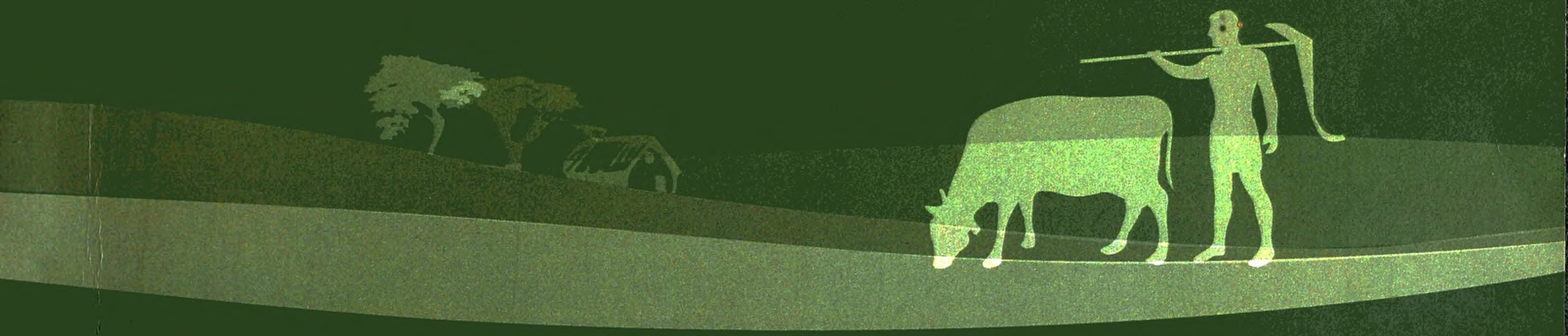
RESEARCH REPORT



VIABILITY OF CONTROLLED ENVIRONMENTAL AGRICULTURE FOR VEGETABLE FARMERS IN SRI LANKA

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FOREWORD

Faced with the limitations of agricultural land, decreasing crop production, climate change and declining biodiversity, and ever increasing population which has led to quadrupling demand for food, protected agriculture has offered a new dimension to produce more in a limited area.

Presently a number of tropical countries, including Sri Lanka, has faced a multitude of constraints which has affected crop production in open fields. Main among them are the unpredictable rainfall distribution patterns, causing severe crop failures and yield losses affecting both consumers and the producers who suffer the twin evils of seasonality in production and price fluctuations.

Introduced to Sri Lanka in 1987 protected agriculture has gradually gained a foothold in today's agricultural system. Protected agriculture has a potential for expansion as is associated with large profits, quality products and produce availability at all times of the year.

This study provides a detailed description of protected agriculture in Sri Lanka in which crops are grown under different types of protective covers such as the polytunnel, rain shelter and net houses. The report discusses the socio-demographic. features of the three different types of operators, crops grown, scale of operation, harvesting, packaging, marketing of vegetables and costs and returns for the profitable crops grown in these structures.

The study finally highlights the future interventions necessary to attract and expand the number of operators to this sector. It is hoped that this report would be beneficial to a vast number of stakeholders who could gain knowledge and understanding of protected agriculture in Sri Lanka.

Director

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EXECUTIVE SUMMARY

Protected Agriculture (PA) is explained as cultivation of crops under a protective cover for various reasons. Production of vegetables under protective covers gained ground in Sri Lanka due to four main reasons: Ensuring a sustained supply of vegetables against seasonality of production, maintaining a farmer income which is not affected by erratic weather conditions and pest problems, circumventing land and labour scarcity in agricultural production, promoting modern technology as a means of crop diversification and attracting youth to the sector. This study attempted to characterize vegetable farming under protective covers in terms of above aspects while identifying the issues and constraints faced by the farmers.

It was evident from the study which was conducted in the four districts of Nuwara Eliya, Badulla, Matale and Kandy that in Sri Lanka, there are three types of protective covers for vegetable production: poly tunnels, net houses and rain shelters. The number of crops grown in polytunnels is limited but shows a variation across the districts. Bell pepper and Japanese cucumber are popular crops among farmers in Badulla and Nuwara Eliya while local tomato varieties were popular in Badulla and Kandy districts. Other exotic vegetables such as beef tomatoes, zucchini and a variety of herbs were found only grown in Nuwara Eliya.

The study reveals that though the initial investment is high small farmers have ventured into poly tunnel farming with funding assistance from various organizations. Despite the huge potential which exists for these vegetables both at the local and export market level production constraints from poor application of modern technologies, pest problems, low quality planting material and environmental constraints have failed to achieve the objectives. However cost benefit analysis confirmed that the production of bell pepper and Japanese cucumber cultivation is viable and proven to be financially profitable for poly-tunnel farmers. Success stories on large scale polytunnel farming are characterized by high tech diversified systems with assured markets.

Means by which polytunnel farming could be improved is to strengthen supply chains in order to increase the market share of exotic vegetables, develop value chains encouraging quality production and assured marketing and improve market intelligence of potential exporters. In addition restructuring of training programmes for poly tunnel operators, research into low cost automated systems to attract young entrepreneurs and women and providing concessions for high quality raw material would attract entrepreneurs to poly tunnel farming.

Promoted as a means to circumvent erratic weather conditions, rain shelters have proved to be a highly profitable venture in the Matale district specifically for onion seed production. The study reveals that while one third of operators had used the harvest as planting material the rest had sold over 50 percent of the harvest. Thus true seed production of onion operates both at subsistence and commercial scales. Whilst been a profitable alternative for the farmers to generate an income during the off season it is a means to make small farmers self-sufficient in planting material

with high quality at a low cost. With demand outstripping the supply of onion seeds in the local market, the one impediment for small farmers to venture into this enterprise is the high initial cost of construction of rain shelters. As there is a huge potential for the expansion of rain shelters the provision of subsidies for construction and production plan to avoid marketing problem needs to be set in place.

Net houses are PA structures promoted under the *Divi Neguma* programme in the Kandy district as a means of self-employment for plant nursery and vegetable cultivation. Vegetable cultivation in net houses is not as viable enterprise as poly-tunnel operations and true seed production of onion under rain shelters. Technical constraints, severe marketing problems combined with high initial cost of construction have discouraged net house farmers. However, as per the success case of tomato production, vegetable production in net houses cannot be disqualified as non-viable. What is required for the success of vegetable cultivation in net houses is the provision of subsidies for construction of net houses with the direction for farmers to cultivate in the off season.

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ABBRIVATIONS

ASCs	Agrarian Service Centers
CEA	Controlled Environment Agriculture
DOA	Department of Agriculture
DSD	Divisional Secretariat Division
EDB	Export Development Board
IFAD	International Fund for Agricultural Development
IFCO	International Foodstuff Company
MOA	Ministry of Agriculture
MOP	Murate of Potash
NGOs	Non-Governmental Organizations
PA	Protected Agriculture
PAEA	Protected Agriculture Entrepreneurs Association
UPEPV	Uva-Paranagama Export Production Village

CHAPTER ONE

Introduction

1.1 Study Background

Vegetable farmers face both social and economic problems which have curtailed the vast potential of the sector. Poor adoption of new technologies, poor access to credit, lack of guaranteed markets, inadequate availability of quality seeds are among some of the issues which have perpetuated the unprofitability of the sector. In particular irregular weather patterns have led to crop failures and decreased yields causing both farmers and consumers to suffer from seasonality in production and price fluctuations. Globally protected agriculture (PA) was adopted as it extends the growing seasons and encourages conservation and preservation of the environment.

From the mid-90s PA was gradually adopted in Sri Lanka by growers of ornamental plants, vegetables and fruits. The impetus for production of vegetables under protective covers gained ground in Sri Lanka for four main reasons :(a). Ensuring a sustained supply of vegetables against seasonality of production, (b). Avoiding decrease in farmer income that lowers due to erratic weather conditions and pest problems (c). Circumventing land and labour scarcity in agricultural production (d). Promoting modern technology as a means of crop diversification and attract youth to the sector.

The promotion and adoption of these PA technologies were encouraged by the Department of Agriculture (DOA), National Agribusiness Centre (NAC), Export Development Board (EDB) and various projects and funding agencies. Introduction of the production of vegetable crops both for domestic and export markets under a controlled environment was also encouraged by the government. This was in line with what has been envisaged in the national development policy framework; *Mahinda Chintana* - Way Forward, (2005) which emphasizes that "Agriculture needs to be diversified conforming to the modern age by introducing new technologies". The EDB launched a project in 2004 to introduce PA to 600 farmers in the Uva-Parangama area in the Badulla district and in 2009 another project was initiated as an export oriented project through which small farmers were encouraged to grow vegetables under protected conditions mainly for export. The latest initiative was by the Ministry of Agriculture (MOA) to provide poly-tunnels to 400 farmers in the four districts of Matale, Kandy, Nuwara Eliya and Badulla (Daily News, 2011).

Research shows that PA has a high potential for expansion and could be an income generator for the vegetable farmer (Weerakoddy *et. al,* 2001). However, field level sources reveal that farmers are reluctant to use PA techniques after a few years of production. If PA is to be promoted as a means of diversifying vegetable production and as an income source for the vegetable farmers, it is imperative to investigate the viability of PA technique as a sustainable production method which can be promoted for adoption by vegetable farmers in the long term.

1.2 Major Objective

This study attempted to characterize the vegetable farming under protective covers in terms of above aspects while understanding the issues and constraints faced by those farmers.

1.2.1 Specific Objectives

1. To evaluate the present status of the adoption of PA techniques by vegetable farmers.
2. To explore the viability of PA techniques at farm level for vegetable farmers.
3. Identify major issues and constraints faced by farmers using PA techniques.
4. Suggest appropriate policy measures to improve the use of PA for vegetable production.

1.3 Method of Study

The study was carried out in the districts of Badulla, Nuwara Eliya, Kandy and Matale in the Uva and Central provinces. The choice of the two provinces was based on the fact that these are the provinces which have the largest number of farmers growing vegetables under PA techniques. The district per province was chosen based on the concentration of PA farmers in the districts. A sample of 286 farmers was surveyed alongside growers of vegetables in the same vicinity who cultivated vegetables in open fields, termed as open field farmers. Focus group discussions with two farmers in each district-who had training on PA but had not installed the PA units and farmers who had discontinued the use of PA units- were also conducted.

Individual farmers were chosen from the data base maintained at the Provincial Agriculture Offices in the Badulla and Nuwara Eliya districts. For the Kandy district, farmers were selected from the lists of Protected Agriculture Entrepreneurs Association (PAEA) and the Department of Up-country Peasantry Rehabilitation Department while for the Matale district, the list was obtained from Agrarian Service Centers (ASCs) in the District.

Random sampling technique was adopted in the selection of the sample farmers and a total 286 farmers from study districts as shown in the Table 1.1 were selected accordingly. Within the district the selection was based so as to cover as many Divisional Secretariats (DSs) and ASCs where farmers were operating at the time of selection (Appendix 1). A number of key informants who were interviewed were officials from the DOA, PAEA, marketing officers of major supermarkets and marketing agents.

Table 1.1: Distribution of Sample by District

District	PA Farmers	Open Field Farmers	Key Informants
Nuwara Eliya	78 (28%)	25	10
Badulla	75 (26%)	25	12
Matale	72 (21%)	25	8
Kandy	61 (25%)	25	8
Total	286 (100%)	100	38

Source: HARTI Survey Data, 2012

It was also evident from the survey that vegetables were cultivated in different types of PA structures (Table 1.2), namely net houses, rain shelters and green houses. For the purpose of this report green houses are referred to as 'polytunnel' henceforth as this is the most commonly used term among the growers in Sri Lanka.

Table 1.2: Distribution of Farmers by Type of PA Structure

Type of Structure	Distribution of Farmer by District				Overall
	Nuwara Eliya	Badulla	Kandy	Matale	
Net Houses	34 (40%)	16 (19%)	36 (42%)	-	86 (30%)
Rain shelters	-	-	-	72 (100%)	72 (45%)
Poly-tunnels	44 (34%)	59 (46%)	25 (20%)	-	128 (25%)
Total	78 (28%)	75 (26%)	61 (21%)	72 (25%)	286 (100%)

Source: HARTI Survey Data, 2012

(a) Net Houses: The frame is made of PVC pipes with an insect proof net around the frame. The net comes in several mesh sizes depending on the strength of sunlight required for the crop.
(b) Rain Shelters: Frame made with PVC pipes with only a polythene cover on the top to stop rain from damaging the crop.
(c) Poly-tunnels: Frames made either of wood or iron with UV treated polythene cover on the top and a space for ventilation and an insect proof netting around the sides of the frame.

The data indicated that the prominent type of PA structure found in Nuwara Eliya and Badulla districts was poly-tunnels with a less percentage in Kandy. No poly-tunnel or net house operators were included in the sample from the Matale district. All the rain shelter operators were found from the Matale district.

1.3.1 Sample Survey

Two separate semi structured questionnaires were used for the PA farmers and for open field farmers. The survey was conducted during the period of August 2012-December 2012 with the other interviews being held during the same period.

1.3.2 Data Analysis and Presentation

Data collected from various sources was analyzed using SPSS 20. Descriptive statistics for each quantitative and qualitative parameter were calculated and presented in tables and figures. Parallel distributed parameters were analyzed for co-relations. A Cost-Benefit analysis was also carried out to determine the economics of cultivation of certain vegetables grown under PA techniques.

1.4 The Report

The introductory chapter is followed by Chapter Two which gives a brief but a comprehensive view of protected agriculture and its uses in the world scenario. This chapter is followed by chapters (three to five) that present a detailed analysis on the operation of three types of PA structures-poly-tunnels, rain shelters and net houses-respectively and details out the key socio-demographic characteristics of sample farmers, the crops grown, the harvesting and marketing, costs and returns of crops grown. This is followed by a chapter on findings and recommendations to expand the use of PA among the farming population.

CHAPTER TWO

Protected Agriculture Worldwide

2.1 Definitions

In the literature, protected agriculture is interchangeably used with Controlled Environment Agriculture (CEA). CEA is a term applied to growing plants under a highly sophisticated method involving environmental control with integrated production systems which are either mechanized or computerized (Albright and Langhans, 1996). It is a system with which the use of agricultural technology the grower manipulates the crop's environment to the desired conditions to obtain a maximum yield. In CEA systems cultivation may be in a totally enclosed environment where environmental control at both root and aerial level is essential whereas protected agriculture encompasses poly-tunnels, green houses, net houses where plants are grown in enclosed structures which permit optimum light to filter for plant production and protect against adverse climatic conditions (Jensan and Malter 1995). Thus CEA and PA are two different systems and the level of complexity of operation in CEA is greater than that of PA. What is mostly found in Sri Lanka is protected agriculture in which crops are grown under different types of protective covers, often explained as green houses, with one or more physical barriers against the environmental factors (Weerakoddy *et.al*, 2001).

