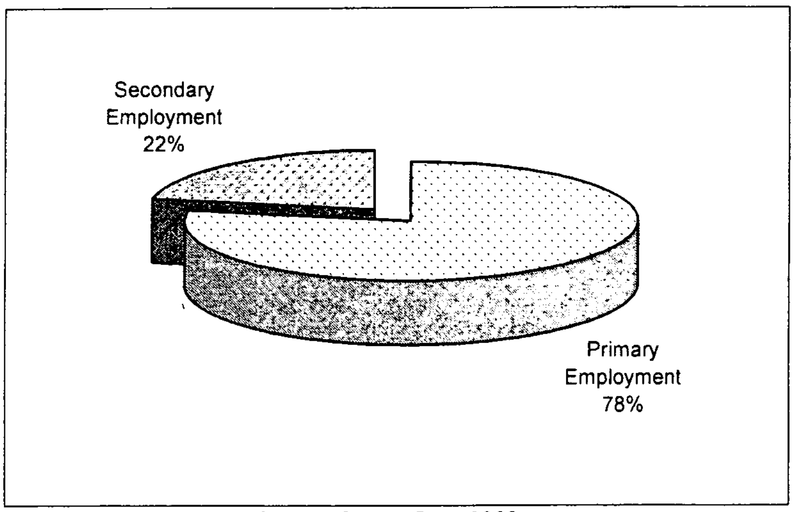
Level of Education	No. of Farmers	% of Farmers
No Schooling	3	1.4
Primary Education – Grade 1-5	41	18.8
Secondary Education – Grade 6-11	89	40.8
GCE Ordinary Level Passed	55	25.2
GCE Advanced Level Passed	28	12.8
Graduate	2	1.0
Total Number of Reported	218	100

Source: Survey Data 2008

4.4. Employment

By nature of sampling in this study to choose up-country vegetable growers, the majority of sample farmers (78 percent) were engaged in the cultivation of up-country vegetables as their primary source of income (figure 4.3). As it is apparent from table 4.3, it was also a supplementary source of income to 44 farmers whose primary employments -- were agriculture related jobs other than up-country vegetable cultivation or non-agricultural jobs. Non-agricultural jobs include both state and private sector jobs and technical and self-employment. Agriculture related jobs vary -- from animal husbandry and working as agricultural labourers -- to cultivation of various crops popular in each location, for instance, chilli, paddy, onion, low-country vegetables and export crops in the Matale district and tea in the Nuwara Eliya and Kandy districts. In addition, they have added up-country vegetables into their farming systems as a supplementary source of income.

Figure 4.3: Up-country Vegetable Production as Primary and Secondary Sources of Income of the Sample Householders



Source: Survey Data 2008

Table 4.3: Primary Employment of Sample Householders who cultivate Up-country Vegetables as a Secondary Source of Income

Primary Employment	Number of Farmers by District				Total
	Matale	Nuwara Eliya	Badulla	Kandy	
Non-Agricultural jobs					
Private/State/Technical/Self Employment	2	7	1	4	14
Agriculture related jobs					
Low-Country Vegetables	3	-	-	1	4
Livestock Farming	-	1	-	1	2
Paddy Cultivation	3	-	-	-	3
Big Onion Cultivation	12	-	-	-	12
Cultivation of Export Crops	1	-	-	-	1
Chilli Cultivation	1	-	-	4	1
Tea Cultivation	-	-	-	1	4
Agricultural Labourer	-	2	-		3
Total Number of Reported	**22**	**10**	**1**	**11**	**14**

Source: Survey Data, 2008

This employment pattern emerges, when principal employments of the employed 415 of the sample families are taken into account (table 4.4). The Matale district predominates over the production of low-country vegetables, big onion and chilli cultivation, while the Kandy district predominates over tea. The majority of agricultural labourers are reported from the Nuwara Eliya district, and the animal husbandry is a characteristic of the Nuwara Eliya and Kandy districts. Thus, the production of up-country vegetables is a main livelihood of the sample population and it is also a supplementary source of income to a considerable portion.

Table 4.4: Employment Pattern of Sample Population

Main Employment	Number of Employed by District				Total
	Matale	Nuwara Eliya	Badulla	Kandy	
Up-country Vegetable Cultivation	68	63	56	61	248
Private/State/Technical/Self Employment	32	21	12	24	89
Low-country Vegetable Cultivation	14	-	-	1	15
Livestock Farming	-	1	-	1	2
Paddy Cultivation	3	-	3	-	6
Onion Cultivation	25	-	-	-	25
Cultivation of Export Crops	1	-	-	-	1
Chilli Cultivation	5	-	-	-	5
Tea Cultivation	-	-	1	5	6
Agricultural Labour	-	10	-	3	13
Coconut Cultivation	1	-	-	-	1
Fisheries	1	-	-	-	1
Total Number of Reported	**150**	**95**	**72**	**95**	**412**

Source: Survey Data, 2008

4.5 Land Availability

Up-country vegetables are grown on both highlands and paddy lands. As apparent from table 4.5, the majority of the farmers (63 percent) operate only highlands, whereas the rest of 37 percent operates both types of lands. The use of paddy lands is seldom reported from the Nuwara Eliya district because paddy lands are scarce in the study locations.

Table 4.5: Land Availability of Sample Households by Districts

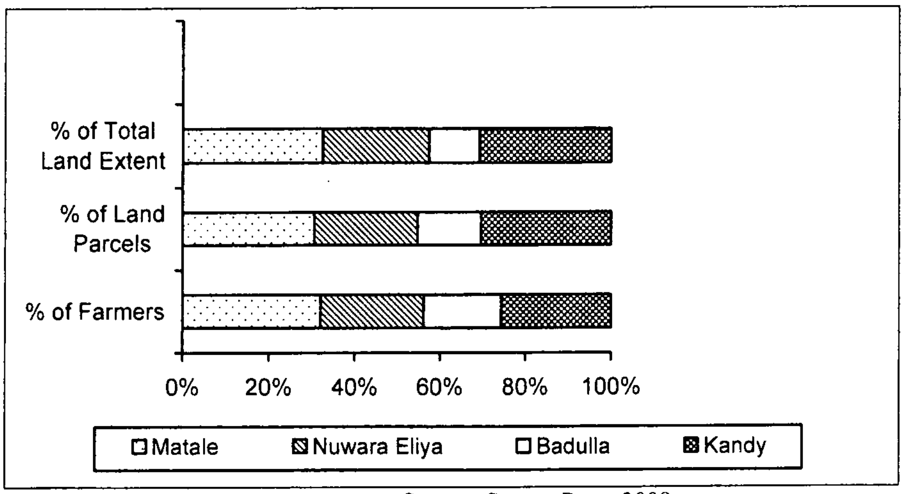
Type of land cultivated	District				Total
	Matale	Nuwara Eliya	Badulla	Kandy	
Highlands Only	33	49	10	48	141 (63%)
Both Highlands and Lowlands	45	1	33	4	82 (37%)
Total	**78**	**50**	**43**	**52**	**223 (100%)**

Source: Survey Data, 2008

Appendix III illustrates data pertaining to the number of land parcels operated by the sample farmers. Accordingly, the number of paddy land parcels operated by a farmer varies from one to five and it is one to eight in the case of highlands. Further, the majority operates only one parcel either upland or paddy land. In the case of paddy lands, 77 percent of farmers have access to a single parcel of land, whereas 99 percent of the farming community operates less than three parcels.

Use of high lands demonstrates a different picture (appendix V). Operators with a single parcel amount to 46 percent, whereas a significant segment of operators (35 percent) has access to two parcels of land. Further, some nine percent of farmers operate three parcels and the rest of five percent, especially from the Nuwara Eliya and Kandy districts have access to a varying number of parcels ranging from four to eight.

Figure 4.4: Availability of Highlands to Sample Farmers



Source: Survey Data, 2008

As shown in figure 4.4, the Matale district has the highest percentage distribution of the sample farmers, while the Badulla district has the lowest. When it comes to the percentage distribution of land parcels and total land extent, Matale and Kandy districts become prominent. But, the Badulla and Nuwara Eliya districts suffer the most, as regards the scarcity of highlands in terms of per-farmer-land availability. Overall, 203 farmers in the sample operate 388 parcels, with a land extent of 370.8 ac and an average land size of 1.82 ac. The effects of these variations are reflected by the land availability parameters, for instance, per-farmer-land availability and average parcel size as given in table 4.6.

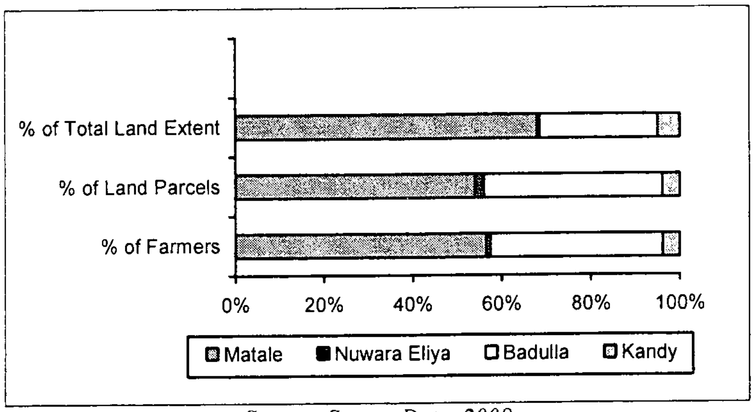
Table 4.6: Highland Availability of Sample Farmers

District	Number of Farmers	No. of Land Parcels	Land Extent (ac)		
			Total	Per Farmer Availability	Average Parcel Size
Matale	65	118	120.25	1.85	1.02
Nuwara Eliya	49	94	92.51	1.88	0.98
Badulla	37	58	43.75	1.18	0.75
Kandy	52	118	114.30	2.19	0.96
Total	**203**	**388**	**370.81**	**1.82**	**0.95**

Source: Survey Data, 2008

As illustrated in figure 4.5, the Matale and Badulla districts predominate over the use of paddy lands for vegetable cultivation.

Figure 4.5: Availability of Paddy Lands to Sample Farmers



Source: Survey Data, 2008

Overall, 101 farmers of the sample operate 133 parcels, with a total land extent of 131.5 ac and an average parcel size of 1.3ac/farmer and 0.98ac/ parcel (table 4.7).

Table 4.7: Paddy Land Availability of Sample Farmers

District	Number of Farmers	No. of Land Parcels	Land Extent (ac)		
			Total	Per Farmer Availability	Average Parcel Size
Matale	57	72	89.25	1.56	1.23
Nuwara Eliya	1	3	0.75	0.25	0.25
Badulla	39	53	34.88	0.89	0.65
Kandy	4	5	6.62	1.65	1.32
Total	**101**	**133**	**131.50**	**1.3**	**0.98**

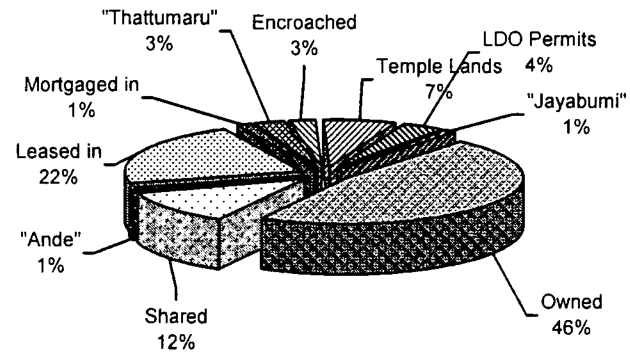
Source: Survey Data, 2008

4.6. Land Tenure

4.6.1. Highlands

The tenure of the highlands operated by the sample farmers are presented in figure 4.6. This shows that 46 percent of farmers operate on their own lands without any ownership constraints-- a crucial factor whether or not to conserve a particular piece of land. It can also be observed that the leasing of lands for the up-country vegetable cultivation is a common practice which amounts to 22 percent of the high land area operated by the sample farmers. Detailed data pertaining to the types of land tenure in terms of location are presented in appendix VI.

Figure 4.6: Extent of Highlands under Different Types of Tenure



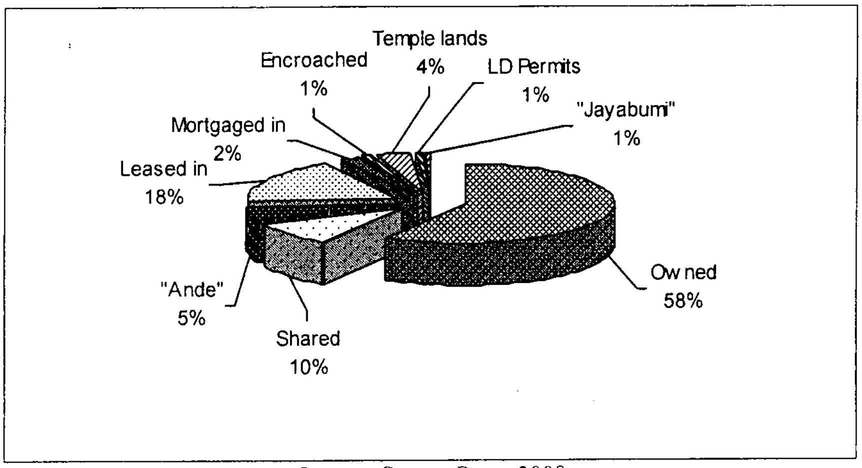
Source: Survey Data, 2008

Accordingly, the most prominent type of land tenure is 'owned' except in the Nuwara Eliya district, where the prominent type is 'leased in', which is largely seen in the Kandy and Matale districts. Many types of land tenure are reported from the Matale district, whereas the least is from the Nuwara Eliya district. The category of 'temple lands' is reported only from the Matale district due to increased use of lands belonging to the Dambulla Rajamaha Viharaya for cultivation purposes.

4.6.2. Paddy Lands

The paddy lands under different types of tenure operated by the sample farmers are presented in figure 4.7. The area under 'owned' type of tenure is prominent amounting to 58 percent of the total land area. Still the 'leased in' type is the second most prominent type and the third is the 'shared'. The latter is the ownership of a particular land parcel by several people, though currently it is used by one person. The percentage of the land area under '*ande*' type is larger than that of highlands due to the prevalence of traditional types of land tenure, especially in the case of paddy lands. Appendix VII shows data on the variation of the types of land tenure across study locations. As evident from appendix VII, 'owned' tenure type is the prominent in each district with the exception of the Nuwara Eliya district, where the sample farmers have no access to paddy lands.

Figure 4.7: Extent of Paddy Lands under Different Types of Tenure



Source: Survey Data, 2008

4.7 Crops Grown on Highlands

With the data collected during the survey, the seasonal cropping intensity and annual cropping intensity were calculated for highlands using the following formulae:

$$\text{Seasonal Cropping Intensity} = \frac{\text{Cultivated Extent of Highland During the Season}}{\text{Total Extent of Highland Available to Farmers}} \times 100$$

$$\text{Annual Cropping Intensity} = \frac{\text{Cultivated Extent of Highland During the Year}}{\text{Total Extent of Highland Available to Farmers}} \times 100$$

The total highland area available to the sample farmers is 370.81 ac. According to the data presented in table 4.8, the extents of highland under different crops vary according to seasons. The highest cropping intensity is reported during the *maha* season amounting to 42 percent. Twenty seven percent of the total highland area under up-country vegetables is used for potato cultivation. Among other prominent up-country vegetables grown in the *maha* season are bean, cabbage, carrot, beet and tomato. In addition, several other crops such as big onion, long bean, okra, winged bean, chilli, brinjal, snake gourd, bell pepper, strawberry and luffa are also grown during the *maha* season with a cropping intensity of 13 percent. Thus, the cropping intensity for highlands during the *maha* season amounts to 42 percent for up-country vegetables and 13 percent for other crops with an overall cropping intensity of 55 percent of the total area cultivated (202.18 ac).

In the *yala* season, water scarcity constraints the vegetable cultivation on highlands so that the extent of highland use decreases up to two-third of the area used for up-country vegetables in the *maha* season. Thus, the cropping intensity drops to 26 percent for up-country vegetables, 13 percent for other crops with an overall cropping intensity of 39 percent of the total highland extent cultivated.

In between these two major seasons, an intermediate season called the *meda kanna* (intermediate season) is in practice depending on the availability of water for off-season vegetable cultivation. During this intermediate season, the use of highlands has decreased to some one-third of the highland area used in the *maha* season. The cropping intensities for up-country vegetables and other crops are 16 percent and one percent respectively. Overall, the intensity of highland use during the *meda kanna* is 17 percent.

From highlands, the seasonal contribution to annual cropping intensity is 111 percent (55 percent during the *maha* season, 39 percent during the *yala* season and 17 percent during the intermediate season). The crop-wise contribution to annual cropping intensity amounts to 84 percent from up-country vegetables and the rest of 27 percent from other crops.