2.2 Use of Controlled Environment Agriculture Technologies

In various parts of the world, different structures and methods of environmental control are used to grow plants under protected conditions. In all these systems agricultural inputs are used systematically and growth of plants is done under protective cover, away from the vagaries of weather. The structures include high and low tunnels of varying sizes, green houses, protected structures or polythene tunnels, glass houses and polythene houses. Among the different methods which employ PA technologies are green houses, hydroponic systems, aquaculture and aqua-phonics where the controlled variables are temperature, humidity, pH and nutrients.

2.2.1 World Scenario

There are many types of CEA systems in various parts of the world from tropical to temperate regions and the structures and methods of environmental control can differ greatly (Jensen, 2010). In deserts and arid regions of the world CEA is an option which has converted waste lands into productive agricultural use.

Originally started in the developed world and mainly in the countries in the Northern hemisphere, as a way to protect crops against cold temperatures and to extend cultivation into the winter months CEA systems are also used in deserts and arid regions to prevent damage caused due to high temperature and excessive water loss by installing cooling systems inside the structure. The level of economic development of a country determines the level of technology used by farmers in green houses. In developing countries, growers may not be able to afford the most sophisticated equipment and therefore what is practiced is a low technology and low input protected systems.

Crop production in the more sophisticated greenhouses covers in total 627100 ha with 443,000 ha in Asia with China and Japan having the highest extent, 105,000 ha in the Mediterranean region, 19,600 ha in the Americas, 42,500 ha in Europe and 17,000 ha in Africa and the Middle East (Encyclopedia of Food and Agriculture, 2011).

In Europe the Netherland greenhouse industry which produces and exports a variety of vegetables and fruits for export is probably the most advanced in the world, relying heavily on glass framed green houses, in order to cope with very cloudy conditions prevalent throughout the year. In the Asian sub-continent, China and Japan are the largest users of green houses. The development of green house technology in China has been faster than in any other country in the world (Zhibin, 1999). In Gulf countries green houses are used due to the extremity in the prevailing climatic conditions with Saudi Arabia growing cucumbers and tomatoes under an evaporative cooling system and Egypt housing 1000ha green houses consisting mainly of plastic covered tunnel type structures. Israel has perfected the art of growing both vegetables and flowers under protected cover with over 15,000ha and is one of the world's largest exporters of cut flowers and crops.

One of the latest developments in CEA is the "VertiCrop technology", a commercial high-density vertical growing system, employed in controlled environments such as glass houses, poly-tunnels or ware houses, which increases production volume for field crops up to 20 times and requires only 8 percent of the normal water consumption used to irrigate field crops. This concept of "Vertical Farming" where multi-story structures also known as the "EDITT Tower" ("Ecological Design in The Tropics") are built in which the internal environment is modified and controlled to suit plant, animal or aqua-cultural life. This prevents the need for land for crop cultivation to meet the increasing food demand and food (The Economist, 2010).

2.2.2 Sri Lankan Situation

The impetus for PA in Sri Lanka gained ground after the initial introduction in the late 80s. Various reasons governed the need to move to PA, such as seasonality of vegetable production and fluctuating weather conditions, decreasing land availability for crop production, the need for crop diversification and labour scarcity for production. High tech agriculture was considered the best alternative to obtain optimum benefits from the available cultivable lands for off-seasonal vegetable production. An additional impetus was provided by the need of the government to promote modern technology and attract the younger generation to the agriculture sector.

In Sri Lanka, three types of structures are used in PA: Net houses, Poly-tunnels and Rain shelters. In net houses the frame is made of PVC pipes with an insect proof net around the frame structure. The net comes in several mesh sizes depending on the strength of sunlight required for the crop. In rain shelters the frame is made of PVC pipes with only a polythene cover on the top to stop rain from damaging the crop. In poly-tunnels the frame is made either of wood or iron with UV treated polythene cover on the top and a space for ventilation and an insect proof netting around the sides of the frame.

There are varied numbers of stakeholders in this sector from the farming community to large scale companies that produce vegetables and fruits for input suppliers and marketing agents who market the final product. Mainly adopted by farmers in the Badulla, Nuwara Eliya, Kandy and Matale districts, taking the lead in vegetable production the rate of adoption of PA techniques has gradually increased.

State sponsored programmes such as *Divineguma* and *Gemidiriya*, Second Community Development and Livelihood Improvement Project and *'Yali Pibidemu'* project had introduced net houses, poly-tunnels and rain shelters to many of the districts in the country. Through the *Gemideriya* project it has been envisaged that there would be one poly-tunnel set up in each *Grama Niladari* division in the country with a 50 percent subsidy granted to each farmer for the construction of a 510 sq ft tunnel.

In addition, the increasing influx of tourists after the end of the conflict in 2009 has also led to the need for exotic vegetables, encouraging farmers to take an interest in the cultivation of vegetables under protective covers.

There were several factors constraining vegetable production among the up country farming community, which had predisposed the farmers to adopt PA. The main factors are the unpredictable climatic conditions and volatile and fluctuating prices which had led farmers to seek new alternatives and economic opportunities by cultivating high value crops. In addition, the government funded projects had given the needed impetus to farmers to initiate cultivation by providing cash/kind and technical advice to farmers.

A project initiated by the EDB targeted 600 young farmers to whom a subsidy was provided but in 2013 of the 600 farmers only around 100 farmers had continued cultivation in poly-tunnels. Since 2010, there was another sharp increase in the number of tunnels constructed with the promotion by the government under the *Divi neguma* programme where subsidies were given to farmers who were interested in initiating cultivation in tunnels.

The average cost of a 510sq.ft poly-tunnel has been estimated at Rs. 168000/= inclusive of construction, equipment, seeds and fertilizer cost to establish and begin cultivation of a poly-tunnel (Sunday Observer, 2011). The construction cost of larger size of over 1000 sq.ft is estimated at Rs.250000/- IFCO had estimated but these costs vary depending on the materials used in the construction such as iron rods versus wooden poles. The technology was initially adopted by middle income farmers/agriculturists, as the initial establishment cost is high compared to open field cultivation of vegetables (Niranjan *et. al.*, 2005). Vegetables that are produced in Sri Lanka for exporting are mainly exported to Middle East and Maldives the vegetable include globe artichokes, green beans, leeks, capsicum, cabbage, carrot, tomato, bell pepper (Perera *et.al*, 2012 unpublished). Of the exported vegetables 40% is imported by Maldives with the remaining sent to Middle East and the European countries. Although all vegetables are not grown under PA systems there is a difficulty in separating out the produce as there are no separate HS codes designated at the point of departure.

2.3 Advantages and Drawbacks of Protected Agriculture Systems

The natural environment of a plant is modified to extend the growing season and permit plant growth during periods when open field crops do not normally grow. The plant thus adapts to achieve optimal growth in the given environment. PA in addition to protecting the environment helps in the conservation of water and land.

Most developed countries will face major challenges in the future with regard to vegetable farming with the ever increasing urbanization, increased regulation of water, fertilizer and pesticide inputs by governments and the increasing conditions of extreme weather conditions. Thus protected agriculture is seen as the next vital step in commercial vegetable production. Globally there exists a large number of studies and research which have been carried out in many countries where this form of agricultural production is viewed as a system for the future. In addition to extending growing seasons in many parts of the world, and in developing countries it is seen as an income source for many communities (Jensen, 1985). Another advantage is that PA can be practiced in a low carbon and climate compatible way by using renewable energy thus reducing the inherent dangers posed to the environment through conventional open field agriculture (Omobowale, 2011).

Despite the above positive impacts of PA there are drawbacks such as high costs and rapid spread of diseases. Increased cropping intensity and the predisposal of waste have hindered its popularity (Aoki, 1995). A study conducted in Sri Lanka shows that CEA is an innovative technological package for agricultural production but it has a high degree of uncertainty (Weerakoddy, 2001).

2.4 Economics of Protected Agriculture

The economics of protected agriculture have been widely addressed in a series of studies and research throughout the world. It has been estimated that annual returns per unit area from protected agriculture could be 10-100 times than those of open field cultivation (Paroda, 2013). In Sri Lanka, studies have shown that crops grown in PA have a higher yield than open field agriculture (Weerakoddy *et. al.*, 2001).

Although there is heavy capital investment and the operational costs are high, the productivity in PA is significantly higher in comparison with open field agriculture (Jensen 2010). Optimum growing conditions and a balanced supply of nutrients are the necessary factors for the increase in yields. In addition, there is the possibility of increased cropping frequency and possibility of beginning cultivation in any month of the year thus adding to the income of the grower who is not dependent on seasonal cultivation as in open field cultivation.

Various factors affect the profitability of PA from the location of the structure, type of structure, inputs and prevailing market price for the produce. Greenhouse designs (Brunad Lagier, 1985; Bailey; Castilla *et al*, 1992) have an impact on the growth and performance of vegetables (e.g., Caruso, 1986; Bakker, 1990; Castilla, 1994; Al-Kadi *et. al.*, 2000). Gross returns from vegetables from PA are high due to higher vegetable yields in tunnels (Waterer, 2003, Schultsz *et. al.*, 2011). Off season cultivation of vegetables offers the farmer distinct advantages of quality, productivity and market price to the grower (Singh and Sirohi, 2006) thus increasing farmer's income substantially. Cultivation of leafy vegetables under protective covers also showed a superior yield and quality of crops as compared to open field conditions (Dixit, 2007) while crops such as tomatoes and bell pepper in poly-tunnels had shown a higher productivity and better returns due to increased yields (Singh and Asrey, 2005).

Training is one of the most important components for a successful PA enterprise. The more advanced the knowledge, the better the profitability of vegetables grown in these environments. Farmer's level of horticultural training, the adoption of good quality system, the use of family labour and, in a lesser extent, the type of crop and area of tunnel has been found positively related to productivity (Bertuglia and Calatrava, 2012).

Another study showed that of the main three poly-tunnel cultivated crops (tomato, bell pepper and japanese cucumber) the gross margins of unit volume shows variations depending on the crop grown whereas gross margin of unit land area per cropping season shows only minor variation/difference (Niranjan *et. al.*, 2005). Uncertain market prices have resulted in farmers having a highly variable income (Weerakoddy *et. al.*, 2001) thus scaling down the popularizing of this method of cultivation among the farming community.

2.5 Market Destinations of Poly-tunnel Products

Of Sri Lanka's annual production of 602,000 metric tons of fresh vegetables (FAO STAT and Department of Census and Statistics, 2012), 21092 metric tons are exported. The main vegetables exported from Sri Lankan shores are carrot, globe artichokes, beans, leeks, radish, all types of peppers, cauliflower and cabbage varieties zucchini, tomatoes and leafy vegetables and low country vegetables ranging from green chili, red onion, pumpkin, bitter gourd and endogenous yams. Sri Lanka's largest exported produce of vegetable is globe artichokes.

Export markets for Sri Lankan fresh produce are mainly Maldives (nearly 90 percent) catering to the ever expanding tourist and local market and the Middle Eastern countries. Of the processed vegetables 70 percent is exported to the European market.

China leads the world in exporting vegetables competing with other exporting countries such as USA and European countries. From the Asian subcontinent China, India, Thailand, Malaysia and Philippines are the top exporters of fruit and vegetables to the world. Sri Lanka's competitors for a share in the Maldivian market are at present India and UAE (Subashini, 2014 unpublished). The export market for the vegetables has narrowed down for Sri Lanka due to quality standards and high price volatility as well as high competition from India, UAE, Thailand and China. Other factors that are impinging on the exports are increasingly stringent food quality and safety requirements, with regard to allowable pesticides and their maximum residue levels (MRLs) in the European Union (EU) and Japan and increasing consumer awareness on organically grown produce.

Quantity of individual vegetables exported is difficult to differentiate as most of the vegetables exported from Sri Lanka are specified under one HS code at the point of exit from the country. This makes it difficult to identify the potential for the export of vegetables and thereby the markets.

CHAPTER THREE

Vegetable Cultivation in Poly-tunnels

3.1 Introduction

Poly-tunnels are made of wooden or iron frames with a UV treated polythene cover on the top and a space for ventilation and an insect proof netting around the sides of the frame. They are the most popular PA structures among the farmers in Nuwara Eliya, Badulla and Kandy districts. The content of this chapter includes socio-demographic features of poly-tunnel operators with the sections on crops grown in poly-tunnels, scale of operation, harvesting, packaging, marketing of vegetables and costs and returns for the profitable crops grown in study locations.

3.2 Socio-demographic Characteristics of Poly-tunnel Farmers

The sample included a total of 128 poly-tunnel operators from Nuwara Eliya (34%), Badulla (46%) and Kandy (20%) districts. It was observed during the survey that females had shown an increased interest to be involved in poly-tunnel farming to supplement their household income. Accordingly there was a considerable percentage of female poly-tunnel operators in the sample (21%) with the majority (79%) being male farmers (Table 3.1). The Badulla district predominated in terms of high female participation (31%) and the lowest from Nuwara Eliya district (12%), with no significant variation in the participation between males and females across districts (χ^2 =5.564; P = 0.062).

Poly-tunnel farming was also characterized by the high involvement (32%) of young farmers below 40 years of age from all districts. Yet the majority (59%) was between 40 to 60 years of age. Whilst a small percentage (9%) was over 60 years, there no significant age wise variations across districts (χ^2 =5.714; P = 0.222).

The study provides evidence that the poly-tunnel operators are a relatively educated crowd. Among the respondents 45 percent farmers had been educated upto G.C.E.A/L or beyond with another 45 percent having been educated up to G.C.E. O/L. Altogether 90 percent poly-tunnel operators had received a good education showing no significant variations across districts (χ^2 = 8.705; P = 0.368).

Table 3.1: Socio-demographic Characteristics of Poly-tunnel Farmers

Socio-demographic Characteristics	Nuwara Eliya	Badulla	Kandy	Overall
Sex				
Male	88	69	84	79
Female	12	31	16	21
Total	**100**	**100**	**100**	**100**
Age (years)				
20-40	33	31	32	32
40-60	51	66	60	59
>60	16	3	8	9
Total	**100**	**100**	**100**	**100**
Educational Status				
1-5 years	0	3	0	2
6 years-up top O/L	12	10	4	8
Passed O/L	35	51	44	45
Passed A/L	42	31	48	38
Degree/Diploma	12	5	4	7
Total	**100**	**100**	**100**	**100**
Main Occupation				
Full time farming	79	70	56	70
Part time farming and other	21	30	44	30
Total	**100**	**100**	**100**	**100**
Experience in PA				
Just started	19	3	20	14
1-5 years	44	58	48	50
6-10 years	19	39	24	27
Over ten years	19	0	8	9
Total	**100**	**100**	**100**	**100**
Training Received				
Yes	56	54	80	63
No	44	46	20	37
Total	**100**	**100**	**100**	**100**

Source: HARTI Survey Data, 2012.

Poly-tunnel farming has been chosen by 30 percent of farmers as an additional source of income. More farmers from the Kandy district had been involved in poly-tunnel farming as a part-time employment.

Nuwara Eliya is the pioneering district for protected agriculture thus around 19 percent of farmers had over ten years' experience while only 8 percent from the Kandy district had the same period of experience. While in the Badulla district there were no experienced farmers. It was also observed that from Nuwara Eliya and

Kandy districts new farmers are engaged in this enterprise as a result of the institutional support extended by various organizations as discussed under section 3.3. In general, the majority of farmers overall (63%) had undergone training on poly-tunnel farming with no significant variations in terms of exposure to training by respondents across districts ($\chi^2 = 5.111$; P = 0.078). However, when individual districts are taken into account, 80% farmers had undergone some form of training. The majority had initiated cultivation only after the training they have undergone, which had been stipulated as compulsory by various programmes and projects which funded the initiation of poly-tunnels. Types of training given were mainly with regard to technology of cultivation, maintenance of the structure and marketing aspects of the crop. An essential component in all the training programmes was the production and the use of organic fertilizer as a promotional campaign of organic fertilizer use. Most of the training was carried out at various research stations in the area and it was generally 3-5 day training. In certain instances training was also extended to practical demonstrations on how to set up poly-tunnels and maintenance of the structure such as how the polythene cover needs to be cleaned and replaced after a period of 2-3 years.

Poly tunnels were promoted as a new and innovative technique of cultivation mainly to attract the younger generation into agriculture. When age-wise distribution of farmers who received training was analyzed, the survey data was contrary to the government predictions that newer and more advanced technologies should attract young farmers. There were not many trained farmers who were below 30 years of age. One of the main factors which prevent younger generation from being attracted to poly tunnel farming is the techniques practiced, which were very primitive and labour intensive. Automation of systems was only found among the larger companies that cultivated these vegetables. The cost involved in initiating cultivation even at the minimal level was very high.

Sample farmers had enhanced their knowledge and skills through training programmes and information from officers at the ASCs across the four districts. In addition, farmers had increased/improved their knowledge and skills after years of experience gained by cultivating the crops. The more educated and more resourceful farmers improved their knowledge by reading books and media and in certain instance through the internet. In Nuwara Eliya and Badulla districts as there were research stations which were directly involved in research and development (R & D) farmers had taken the opportunities to update knowledge by frequenting research stations and meeting with research officers involved in the subject. The sample included farmers who received training on poly tunnel farming in the year 1992 in the Nuwara Eliya district, 1995 in the Kandy district and 2001 in the Badulla district. Table 3.2 shows that there is a recent trend towards popularization of poly tunnel farming in the Kandy district while keeping pace in other two districts too.

Table 3.2: Period of Training Received by Farmers by District

Period of Training Received	Percentage of Farmers by District		
	Nuwara Eliya	Badulla	Kandy
Before 2004	12	26	35
2005 – 2009	60	62	10
After 2010	28	12	55

Source: HARTI Survey Data, 2012

Most of the open field farmers (65%) had some knowledge about poly tunnel farming by observing it at some neighbours or else through the media. Others had attended agricultural training programmes where topics of the use of modern technology in cultivation had been highlighted. Only a very few of the open field farmers (10%) had some training but had not been able to afford to start cultivation as they had not received any grants or subsidies. The factors that had deterred open field farmers from venturing into this practice were the lack of initial capital, their lack of knowledge and training and unavailability of training programmes. Almost 95 percent of the open field farmers responded that given an opportunity (necessary cash and kind) they would like to employ the PA techniques. However, they were hesitant to reduce the extent under open field cultivation as they may lose the income by changing cultivation methods.

3.3 Institutional Assistance to Popularize Poly-tunnel Farming

Various institutions such as the EDB, the Ministry of Rural Development of Economic Affairs, MOA, the *Samurdhi* Authority and PAEA were the main contributors for the popularization of PA through the years. Several benefits had been offered in the form of cash and kind, training, subsidies on construction costs and materials and other inputs. In addition, there had been several private and public banks and foreign funded projects which had also provided subsidies in cash and kind towards the promotion of PA.

There were two different methods of finances used in constructing and commencing cultivation: own funds and grants. Farmers either utilized a full grant from an organization or a partial subsidy either in cash or kind which was supplemented by contribution of their own funds towards the cultivation. Data in the Table 3.3 indicates that the majority of operators (67%) had constructed their tunnels utilizing their personal funds whereas few percentages (7%) had received partial grants with the rest (26%) receiving full grants.

Table 3.3: Types of Institutional Assistance for Poly-tunnel Construction

Type of Assistance	Nuwara Eliya	Badulla	Kandy	Overall
Own Funds	60	80	48	67
Partial Grants	5	8	8	7
Full Grants	35	12	44	26
Total	100	100	100	100

Source: HARTI Survey Data, 2012

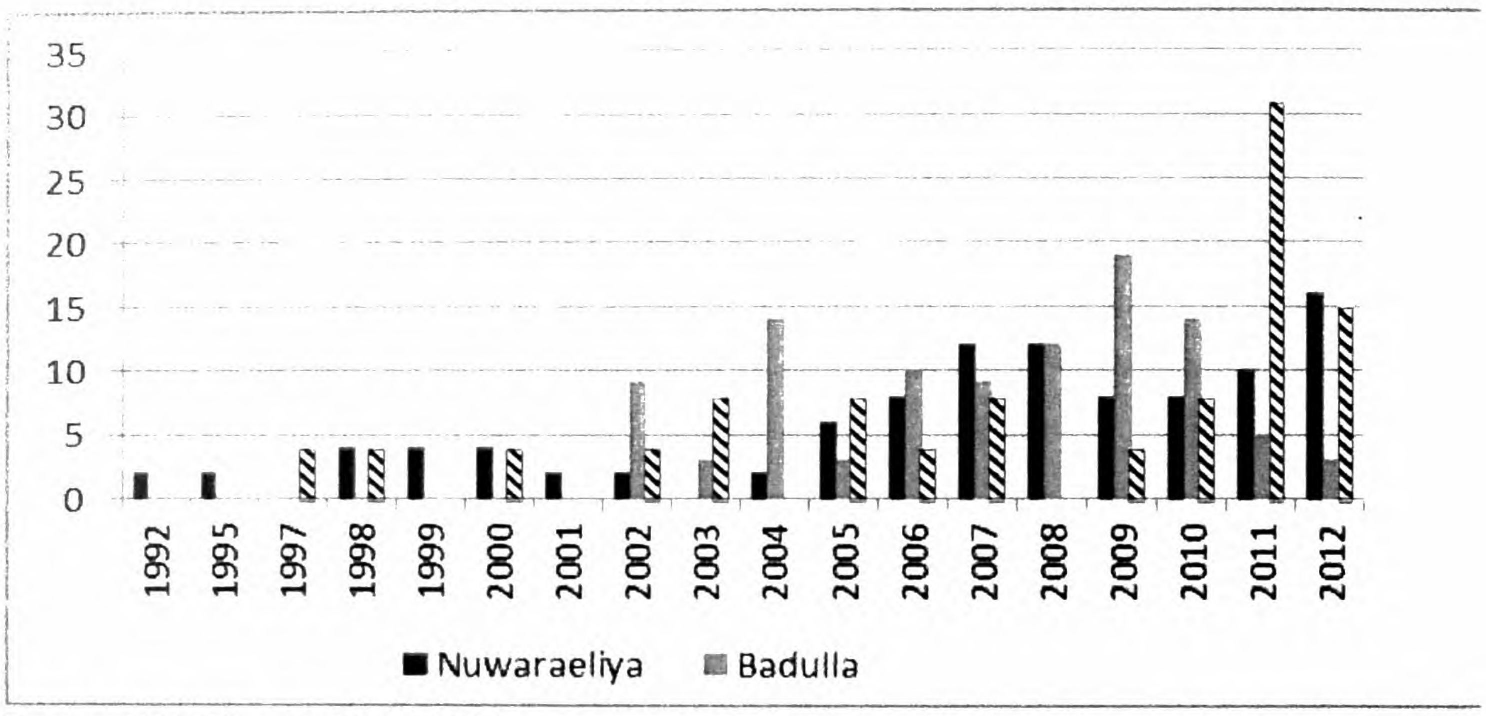
In the Nuwara Eliya district under the *Divi Neguma* programme, the estimated tunnel cost was Rs. 110,000/= of which the farmers were entitled to Rs. 80,000 after the construction of the poly-tunnel of 574 sq. ft. Only seven percent of the farmers availed themselves of the subsidy which was given by the *Samurdhi* Authority under the auspices of the *Divi Neguma* programme. In yet another scheme, farmers were given the UV treated polythene by the DOA when they completed the construction of the poly-tunnel. Of the total, 40 percent farmers in Nuwara Eliya had received such grants for the construction of poly-tunnels.

EDB and the Ministry of Rural Development had commenced a project in 2004 to introduce 600 poly-tunnels in the Uva Paranagama area in the Badulla district. Through training programmes and a loan scheme young farmers were introduced to high tech farming of crops such as beef tomatoes, bell pepper and Japanese cucumber with a guaranteed market. Sample data showed that 12 percent of farmers were recipients of this scheme. Under this scheme the entire structure of 1000sq.ft. tunnel was imported from India including the UV treated polythene and the insect proof netting at a cost of Rs. 257,000. This was given to the farmer as a loan to be recovered within four years. Overall 20 percent farmers from the Badulla district had received subsidies for the construction of poly-tunnels.

In the Kandy district under the *Divi Neguma* programme, 21 percent of the sample farmers were given subsidies by the Department of Up-country Peasantry Rehabilitation and the *Samurdhi* Authority. Under this scheme the total cost for poly-tunnel was estimated at Rs. 168,500 with the construction cost of Rs. 148,500 and input cost of Rs. 19,650 (fertilizer, seeds and other inputs). The farmers had to initially construct a poly-tunnel of 510-574 square feet with his/her own cash after which they were entitled to Rs. 84,000 which is half the cost of the tunnel. The rest was borne by the farmer. Overall 58 percent farmers from the Kandy district had received grants for the construction of poly-tunnels.

Another aspect of institutional support was the membership of the PA farmers with various organizations dealing with promotion and marketing of products. Pioneering organizations dealing with PA products was PAEA in Kandy and Uva Paranagama Export Production Village (People's) Co. Ltd (UPEPV or the EDB centers). Only 30 percent of the farmers from the Kandy and Nuwara Eliya districts and 19 percent from the Badulla district were members of this organization. The membership was mainly with the PAEA in the Kandy district and the UPEPV. In the Badulla district under the IFAD project which promoted PA, recipients were grouped into an organization. In addition, a number of other PA farmers were members of various small organizations formed under various Non-Governmental Organizations (NGOs) operating in the area. There was a buy back agreement with the members and the UPEPV or the EDB, where marketing of the farmers' produce was guaranteed by the association and the prices were predetermined, leading to a satisfactory income generation on a long term basis. In addition, ten percent was deducted against the loan as a loan repayment.

Various development programmes and projects in the late 1990s had introduced poly-tunnels as a means to motivate vegetable farmers to cultivate vegetables for the export market. Among the sample farmers the oldest poly-tunnels were found in the Nuwara Eliya district and both the number and the number of locations of tunnels have increased gradually over the years (Figure 3.1).



Source: HARTI Survey Data, 2012

Figure 3.1: Year of Initiation of Poly-tunnels in Study Locations

Since year 2010 there has been another sharp increase in the number of tunnels constructed with the promotional programme of the government under the *Divi Neguma* project in which subsidies were given to farmers those who were interested in cultivating in poly-tunnels.

3.4 Nature and Scale of Operating Poly-tunnels

The study revealed that the majority of poly-tunnel operators had only one tunnel across the three districts (Table 3.4). It was only in the Nuwara Eliya district that there were farmers who can be termed as large scale poly-tunnel operators by virtue of the fact they owned more than four tunnels with one having as many as 23 poly-tunnels. The majority of farmers (50%) owned around1000sq.ft. tunnels in the three districts (Table 3.5) with the highest number from Badulla and the lowest number from Kandy.

Table 3.4: Percentage Distribution of Farmers by Number of Poly-tunnels

Number of Poly-tunnels	District			Overall
	Nuwara Eliya	Badulla	Kandy	
1	70	58	56	62
2	16	28	16	22
3	5	12	20	11
4-7	7	2	8	4
23	2	-	-	1
Total	100	100	100	100

Source: HARTI Survey Data, 2012.

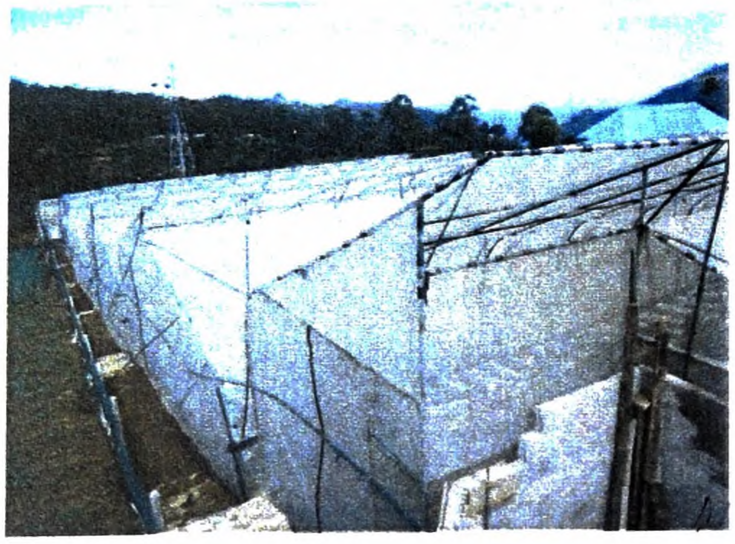
Table 3.5: Percentage Distribution of Poly-tunnels Categorized by Size across District

Sizes (Sq. ft.)	Distribution of Poly-tunnels by District and Size (Percentage)			Overall
	Nuwara Eliya	Badulla	Kandy	
<500	8 (18%)	-	-	8 (6%)
Around 500	6 (14%)	1 (2%)	6 (24%)	13 (10%)
Around 750	5 (11%)	1 (2%)	-	6 (5%)
Around 1000	15 (34%)	46 (78%)	10 (40%)	71(55%)
>1000	10 (23%)	11(19%)	9 (36%)	30 (23%)
Total	100 (N=44)	100 (N =59)	100 (N= 25)	100 (N=128)

Note: Number of poly-tunnels exceeds the number of respondents as some owned more than one tunnel
Source: HARTI Survey Data, 2012.