Table 4.8: Seasonal Variation of Crops Grown on Highlands by Sample Farmers

Crops	Seasonal distribution of extent under different crops (ac)			Total annual extent cultivated	
	Maha 2006/07	*Yala* 2007	*Meda Kanna* 2007	ac	%
Potato	42.40	18.38	5.73	66.51	21.4
Bean	22.81	8.42	8.25	39.48	12.7
Carrot	19.25	15.69	13.62	48.56	15.7
Cabbage	18.24	19.91	15.62	53.77	17.3
Leeks	8.25	6.67	2.30	17.22	5.5
Knol khol	2.50	2.25	0.50	5.25	1.7
Beet root	15.06	6.87	1.25	23.18	7.5
Radish	6.25	7.75	3.24	17.24	5.6
Tomato	17.00	3.88	5.50	26.38	8.5
Capsicum	3.51	5.67	3.50	12.68	4.1
Extent of Up-country vegetables (ac)	**155.27**	**95.49**	**59.51**	**310.27**	**100.0**
Seasonal Cropping Intensity[1]	**42%**	**26%**	**16%**	**84%**	-
Extent of other crops* (ac)	**46.91**	**47.5**	**5.24**	**99.65**	-
Seasonal Cropping Intensity[2]	**13%**	**13%**	**1%**	**27%**	-
Total extent cultivated (ac)	**202.18**	**142.99**	**64.75**	**409.92**	-
Cropping Intensity[3]	**55%[4]**	**39%[4]**	**17%[4]**	**111%[5]**	

Note:

[1]Cropping Intensity for up-country vegetables
[2]Cropping Intensity for other crops
[3]Cropping Intensity for all crops
[4]Seasonal Cropping Intensity
[5]Annual Cropping Intensity
* big onion, long bean, okra, winged bean, chilli, brinjal, snake gourd, bell pepper, strawberry and luffa

Source: Survey Data, 2008

4.8 Crops Grown on Paddy Lands

The seasonal and annual cropping intensities of the paddy lands were calculated using the following formulas.

$$\text{Seasonal Cropping Intensity} = \frac{\text{Cultivated Extent of Paddy Land During the Season}}{} \times 100$$

Total Extent of Paddy Land Available to Farmers

$$\text{Annual Cropping Intensity} = \frac{\text{Cultivated Extent of Paddy Land During the year}}{\text{Total Extent of Paddy Land Available to the Farmers}} \times 100$$

The total paddy land area accessible to the sample farmers amounts to 131.5 ac. Table 4.9 indicates the variation of crops grown on paddy lands by season and the annual cropping intensity is reported as 136 percent (table 4.9). Paddy lands are largely utilised during the *maha* season at a rate of 71 percent of the total accessible area to them. Seventy nine percent of this area is occupied by paddy, 14 percent by up-country vegetables (bean, carrot, cabbage, knol-khol, raddish, tomato, capsicum) and the rest by other crops (chilli and snake gourd).

Table 4.9: Seasonal Variation of Crops Grown on Paddy Lands by Sample Farmers

Crops	**Total area of crops (ac) cultivated during**			**Total extent cultivated**	
	***Maha* 2006/07**	***Yala* 2007**	***Meda Kanna* 2007**	**ac**	**%**
Potato	2.50	18.58	0.50	21.58	25.0
Bean	7.50	5.00	6.50	19.0	22.0
Carrot	1.75	0.50	3.00	5.25	6.1
Cabbage	0.50	4.25	2.25	7.0	8.1
Leeks	-	-	-	-	-
Knolkhol	0.50	6.75	0.50	7.75	9.0
Beet root	-	10.75	-	10.75	12.5
Radish	0.50	0.50	2.75	3.75	4.4
Tomato	4.75	3.87	0.25	8.87	10.3
Capsicum	0.25	1.75	0.25	2.25	2.6
Total extent (ac) Percentage	**18.25**	**51.95**	**16.00**	**86.2**	**100.0**
Cropping Intensity[1]	**14%**	**39%**	**12%**	**65%**	-
Total extent of other crops * (ac)	**75.5**	**15.75**	**2**	**93.25**	-
Cropping Intensity[2]	**57%**	**12%**	**2%**	**71%**	-
Total extent of cultivation (ac)	**93.75**	**67.7**	**18**	**179.45**	-
Cropping Intensity[3]	**71%**	**51%**	**14%**	**136%**	

Note: [1]Cropping Intensity for up-country vegetables

[2]Cropping Intensity for other crops including paddy

[3]Cropping Intensity for all crops

* big onion, long bean, okra, winged bean, chilli, brinjal, snake gourd, bell pepper, strawberry and luffa

Source: Survey Data, 2008

During the *yala* season, the paddy cultivation drops to some three percent of the total extent cultivated. Instead, the extent of up-country vegetables such as potato, bean, carrot, cabbage, knolkhol, beet, radish, tomato, capsicum is grown at the rate of 39 percent, where the area under potato amounts to 27 percent of the total extent. Thus, the cropping intensity of other crops decreases to some 12 percent with a total seasonal cropping intensity of 51 percent.

Paddy lands are also used for off-season cultivation, where all up-country vegetables except for leeks are grown at an intensity of 12 percent. Other crops utilise two percent with a total of 14 percent of the total land extent. The variation in crops grown has resulted due to both seasons and crops grown. The variation of cropping intensity on paddy lands is 65 percent for up-country vegetables and 71 percent for other crops. The seasonal contribution amounts to 71 percent during the *maha* season, 51 percent during the *yala* season and the rest of 14 percent from the cultivation in the *meda kanna*. The ultimate outcome of these variations is the annual cropping intensity of 136 percent.

4.9 Summary

The sample of the farming community chosen from the Matale, Nuwara Eliya, Kandy and Badulla districts consisted of 223 households. The main livelihood of farmers sampled was agriculture comprising cultivation of paddy and other field crops including up-country vegetables. The majority of them were engaged in the up-country vegetable production as their primary source of income, and to a significant portion it was a secondary source of income. In addition, each farmer has other means of income too. The up-country vegetable production is a family business to sample farmers who are from a wide range of ages and having educational attainments.

About two-thirds of the farmers sampled operate on highlands with the rest operating on both highlands and paddy lands. Per-farmer availability of highlands in the Badulla and Nuwara Eliya districts is limited, when compared to other districts. Farmers operate the available land under different terms of tenure, but owner operators predominate. Leasing of lands for the up-country vegetable production is a common occurrence with regard to both highlands and paddy lands but the owner operators predominate.

The up-country vegetable production provides a considerable contribution to the seasonal and annual cropping intensity of both highlands and lowlands in UPVEGSYS, particularly during the *maha* season. The annual cropping intensity of paddy lands is higher than that of highlands amounting to 136 and 111 percents respectively. The cumulative contribution to these annual cropping intensities of the up-country vegetables during three seasons amounts to 84 percent from high lands and 65 percent from paddy lands. Seasonal contribution to annual cropping intensities amounts to 71 percent during the *maha* season, 51 percent during the *yala* season and 14 percent during the *meda kanna*.

Chapter Five

Farmers' Knowledge, Attitudes and Responses towards Natural Resources

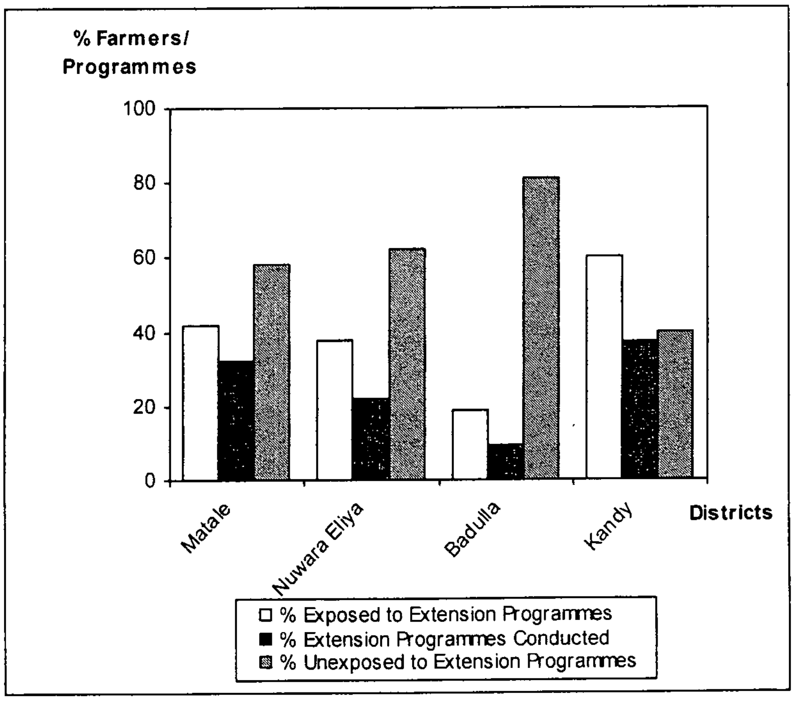
5.1 Introduction

This section deals with the findings of the investigation into the knowledge and attitudes of farmers towards the use and management of natural resources during the up-country vegetable production and their responses in relation to environmental impacts. In line with this, it has first been attempted to assess the degree of farmers' exposure to extension programmes and knowledge building efforts launched by a variety of partners. Consequently, the analysis has been extended to explore the diversity of such efforts made, the level of farmers' knowledge and the adoption of eco-friendly farming techniques in comparison to conventional farming techniques employed by the up-country vegetable farming community.

5.2 Farmers' Knowledge on Use and Management of Natural Resources

The major focus of this section is to present the findings of the investigation made to learn about how farmers have been exposed to a variety of knowledge improvement programmes launched during the past five years. They are reported as extension programmes in this study report. Survey findings reveal that only 41 percent of the sample farmers has been exposed to extension programmes launched in the study locations with a remarkable variation in reaching the farming community both in terms of district and eco-zone (figures 5.1 and 5.2).

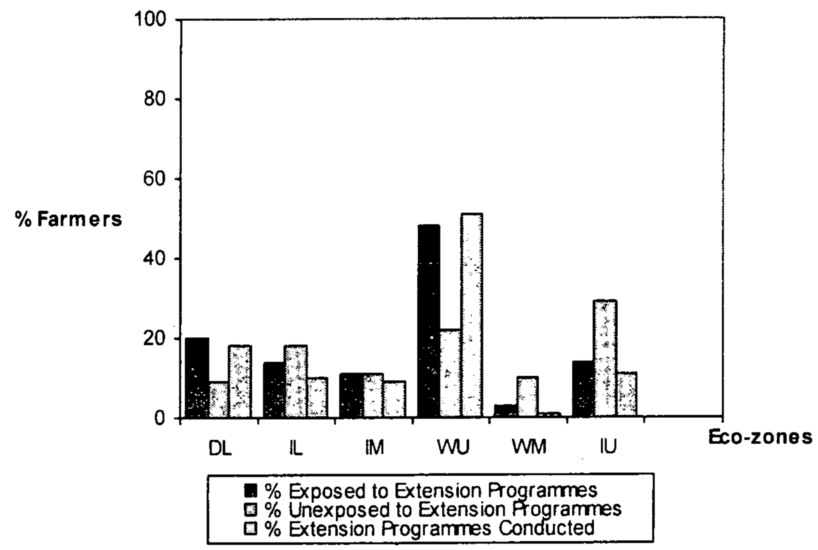
Figure 5.1: Farmers' Exposure to Extension Programmes across Districts



Source: Survey Data, 2008

In terms of districts, a considerable segment of the sample farmers from the Matale (42 percent) and Kandy (60 percent) districts have been exposed to extension programmes amounting to 32 percent and 37 percent of the total number of programmes respectively. However, the data related to eco-zone establish that the farmers in the WU zone have received the highest exposure followed by the farmers in the DL and IU zones.

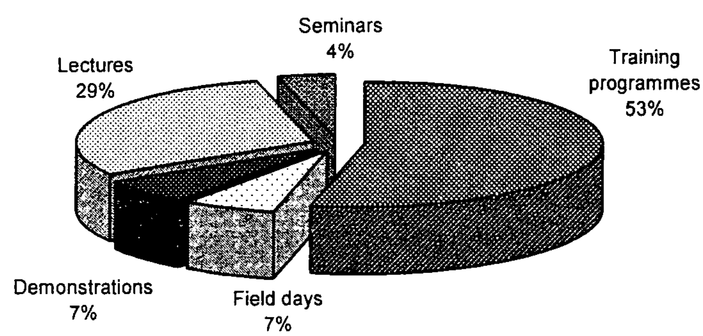
Figure 5.2: Farmers' Exposure to Extension Programmes by Eco-zones



5.2.1 Extension Methods

The extension programmes vary from training programmes, field days, demonstrations and lectures to seminars. As shown in figure 5.3, the training programmes and lectures are the commonest types among which the major focus is to disseminate general agricultural information to the farming community.

Figure 5.3: Extension Methods Adopted in Extension Programmes



Source: Survey Data, 2008

The specialised cultural methods including the production of big onion seed, the pest and disease control, the organic farming, the post harvest technologies and the soil conservation measures have also been covered in the training programmes. Further, the farmers have been exposed to soil conservation measures and organic farming practices through field days. Demonstrations on the safe use of pesticides and organic farming practices are also reported. Seminars are among other means of disseminating knowledge to the farming community. The training programmes predominate among group communication methods, whereas result and method demonstrations and field days are seldom reported. It is no doubt that the training programmes can accommodate both theoretical and practical aspects that improve farmers' knowledge relating to a particular discipline. Demonstrations and field days, though they deserve more effort and expenditure, are comparatively comprehensive, that they could make the farming community more cognizant through several steps along the adoption process[1]. Hence, it is important to consider these aspects when designing extension programmes.

5.2.2 Contents of Extension Programmes

Table 5.1 presents the distribution of extension programmes which are broadly categorised on the basis of the content of the programmes in terms of districts. Accordingly, there are four broad categories of programmes under following themes:

(a) General Agricultural Information
The highest priority has been placed on disseminating general agricultural information which incorporates a variety of aspects of agriculture such as crop establishment, fertilisation, crop protection, irrigation, harvesting and marketing. Such programmes amount to 42 percent of the total number of programmes (139) conducted.

(b) New Technology, Skills and Information
The second prominent category contains programmes on new technology, skills and information particularly on sprinkler irrigation, poly tunnels, post harvest technologies, animal rearing, use of quality seeds and financial management amounting to 25 percent of the programmes.

(c) Soil Fertility Management
Included in the third category, soil fertility management programmes (19 percent) are all eco-friendly practices such as soil conservation measures, organic farming, use of straight fertilisers and soil testing based fertilisation.

(d) Plant Protection Measures
The final category which talks about plant protection measures (14 percent) are two fold; dissemination of general information relating to control of pest and diseases and eco-friendly practices such as safer use of pesticides, use of natural pesticides and integrated pest management.

Several aspects should receive attention during the design of extension programmes. Firstly, as farmers are adults, they need a replenishment of knowledge before practice in

[1] Adoption is a process which consists of five steps; awareness, interest, evaluation, first trial, repeated use or adoption.

accordance with adult education principles. Secondly, the generality of extension efforts, in other words, general farmer education is essential to educate the farming community of continuously changing knowledge and technologies. Thirdly, the extension programmes should also cater to the specific farming needs so as to make agriculture more competitive and profitable. Striking a balance between all these features in designing extension programmes is crucial for the advancement of agriculture.

The given data and information depict that the contents of the extension efforts are rather specific than generic. Whilst this particular specificity has been signified through addressing sustainability and productivity (profitability) issues of the farming systems, the generality of extension programmes is also maintained to a certain extent. Thus, as evident from table 5.1, the extension curriculum is in the right direction in spite of the limited coverage across the locations and the limitations in choosing and employing appropriate extension methods aforesaid.

Table 5.1: Contents of Extension Programmes across Districts

Programme Content	No. of Programmes by Districts				Total (%)
	Matale	Nuwara Eliya	Badulla	Kandy	
1.General Agricultural Knowledge	33	9	3	13	58 (42%)
2.New Technology, Skills and Information	7	10	3	14	34 (25%)
3.Soil Fertility Management	3	8	4	12	27 (19%)
4.Plant Protection	2	3	2	13	20 (14%)
Total	45	30	12	52	139 (100%)

Source: Survey Data, 2008

Of the four categories of extension programmes, a plant protection category consists of both conventional and eco-friendly farming practices, while all the farming practices in the soil fertility management category can be identified as eco-friendly farming practices. Table 5.2 presents the data pertaining to extension programmes which come under each category, and therefore the share of eco-friendly farming techniques amounts to 26 percent of the total number of extension programmes conducted (139).