Larger tunnels of over 1000sq. ft. constituted around 23 percent of the total number of poly-tunnels and there was variation in the distribution of poly-tunnels with different sizes across districts. Poly tunnels from small and medium to large sizes were found in the Nuwara Eliya district but almost all the tunnels were of medium or large sizes in Badulla and Kandy districts.

Different Types of Poly-tunnels



Commercial Oriented Poly-tunnel Structure

High initial cost of structure was a decisive factor of the size of the poly-tunnel and therefore initially the farmers had begun cultivation with one poly-tunnel which they had constructed on a subsidy or grant. With time growers seem to be in favor of making further investments on increasing the tunnel area as they realize the profitability of the venture.

Affordable farmers who had seen the profitability of cultivating crops in poly-tunnels had utilized their own resources to construct and set up a further number of tunnels. Around 50 percent farmers who self-financed their structures had obtained formal loans from banks ranging from Rs. 50,000 to 240,000/= where the interest rate ranged from 8 to 15 percent depending on the different banks. Poly-tunnel techniques were first introduced to Nuwara Eliya and Badulla districts and the farmers were well aware of the income which can be obtained from the cultivation of vegetables in poly-tunnels in comparison to open field farming and thus were willing to self-finance the structures. Therefore these farmers were willing to obtain loans to initiate cultivation in poly-tunnels.

3.5 Crops Grown in Poly-tunnels

The number of crop species grown in poly-tunnels was limited. Overall a majority of the operators from study locations grew bell pepper (40%) and japanese cucumber (19%) (Table 3.6). Local tomatoes are popular in Badulla and Kandy districts. Beef tomatoes, zucchini and herbs are only grown in the Nuwara Eliya district. In a smaller extent, beef tomato and cherry tomatoes are cultivated in Nuwara Eliya and Kandy districts on the requests of buyer mainly the PAEA.

A very few farmers had grown cauliflower or/and broccoli in poly-tunnels as these crops can be grown in the open fields in Nuwara Eliya and Badulla districts during colder months of the year from November to January. Cultivation of cauliflower in poly-tunnels had a quality advantage as the curd being pure white in color compared to the ones grown in the open field. The farmers who had regular buyers cultivated these crops in poly-tunnels to get the white color of the "curd". Lettuce (salad leaves) and herbs were grown by a very few farmers in the Nuwara Eliya district. According to the data, 90 percent operators practice mono cropping cultivating a single crop at a time in poly tunnels. Kandy predominates in multiple cropping (18%) practices.

Table 3.6: Percentage Distribution of Farmers by Crops Grown in Year 2012

Type of Vegetable	Percentage of Farmers			
	Nuwara Eliya	Badulla	Kandy	Overall
Bell Pepper	31	50	32	40
Japanese Cucumber	10	21	32	19
Local tomatoes	-	19	9	11
Beef tomato	10	-	-	3
Lettuce	2	-	5	2
Chinese cabbage	2	3	-	2
Zucchini	10	-	-	3
Herbs	2	-	-	1
Other crops	12	3	5	7
Multiple crops	14	3	18	10

Source: HARTI Survey Data, 2012

A very few farmers who had a regular and assured buyer had started cultivation of lettuce in hydroponics or soil less culture while other farmers still cultivate different varieties of salad leaves in soil medium. Table 3.6 illustrates further information on crops grown in poly-tunnels.

The frequency of cropping of the different crops in a poly-tunnel was found for a few of the crops where the growing period was between 2-6 months (Table 3.7). Such crops were cucumber, tomatoes (both local and the beef varieties) and zucchini. Lettuce was grown generally around 3 to 5 times per year. Around 20 English herb varieties were cultivated and harvested according to the dictates of the market. Some of the herb varieties had a life span of 7-9 years (Table 3.7). Lettuce was cultivated only in Nuwara Eliya thrice a year. One farmer from Nuwara Eliya had cultivated beet in poly tunnels twice a year.

Table 3.7: Some Information on Crops Grown in Poly-tunnels

Common Name	Scientific Name	Duration	Harvesting begins at
Pepper(Green)	*Capsicum annuum*	9 months	2nd- 3rd month
Pepper (Red)	*Capsicum annuum*	9-12months	3 ½ month
Pepper(Yellow)	*Capsicum annuum*	9-12months	3 ½ month
Japanese cucumber	*Cucumissativus*	4 -6months	2 month
Beef tomato	*Lycopersicon esculentum*	5-6 months	3 month
Cherry tomato	*Lycopersicon esculentum.*	9-12 months	3 ½ month
Broccoli	*Brassica oleracea*	3-4 months	after 2 ½ months
Cauliflower	*Brassica oleracea*	3-4 months	after 2 ½ months
Salad leaves	*(Lactuca sativa*	2 month	1 ½ month
Herbs: Parsley Sage Oregano Tarragon Fennel Thyme Chives Rosemary Mint Lemon grass etc	 *Thymus selections* *Artemisia dracunculus* *Salvia officinalis* *Melissa officinalis* *Cymbopogon citrates* *Origanummajorana* *Mentha selections* *Origanumvulgare* *Petroselinum selections* *Rosmarinusofficinalis*	1-10 years	depends on the type of herb

Source: Department of Agriculture, 2004

Table 3.8: Frequency Distribution of Farmers Cultivating Vegetables in Poly-tunnels by District

Crops	Districts and Number of Crops Grown/Year					
	Nuwara Eliya		Badulla		Kandy	
	Twice/ Year	Thrice/ year	Twice/ year	Thrice/ year	Twice/ year	Thrice/ year
Japanese Cucumber	10	3	5	2	13	5
Zucchini	5	-	-	-	8	-
Tomatoes	-	-	11	-	9	-

Source: HARTI Survey Data, 2012

Most of the farmers who cultivated bell peppers (35%) followed a mono cropping system across the districts. A small percentage (10%) of farmers who followed multiple cropping with short term crops such as lettuce, tomatoes and cabbage varieties and the crops were grown in different sections of the tunnel 3-4 times a year. The main reason for mono cropping was the possibility of generating a high income by the specific crops within an 8-9 month season. In addition difficulty in finding markets for other crops had also prevented the farmer from wanting to grow more than one crop per year. The box 3.1 illustrates a success case of poly-tunnel farming with diversified cropping.

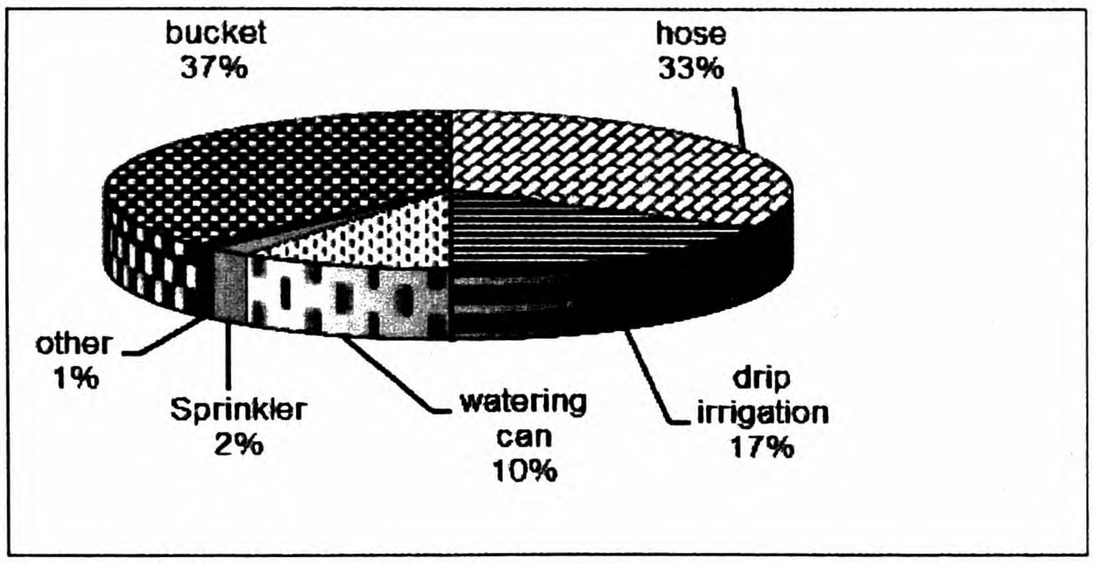
3.6 Use of Planting Materials and Other Cultural Practices of Poly-tunnel Farming

Selection of varieties is an important factor for crop productivity. Due to lack of local varieties, imported seeds are used for the crops commonly grown in poly-tunnels and there were several varieties of each crop at a varying price range. The sources of seeds varied across districts. Farmers claimed that they would prefer to buy seeds from private dealers as availability and reliability of the seeds were assured.

Irrigation of the crop is an important component as the crops are protected from the environment and thereby deprived of receiving rain or any other outside source of precipitation. There were different systems of irrigation practiced by the sample farmers namely drip, sprinkler, mist and manual watering (with hose and using small utensils such as yogurt cups and saucers to water the crop). Modern irrigation technologies such as drip and sprinkler systems were used to a lesser extent - fourteen percent (Figure 3.2). A majority of farmers used the ordinary hose to irrigate crops in all three systems as it was both cheap and a convenient method.

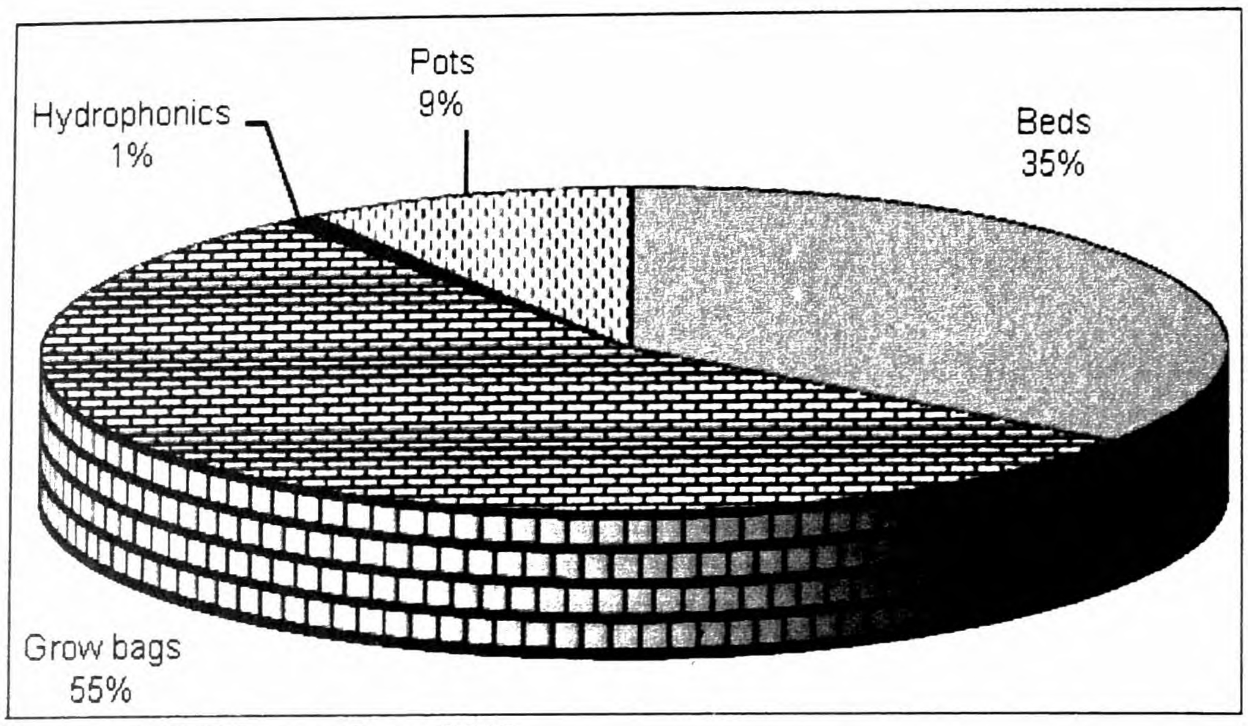
Growing Media:

Grow bags were mostly used in poly-tunnels whereas hydroponics was used for cultivation of lettuce varieties mainly in the Nuwara Eliya district but to a lesser extent (Figure 3.3). Most of the poly-tunnel farmers used the potting medium of coir dust, top soil and sand in a 2:1:1 ratio although the recommended method is sand/partially burnt paddy husk: coir dust in 1:1 ratio (Weerakkody, 2003). In certain instances some poly-tunnel farmers used compost, cow dung, goat manure, tea refuse and saw dust as the potting media depending on the availability of these products in the area.



Source: HARTI Survey Data, 2012

Figure 3.2: Percentage Distribution of Farmers by Type of Irrigation



Source: HARTI Survey Data, 2012

Figure 3.3: Percentage Distribution of Farmers by Type of Potting Medium

Fertilizer

It was evident that the main fertilizer used in poly-tunnels was Albert's solution which was used by almost all the farmers (CIC and Unipower, Colombo). Albert's solution is used throughout the life of the crop and the quantity used ranged from 50 to 70 kg, increasing with the size of the tunnel. At the time of flowering, farmers use fertilizer with a high content of potassium to stimulate flowering of the crop. The type of fertilizer used varied with what was available in the market at a given time. When the question of fertilizer use was probed, farmers admitted that they used a larger quantity than what has been recommended by the DOA as they believed that more the fertilizer used better the growth of the crop. Data showed that the DOA's recommendation to use compost and cow dung as sources of fertilizer was only followed by 5-6 percent of the farmers.

Equipment

Equipment used in PA structures in the country was minimal. One such equipment used by a majority of the PA farmers was the sprayer. Among the poly-tunnel farmers who had larger sizes of tunnels Knapsack sprayer was used while for smaller tunnel sizes farmers had used hand sprayers. None of the farmers in the sample had used protective clothing when pesticides and fungicides were used although they were aware of the ill - effects of spraying highly toxic agro-chemicals in closed environments. A majority of the poly-tunnel farmers had used hired labour for this activity.

Box 3.1: A Successful Entrepreneur Involved in Poly-tunnel Farming

Fifty nine year old Akila Bandara Thenuwara from Nuwara Eliya district is a versatile and enterprising full time farmer. With initial training from PAEA in 1995 he commenced cultivation of crops in poly tunnels in a 1000sq feet tunnel which he purchased with his own money.

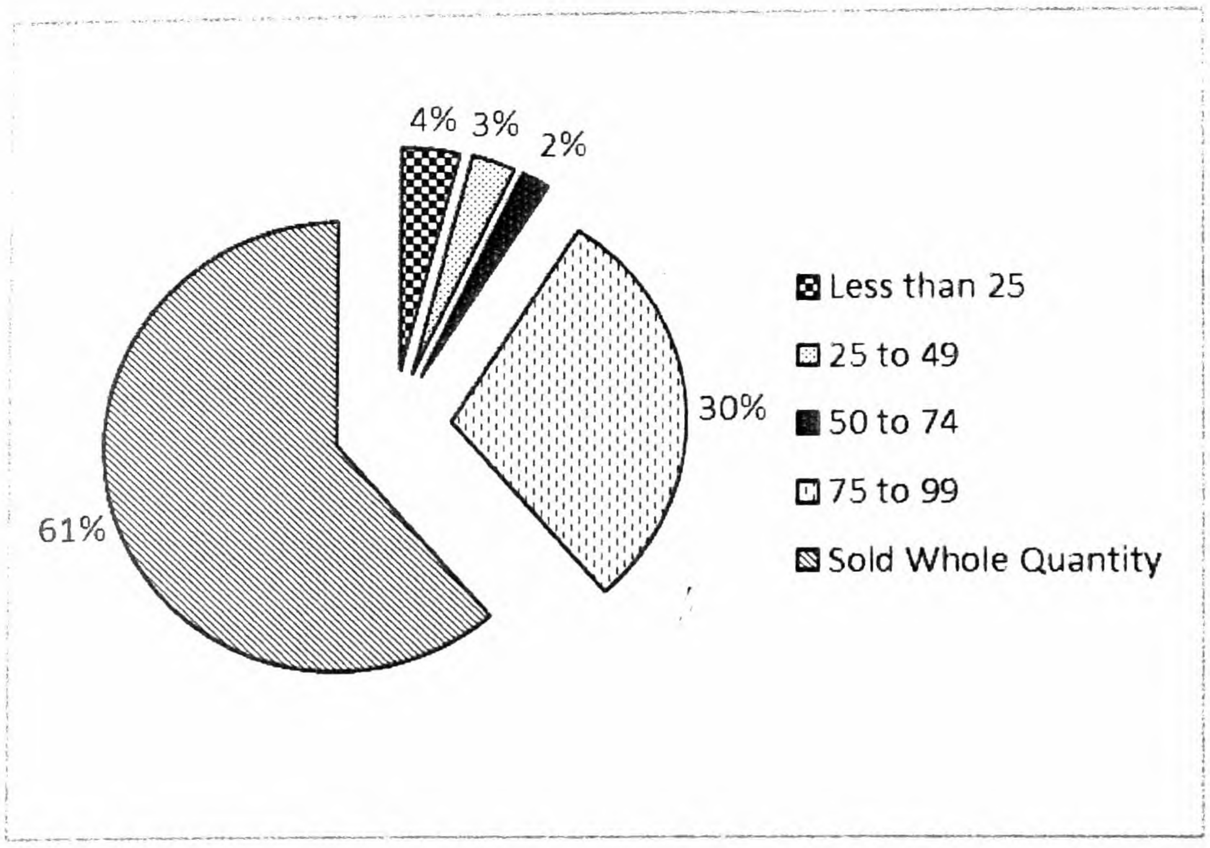
Through the internet and learning by visiting various companies he has at present expanded the number of tunnels to include a further 3 tunnels of varying sizes which range from 1500sq feet to 3150sq feet. These tunnels are rented out by owners who are at present not cultivating crops in tunnels. The cost of the rent is Rs 30000/- for 5000sq feet per month.

The largest cost item in the cultivation process has been the labour cost for the retinue of 6 permanent staff and a number of temporary staff when required. While fertilizer usage and cost is high the use of fungicides is more than pesticides.

While peppers are the main crops cultivated a variety of other crops are also cultivated. List of crops cultivated for the year 2012 in the different tunnels are given below.

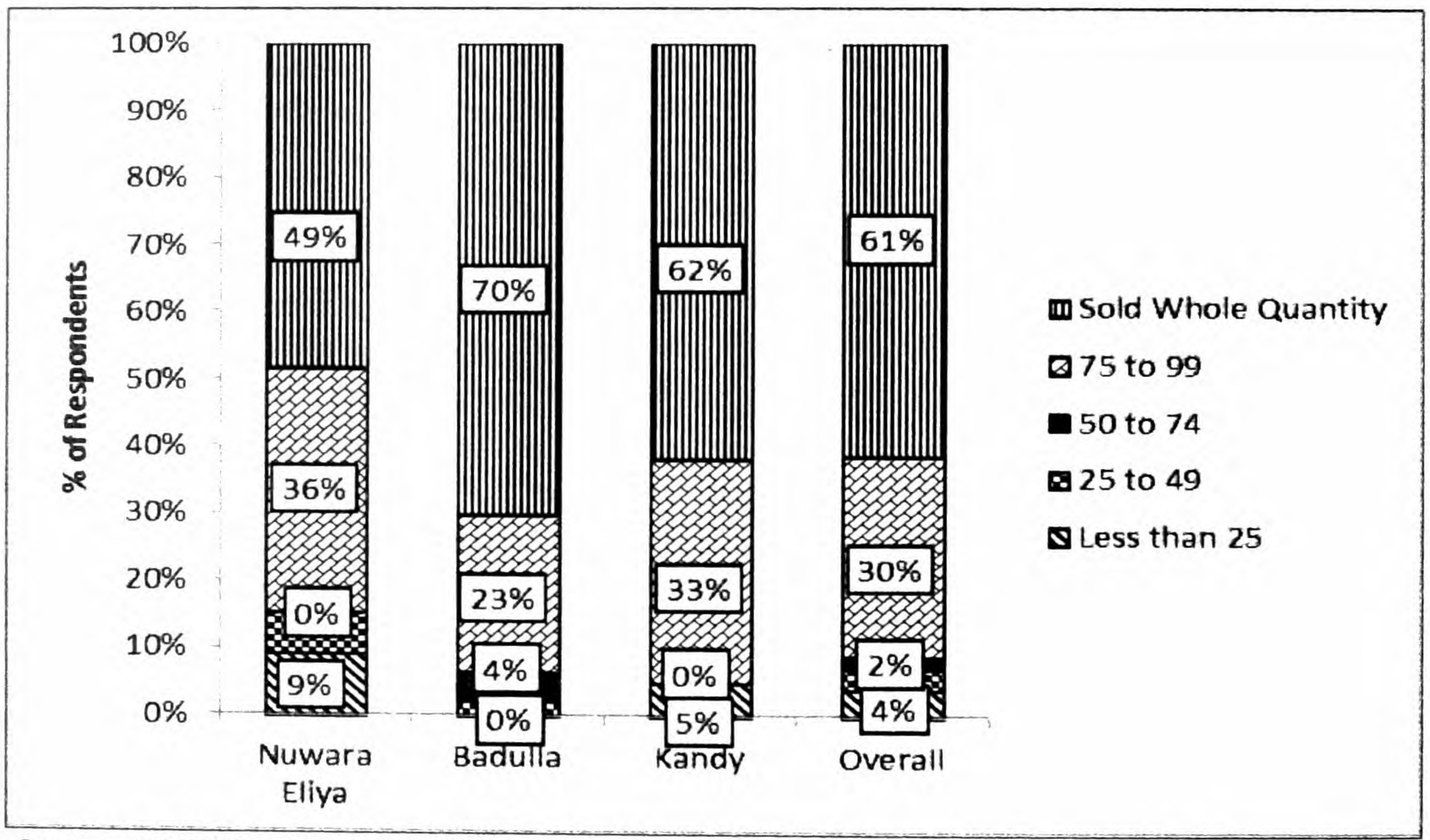
Crop	Total Harvest (Kg)	Price (Rs/kg)
Yellow Pepper	1500	350
Red Pepper	1500	350
Cherry Tomato	200	100
Beef Tomato	500	70
Broccoli	100	150
Cauliflower	100	200
Iceberg Lettuce	200	100

In general he sells his entire harvest. Main Buyers are Cargills, Keels the two super market chains, Hotels, PAEA and the local market. Whilst he had sold the entire harvest his annual income from the crops grown in poly-tunnels amounted to Rs. 1,160,000/= in the year 2012.



Source: HARTI Survey Data, 2012

Figure 3.4: Percentage of Marketing Distribution of Farmers by Sold Quantity of Poly-tunnel Products (2012)



Source: HARTI Survey Data, 2012

Figure 3.5: Distribution of Farmers with Respect to Percentage of Quantity Marketed

Data pertaining to respondents who operated only one tunnel showed (Table 3.9) that in general the larger the tunnel size the greater the quantity of harvest that had been sold by the farmers (Table 3.9)(γ = **0.617**; P =0.136). The larger the tunnels and higher the investment growers make a greater effort to earn a higher income by selling a larger quantity of the produce. This has been assured by the fact that the grower had agreements/forward contracts with buyers before going into cultivation.

Table 3.9: Distribution of Respondents by Size of Poly-tunnels by Sold Quantity

Quantity of Harvest Sold (%)	**Tunnel Size Class (sq. ft.)**				
	< 500	**Around 500**	**Around 750**	**Around 1000**	**More than 1000**
Less than 25	33	9	-	2	-
25 to 49	17	-	25	2	-
50 to 74	0	-	0	4	-
75 to 99	17	18	50	32	30
100	33	73	25	60	70
Total	100	100	100	100	100

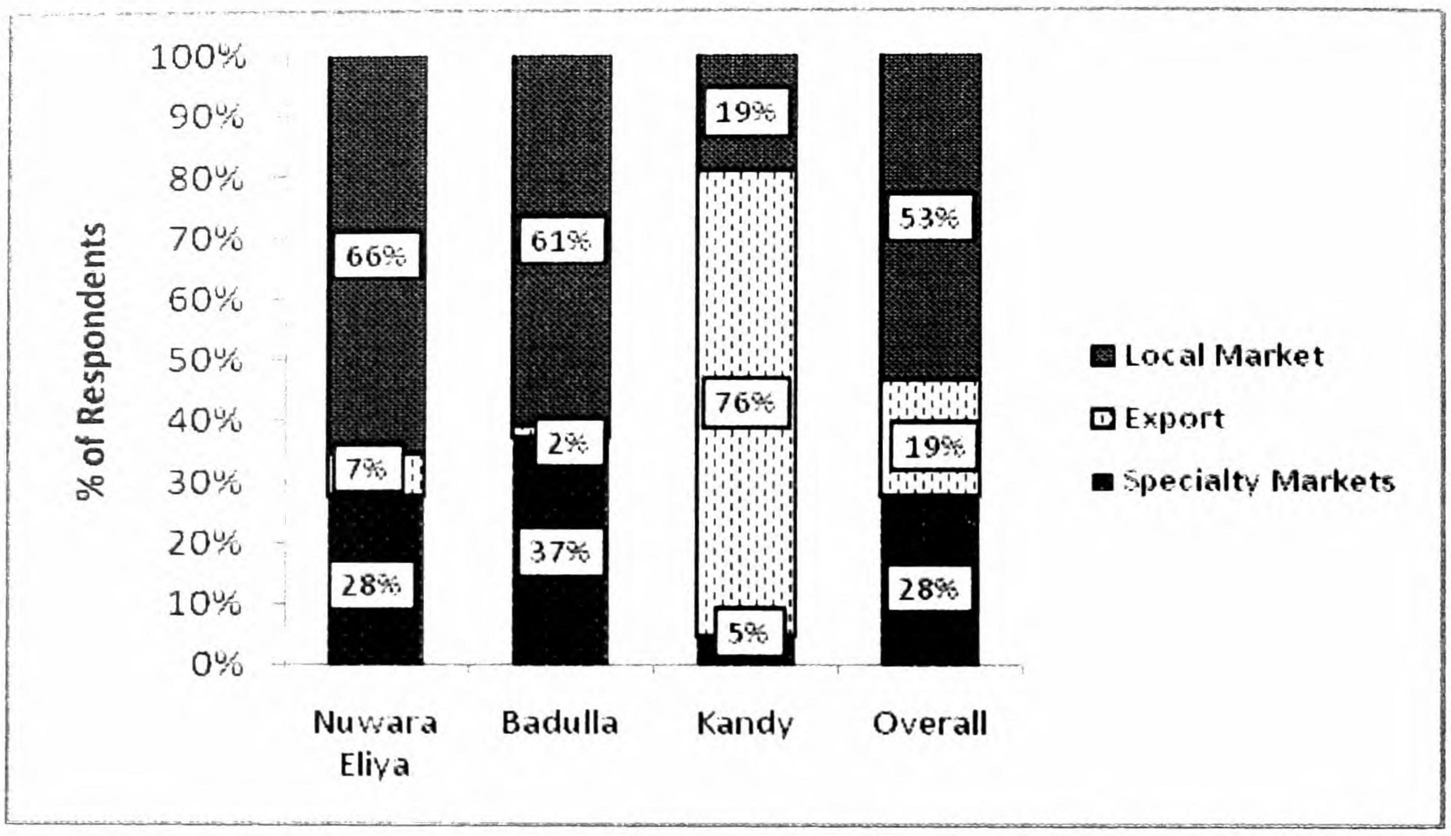
Source: HARTI Survey Data, 2012

Post-harvest grading is a must in marketing of vegetables produced in poly-tunnels and is carried out in two stages. At the first stage, farmer grades before dispatching crop to the buyer and then it is once again graded at the buyer point of sale. Post-harvest grading had become an essential element mainly for bell pepper, tomatoes, japanese cucumber and zucchini as they were mainly grown for specialty markets, such as supermarkets and tourist hotels and a small percentage for export markets. These crops were graded based on maturity of the crop, size, color, variety, shape and texture of the vegetable. Different grades fetched different prices in the market. Certain buyers specified the size and the color as the main quality parameters that can be fulfilled by adjusting the harvesting stage.