Table 5.2: Extension Programmes to Popularise Eco-friendly Farming Techniques

Programme Content	No. of Programmes by District				
	Matale	Nuwara Eliya	Badulla	Kandy	Total *(%)
Plant Protection	1	2	1	6	10 (7%)
Soil Fertility Management	3	8	4	12	27 (19%)
Total	4	10	5	18	37 (26%)

Note: *Out of the total number of extension programmes reported (139)

Source: Survey Data, 2008

5.2.3 Extension Partners

According to respondents, a variety of partners have contributed to the knowledge dissemination process which is dominated by various research institutes. Whilst the DOA including Horticultural Research and Development Institute (HORDI) has conducted some

61 percent of the total number of extension programmes, many private sector organisations such as Cepetco, Baurs, Hayles and Uni Power are among them, while the Colombo Industries Chemicals (CIC) is the leading company. International organisations such as United Nations Development Programme (UNDP) and GTZ, Regional Development Banks, Samurdhi Bank and Hatton National Bank have also taken part in the knowledge dissemination process. Numerous other partners are Sarvodaya, Upper Watershed Management Project (UWMP), Regional Economic Advancement Project (REAP), Hadabima Authority of Sri Lanka and Tea Small Holding Development Authority (TSHDA).

5.2.4 Projects

There have been three major projects in the study locations with conservation orientation during the past decade, namely UWMP, REAP, and Environmental Action 1 (EA 1) Project. Table 5.3 indicates the farmers' knowledge about and access to these projects across districts. Accordingly, UWMP has been the most recent and popular project which also has a significant concern on prevention of environmental degradation due to small-scale farming. Farming community has been the target group of this project and therefore, it has been more popular among the farmers. There has been a component in the EA 1 Project which targeted the farming community and handled by the Natural Resources Management Centre of the DOA. REAP which mainly concentrated in the Matale district and to a certain extent in the Nuwara Eliya district had incorporated environmental concerns to a certain extent.

Table 5.3: Percentage Distribution of Sample Farmers Based on Knowledge and Receiving Benefits from Projects by Districts

Project	Districts					
	Matale		Nuwara Eliya		Badulla	
	% A*	% B**	% A	% B**	% A*	% B**
REAP	71	24	-	-	-	-
UWMP	-	-	43	3	100	67

Note: A* Knowledge **B**** Benefited
Source: Survey Data, 2008

It is common that the knowledge gathered by farmers through various means is applied largely with the aim of increasing yield, thereby increasing income from farming. In addition to this, protection of environment, safer use of pesticides, minimum use of agro-chemicals and efficient water management are among the other objectives to protect the environment.

However, as reported there are some constraints on the use of knowledge and technologies disseminated through these programmes. Some of the constraints encountered, are: (a) poor practicability of natural pesticides and IPM, (b) high cost of cattle manure, (c) preparation and application difficulties of natural pesticides, and (d) poor results obtainable through the practice of organic farming. These will be discussed at length in the subsequent sections.

5.3 Field Level Extension Personnel

The study findings surface a changing scenario of the linkages between the farmer and the extension personnel of the state sector at field level. As evident from table 5.4, the ARPA has gained recognition as the most prominent village level contact person for agriculture related matters across all districts. However, a HARTI study carried out in the Matale and Badulla districts in 2000 (Weerakkody *et al.*, 2004) provided evidence that the AI is the closest contact personnel at the village level who has been replaced by ARPA in the current context. The input dealer is the third in line.

Table 5.4: Farmers' Rating of Prominent Extension Personnel by Districts

Contact Personnel	Number of Responses from the Districts				Overall
	Matale	Nuwara Eliya	Badulla	Kandy	
ARPA	57	28	22	17	124
AI	50	13	13	19	95
Input Dealer	4	13	19	19	55
Other	-	7	3	11	21
Total	111	61	57	66	295

Source: Survey Data. 2008

As revealed, the provision of services is in accordance with the duties and responsibilities of each category of officers. According to farmers' responses, the ARPA's functions could be broadly categorised into four functions:

(a) Provision of advisory services: dissemination of knowledge and information,
(b) Supply of inputs: distribution of fertilisers, seeds and agro-chemicals,
(c) Co-ordination of functions: services such as credit arrangement through financial- institutions and introducing farmer pension schemes, and
(d) Solving farmer problems: solving land use and water management problems faced by farmers.

Among the few responses on the drawbacks of the services of the AI and the ARPA are the lack of commitment, ineffective service delivered in the absence of adequate knowledge, inexperience and time limitations, inadequate number of farm visits made due to the lack of transport facilities and shortage of officer cadres.

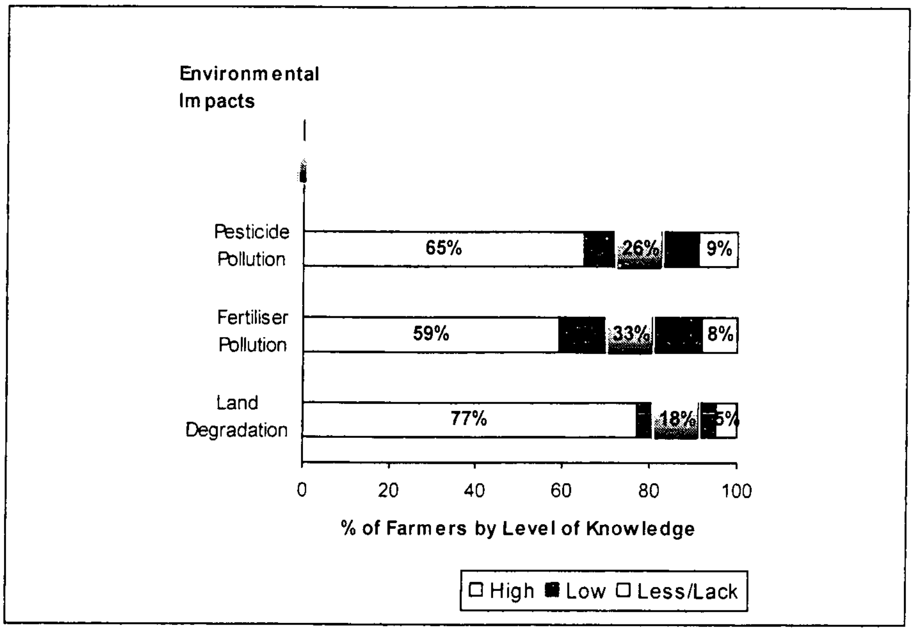
5.4 Level of Farmers' Knowledge on Environmental Impacts due to Farming

Measuring farmers' knowledge on environmental impacts due to agriculture is rather complex. Nevertheless, it was attempted to assess the farmers' level of knowledge relating to three major environmental impacts; land degradation due to soil erosion, fertiliser pollution, and pesticide pollution, which were identified as mostly prevalent in the study locations in the course of literature survey. The questions directed to the farmers covered the aspects of the causes, consequences and remedies for the said environmental impacts. Farmers were divided into three categories based on how they responded with regard to said environmental issues.

(a) Farmers with high levels of knowledge: Those who explained well the causes, consequences and remedies for the said environmental impacts
(b) Farmers with low levels of knowledge: Those who had low knowledge on the same
(c) Farmers with less knowledge or lack of knowledge: Those who had less or lack of knowledge on the same

Overall, the data stress the fact that the large majority of the sample of the farming community has a good understanding of the three environmental impacts; land degradation due to soil erosion and pollution due to agro-chemicals both from pesticides and fertilisers. However, a considerable segment of the sample of the farming community is either less aware of or lacks knowledge, despite intensive use of land and chemical inputs for the production of up-country vegetables. Figure 5.4 shows that farmers are more aware of land degradation due to soil erosion than agro-chemical pollution.

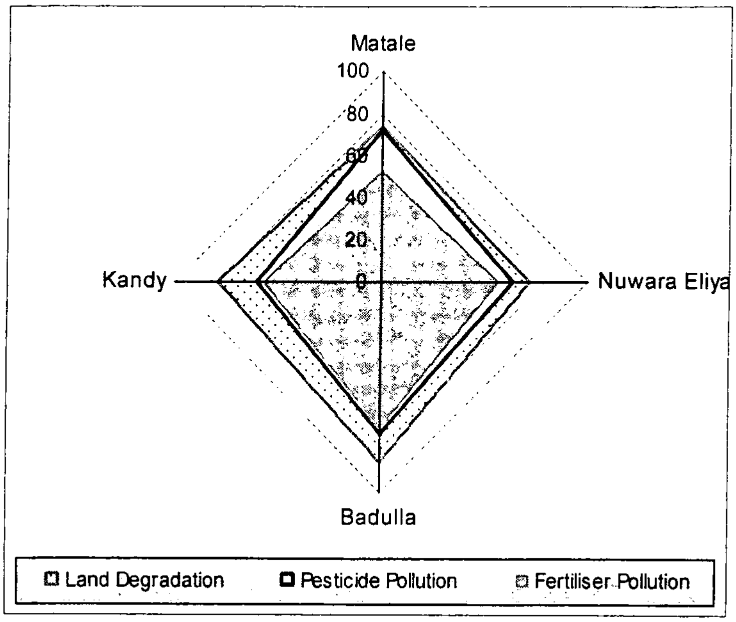
Figure 5.4. Farmers' Knowledge on Environmental Impacts due to Farming



Source: Survey Data, 2008.

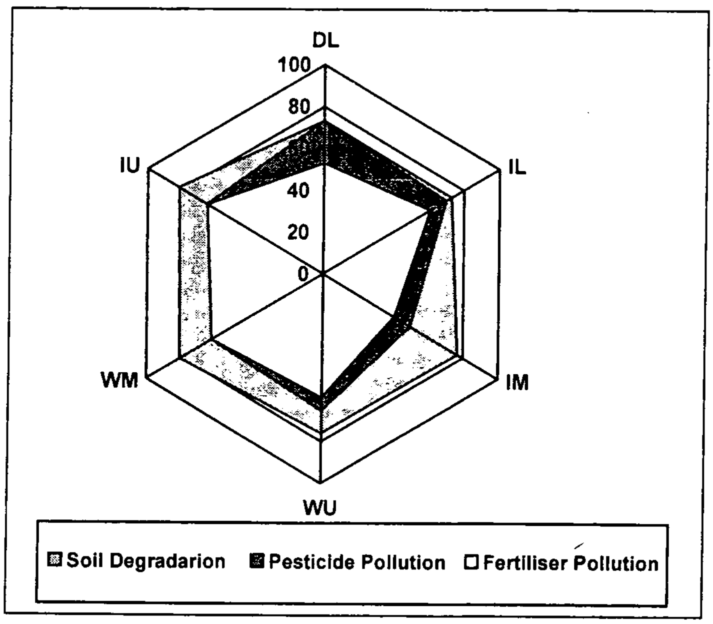
Figures 5.5 and 5.6 illustrate the percentage distribution of farmers with adequate knowledge on three environmental impacts in terms of district and eco-zone. Accordingly, the farmers from the Badulla district in the IU eco-zone have increasingly learnt about the issues. Across the district and eco-zone, a certain percentage of farmers has adequate knowledge. The farmers' knowledge on the selected impacts could be placed in the order of land degradation due to soil erosion, pesticide pollution followed by fertiliser pollution.

Figure 5.5: Farmers' Knowledge on Environmental Impacts across Districts (% of Farmers)



Source: Survey Data, 2008

Figure 5.6: Farmers' Knowledge on Environmental Impacts across Eco-zones (% of Farmers)



Source: Survey Data, 2008

Given the circumstances, it seems that the land degradation due to soil erosion is the prominent environmental concern in the UPVEGSYS as it has been established through literature sources as well. When it comes to agro-chemical pollution, the situation is certainly different where farmers have less understood about fertiliser pollution than pesticide pollution. Studies have shown that fertiliser pollution is a serious environmental concern, but the farmers' knowledge on fertiliser pollution is lower than that of pesticide pollution and land degradation. Farmers are of the opinion that even the DOA promotes the use of chemical fertilisers in its straight fertiliser programme and thus, the fertiliser pollution is not a serious concern for the up-country vegetable cultivation than the pesticide pollution which occurs due to indiscriminate use of pesticides.

It is also noteworthy to mention that the knowledge alone is insufficient for the protective use of resources, but the practice itself is the crucial factor. The next section deals with the farmers' response towards the adoption of key eco-friendly farming practices that would remedy the concerned environmental issues.

5.5 Knowledge and Adoption of Plant Protection Measures

In this section, the outcome of the assessment is presented to understand how farmers adopt eco-friendly plant protection measures in comparison with popular conventional plant protection measures.

The assessment focuses on the farmers' knowledge and adoption behaviour between eco-friendly and conventional plant protection/pest and disease control methods. Sources revealed two eco-friendly plant protection methods which are familiar to up-country vegetable farmers.

(a) Application of *neem* preparations.
(b) Integrated pest management (IPM) techniques.

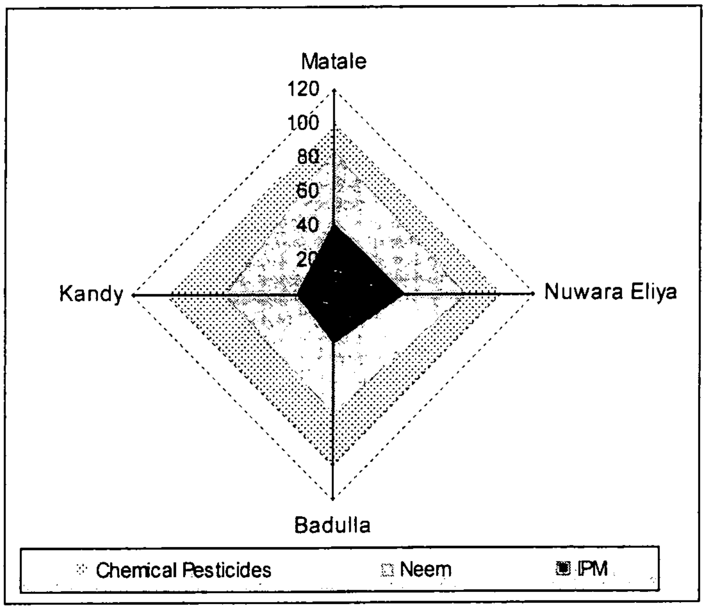
Hence, the knowledge and adoption behaviour of these eco-friendly techniques were assessed in comparison with the conventional plant protection methods and the use of chemical pesticides. The questions were directed to farmers on five major aspects of each method; knowledge, use, availability, quality and benefits of use. Each aspect is described below.

Knowledge:	Farmers' knowledge on the techniques and procedures of using each plant protection method and the benefits obtainable through the practice.
Use:	Whether the farmer has really applied the technique on the farm.
Availability:	Whether the inputs and raw materials are often accessible for use when and where in required quantities.
Quality:	Farmers' satisfaction on the available preparations but only with regard to *neem* and chemical pesticides.
Benefits:	Whether increased benefits are obtainable through the practice of a particular plant protection method.

5.5.1 Knowledge of Conventional and Eco-friendly Plant Protection Measures

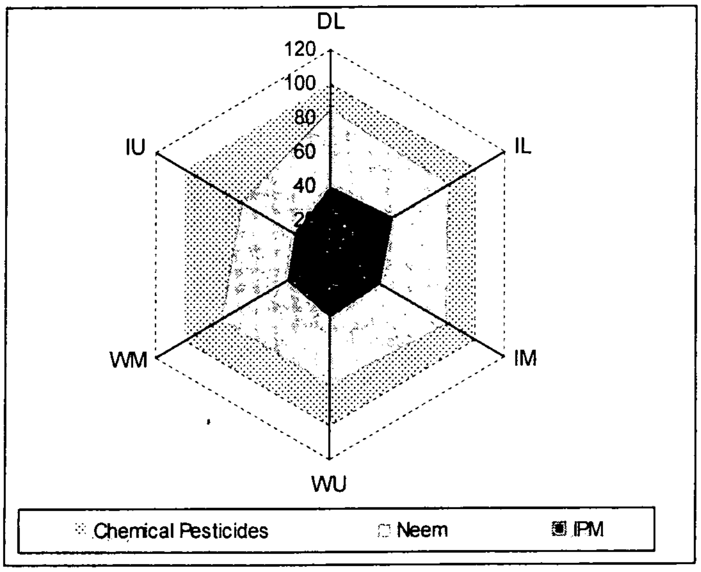
Overall, 76 percent of the sample has a proper knowledge on *neem* preparations, while only 36 percent are knowledgeable about IPM. These levels of knowledge are in comparison to 100 percent level of knowledge on chemical pesticides by the farming community. Figures 5.7 and 5.8 provide illustrations on the percentage distribution of farmers having adequate knowledge on each technique. The data establish that the knowledge of the farming community about IPM and *neem* are far below than that of chemical methods.