After harvesting the crop the produce is transported to the market/buyer in a variety of packaging materials such as plastic crates, shopping bags (cellophane bags) and cardboard boxes, which is the most preferred packing material used by the farmers in the three districts. The choice of the packing material depends on the distance to which it needs to be transported and the mode of transport used by the farmer.

The avenues open for marketing of their harvest were of three types: specialty markets, export market and the local market. Markets include supermarkets and hotels, PAEA in Kandy, a few farmer associations instituted by EDB and a few individual farmers from Badulla and Nuwara Eliya districts who are involved in export of poly-tunnel products. Whenever the producers cannot sell the entire produce the surplus is sold at the local markets such as the dedicated economic centers or Manning market, to neighbor's and agents who were collectors/middlemen.

Most of the poly-tunnel operators from the Badulla (61%) district had sold their products at the local market in 2012 through middlemen who were generally farmers or business men from the area. They acted as collectors and purchased the produce from the farmer at a price slightly lower than the actual market prices prevailing for the day, retaining a higher profit margin. They sold the purchased products to local supermarkets or hotels and other agents. Agents here are referred to persons who were regular buyers of produce from the farmer mainly for the range of exotic vegetables such as bell pepper, Japanese cucumber, beef tomatoes and cabbage varieties for export. There were 37 percent respondents who had directly sold their products to specialty markets with a few (2%) supplying vegetables to the export market.



Source: HARTI Survey Data, 2012

Figure 3.6: Percentage Distribution of Poly-tunnel Farmers by Modes of Marketing of Harvest and District

The produce marketing pattern in the Nuwara Eliya district too was not largely different from that of the Badulla district. Whilst the local market sales dominated (66%) middlemen and economic centers were the key buyers. Farmers preferred to sell to the specialty markets such as supermarkets and hotels as the price offered was comparatively higher than what was found in the retail market. Agents from export companies in Badulla and Kandy districts had visited the farms and purchased the produce directly from the farmer. There were different pricing systems offered by agents. Under forward sales agreements, a price had been fixed at the beginning of the year and the farmer was paid that price despite the market price fluctuations during the time of harvest. Other agents had paid the prevailing market value while others had purchased the produce from operators at a slightly lesser price, retaining only a small profit margin.

Data shows that most of the vegetables produced in the Kandy district are supplied to the export market. The PAEA played the prominent role in the Kandy district followed by export companies. PAEA was based in Peradeniya town and farmers found this was easily accessible. The PAEA and the purchasing centre of the Export Development Board had purchased the produce which was exported to other countries or sold to supermarkets. In all three districts a small percentage was sold at the retail market where the price was determined by retailer. This was the last resort of the operator if he/she was unable to sell the produce to high -priced markets.

There was price variation among the buyers when there was a glut of produce, thus making it unprofitable. To circumvent this problem the cultivation period of bell pepper, cucumber, beef tomatoes and lettuce varieties had been timed by a few operators. Knowledge and experience of the market structure for the products were prerequisites to obtain the highest price. Among the sample farmers only a very few farmers from Nuwara Eliya and Kandy districts had this knowledge and experience as they were cultivating vegetables in poly-tunnels for more than 10-15 years. Price offered by the buyer and on time payment was among the key factors that led farmers to choose a buyer. The next reason was convenience of selling. Buyer who comes to the doorstep of the poly-tunnel farmer to purchase the produce was in demand in areas which are not easily accessible or in interior areas. There were still other farmers who lacked knowledge about buyers and there were others who do not directly export the produce but act as middlemen who buy produce to be sold to exporters.

3.7 Costs and Returns from Bell Pepper Cultivation in Poly-tunnels

Costs and returns were estimated for bell pepper (BP) and Japanese cucumber (JC) based on two sizes of poly-tunnels to show the break-even point for that specific crop. Estimation of costs and returns of other crops was not attempted due to a less number of respondents.

The costs and returns from BP cultivation were estimated for medium and large tunnels (Table 3.10) with the data gathered from farmers who cultivated bell pepper (BP) in grow bags or pots with the use of recommended potting media. All the medium size tunnels were 1000sq. ft. and the size of large tunnels varied from 1200sq. ft to 2400sq. ft. Accordingly, the average sizes of medium and large poly tunnels were 1000sq. ft. and 1749 sq. ft. respectively.

According to the data, approximately Rs. 42,000 is spent on materials for the cultivation of BP in a medium size poly-tunnel where as it amounts to Rs.56, 000 for large size tunnel. The data shows that the material cost increases with the increase of the tunnel size.

Table 3.10: Costs and Returns from Cultivation of Bell Pepper by Tunnel Size

Activities/Costs/Returns (Rs.)	Tunnel Size and Sample Size	
	Medium (N=12)	Large (N=13)
Potting Media	9672	12,425
Pots/Bags	2373	5669
Seeds	3555	6644
Crop supporting Materials	2648	2167
Fertilizer	16,830	21,341
Agro Chemicals	4382	3786
Crates/Boxes	1333	2079
Other Materials	1195	2040
Total Material Cost	41,988	56,152
Hired Labour Cost	215	2341
Family Labour Cost	30,181	23,792
Total Labour Cost	30,396	26,133
Total Cost with Family Labour	72,385	82,285
Total Cost without Family Labour	42,209	58,493
Average Total Harvest (kg)	792	956
Average Quantity Sold (kg)	748	951
Average Selling Price (Rs./kg)	221	215
Revenue	16,5308	20,4465
Value of the Total Harvest	17,5032	20,5540
Profit (Without Family Labour Cost)*	123,104	145,972
Profit (With Family Labour Cost)*	92,923	122,180
Benefit Cost Ratio (without family labour)	3.92	3.50
Benefit Cost Ratio (without family labour)	2.28	2.48

***Excluding the fixed costs**

Source: HARTI Survey Data, 2012

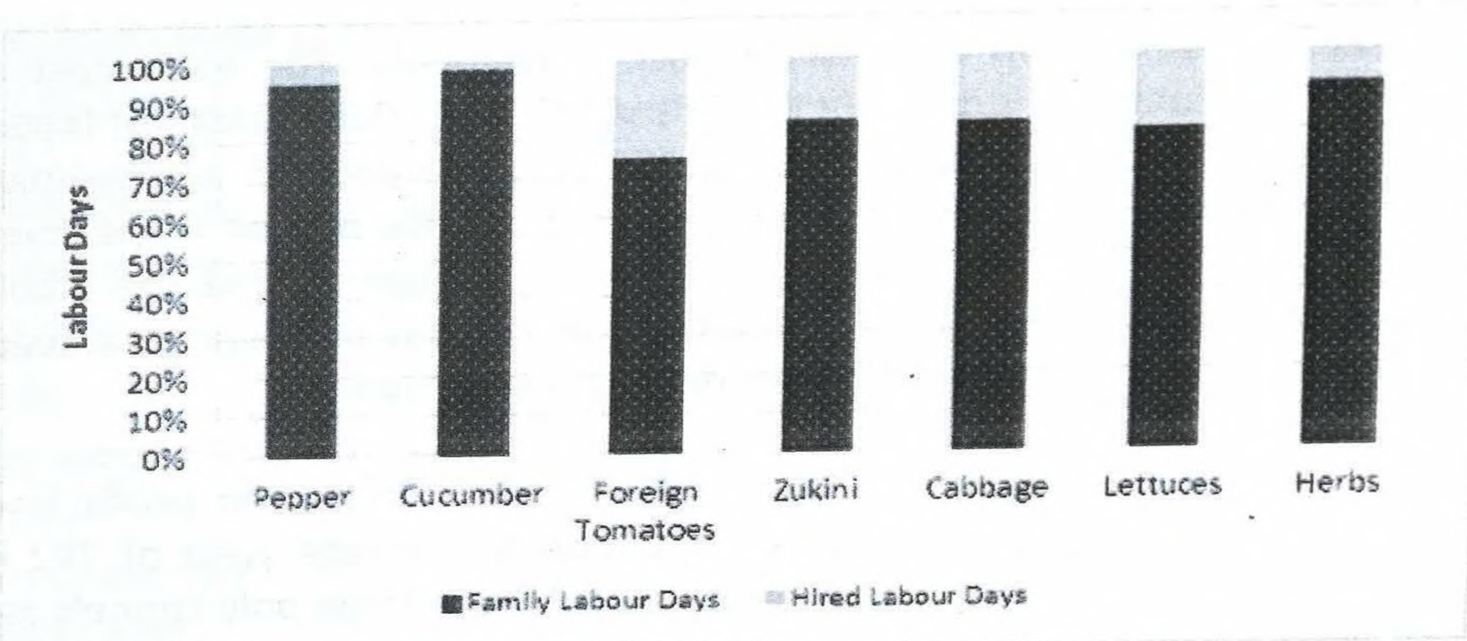
The labour use pattern of sample farmers demonstrates variations by tunnel size. Even though family labour predominates in both scenarios hired labour use increases with the increase in tunnel size. Out of the total number of labour days used in medium and large size poly tunnels which amount to 41 and 45 man days respectively, in medium size poly tunnels 92 percent use family labour while in larger tunnels only 78 percent use family labour. Though there are differences in the type of labour use, there is no significant difference in the extent of labour use between two tunnel sizes. There is free availability of family labour therefore efficiency of family labour is low in medium size poly tunnels. In contrast with the increased use of hired labour, efficiency had increased. In the case of medium size poly tunnels, labour use efficiency has decreased due to increased use of family labour. If the imputed cost of family labour is added to the cost of cultivation the overall cost becomes considerably high. Thus the total cost of labour in medium and large tunnels amounted to Rs. 30,000 and Rs. 26,000 respectively. The total cost of cultivation of BP in medium and large poly tunnels with the imputed costs of labour approximately amount to Rs. 72,000 and Rs. 82,000 respectively. The approximate figures without imputed costs of labour are Rs. 42,000 and Rs. 58,000 respectively for medium and large poly tunnels. Accordingly one could observe that the labour use efficiency is a key determinant of cost of cultivation and this difference too leads to variation in profit which can be earned from poly tunnel cultivation.

Yield is another important determinant which affects the income and profit from poly-tunnel farming. The sample farmers had obtained an average yield of 792 kg through the cultivation of BP in medium size tunnels whereas large poly tunnels had yielded 956kg. At a glance, yield data proves the general fact that the larger the tunnel size the higher the yield, but the variation is insignificant (t= -0.648; P = 0.523) owing to greater variation in the number of plants grown in two types of poly tunnels. On average, a medium size tunnel had occupied 515 plants whereas a large tunnel had occupied 859 plants, however, there was a large variation in the number of plants grown in two types of poly tunnels showing no significant variation (t= -2.492, P = 0.020).

Average prices received by the farmers cultivating BP in medium and large poly tunnels are Rs. 221 and Rs. 215 respectively and do not vary significantly (t= 0.137; P= 0.892). In terms of districts the average prices for BP were Rs. 275/=, Rs. 220/=, and Rs. 288/= for Nuwara Eliya, Badulla and Kandy districts respectively. In terms of markets, the average prices were Rs. 226/= in specialty markets, Rs.317/= in export markets and Rs. 225/= in local markets. However, the price variations were neither significant in terms of districts (F = 1.918; P = 0.171) nor markets (F = 2.127; P = 0.145). This suggests that farmers do not derive exceptional benefits from the cultivation BP in poly tunnels in different locations or supplying them for different markets.

Subject to above variations, cultivation of BP in a medium size poly tunnel fetches a gross income around Rs. 165,000 with an approximately net profit of Rs. 94,000 whereas the relevant figures for large poly tunnels amount to Rs. 200,000 and Rs. 124,000. Benefit Cost analysis shows that the production of BP both in medium and large size poly tunnels are viable options but the larger the tunnel size the higher the profit that could be earned under both scenarios i.e. with and without taking cost of family labour into consideration.

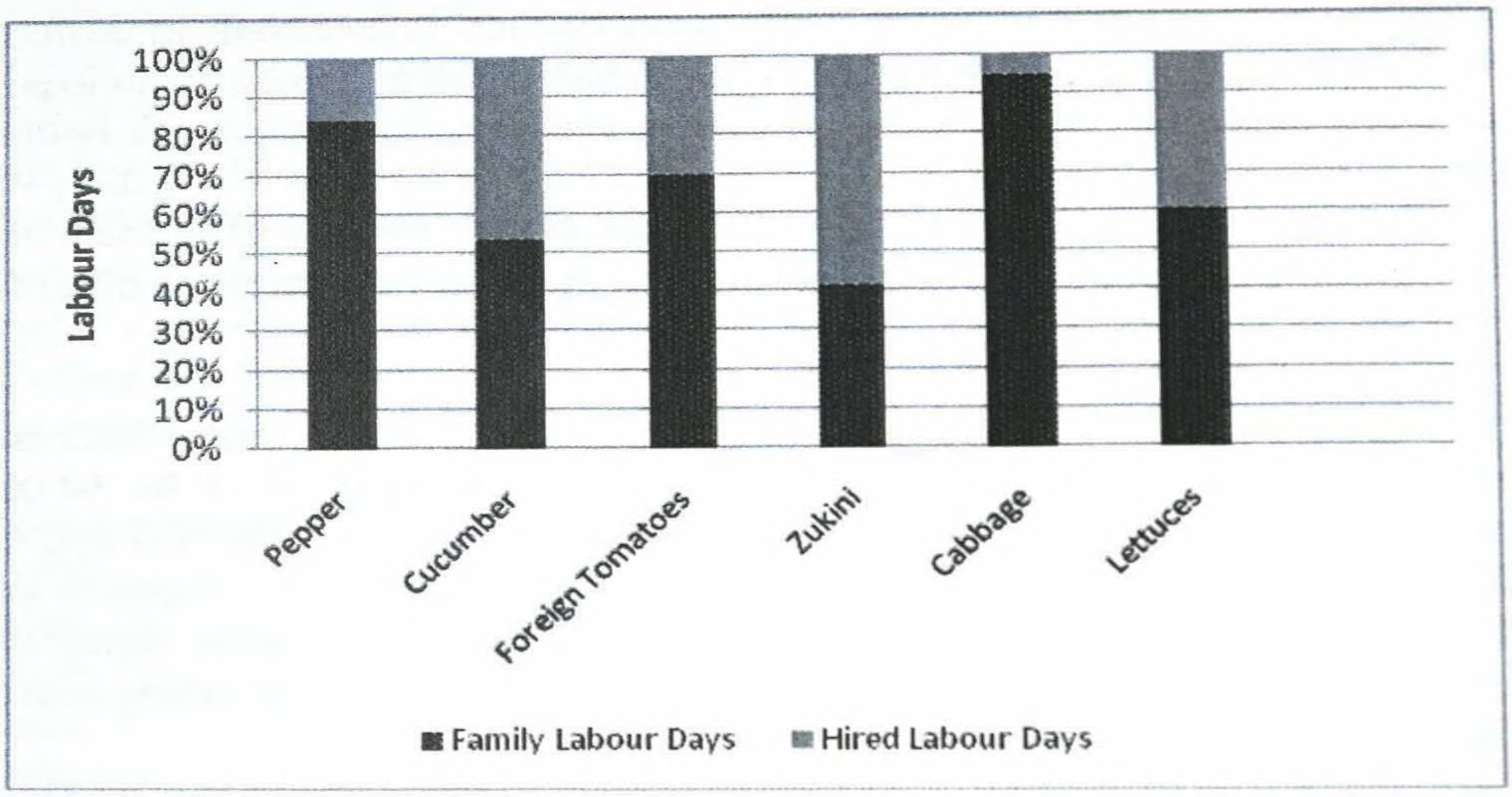
Vegetable production in poly-tunnels is a labour intensive practice. Labour is a constant need for watering of the crop as these crops do not have any outside source of water and the majority does not use micro irrigation for weeding and in harvesting. As the cultivation techniques used by 99 percent of the farmers are very primitive (no automation) there is a need for labour for almost all operations. As shown in Figure 3.7 and Figure 3.8, farmers mainly depend on family labour but the hired labour use increases with the increase of tunnel size.