Figure 5.7: Farmers' Knowledge on Eco-friendly and Conventional Plant Protection Techniques across Districts (% of Farmers)



Source: Survey Data, 2008

Figure 5.8: Farmers' Knowledge on Eco-friendly and Conventional Plant Protection Techniques across Eco-zones (% of Farmers)

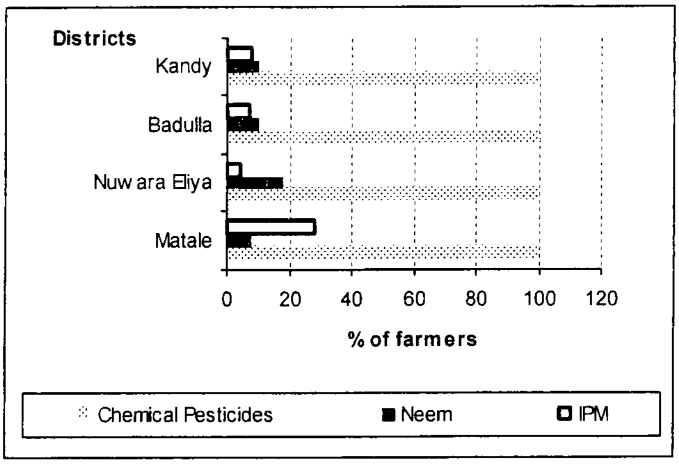


Source: Survey Data, 2008

5.5.2 Adoption of Conventional and Eco-friendly Plant Protection Measures

Figure 5.9 presents the percentage distribution of farmers using eco-friendly and conventional chemical plant protection measures in terms of districts.

Figure 5.9: Use of Eco-friendly and Conventional Plant Protection Measures across Districts (% of Farmers)

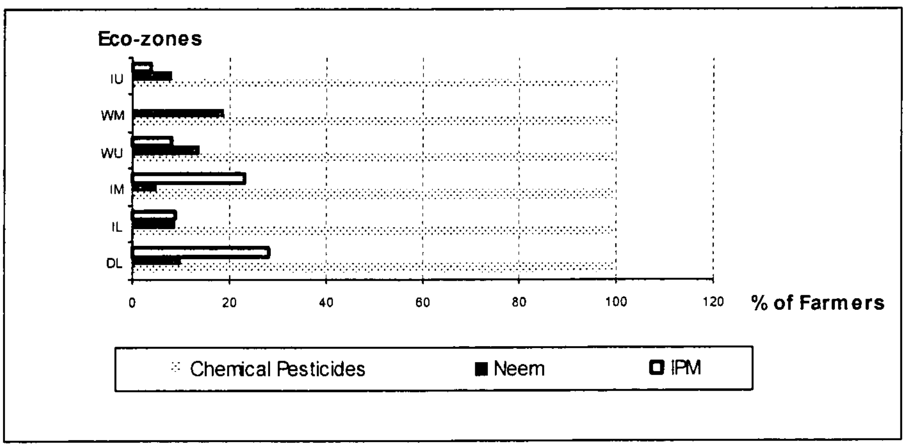


Source: Survey Data, 2008

The use of *neem* is the lowest amounting to 8, 18, 10 and 10 percents for the districts of Matale, Nuwara Eliya, Badulla and Kandy respectively. IPM is practised by 28 percent of the sample farmers in the Matale district. This may be due to the efforts of the DOA to popularise IPM in the Matale district during the past few years as shown in appendix VIII. But, there are a few users (less than 8 percent) in other districts indicating a wider gap of knowledge between eco-friendly and conventional plant protection measures among the farming community.

Figure 5.10 indicates the variation of the adoption of eco-friendly plant protection measures in terms of eco-zone -- such as *neem* preparations and IPM and the chemical pesticides-- by the sample of the farming community. This also indicates a constant rate of the adoption of chemical methods regardless of eco-zone variations. *Neem* users are found in the DL, WM and WU areas amounting to 10, 14, and 19 percent respectively. IPM followers are found in the DL (28 percent) and IM (23 percent) areas, where the DOA has carried out IPM programmes during the past five years.

Figure 5.10: Use of Eco-friendly and Conventional Plant Protection Measures across Eco-zones (% of Farmers)



Source: Survey Data, 2008

5.5.3 Drawbacks of Eco-friendly Plant Protection Measures

Farmers prefer to employ eco-friendly plant protection measures aiming at both economic and environmental gains ranging from cost reduction to producing non-toxic foods. In addition, they reason out the factors that maintain the significant gap prevalent between the knowledge and the practice of eco-friendly farming techniques as illustrated in figure 5.11a.

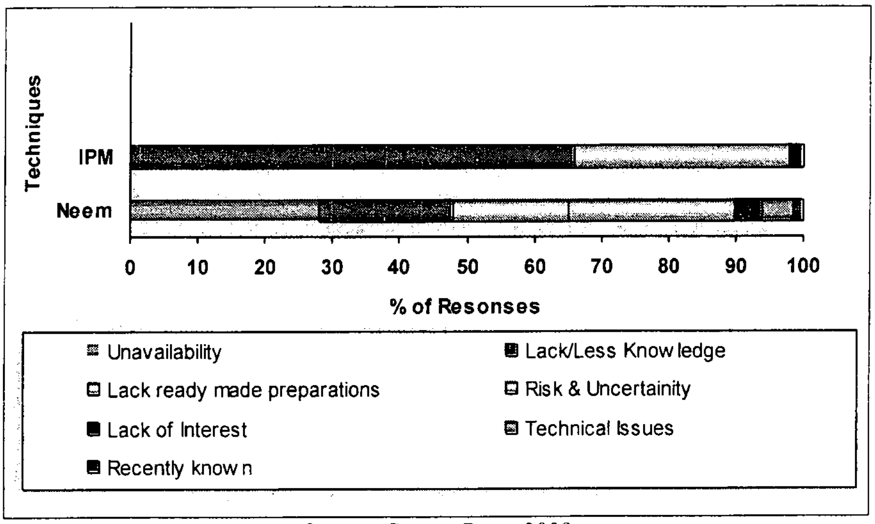
On the basis of percentage analysis of 227 responses, the application of *neem* is largely restricted due to several factors:

(a) Unavailability (28 percent): This stems from the difficulties in obtaining raw materials as frequently reported from the Badulla and Kandy districts.
(b) Uncertainty (25.5 percent): Though some farmers are more progressive both as users and recipients of benefits from eco-friendly practices, its effectiveness is still an uncertain factor. Using *neem* has become futile to certain individual users, as results have shown no marked payback from initial trials/use amidst others applying chemicals. This is because -- the pests feed on the non-toxic crops grown -- cause huge losses to the farmers.
(c) Lack of knowledge or/and skills of preparation (20 percent)
(d) Inconvenience (17 percent): Preparation consumes time, another drawback in the absence of ready made preparations and the necessity for the busy schedules of the farmers and immediate needs arising in the field.
(d) Scale unfitted (4 percent): *Neem* is disqualified for the large-scale application.
(e) Lack of interest: All these have led to a drop in the farmer interest turning them towards the convenient and long adopted chemical methods which are well-suited to prevailing weather conditions as directly quoted by four percent of the responses. A smaller category of farmers (1.5 percent) have only recently become aware of this method. It is also reported that technical problems occur in equipment after *neem* application (0.5 percent).

Some of these requirements were also emphasised by the Registrar of Pesticides too, whose office receives a variety of *neem* preparations for registration, but has not accredited in the absence of evidence on wider scale and longer field application. Natural preparations also can carry harmful effects and impacts so that a mere *'neem' product* or mixture is inadequate to provide the certification.

Similar circumstances appear to be applicable with regard to non-adoption of IPM practices by the farmers. The farmers have reasoned out why they are reluctant to practise IPM -- through 184 responses. According to the percentage analysis, these reasons are in order (figure 5.11a) and the key reason is the lack of proper knowledge on IPM practices (66 percent). In addition, the farmers perceive that in comparison with chemical methods, the practice of IPM is ineffective as it has not proved to produce faster and better results in vegetable farming. Thus, the perceived risk and uncertainty reported through 32 percent of responses coupled with less knowledge in general have led to the lack of interest among the farmers, as it has been directly indicated by 1.5 percent of responses. There are a few non-adopters (1.5 percent) who have become recently aware of the method.

Figure 5.11a: Drawbacks of Eco-friendly Plant Protection Measures

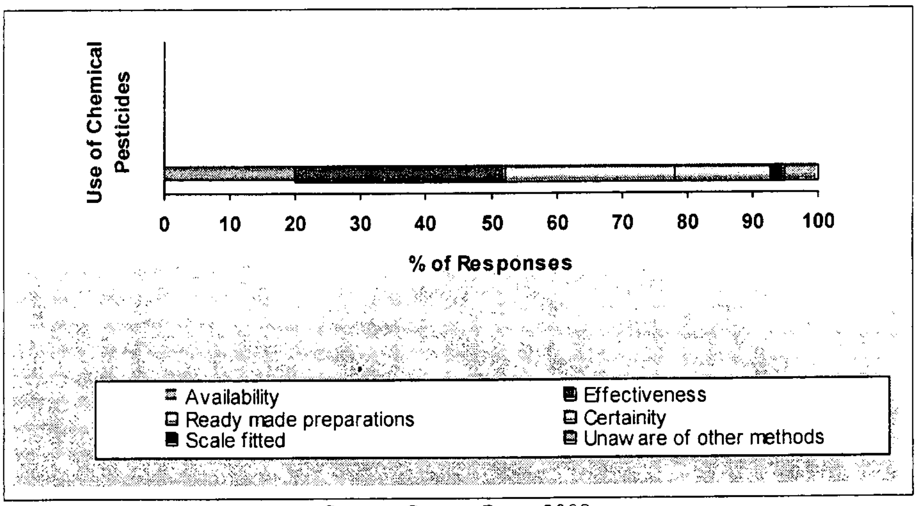


Source: Survey Data, 2008

5.5.4 Reasons for Frequent Use of Conventional Plant Protection Measures

Aiming at a comparison between eco-friendly and chemical methods, the farmers were questioned on their perceptions towards merits and demerits of the chemical methods. Despite huge financial and environmental costs incurred due to the use of chemical methods, none of the farmers have cited such reasons for not using chemical pesticides. Instead, 175 responses were received on the merits of chemical methods and the percentage analysis of these responses is presented in figure 5.11b.

Figure 5.11b: Merits of Chemical Plant Protection Measures



Source: Survey Data, 2008.

It was revealed that quicker control of pest attacks (32 percent), trouble-free preparation and time and labour saving in application (26 percent), common availability (20 percent), confidence built up over extensive and long use and tolerability of crops to chemical methods (15 percent), lack of knowledge of other methods (5 percent) and convenience in large-scale use (2 percent) are the merits of chemical methods.

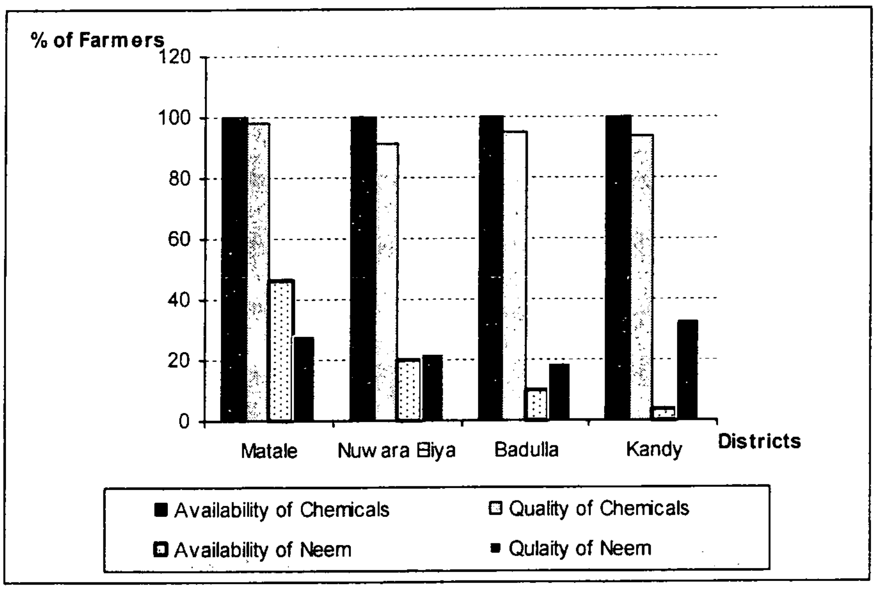
5.5.5 Availability and Quality of *Neem* Preparations and Chemical Pesticides

It is apparent from the given circumstances that achieving widespread of adoption of eco-friendly plant protection measures appears a composite task including the following:

(a) Adaptive research on suitability for field conditions,
(b) Formal certification by the state sector institutions for wider acceptance,
(c) Dissemination through result and method demonstrations,
(d) User incentives for the inducement of adoption, and
(e) Efficient input delivery in user friendly forms to ensure widespread availability and variety in products.

Figure 5.12 shows the district wise variation of availability and quality of chemical pesticides and *neem* preparations in which the availability of data for *neem* preparations amounts to 46, 20, 10, and 4 percents for the districts of Matale, Nuwara Eliya, Badulla and Kandy respectively. This indicates that the availability of *neem* in the Matale district is higher than that of other districts. Figure 5.12 also indicates that around 95 percent of the farming community ensures that there are no quality problems of the chemical pesticides that have been used in agricultural activities.

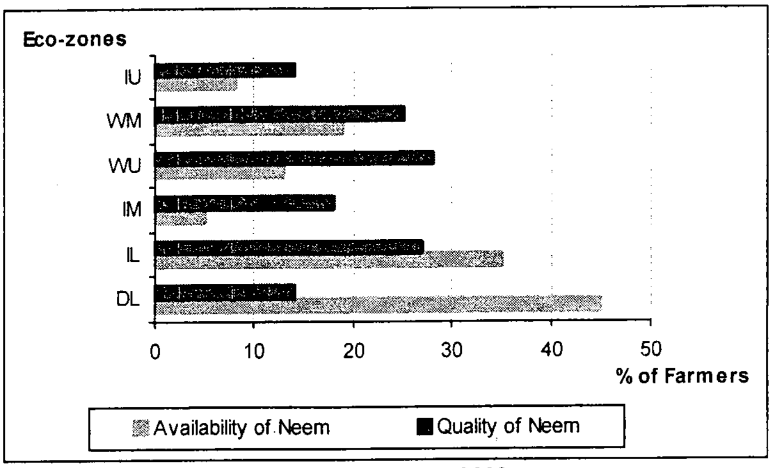
Figure 5.12: Availability and Quality of *Neem* Preparations against Chemical Pesticides across Districts (% of Farmers)



Source: Survey Data, 2008

Figure 5.13 indicates the data on availability and quality of *neem* preparations by eco-zones. For the clarity of presentation of data on poor availability and quality of *neem* preparations, the graph has been drawn taking the maximum scale as 50 without indicating the data on chemical pesticides which is 100 percent in each eco-zone.

Figure 5.13: Availability and Quality of *Neem* Preparations across Eco-zones (% of Farmers)



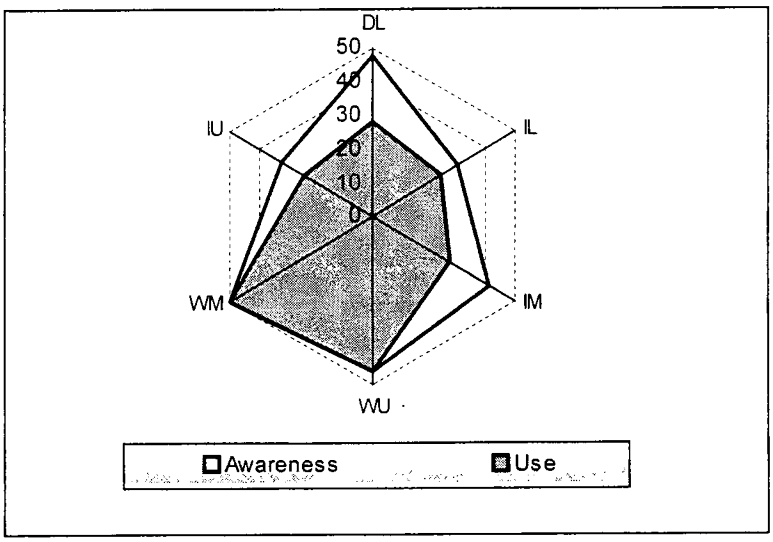
Source: Survey Data, 2008

Figure 5.13 shows the availability of *neem* in the low-country areas despite quality constraints of the available preparations. Overall, the data in figures 5.12 and 5.13 show how strongly research and extension efforts are required to make a shift from chemical methods to eco-friendly pest control methods in the up-country vegetable cultivation in each district and eco-zone.

5.5.6 Knowledge and Use of Resistant Varieties

Consistent with the principle that 'prevention is better than cure' the use of pest resistant varieties is a common practice in many agricultural systems. This is also one among many steps of an integrated pest management programme. The up-country vegetable farmers are also well aware of pest and disease resistant varieties.

Figure 5.14: Knowledge and Use of Resistant Varieties in Up-country Vegetable Cultivation (% of Farmers)



Source: Survey Data, 2008

Though in limited scale, they have paid attention to select planting materials free of pests and diseases as shown in figure 5.14, which have been drawn from 0 to 50 percent scale for the clarity of the presentation of data. The data also reveal the increased knowledge and use of resistant varieties by the farmers in the Nuwara Eliya district and the WU and the WM in eco-zones.

5.6 Knowledge and Adoption of Soil Fertility Management Practices

Crop fertilisation is of two types: applying organic manure and chemical fertilisation, based on the origin of fertilisers.

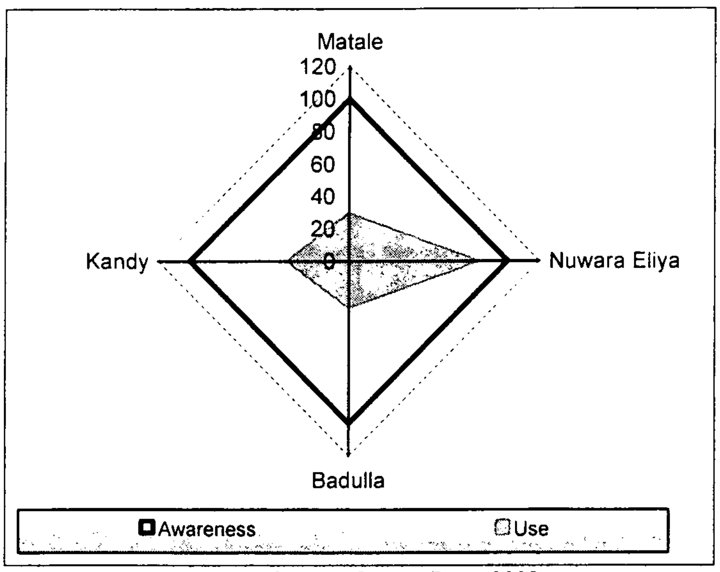
5. 6.1 Application of Organic Manure

Application of organic manure having plant and animal origin is supposed to be one of the eco-friendly means of crop fertilisation. Farm yard manure, a range of animal manure (cattle, poultry and goat), biogas slurry, compost, crop residues and green manure are the commonest types of organic manure. In this study, it was attempted to assess two types of organic manures widely popular, namely the farm yard manure (FYM) i.e. manure from cattle sheds and the compost and poultry manure which are available at distinct locations and have been recommended for use during the production of up-country vegetables.

i. Farm Yard Manure and Compost

Almost all the sample farmers are aware of the use of FYM and compost, but only 42 percent of them use it in vegetable cultivation. Figure 5.15 shows the gap between the knowledge and the application of FYM and compost across the districts which are largely seen among the vegetable growers (80 percent) in the Nuwara Eliya district. The WU and WM are the greater users of FYM and compost.

Figure 5.15: Knowledge and Application of Organic Manure across Districts (% of Farmers)



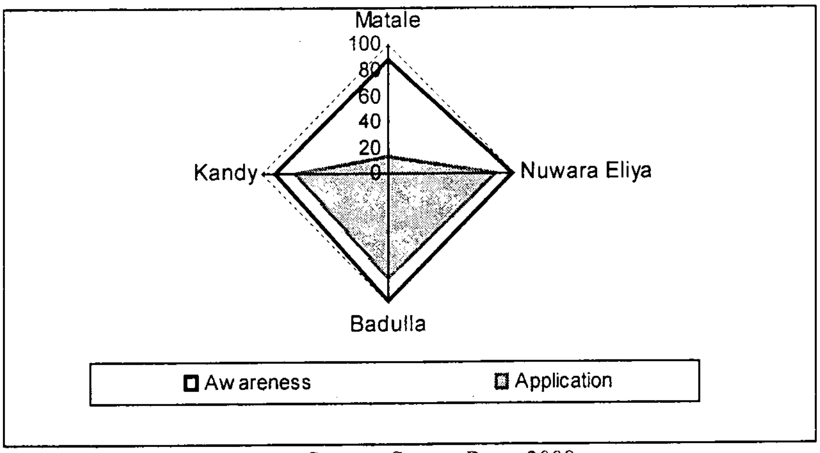
Source: Survey Data, 2008

As revealed through the field survey, the farmers are well conversant with the advantages of FYM and compost. As they understand, it helps retain soil moisture, build up soil structure and loosen the soil, thus improving aeration and promoting vigorous crop growth and increase yield. Farmers also show an interest for conserving the environment through lesser use of chemical fertilisers, thereby producing healthy foods. However, several factors have constrained the wider use of FYM and compost. The unavailability -- both in qualitative and quantitative terms is the prominent factor. Farmers are also in the opinion that FYM and compost take a long time to become effective on the soil, thereby helping crops to grow well. Difficulties encountered in transportation due to high cost and bulky nature are the other constraints.

ii. Poultry Manure

Poultry manure (PM) is useful in two ways. Whilst it improves soil fertility, it also acts as a soil de-acidifying substance which is largely used for tomato grown in the up-country intermediate zone. Overall, 92 percent of the sample farmers are aware of the use of PM, however only 64 percent of them use it. As shown in figure 5.16, except in the Matale district, the poultry manure is largely popular among the vegetable growers in other districts.

Figure 5.16: Knowledge and Application of Poultry Manure across Districts (% of Farmers)



Source: Survey Data, 2008

According to farmers' knowledge, poultry manure helps loosen the soil which, in technical terms structurally improves. It is supposed to be a low cost alternative which results in increased yields. It is also reported that some farmers have used it together with straight fertiliser as recommended by the soil tests. At times, both the availability and storability of PM has encouraged the usage. Like -- in the case of cattle manure, the unavailability has largely refrained farmers from using PM. Further, the low quality or lack of standards, high cost of transportation and delays in obtaining effective results are similarly applicable to prevent farmers from using PM. The bad odour is another drawback. There are also several mis/conceptions that PM causes soil toxicity, its longer use deplete soil fertility, retard the crop growth and make susceptible to pest and diseases. These issues need to be addressed through research and extension programmes.

5.6.2 Chemical Fertilisation

Inorganic fertilisers used in chemical fertilisation are of two forms:

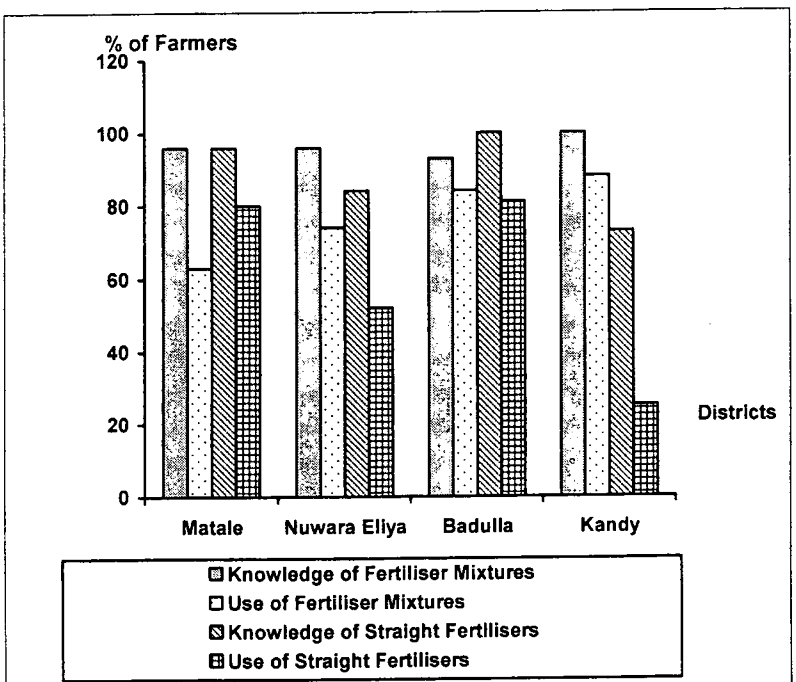
(a) Straight fertilisers: N, P and K fertilisers which are available separately have to be proportionately mixed in recommended ratios for each crop prior to use.

(b) Fertiliser mixtures: N, P and K fertilisers are available in ready-mixed forms.

Literature revealed that overuse of fertilisers, in particular fertiliser mixtures, has led to nutrition build up (eutrophication) on vegetable growing soils in the up-country areas. Numerous measures have also been recommended to control these adverse effects and impacts. As cited in Dissanayake (1999), the application of straight fertilisers avoids build up of P on the soil. It is also an economic alternative to reduce the fertiliser requirement and safeguard the nutrient balance of the soil for satisfactory crop growth (Wijewardene, 2001). Thus, one of the key ideas for popularisation of straight fertilisers was to avoid overuse. Hence, it was attempted to learn the farmer perceptions on the use of these two types of fertilisers during the production of up-country vegetables.

In general, the farmers' knowledge on fertiliser mixtures is significantly higher across locations (figure 5.17) with a comparatively less knowledge of straight fertilisers among certain farmers in the Nuwara Eliya and Kandy districts. Both types of fertilisers are also used in the up-country vegetable cultivation at varying degrees across locations. In the Matale district, the use of straight fertilisers is comparatively higher than that of fertiliser mixtures, whereas the use of fertiliser mixtures predominates in other three districts. The Badulla and Matale districts report the highest use of straight fertilisers and the least use is reported from the Kandy district.

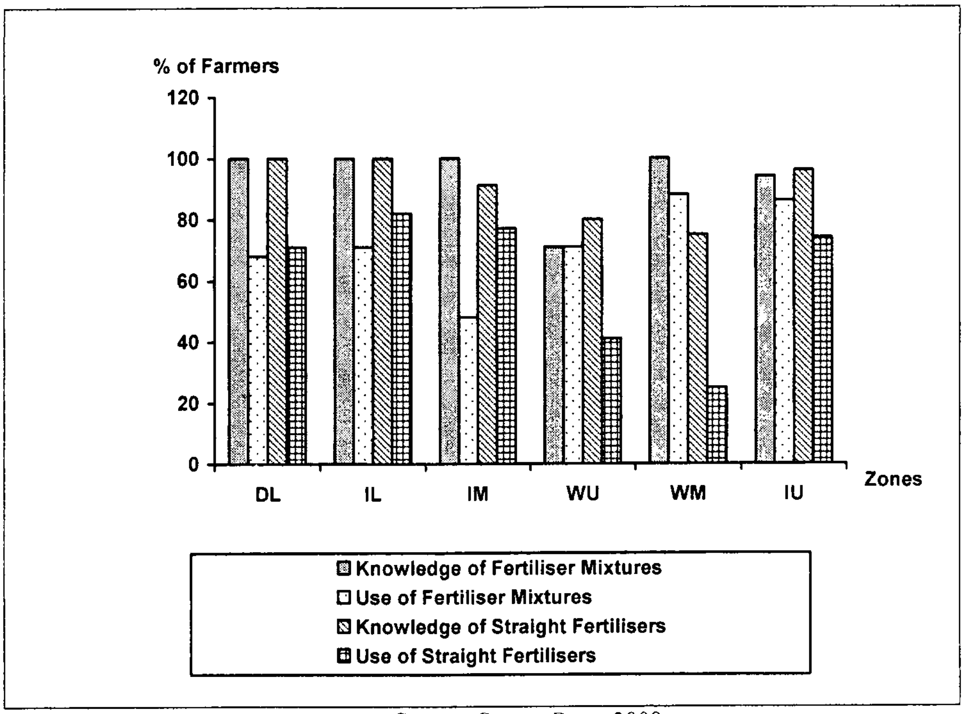
Figure 5.17: Knowledge and Use of Straight Fertilisers and Fertiliser Mixtures across Districts (% of Farmers)



Source: Survey Data, 2008

The data on knowledge and use of straight fertiliser and fertiliser mixtures in terms of eco-zone is presented in figure 5.18. It is obvious from these data that both knowledge and use of fertiliser mixtures is higher than that of straight fertilisation among the sample farmers and it varies according to eco-zones. The least mobility is reported in the WM zone followed by the WU zone. The highest usage is reported in the IL followed by the IM and IU. The DL also uses considerably. All these facts points to the increased use of straight fertilisers in paddy producing areas.

Figure 5.18: Knowledge and Use of Straight Fertilisers and Fertiliser Mixtures across Eco-zones (% of Farmers)

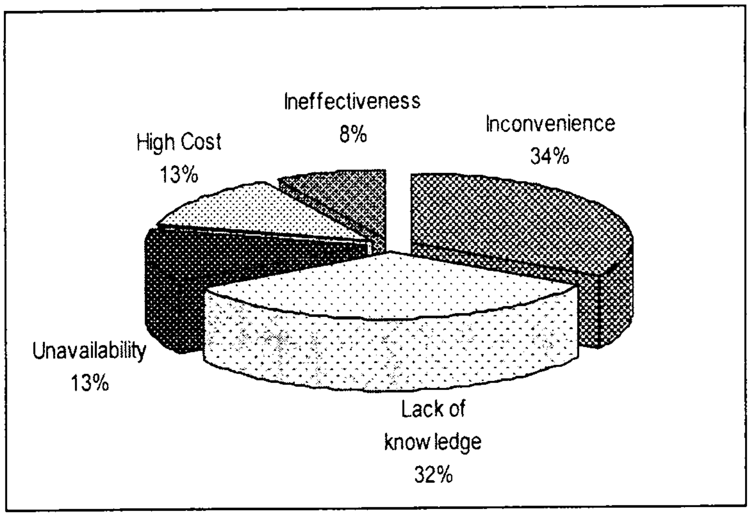


Source: Survey Data, 2008

Hundred and forty seven responses have been received to the question, "why do farmers chose to use straight fertilisers?" The analysed data show that it is largely due to mixing ability of straight fertilisers, as has been indicated by 35 percent responses. Though straight fertilisers are not provided for vegetable cultivation, it has been a certain kind of motivation to use them for vegetables as indicated through 34 percent responses as largely reported from the Matale and Badulla districts. To some 12 percent, the straight fertiliser is an important means of cost reduction. There are also some good qualities of straight fertilisers such as absence of degrading materials (8 percent), relatively high storability (5 percent) and long persistence on soil (3 percent). Educational programmes, reduced transportation cost (1 percent) are among other positive aspects.

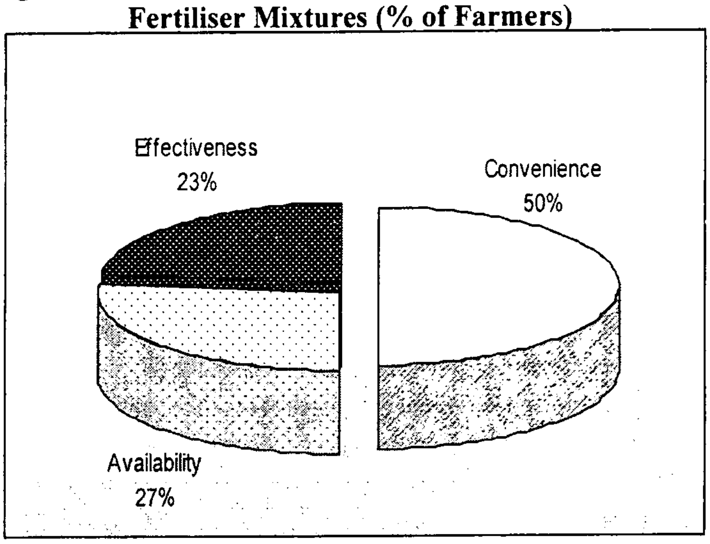
Responses received to the question, "why farmers do not use straight fertilisers?" are substantial (98 responses). Farmers from the Kandy district have grievances with regard to the use of straight fertilisers. Further, in the Nuwara Eliya district, the respondents are high due to less mobility of subsidised straight fertilisers in the area. Inconvenience of storing and mixing of three ingredients is rated as the major drawback of straight fertilisers (figure 5.19). The poor knowledge on the proportional mixing of three major fertilisers has refrained farmers from using straight fertilisers. In addition to this unavailability as largely reported from the Kandy district (straight fertilisers should be transported to study areas in the Kandy district from longer distances) and the high costs, when purchasing from retailers -- are other drawbacks. There exist adverse perceptions among the farmers that straight fertilisers result in comparatively low yields, do not contain essential micro nutrients, carries harmful effects which further hamper the wider usage.

Figure 5.19: Drawbacks of Straight Fertilisers (% of Farmers)



Source: Survey Data, 2008.

Figure 5.20: Vegetable Farmers' Perception on Merits of Fertiliser Mixtures (% of Farmers)



Source: Survey Data, 2008

The drawbacks of straight fertilisers have also contributed to increase the farmers' interest for use of longer adopted ready made fertiliser mixtures commonly available in the market. Figure 5.20 further establishes the fact that convenient use, availability and effectiveness are the key aspects which the farmers expect from a particular mix of fertilisers. As farmers view, ready mixed and well-packed fertiliser mixtures make it convenient both for transportation and application and save the valuable time of farmers. Availability means that the farmers can get fertiliser for any crop whenever needed in required quantities. Farmers also held the views that the availability of micro nutrients, increased yields and quality, vigorous growth of crops and overall faster gains from farming are the merits of fertiliser mixtures that result in wider adoption by the farming community.

Overall, the multiple disparities prevalent between eco-friendly measures and chemical methods explain the severity of the challenge that the research, extension and input delivery services have to face in the shift towards a precision system of agriculture. The research system should be competent to build farmer consensus towards the eco-friendly measures through adoptive research. Extension services have to work hard to popularise these technologies through appropriate and user attractive extension methods. In line with this, the extension programmes should incorporate appropriate contents comparable to demerits of eco-friendly methods. Lessons for the same can be drawn from the merits of conventional chemical measures too. It also stresses the need for a wider coverage of input delivery services to address the farmers' preferences in terms of the availability and variety of product.