Source: HARTI Survey Data, 2012

Figure 3.7: Use of Family and Hired Labour in Poly-tunnels of 1000sq. ft.

Bell pepper and cucumber are the most labour intensive crops followed by herbs. Hired labour is generally used in larger tunnels. Hired labour is utilized mainly for the preparation and fumigation of potting medium and spraying of agrochemicals and it is unskilled male labour rather than unskilled female labour hired for various operations.



Source: HARTI Survey Data, 2012

Figure 3.8: Use of Family and Hired Labour in Poly Tunnels of Over 1000sq. ft.

3.8 Costs and Returns from Japanese Cucumber Cultivation in Poly-tunnels

The costs and returns were estimated for the cultivation of Japanese cucumber in medium and large size poly tunnels with the use of grow bags or pots in recommended potting media (Table 3.11). Large size poly tunnels varied from 1260 sq. ft to 3200sq. ft with an average of 1865sq. ft. in size. The medium size poly tunnels varied from 1000sq. ft to 1080sq. ft with an average area of the medium size tunnel is 1006sq. ft. Accordingly a large size tunnel is doubled the size of a medium size poly tunnel.

Table 3.11: Costs and Returns from the Cultivation of Japanese Cucumber by Tunnel Size

Activities/Costs/Returns (Rs.)	Tunnel Size and Sample Size	
	Medium (N=14)	Large (N=2)
Potting Media	8231	7525
Preparation of Pots/Bags	3396	10,995
Seeds	7019	12,550
Crop Hanging Materials	1625	5780
Fertilizer	11,069	12,408
Agro Chemicals	2733	2880
Crates/Boxes	2263	3000
Other Materials	783	4000
Total Material Cost	37,119	59,138
Hired Labour Cost	186	3,000
Family Labour Cost	29,349	24,465
Total Labour Cost	29,535	27,465
Total Cost with Family Labour	66,654	86,603
Total Cost without Family Labour	37,305	62,138
Average Total Harvest (kg)	789	2,144
Average Quantity Sold (kg)	775	1,969
Average Selling Price (Rs./kg)	100	94
Revenue	77,500	185,086
Value of the Total Harvest	78,900	201,536
Profit (Without Family Labour)	40,195	122,949
Profit (With Family Labour)	10,846	98,483
Benefit Cost Ratio(Without Family Labour)	2.08	2.98
Benefit Cost Ratio (With Family Labour)	1.16	2.14

Source: HARTI Survey Data, 2012

For the cultivation of Japanese Cucumber (JC) in medium size poly tunnels, the sample farmers had spent around Rs. 37,000 whereas it amounted to Rs.59,000 for a large tunnel as material cost. Use of family labour predominates in JC cultivation too.

The problem of labour use efficiency was also prevalent in JC cultivation. Thus the total cost of labour in medium and large tunnels amounted to Rs. 29,500 and Rs. 27,500 respectively. The total cost of cultivation of JC in medium and large poly tunnels amounted to Rs. 38,000 and 62,000 respectively without the imputed cost of labour. With the imputed cost of family labour the cost of cultivation amounts to Rs. 66,500 and Rs. 86,500.

The data also establishes the fact that there is a significant increase in the yield which can be obtained from a large poly tunnel (average yield 2144 kg) than a medium poly tunnel (average yield 789 kg) through the cultivation of JC (t= -2.318; P = 0.035). In regard to prices, medium poly tunnel operators had received an average price of Rs. 100/kg whereas large poly tunnel operators had received an average price of Rs. 94/kg with no significant variation in prices obtained by two types of tunnel operators. JC farmers were mainly found from Badulla and Kandy districts and the respective average prices were Rs. 98/kg and Rs. 100/kg. Farmers had sold their products to the specialty markets at Rs. 83/kg, export markets at Rs. 100/kg and local markets at Rs. 102/kg. Thus prices of JC had varied neither by district nor market.

According to this analysis, cultivation of JC in a medium poly tunnel fetches a gross income of around Rs. 77,500 with an approximately net profit of Rs. 40,000 whereas the relevant figures for large poly tunnels amount to Rs.185, 000 and Rs. 123,000 proving the possibility for deriving economies of scale through JC cultivation in poly tunnels.

As in case of BP, JC cultivation in poly tunnels too is viable according to cost benefit analysis and the larger the tunnel size the higher the profit that could be earned from the cultivation of JC under both scenarios i.e. with and without the cost of family labour. When the returns to labour is considered the most efficient is large tunnels than medium size tunnels as the profit margin with imputed cost of labour has drastically decreased in medium tunnel poly tunnels.

3.9 Costs and Returns from Different Crops Grown in Different Tunnel Sizes

Data in the Table 3.12 provides the costs and returns from the cultivation of BP and JC in different sizes of poly tunnels. Accordingly, an operator having a poly tunnel should be ready to spend at least Rs. 37,000 to Rs. 59,000 as material cost for the commencement of cultivation of an exotic vegetable like BP or JC in a medium or large size poly tunnel. In addition to this, an operator should be able to allocate some 36 labour days for various operations involved in the cultivation of above crops for various operations from the preparation of grow bags/pots, watering, crop hanging, and application of fertilizer and pesticides and harvesting to post harvest operations required for a crop cycle. Therefore, in addition to the fixed cost for the construction of poly tunnels, other costs comprising of the cost of materials and labour seem to be unaffordable to an ordinary farmer unless s/he is assisted in cash or kind. Even if the farmer depends on family labour for almost all the operations s/he should be ready to spend around Rs. 37,000 to Rs. 59,000 as cost for materials.

Table 3.12: Comparison of Costs and Returns by Crop and Tunnel Size

Costs and Returns (Rs)	Crops and Tunnel Sizes			
	Bell Pepper		Japanese Cucumber	
	Medium	Large	Medium	Large
Total Material Cost	41,968	56,152	37,119	59,138
Hired Labour Cost	215	2341	186	3,000
Family Labour Cost	30,181	23,792	29,349	24,465
Total Labour Cost	30396	26133	29,535	27,465
Total Cost With Family Labour	72,385	82,285	66,654	86,603
Total Cost Without Family Labour	42,204	58,493	37,305	62,138
Revenue	165,308	204,465	77,500	185,086
Profit (Without Family Labour)	123,104	145,972	40,195	122,949
Profit (With Family Labour)	92,923	122,180	10,846	98,483
BC Ratio (Without Family Labour Cost)	3.92	3.50	2.08	2.98
BC Ratio (With Family Labour Cost)	2.28	2.48	1.16	2.14
Number of Labour Days	36	31	34	32

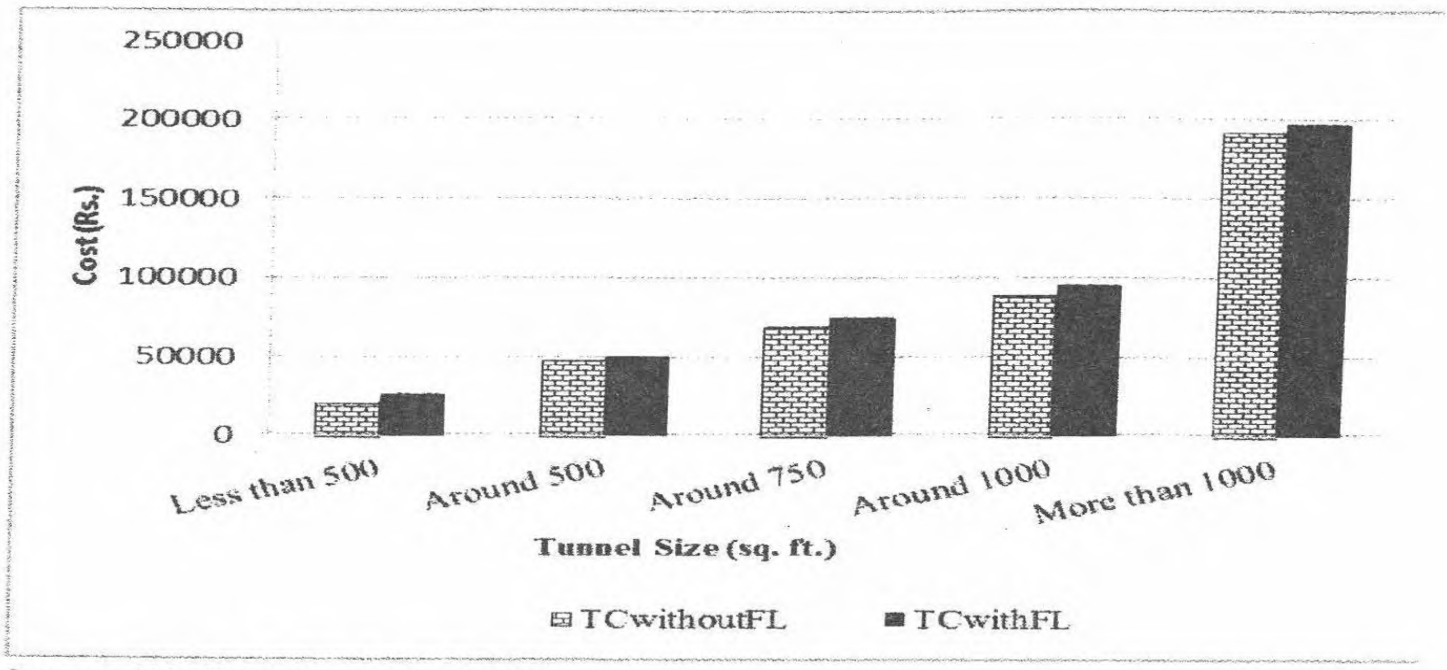
Source: HARTI Survey Data, 2012

Nevertheless, data shows that farmers had earned minimum revenue of Rs. 77,500 from the cultivation of JC in medium size poly tunnels and maximum revenue of Rs. 204,465 from the cultivation of BP in a large poly tunnel. The profit margins are determined by the labour use efficiency of both family and hired labour. Whilst the cultivation of both crops in all the three sizes of poly tunnels is viable, the most viable option is the cultivation of BP in medium poly tunnels whereas the least viable option is to produce JC in medium poly tunnels. When the two crops are compared, the production of BP is the most viable but the viability varies depending on the efficiency of family labour used as per the data in the Table 3.11.

3.10 Constraints for Crop Production in Poly-tunnels

3.10.1 Poor Affordability of Small Farmers for Initial Investment on Poly-tunnels

Overall the capital required for construction of poly-tunnels is unaffordable for small farmers (Figure3.9). The two most expensive components of a poly-tunnel are the frame and the cladding material.



Source: HARTI Survey Data, 2012

Figure 3.9: Cost of Construction of Poly-tunnels by Size

Poly tunnel frames are of three types either made of iron pipes, wooden frames and PVC pipes. The cost for the wood ranges from Rs 50,000-300,000 while in the districts of Nuwara Eliya and Kandy the most preferred material is galvanized iron ranging from Rs. 100,000-300,000. With respect to covering material, imported polyethylene films (PE), Polyvinyl chloride (PVC) Poly Olefine (PO) are widely used. Poly-tunnel farmers complained of difficulties in finding the correct type of polythene in the market when required. The nylon netting, since it is locally produced, does not prove to be a problem in purchasing except for the fact that there is an ever increasing price. There are some growers who use imported UV-treated insect proof netting which comes at a high price leading to the rise of installation costs.

In the Uva Paranagama area of the Badulla district instead of the netting, a few farmers could be seen to be using cheaper materials such as old used saris around the structure so as to reduce the cost. Besides giving a sub-standard appearance to the tunnels it also allowed entry of pests. This is clear evidence of unbearable costs, which has added to the litany of problems of the farmer. High capital investments and the lack of financial support required to initiate cultivation had prevented farmers from adopting this technology. Material inputs required for the structure such as GI pipes, UV treated polythene, shade nets are items which are expensive and need to be replaced periodically which prevent farmers from investing in PA. Therefore the small farmers are incapable of investing in poly-tunnels unless they are provided a subsidy or an outright grant for the construction of the tunnel.

3.10.2 Shortage of Good Quality Planting Material

Farmers used imported seed varieties of exotic crops such as bell pepper, cucumber, beef tomatoes and cabbage varieties. The increasing prices of imported varieties of seeds plus the unavailability of certain varieties which were used to be cultivated by farmers as they are not imported by dealers were among the complaints made by farmers mainly with regard to bell pepper and Japanese cucumber. Most poly-tunnel operators were reluctant to grow new varieties as they were uncertain of the outcome in terms of the yield and their adaptability under pest and disease problems.