5.6.3 Soil Fertility Management Techniques

Soil erosion is supposed to be the major environmental problem in the country. This is mostly prevalent in the central hilly areas of the country due to steep landscape and misuse and mismanagement of the land resources for a variety of purposes. Vegetable cultivation is one such purpose. As revealed through the literature survey, a variety of soil fertility management practices and techniques have been recommended for the up-country vegetable farming systems (chapter 2). Included are:

(a) Soil testing and soil test based fertilisation,
(b) Use of Eppawala rock phosphate in place of triple super phosphate,
(c) Crop rotation, and
(d) Organic farming.

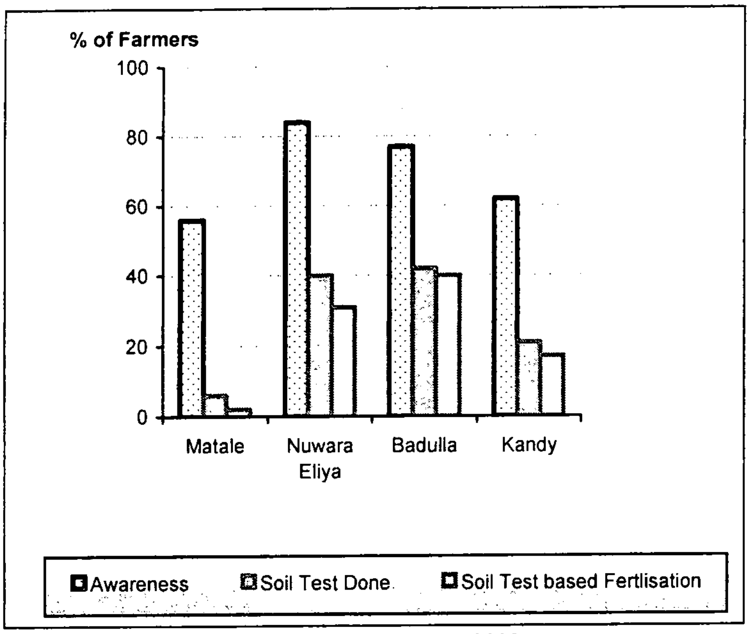
(a) Soil Test Based Fertilisation

Soil test based fertilisation was a long felt need in the up-country vegetable farming systems. The following three aspects were studied in this regard:

(a) Farmers' awareness about soil testing,
(b) Whether or not the soil test is done, and
(c) Whether or not fertilisation done on test recommendations.

According to data from figure 5.21, soil testing has been a well-known concept for sample farmers, though the practice of adhering to recommendations is not hundred percent. It is also apparent from the data that a similar pattern of variation exists across locations with regard to the above three aspects concerned. This proves the importance of educating them with the adoption of techniques.

Figure 5.21: Knowledge and Application of Soil Testing and Fertilisation across Districts (% of Farmers)



Source: Survey Data, 2008

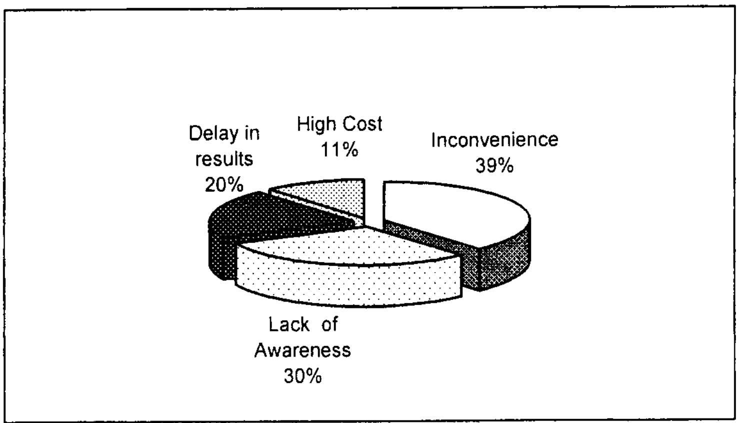
The ultimate expectation of soil test is to avoid excessive fertilisation in agricultural activities. Hence, the required rates of NPK fertilisers are recommended at the end of each test. However, data indicate that all the farmers who have done soil tests have followed the recommendations made as shown in figure 5.21. It is common that those who have not received recommendations cannot practise it. At the time of survey, a certain percentage of sample framers had not received the results. By observing the recommendations other farmers received, some farmers believe that most recommendations are approximately similar, and therefore do not see much importance in it. Apart from that, they do not experience marked effects through fertilisation on recommendations. Lack of knowledge, interest and advice on soil testing and fertilisation are other drawbacks. All these have ultimately instituted unfavourable perceptions and misconceptions among the farming community towards soil testing based fertilisation.

As reported, the farmers have preferred soil testing to have an account of soil fertility on their farm lands largely due to the directive of the ARPA. In principle, they agree with the concept so as to avoid the overuse of chemical fertilisers. A variety of reasons have led the farmers to test the soil of their farm lands. Symptoms such as wilting of crops, low yield, tuber growth in cabbage (in Kandy district), receptiveness to pest and diseases, speedy growth of weeds *(kalanduru)* have pushed them for soil testing.

Despite increased knowledge of the soil testing, the farmers have refrained from adopting soil testing due to multiple reasons (figure 5.22). The main reason is the lack of proper awareness so that they are unsure about whether it is necessary or not for their farms. This again establishes the fact that just being aware of a particular practice is not enough to motivate farmers to adopt it, but repeated encouragement and knowledge building are necessary. As revealed through the previous discussion, the knowledge level of the farming community on fertiliser pollution and allied impacts on agriculture and environment is the lowest. These could be the reasons for the impassive response from the farmers towards soil testing.

They feel the procedure for soil testing and taking soil samples to Peradeniya is inconvenient. They hold the opinion that it is required to fallow the farm lands to obtain soil samples. A considerable segment of farming population is still doubtful whether or not they require soil testing for their farming lands. On the other hand, a category of farmers are interested but the delay of receiving results of the soil test and high cost are matters of concern to some farmers.

Figure 5.22: Reasons for not Applying Soil Test (% of Farmers)



Source: Survey Data, 2008

(b) Use of Eppawala Rock Phosphate

Locally available Eppawala rock phosphate (ERP) is seen as one alternative method of P fertilisation to avoid P build up on up-country vegetable farming lands. Wijewardena (1990) has recommended applying ERP at the rate of 100 kg/ha to get high yields from up-country vegetables such as potato, cabbage, pole bean and tomato in the IU areas, where soils are acidic. The inquiry into farmers' knowledge on ERP and its use indicates that at least, half of the farming community is not aware of this alternative for P fertilisation. Overall, 42 percent are aware of the ERP but none of the farmers were used to this practice largely attributing to lack of knowledge and unavailability. According to few responses, the farmers believe that ERP is not suitable for up-country vegetable cultivation due to its slow-nature of nutrient release.

(c) Crop Rotation

Crop rotation has seen as a means of soil fertility management of the up-country vegetable growing lands. It is also helpful in many ways.

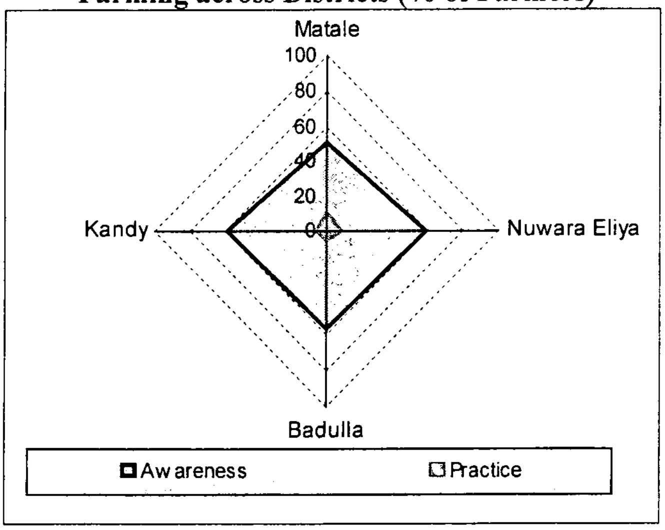
(a) Crop rotation prevents pest and diseases, thereby reducing pesticide needs.
(b) It is also an effective and efficient means of soil nutrient utilisation which prevent build up nutrient imbalances on the soil.
(c) It prevents soil erosion in a number of ways.

Overall, 69 percent of the farmers are capable of explaining the benefits of crop rotation, but only 63 percent practise it largely in the areas where land availability is high. Farmers are aware that soil fertility can be improved through crop rotation and it naturally happens with the cultivation of crops appropriate for the season, thus leaving considerable disparity between knowledge about crop rotation and its application to farming situations. But, the major limiting factor for crop rotation in the up-country areas is -- land. However, the crops are naturally rotated on farm lands due to seasonal variations of the up-country vegetables grown. Most of the farmers also understand the importance of crop rotation as a means of pest control and obtaining increased yields from the same land through soil fertility management.

(d) Organic Farming

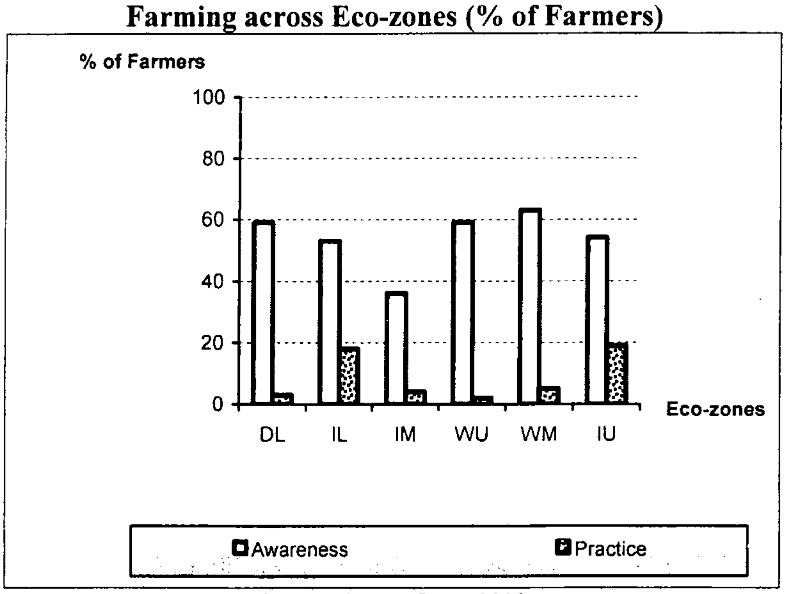
Organic farming, a long felt need is well known to the majority of the sample farmers despite a very low level of its application as presented in figures 5.23 and 5.24.

Figure 5.23: Knowledge and Practice of Organic Farming across Districts (% of Farmers)



Source: Survey Data, 2008

Figure 5.24: Knowledge and Practice of Organic Farming across Eco-zones (% of Farmers)



Source: Survey Data, 2008

A host of constraints hamper the practice of organic farming. The variety of perceptions expressed through a total of 105 responses can be broadly categorised into three as illustrated in figure 5.25.

(a) Inconvenient to practice

Organic farming is a process which requires more labour, time and space. Thus, it is seen as inappropriate for large-scale cultivation. Further, the scarcity of organic manure both in qualitative and quantitative terms is a major difficulty. All these have made organic farming a tiresome practice.

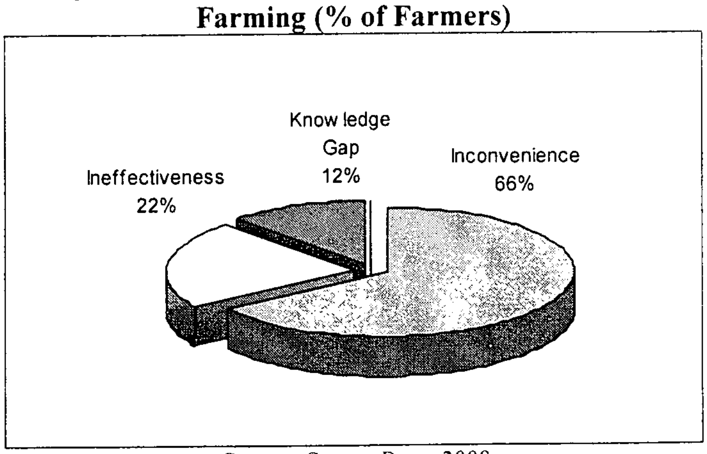
(b) Ineffective results from the use

As farmers perceive, ineffectiveness in organic farming is multifaceted. Farmers perceive that organic farming takes time to produce necessary results which is economically detrimental and cannot be borne by the farmer. Also, the organic cultivations are susceptive to pests and diseases. Further, the quality of the available types of organic manure is not so good and initially results in low yields.

(c) Lack of knowledge

Farmers also do not attempt to practice organic farming attributing to lack of knowledge due to absence of proper guidance and training to them.

Figure 5.25: Constraints on Adoption of Organic Farming (% of Farmers)

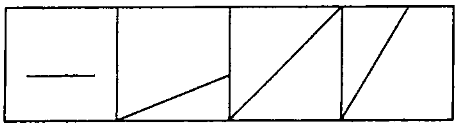


Source: Survey Data, 2008

5.7 Knowledge and Adoption of Soil Conservation Measures

5.7. 1 Landscape

The landscape characteristics of a farming system have a greater link with its conservation aspects, particularly the slope of the land. The collection of data on the slope parameter was based on two types of observations: (a) farmers' own description on the steepness of the each parcel of land, and (b) investigators' observation at possible instances. Though both of these eye estimates appear subjective, the information gathered are of importance to a certain extent in determining the erosive features of a parcel of land. Further, the farmers also recognise the need for applying conservation measures on similar sort of eye estimates. Accordingly, four slope categories identified and defined for the purpose of this study are shown in the following chart, namely: (a) "flat" lands: lands with less or no slope recommended for agricultural use, (b) "steep" lands: lands with a slight slope appropriate for agricultural use with conservation, (c) "steeper" lands: lands with a slope beyond the category b up to 100 percent restricted agricultural use with strict conservation, and (d) "steepest" lands: lands beyond 100 percent slope prohibited for agricultural use.



a b c d

Table 5.5: Number of Operators and Various Slope Categories of Highlands by Districts

District	Slope Category				Total
	"Flat"	"Steep"	"Steeper"	"Steepest"	
No. of Operators	**56 (84%)**	**9**	**2**	-	*
Matale	10	31	7	10	*
Nuwara Eliya	6	28	7	3	*
Badulla	12	31	21	8	*
Kandy	84	99	37	21	*
Total % of operators	**38%**	**44%**	**17%**	**9%**	*
Land Extent (ac)	**107.25 (89%)**	**12.25**	**0.75**	-	**120.25**
Matale	5.69	61.18	11.40	14.24	92.51
Nuwara Eliya	3.75	33.00	4.25	2.75	43.75
Badulla	8.91	72.32	26.37	6.50	114.30
Kandy	125.60	**178.75**	**42.77**	**23.49**	**370.81**
Total % of Area	**(33.9)**	**(48.2)**	**(11.6)**	**(6.3)**	**(100)**

Note: * - Not applicable as sample farmers operate more than one parcel in some cases
Source: Survey Data, 2008

Table 5.6 presents the data on land distribution under different slope categories on eco-zone basis. Accordingly, the largest share of "flat" lands is operated by a largest percentage of vegetable growers in the low-county, particularly in the DL and IL eco-zones with the rest of all over the eco-zones. In the land use of the mid-country (IM and WM), the "steep" land category predominates, whereas all three fragile categories, "steep", "steeper" and "steepest" are prominent in the up-country with an increasing trend of using "steeper" and "steepest" than in the mid-country. In general, the land use by up-country farmers (WU and IU) shows a wider distribution among all slope categories.

Table 5.6: Number of Operators and Various Slope Categories of Highlands by Eco-zones

Eco-zone Category	Slope Category				Total
	"Flat"	"Steep"	"Steeper"	"Steepest"	
No. of Operators					
DL	26	3	-	-	*
IL	25	3	-	-	*
IM	6	9	3	-	*
WU	14	39	26	16	*
WM	4	12	1	1	*
IU	9	33	7	4	*
Total (%)	84 (34.71)	99 (40.90)	37 (15.28)	21 (8.67)	*
Land Extent - ac					
DL	61.35	3.75	-	-	*
IL	38.50	3.75	-	-	*
IM	7.75	32.25	1.75	-	*
WU	10.44	73.67	36.02	19.24	*
WM	2.50	29.50	0.75	0.50	*
IU	5.16	35.83	4.25	3.75	*
Total	125.60	178.75	42.77	23.49	*

Note: * - Not applicable as sample farmers operate more than one parcel in some cases
Source: Survey Data 2008

5.7.2 Up-country Vegetables Grown under Different Slope Categories on High lands

The data on up-country vegetable production vary with identified slope categories on high lands (table 5.7) and the proportional distribution of the up-country vegetable production by the sample farmers during the *maha* season amounts to 27 percent on "flat" lands, 56 percent on "steep" lands, 9 percent on "steeper" lands and the rest of 8 percent on "steepest" lands (figure 5.26). Potato predominates (27 percent) over the vegetables produced during the *maha* season followed by bean, carrot, cabbage, tomato and capsicum.

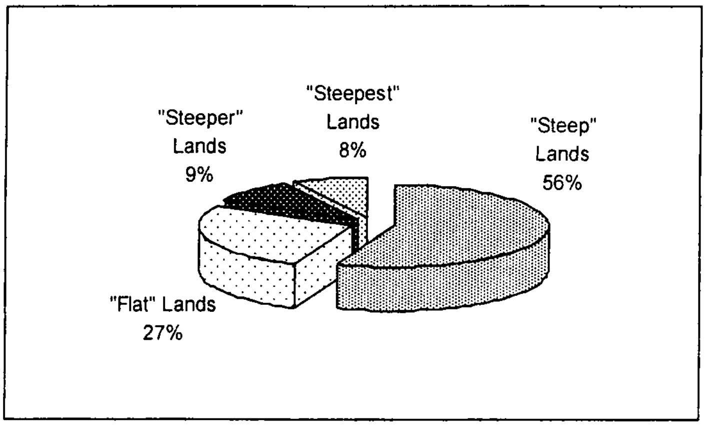
Table 5.7: Highland Area (ac) under Up-Country Vegetables in 2006/07 *Maha* Season by Slope Category

Up-country Vegetables	Area under Each Slope Category (ac)				Total area (ac)
	"Flat"	"Steep"	"Steeper"	"Steepest"	
Potato	3.75	23.78	6.75	8.12	42.40
Bean	30.00	11.06	0.50	1.25	22.81
Carrot	0.75	14.87	0.88	2.75	19.25
Cabbage	9.50	7.37	1.37	-	18.24
Leeks	0.50	6.75	0.50	0.50	8.25
Knol khol	1.00	1.50	-	-	2.50
Beet root	5.94	6.75	2.37	-	15.06
Radish	1.00	3.00	2.25	-	6.25
Tomato	9.00	7.50	-	0.50	17.00
Capsicum	1.13	2.38	-	-	3.51
Total	**42.57 (27%)**	**84.96 (56%)**	**14.62 (9%)**	**13.12 (8%)**	**155.27 (100%)**

Source: Survey Data, 2008

Further, the potato is grown in an area of 42.4 ac which includes 14.87 ac of high lands of "steeper" and "steepest" categories. This amounts to 10 percent of the total up-country producing high land areas in the *maha* season.

Figure 5.26: Percentage Distribution of Highland Area under Up-country Vegetables in 2006/07 *Maha* Season by Slope Category



Source: Survey Data, 2008

Table 5.8 shows the distribution of up-country vegetables under different slope categories of highlands during the *yala* season. Accordingly, the use of highlands during the *yala* season under each slope category amounts to 21 percent on "flat" lands, 56 percent on "steep" lands, 15.5 percent on steeper lands, and the rest of 7.5 percent on "steepest" lands. The marked production of tomato, cabbage and beet root in "flat" lands is from the Matale district.

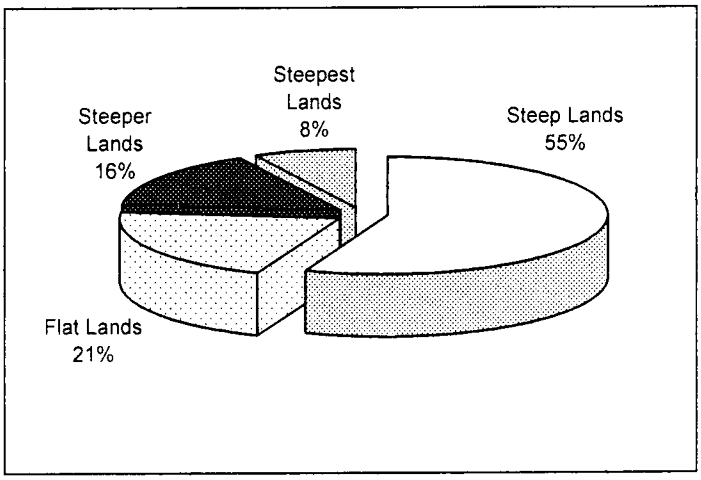
Table 5.8: Highland Area (ac) under Up-country Vegetables in 2007 *Yala* Season by Slope Category

Crops	Flat	Steep	"steeper"	"steepest"	Total
Potato	0.25	15.63	2.25	0.25	18.38 (19%)
Bean	1.41	5.00	1.26	0.75	8.42
Carrot	1.94	7.56	4.44	1.75	15.69
Cabbage	3.00	14.29	1.37	1.25	19.91
Leeks	1.75	3.67	1.25	-	6.67
Knoh khol	0.25	2.00	-	-	2.25
Beet root	4.75	0.12	-	2.20	6.87
Radish	1.25	3.25	2.25	1.00	7.75
Tomato	3.25	0.63	-	-	3.88
Capsicum	2.25	1.42	2.00	-	5.67
Total (%)	**20.1 (21%)**	**53.57 (55%)**	**14.82 (16%)**	**7.2 (8%)**	**95.49 (100%)**

Source: Survey Data, 2008

Figure 5.27 shows the percentage distribution of the highland area under up-country vegetables during the *yala* season in 2007 by slope category. The potato is the principal crop in the *yala* season too. Most of the other up-country vegetables are increasingly grown on highlands during this season. Some 24 percent of the total extent under up-country vegetables is grown under "steeper" and "steepest" categories during the *yala* season, but in the *maha* season, it amounts to 17 percent. A comparison between the *yala* and the *maha* seasons compels to conclude that the largest share of the up-country vegetables is grown on "steep" lands followed by "flat" lands through year round cultivation. In addition to this, there seems to be seasonal variations in extents of lands used for up-country vegetables under the "steeper" and "steepest" slope categories of highlands.

Figure 5.27: Highland Area under Up-country Vegetables in 2007 *Yala* Season by Slope Category (% of Farmers)



Source: Survey Data, 2008

The extent of highlands used for up-country vegetable production goes down during the *meda kanna* as shown in table 5.9.

Table 5.9: Highland Area (ac) under Up-Country Vegetables in *Meda Kanna* by Slope Category

Crops	"Flat"	"Steep"	"Steeper"	"Steepest"	Total
Potato	2.69	3.04	-	-	5.73
Bean	5.00	3.00	0.25	-	8.25
Carrot	1.50	4.93	6.19	1.00	13.62
Cabbage	7.62	5.75	2.25	-	15.62
Leeks	0.00	1.30	0.25	0.75	2.30
Knol khol	0.50	-	-	-	0.50
Beet root	-	1.00	-	0.25	1.25
Radish	-	1.50	0.99	0.75	3.24
Tomato	3.25	1.25	1.00	-	5.50
Capsicum	1.00	1.25	0.25	1.00	3.50
Total (%)	**21.56 (36.2)**	**23.02 (38.7)**	**11.18 (18.8)**	**3.75 (6.3)**	**59.51 (100)**

Source: Survey Data, 2008

5.7.3 Soil Conservation by Sample Farmers

As described in the chapter four, 203 sample farmers have access to 388 highland plots with an acreage of 370.81. Out of the total number of sample farmers, 194 farmers (87 percent) have responded with regard to conservation aspects of 327 highland plots they operate (84 percent of the total number of highland plots). It covers a total land area of 330.21 ac amounting to 81 percent of the total highland area accessible to sample farmers.

Data show that only 49 percent area of these highlands is adequately conserved and the rest of the area of these plots are not so. Data also indicate the variation of highland area under conservation and the farmers who made conservation efforts by eco-zones, where attention for soil conservation is largely found at higher altitudes (table 5.10).

Table 5.10: Number of Farmers, Highland Plots and Area under Conservation by Eco-zones

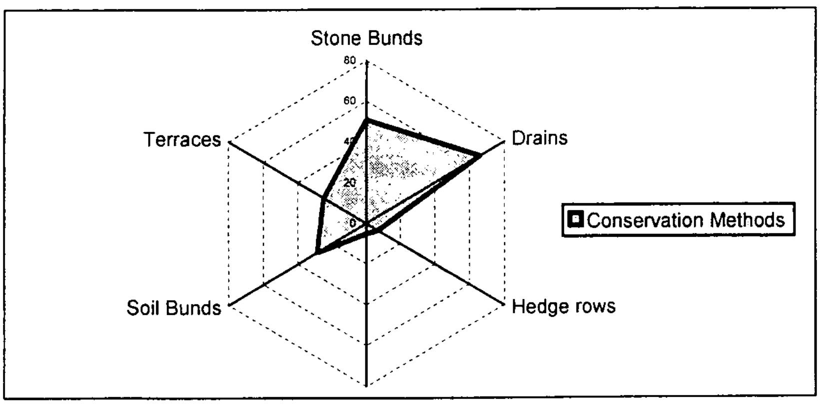
Eco-zone	Farmers		No. of Plots	Total Area of Plots (ac)	Conserved Area	
	Number	%			ac	%
DL	29	97	52	61.5	18.0	29
IL	27	79	45	41.0	6.5	16
IM	17	77	23	27.25	16.5	61
WU	68	96	129	108.04	74.1	69
WM	16	94	17	15.25	8.5	56
IU	17	74	61	47.17	59.4	65
Total	194	NA	327	300.21	183.0	61
%*	NA	87%	84%	81%	49%	NA

Note: Calculated in relation to total number of farmers, high land plots and total high land area available to sample farmers where appropriate

Source: Survey Data, 2008

Figure 5.28 presents the information on the variety of conservation methods adopted by the farmers. Accordingly, the drains predominate over the conservation methods followed by stone bunds, soil bunds, terracing with least contribution from SALT and hedge rows.

Figure 5.28: Percentage Distribution of Farmers Adopting Different Soil Conservation Methods



Source: Survey Data, 2008

Given the situation, the magnitude of agro-environmental impacts of the UPVEGSYS, its knowledge of the up-country farming community and their response towards them and overall diffusion of conservation farming techniques appear to be varying across locations.

5.8 Summary

The farmers' knowledge on the agro-environmental impacts reveals several noteworthy facts about extension methods. Only a portion of the farming community has been exposed to extension programmes which adopted a variety of extension methods. The major focus has been on general agricultural knowledge; training on new technology, skill development and dissemination of new information; soil fertility management and plant protection aspects. The ARPAs' achievement as the closest contact personnel to the farming community confirms strengthened relationships at the grass-roots level. Functionally, these field level personnel are active in four areas: (a) facilitation of advisory services, (b) input distribution, (c) co-ordination functions, and (d) solving farmer problems.

The farmers' knowledge of three principal environmental impacts varies in a decreasing order from soil degradation followed by pesticide pollution to fertiliser pollution. It also shows a spatial variation. Their knowledge on the use of *neem* and IPM are far below than that of chemical methods. Adoption of such measures is lower than their knowledge levels. On eco-zone basis, these two methods show varying degrees of the popularity. The farmers prefer to employ *neem* both for economic and environmental reasons but the limited application is attributed to unavailability, lack of knowledge, inconvenience, uncertainty and lack of interest as it is inapplicable to large-scale use and technical issues. The lack of knowledge and uncertainty constraints the use of IPM. These weaknesses are the strengths or merits of chemical methods despite huge financial and environmental costs. The chemical pesticides are preferred due to quicker pest control ability, trouble free preparation and application, common availability, certainty of results and poor knowledge on other promising methods.

Farm yard manure (FYM), compost and poultry manure (PM) are the commonest types of organic manure used under UPVEGSYS, where FYM and compost are largely used in the WU and WM. Wider use of FYM and compost is restricted due to unavailability, issue of conversion period, cost of transportation and the bulky nature of the manure. Application of PM which is largely found in the IU, appears to be useful in two ways due to its soil fertilising and de-acidifying abilities. The use of PM has largely constrained by the unavailability and the misconception that PM manure causes soil toxification. Other drawbacks are similar to FYM.

Chemical fertilisation is the most prominent method of fertilisation which is available in two forms: straight fertilisers and fertiliser mixtures. The fertiliser pollution stemming from the excessive use of chemical fertilisers, continuous and heavy application of organic manure, continuous cropping, excessive lime application and frequent exposure of the soil has led to environmental and health concerns along with substantial economic losses to the farmers. In this regard, straight fertilisation was promoted to safeguard the nutrient balance of the soil and as a means of cost reduction. The knowledge of farmers on the use of straight fertiliser is very high and they prefer it due to mixing ability, storability and as a means of cost reduction. As a result of motivation by officers and increased awareness due to implementation of fertiliser subsidy programme, the use of straight fertiliser has been induced. But, the use of straight fertiliser is lower than that of commercial mixtures attributing to inconvenience, the poor knowledge of proportional mixing, the unavailability due to less mobility in some study locations and the lack of marked results from the use of straight fertiliser, compared to the use of fertiliser mixtures. The increased levels of knowledge and use of chemical fertilisers are due to convenience, availability and effectiveness, largely the opposite of the drawbacks of straight fertilisers.

Among the variety of soil fertility management practices recommended for the up-country vegetable farming systems are soil testing and soil test based fertilisation, use of Eppawala rock phosphate in place of triple super phosphate, crop rotation and organic farming. It appears that farmers prefer to have an account of soil fertility through soil testing and have an increased level of knowledge on soil test based fertilisation despite limited adoption due to lack of knowledge, interest and advice.

Farmers' knowledge on fertiliser pollution and allied impacts is the lowest in the UPVEGSYS leading to impassive response to soil fertility management. This also stems from constraints of soil testing procedure that farmers view it as inconvenient and thereby lacking interest. The poor knowledge of farmers about the process, procedural delays and cost incurred are other drawbacks. ERP as a means of P fertilisation is known to some 42 percent of the farming community, but they never used it.

Organic farming is well known to the majority of the vegetable growers despite extremely limited attempts applying only for the organic farming for domestic consumption. A host of constraints hamper the practice of organic farming ranging from its inconvenience to practice, ineffectiveness and poor knowledge.

The UPVEGSYS lie across four land slope categories; "flat", "steep", "steeper" and "steepest" lands, in the order of increasing steepness defined for the purpose. Some 26 percent of the operators operate in some 27 percent of the upland area lying in ecologically fragile landscapes. In the mid-country, "steep" land category predominates, whereas in the up-country, both "steeper" and "steepest" categories predominate. The largest share of up-country vegetables comes from "steep" and "flat" lands cultivated during the *yala, maha* and the *meda kanna*. But, the conservation efforts are restricted to 49 percent of the area, thus appealing soil conservation measures.

Chapter Six

Conclusions and Recommendations

Conclusions

There has been an exceptional expansion in the UPVEGSYS over the last half a century due to competitive and cost effective nature of the up-country vegetable production supported by required climatic conditions. Concurrent with its expansion, there have been impacts on the triple compartments of the environment; land, air and water and the resulted temporal and spatial repercussion has links to sustainability of the UPVEGSYS.

In response to sustainability concerns grown over time, several efforts have been made to address key environmental issues; land degradation due to soil erosion, fertiliser pollution and pesticide pollution and the gravity of economic and environmental costs are understood by the farming community to a certain level, though they have yet failed to maintain the true sustainability in their farming systems. However, understanding of the depth and degree of the damage to human has hardly been assessed.

The knowledge of the farming community on eco-friendly cultural methods identified for the UPVEGSYS shows a spatial variation. The changes made by project-based interventions in terms of knowledge and attitudes of the farming community in certain locations are significant. However, the adequacy of applying such eco-friendly practices which are mostly incentive based is not satisfactory after the project period. Evidence suggests that the contents of the extension programmes are in right direction, but there exists inequity in the access to them and the programmes are less practical oriented. Overall, the farmers have a satisfactory level of knowledge about eco-friendly farming techniques though their application is constrained due to a number of factors distinctive to each method.

Neem based preparations appear to be one of the eco-friendly plant protection methods familiar to the farming community, but it needs to address a number of constraints that hamper widespread adoption of it. It is a pre-requisite to carry out intensive research to search for effective and efficient *neem* based preparations in the absence of marked pay back currently received. A promotion effort should look into the matters relating to the scarcity of raw materials, poor preparation skills and inadequate interest of farmers. The poor knowledge and uncertainty are the major issues to be addressed in an IPM programme. As it is already agreed, the farmers' expectations are faster (efficient), convenient and effective methods of pest control. However, over time there has been an over emphasis on the control of insect pests by chemicals discouraging other pest control methods, in particular, the biological control methods.

Soil erosion is a major environmental concern and the prevention of which has been the prime concern of most of the interventions. However, most of the agronomic measures such as SALT and hedge raw systems are not widely adopted due to crop-hedge competition and limited land availability. The highest preference has been on mechanical soil conservation measures which are also induced by incentives due to project-based interventions. Less attention has been received on the promotion of appropriate eco-friendly plant protection methods, fertilisation measures and cropping systems.

The fertiliser pollution which largely stems from excessive use of fertiliser mixtures has to be streamlined through popularisation of straight fertiliser use. This requires addressing factors limiting straight fertiliser use by the farming community.

As already suggested, either weaning of people from this fragile land use systems or directing them to sustainable means of the up-county vegetable production through providing a package of intervention seem to be no one's interest. Hence, it is worthwhile to investigate the sustainable means of producing up-country vegetables through alternative options (materials and methods) that would be practical at grass-roots level so as to minimise the damage to the human and the environment.

This will be a system of activities including the following:

Recommendations

- The data base gathered at the grass-roots level should be strengthened through including environmentally sensitive parameters in terms of plots. It will ensure more meaningful utilisation of data and information to provide trade offs to the farmers for sustainable utilisation of land with eco-friendly practices in compliance with agro-ecological variations.
- Appreciate the role played by a variety of stakeholders towards sustainability of UPVEGSYS and encourage them to promote low input farming systems in the up-country vegetable production.
- Encourage research into developing more economically and environmentally viable cropping systems and land management technologies affordable to farmers who utilise fragile land categories in the UPVEGSYS covering the following themes;
  - Alternative materials and methods of pest control that would not create adverse effects on the human and the environment such as growth regulators,
  - Harmful effects on the human and the environment due to agricultural activities,
  - Role of demographic, socio-economic and cultural variables in sustainable land use,
  - Impact of innovative approaches, technologies and methods, co-operation between people and institutions on sustainable land use,
  - Conservation and maintenance of natural enemies, cultural practices and favourable cropping systems that encourage growth of natural enemies, and
  - Rational use of pesticides.
- Avoid shortcomings of soil test based fertilisation, ensure increased mobility of straight fertilisers and provide simple guidelines to optimisation of chemical fertiliser use for up-country vegetables.
- Strengthening of knowledge and technology dissemination process through making improvements in extension curriculum, teaching methods and extent of investment;
  - to narrow the existing knowledge gap of eco-friendly technologies such as IPM and *neem* based preparations,
  - to improve the operability of these technologies at the grass-roots level to ensure wider adoption, and
  - to provide appropriate soil conservation mix fitted to small scale farmers.
- Programmes to derive the uncaptured potential of ARPAs to promote sustainable agriculture at the grass-roots level that should comply with productivity, profitability and sustainability.

- Strengthening policy spheres through;
  - incorporating environmental issues that are inadequately emerged at policy level, for instance, fertiliser and pesticide pollution in UPVEGSYS, and
  - looking into possibilities for the provision of fertiliser subsidy for up-country vegetables grown in soils where nutrient imbalances exist.

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Appendix I: Total Land Extent for Up-country Vegetables in Ten Selected Districts in 2006

	Matara		Kurunegala		Kegalle		Ratnapura		Kandy		Matale		Nuwara Eliya		Badulla		Moneragala		Hambantota		Total	%
	ha	%	ha	%	ha	%	Ha	%	Ha	%	ha	%	ha	%	Ha	%	ha	%	ha	%		
Potato	-	-	-	-	-	-	-	-	18	0.6	1	0.0	1458	12.0	3760	29.1	-	-	-	-	5237	15.2
Bean	2	1.3	34	2.4	15	32.6	553	47.1	856	28.3	898	32.7	1595	13.1	3608	27.9	67	18.5	-	-	7628	22.2
Cabbage	-	-	6	0.4	-	-	52	4.4	448	14.8	210	7.6	1721	14.1	1196	9.2	1	0.28	-	-	3634	10.6
Carrot	-	-	-	-	-	-	11	0.9	204	6.7	8	0.3	1954	16.0	650	5.0	-	-	-	-	2827	8.2
Leeks	-	-	-	-	-	-	7	0.6	141	4.6	3	0.1	1346	11.0	181	1.4	-	-	-	-	1678	4.9
Knol-khol	-	-	127	9.0	-	-	32	2.7	136	4.5	133	4.8	526	4.3	449	3.5	-	-	-	-	1403	4.1
Radish	105	66.9	218	15.4	6	13.0	101	8.6	189	6.2	87	3.2	797	6.5	586	4.5	24	6.6	63	18.8	2176	6.3
Tomato	17	10.8	177	12.5	12	26.0	349	29.7	878	29.0	956	34.9	1121	9.2	1702	13.1	152	41.9	250	74.6	5614	16.3
Beetroot	0	-	519	36.8	-	-	13	1.1	55	1.8	171	6.4	949	7.8	254	1.9	-	-	-	-	1961	5.7
Capsicum	33	21.0	330	23.4	13	28.2	56	4.7	101	3.3	277	10.0	700	5.7	557	4.3	119	32.8	22	6.6	2208	6.4
Total	157	100	1411	100	46	100	1174	100	3026	100	2744	100	12167	100	12943	100	363	100	335	100	34366	100
% of the Total extent*	0.4		3.8		0.1		3.1		8.1		7.3		32.6		34.7		1.0		0.9		92.0	

Note: * Total land extent under up-country vegetables in the country in 2006 =37,354ha.

Source: Department of Census and Statistics, 2007

Appendix II: Study Locations by Districts, Divisional Secretariats and Agrarian Services Centres

AEZs	Districts	Divisional Secretariats	ASC	Villages
1. DL 1b	Matale	Dambulla	Dambulla	Pohoranwewa, Yapagama, SaluapulluanaWewa, Nawagashinna, Kapuwatta
2. IL 2	Matale	Naula	Koongahawela	Maragamuwa, Pubbiliya, Dambagolla, Bambaragahawatta
3. IL 3	Matale	Galewela	Galewela	Aluthwewa, Hombawa, Pibidunugama
4. IM 3b	Matale	Pallepola	Pallepola	Kirioruwa
5. IM 1b	Matale	Laggala Pallegama	Illukkumbura	Kahagala, Illukkumbura, Mahalakotuwa
6. WU 3	Nuwara Eliya	Nuwara Eliya	Nuwara Eliya	Windi Cornar, Gorandihela, Ruwan Eliya, Maagasthota, Meepilimana, Seetha Eliya, Sandathenna
7. WU 2b	Nuwara Eliya Kandy Kandy	Nuwara Eliya Doluwa Udapalatha	Lindula Mulagam Delpitiya	Agarapathana Pupurassa Doragala
8. WM 2a	Nuwara Eliya	Kotmale	Helboda	Kudaoya
9. IU 3d	Badulla	Welimada	Boralanda Bogahakumbura Keppetipola	Pitapola Kandepuhulpola, Wangiyakumbura Hewanakumbura
10. IU 3e	Badulla	Welimada	Boralanda	Rathkaravva
12. IU 2	Kandy	Delthota	Galaha	Gonangoda
13. IM 3c	Kandy	Pathahewaheta	Marassana	UdaMailapitiya, PathaMailapitiya
14. WM 3b	Kandy	Delthota	Galaha	Gabadagama
16. WU 1	Nuwara Eliya	Ambagamuwa	Vidulipura	Seethagangula

Source: Survey Data, 2008

Appendix III: Distribution of Farm Households by Agro-ecological Zone and Eco-zone Categories

Agro Ecological Zones (AEZ)	No. of HHs*	Eco-zone (EZ)	No. of HHs* (%)
Dry Zone Low-Country 1b (DL 1b)	30	Dry Zone Low Country (DL)	30 (14%)
Intermediate Zone Low-Country 2 (IL 2)	16	Intermediate Zone Low-Country (IL)	34 (15%)
Intermediate Zone Low-Country 3 (IL3)	18		
Intermediate Zone Mid-Country 3b (IM 3b)	7	Intermediate Zone Mid-Country (IM)	22 (10%)
Intermediate Zone Mid-Country 1b (IM 1b)	7		
Intermediate Zone Mid-Country 3c (IM 3c)	8		
Wet Zone Up-Country 3 (WU 3)	21	Wet Zone Up-Country (WU)	71 (32%)
Wet Zone Up-Country 1 (WU 1)	7		
Wet Zone Up-Country 2b (WU 2b)	43		
Wet Zone Mid-Country 2a (WM 2a)	11	Wet Zone Mid –Country (WM)	16 (7%)
Wet Zone Mid -Country 3b (WM 3b)	5		
Intermediate Zone Up-Country 3d (IU 3d)	41	Intermediate Zone Up-Country (IU)	50 (22%)
Intermediate Up-Country 3e (IU 3e)	2		
Intermediate Zone Up-Country 2 (IU 2)	7		
Total	**223**	-	**223 (100%)**

Note: *HHs- Households

Source: Survey Data, 2008

Annex IV: Agro-ecological Zones (AEZs) of UPVEGSYS

AEZ	RF*	Soils	Terrain
DL 1b	>900	Reddish Brown Earth & Low Humic Gley Soils	Undulating
IL 2	>1600	Reddish Brown Earth, Low Humic Gley Soils & Reddish Brown Latosolic Soils	Rolling, hilly & undulating
IL 3	>1100	Non Calcic Brown, Reddish Brown Earth & Low Humic Gley Soils	Undulating
IM 3b	>1200	Reddish Brown Latosolic, Reddish Brown Earth & Low Humic Gley Soils	Rolling & undulating
IM 1b	>2000	Reddish Brown Earth, Reddish Brown Latosolic, Low Humic Gley, Mountain Regosol & Lithosol Soils	Hilly, rolling & undulating
WU 3	>1800	Red Yellow Podzolic sois with prominent A1 horizon & Red Yellow Podzolic soils with dark B horizon	Hilly & rolling
WU 2b	>2200	Red Yellow Podzolic, Mountain Regosol & Lithosol Soils	Mountainous, steeply dissected, hilly & rolling
WM 2a	>2200	Red Yellow Podsolic, Reddish Brown Latosolic & Low Humic Gley Soils	Steeply dissected, hilly & rolling
IU 3d	>1300	Red Yellow Podzolic & Mountain Regosol Soils	Steep, hilly & rolling
IU 3e	>1400	Red Yellow Podzolic & Low Humic Gley Soils	Steeply dissected, hilly & rolling
WM 3b	>1400	Reddish Brown Latosolic, Immature Brown Loam & Low Humic Gley Soils	Hilly, rolling, undulating & steep
IM 3c	>1100	Reddish Brown Latosolic & Immature Brown Loam Soils	Steeply dissected, hilly & rolling
IU 2	>2100	Red Yellow Podzolic, Mountain Regosol & Lithosol Soils	Mountainous, steeply dissected, hilly & rolling
WU 1	>3100	Red Yellow Podzolic, Mountain Regosol & Lithosol Soils	Mountainous, steeply dissected, hilly & rolling

Note: *rainfall at 75% probability

Source: Department of Agriculture, 2003

Appendix V: Number of Land Parcels Operated by a Farm Household by Districts

No. of Land Parcels	Districts								Overall	
	Matale		Nuwara Eliya		Badulla		Kandy			
	PL*	UL**	PL	UL**	PL*	UL**	PL*	UL**	PL*	UL**
1	47	28	-	27	29	18	3	20	79	93
2	7	26	-	12	8	17	1	16	16	71
3	4	8	1	2	1	2	-	7	6	19
4	-	1	-	4	-	-	-	5	-	10
5	-	2	-	3	1	-	-	2	1	7
6	-	-	-	1	-	-	-	1	-	2
7	-	-	-	-	-	-	-	1	-	1
Total	**58**	**65**	**1**	**49**	**39**	**37**	**4**	**52**	**102**	**203**

Note: * PL-Paddy Lands, **UL-Highlands
Source: Survey Data, 2008

Appendix VI: Distribution of Highland Area under Different Tenurial Arrangements

Type of Ownership	Matale District	Nuwara Eliya District	Badulla District	Kandy District	Overall
Owned	45.5	33.76	27.88	66.8	173.94
No. of farmers /parcels	36/53	36/48	30/41	35/71	137/213
Average land size	1.26/0.86	0.93/0.7	0.92/0.68	1.90/0.94	1.26/0.81
Shared ownership	11.0	3.81	5.75	22.99	43.55
No. of farmers/parcels	8/12	6/9	5/6	9.21	28/48
Average land size	1.37/0.91	0.63/0.42	1.15/0.95	2.55/0.09	1.55/0.9
Taken *ande*	2.75	-	-	-	2.75
No. of farmers /parcels	4/4				4/4
Average land size	0.67/0.67				1.68/0.68
Leased in	14.25	50.33	3.5	12.5	80.58
No. of farmers /parcels	8/13	12/28	2/2	8/8	30/51
Average land size	1.78/1.09	4.79/1.8	1.75/1.75	1.56/1.56	2.68/1.58
Mortgaged in	3.0	-	2	-	5
No. of farmers/parcels	1/1		1/1		2/2
Average land size	3/3		2/2		2.5/2.5
Thattumaru	9.5	-	1	-	10.5
No. of farmers /parcels	4/5		1/1		5/6
Average land size	2.37/1.9		1/1		21.1/1.75
Encroached	2.25	1.5	1.75	4.01	9.51
No. of farmers /parcels	4/4	¾	3/3	7/9	17/20
Average land size	0.56/0.56	0.5/0.37	0.58/0.58	0.57/0.44	0.56/0.47
Temple lands	24.75	-	-	-	24.75
No. of farmers/parcels	11/19				11/19
Average land size	2.25/1.3				2.25/1.3
LD permits	7.25	-	1.25	8.0	16.5
No. of farmers /parcels	3/7		2/2	5/9	10/18
Average land size	2.4//.03		0.62/0.62	1.6/0.9	1.65/0.91
Jayabhumi	-	3.11	0.62	-	3.73
No of farmers /parcels		1/5	2/2		3/7
Average land size		3.11/0.62	0.31.0.31		1.24/0.53
Total No. of farmers (%)	120.25	92.51	43.75	114.3	370.81

Source: Survey Data, 2008

Appendix VII: Distribution of Paddy Land Area under Different Tenure Patterns by District

Type of Ownership	Matale	Nuwara Eliya	Badulla	Kandy	Overall
Owned	53.75	-	18.73	3.5	75.98
No. of farmers/parcels	43/47		27/30	2/2	72/79
Average land size	1.25/1.14		0.69/0.62	1.75/1.75	1.05/0.96
Shared ownership	3.75	-	8.9	-	12.65
No. of farmers/parcels	4/4		8/13		12/17
Average land size	0.93/0.93		1.11/0.68		1.05/0.74
Taken *ande*	4	-	1.5	1.25	6.75
No. of farmers/parcels	¾		2/2	1/1	6/7
Average land size	1.33/1		0.75/0.75	1.25/1.25	1.12/0.96
Leased in	18.75	-	3.5	0.75	23
No. of farmers/parcels	5/9		4/5	1/1	10/15
Average land size	3.75/2.08		0.87/0.7	0.75/0.75	2.3/1.53
Mortgaged in	1.25	-	1.5	-	2.75
No. of farmers/parcels	1/1		2/2		3/3
Average land size	1.25/1.25		0.75/0.75		0.91/0/91
Encroached	-	-	-	1.12	1.12
No. of farmers/parcels				1/1	1/1
Average land size		-		1.12/1.12	1.12/1.12
Temple lands	4.75	-	-	-	4.75
No. of farmers/parcels	5/5				5.5
Average land size	0.95/0.95	-			
LDO permits	1	0.75	-	-	1
No. of farmers/parcels	1/1	1/3	-		1/1
Average and size	1/1	0.75/0.25			1/1
Jayabhumi	-	-	0.75	-	0.75
No. of farmers/parcels		-	1/1		1/1
Average land size			0.75/0.75		
Ownership not reported	2	-	-	-	2
Total	89.25	0.75	34.88	6.62	131.5

Source: Survey Data, 2008

Appendix VIII: Intergraded Pest Management Programmes Conducted by the Plant Protection Centre of the Department of Agriculture from 2003 to 2006 in the Study Locations

Year	District	Places	No. of Modules	Vegetables	No. of Farmers
2003	Matale	Walmoruwa	01	Cabbage	18
2004	Do	Kalogahaela	01	Cabbage	08
2004/06	Do	Galwetiyaya	04	Chili/Brinjal	20
2004/05	Do	Dambawa	03	Bean	34
2004	Do	Walmoruwa	01	Tomato/Bean	07
2004	Do	Salagama	01	Bean	25
2004	Do	Galagama	01	Bean	08
2005/06	Do	Undurampelessa	02	Bean/Sweet Potato	20
	Do	Angunawelpelessa	02	Cabbage/Big Onion	40
2006	Do	Medabedda	02	Chili/Bean	20
		Meewelpitiya	01	Big Onion	20
		Tumbakaravila Yaya	01	Brinjal	21
2005/06	Do	Undurampelessa	02	Bean/Sweet Potato	20
	Do	Angunawelpelessa	02	Cabbage/Big Onion	40
2006	Do	Medabedda	02	Chili/Bean	20
		Meewelpitiya	01	Big Onion	20
		Tumbakaravila Yaya	01	Brinjal	21

Source: Plant Protection Centre, Department of Agriculture, 2007