A Substandard Structure Covered with Old Sarees

3.10.3 Produce Marketing Problems

Poly-tunnel operators complained that they did not have sufficient market information to find good markets and buyers. The overriding problem faced by farmers was the lack of fixed markets and prices even though they sold the produce to the retail market, middlemen or specialty markets (Table 3.13). They sell their produce to middleman who retains a wide margin, thereby offering low prices to the farmer/grower. A large majority of farmers lacked direct contacts with exporters. Varying prices offered by supermarkets and hotels for the produce at the time of harvest based on grading of produce which sets aside a large portion of harvest. From the buyer's perspective the main complaint was that small producers did not have the sufficient quantities required to meet the demand of export markets, which had affected export of crops and violation of agreements when alternative markets open up. Growers have a similar allegation towards buyers.

Table 3.13: Marketing Problems as Prioritized by Farmers

Marketing Problem	Distribution of Respondents	
	No	%
Price Fluctuation	37	51
Lack of a Fixed Market	25	34
Increased Involvement by Middlemen	5	7
High Quality Standards Expected	2	3
High Transportation Cost	1	1
Lack of Links with Export Market	1	1
Delayed Provision of Money	2	3
Total	73	100

Source: HARTI Survey Data, 2012

3.10.4 Environmental Constraints

Destruction of tunnels due to wind and rain is the key environmental problem faced by poly tunnel operators (Table 3.14). In addition, pests and diseases of the crops were rampant though theoretically cultivation in poly-tunnels was supposed to reduce such attacks. One factor which affected this was the technology used was limited/low therefore, crops are more prone to attacks. Some poly-tunnels were not fully sealed so as to prevent incidence of pest and disease. One of the main advantages of PA is apparently the less use of pesticides but in reality, one finds an overuse of such agrochemicals due to the substandard structures and lack of sanitation. Since farmers had invested a large sum for the crops they were unwilling to risk incidence of pest attacks and therefore pesticides were used more as a preventive measure. This was a major constraint to farmers as high costs are involved in the purchase of pesticides. In addition, these crops were prone to diseases as most of the poly-tunnels are not securely closed as recommended and therefore the probability of attacks is high. Data also highlights the fact that control of environmental factors such as temperature, light and humidity cause crop losses in poly tunnels due to inadequate application of advanced technologies in poly tunnel operation.

Table 3.14: Environmental Issues as Prioritized by Farmers

Environmental Problem	Distribution of Respondents	
	No	%
Destruction of Tunnels due to Wind and Rain	29	64
Spread of Pests and Diseases with Rain	3	7
Low Yield due to Rain	3	7
Water Scarcity during Dry Period	3	7
Shedding Flowers and Fruits with High Temperature	2	4
Poor Cleanliness and Inadequate Light due to Growth of Algae on Roofing Material	2	4
Sun burn of Crops due to Exposure to Strong Sun Light	2	4
Increase in Humidity	1	2
Total	45	100

Source: HARTI Survey Data, 2012

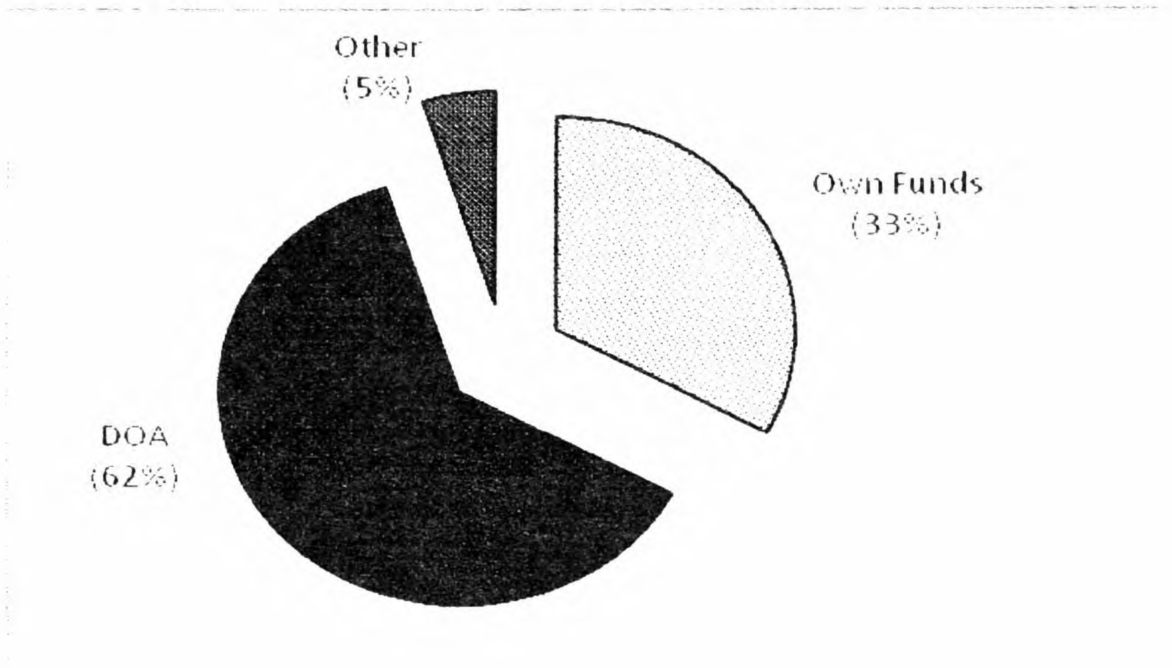
Due to the lack of continuous training to enhance knowledge in new technology in regard to poly tunnel farming, farmers were dissatisfied. After the initial training many of the farmers had to enhance knowledge through their own devices either via media or friends. One of the requests of farmers was for more training programmes mainly on pest and disease control which is prevalent in cultivation of these crops. The technology used among the farmers was limited and at a very basic level in comparison to other countries. Enabling the export of these vegetables there is a need for the development of the presently used technology to an advanced level.

CHAPTER FOUR

True Seed Production of Onion in Rain Shelters in Matale District

4.1 Introduction

The DOA in the Matale district had initiated a programme where onion farmers were provided with protective structures called rain shelters at an estimated cost of Rs 100,000. The DOA awarded the contract to construct rain shelters for farmers to Hayley's (Pvt) Ltd. Of the Rs. 100,000, Haley's was given Rs. 75,000 for the construction of the rain shelter which commenced after the farmer deposited Rs. 25,000 at DOA. The data showed that 62 percent of farmers in the sample were recipients of this scheme (Figure 4.1). Among the other organizations and other institutional setups which aided farmers were *Divi Neguma* programme, *Mahaweli* Authority and provincial council.



Source: HARTI Survey Data, 2012

Figure 4.1: Sources of Finance for Rain Shelters in Onion Farming

This study was responded by 72 onion farmers who produced true seeds in rain shelters. Some of the noteworthy characteristics of the majority of respondents were; almost all the respondents were male farmers (100%), the majority was relatively young (less than 40 years of age) that is 53 percent, and were involved in full time farming (93 percent), having 1-5 years of experience (92 percent), most of them had not undergone any training on cultivation under rain shelters (61%) (Table 4.1). Farmers were not interested in training as they were confident as they had been producing onion seeds for years prior to the installation of the present structures. The cultivation methods were also not different therefore there was no new knowledge that could be gained through training.

Table 4.1: Socio-demographic Features of Respondents

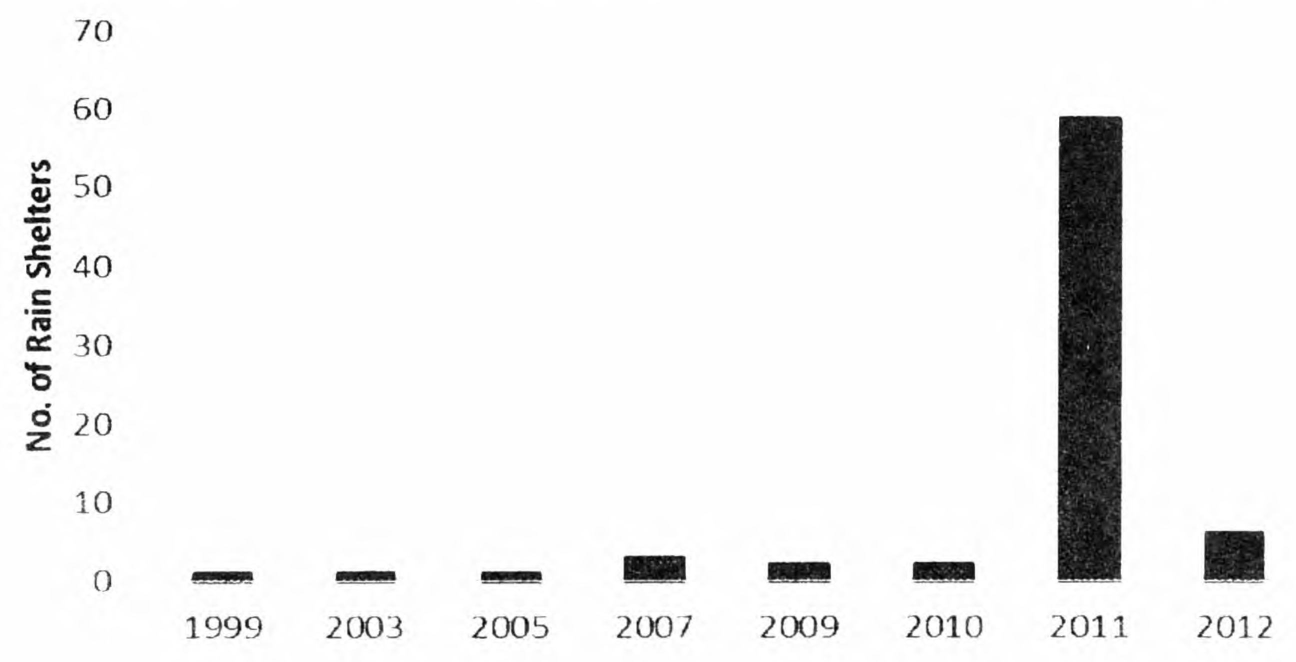
Socio-Demographic Characteristics	% of Respondents
Age	
20 - 40 Years	53
40 - 60 Years	46
More than 60 Years	1
Total	**100**
Level of Education of Respondents	
Primary Education	8
Secondary Education	26
O/L Passed	58
A/L Passed	7
Total	**100**
Degree of Involvement in Farming	
Full Time	93
Part Time	7
Total	**100**
Experience in PA	
Just Started	4
1 - 5 Years	92
6 - 10 Years	3
More than 10 Years	1
Total	**100**
Training	
Yes	39
No	61
Total	**100**

Source: HARTI Survey Data, 2012

4.2 Scale of Operating Rain Shelters

Rain shelters was an innovative structure for true seed production of onion which is carried out in the *Maha* season within 3 ½ - 4 months. Prior to rain shelters onion farmers had small polythene covered structures which were wooden structures (mainly made of bamboo) which were rickety or bought imported seeds for cultivation from the market. As a means of promotion for farmers producing their own onion seeds, rain shelters were promoted and introduced by the MOA through DOA and thus initiated in the Matale district mainly in the onion producing regions of Walapane, Naula, Dambulla and Galewela. This programme was extended to Anuradhapura, Kurunegala and Polonnaruwa Districts. The aim was to meet 50 percent of the local big onion seed requirement by providing good quality seeds to the farmers for which Rs. 20 million was allocated in the year 2011 (Figure 4.2).

Under the government programme a maximum of 250g of mother bulbs were also given to each farmer. Further, a training programme was also conducted to train farmers on onion seed production.



Source: HARTI Survey Data, 2012

Figure 4.2: Year of Initiation of Rain Shelters by Farmers in Matale District

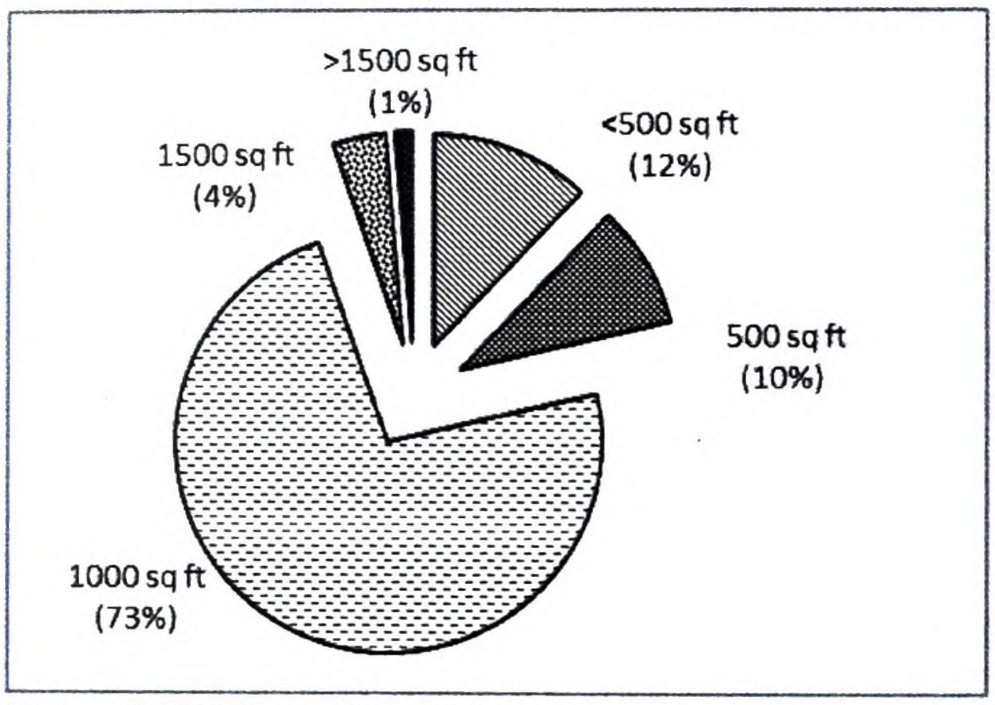
Under this programme, farmers were also given rain shelters - a structure made of PVC rods and covered with polythene required to protect onion flowers from rain and frost. The maximum number of rain shelters was initiated in 2011(Figure 4.2), under which 79 percent of the sample farmers in Matale district had initiated cultivation under rain shelters.

A subsidy was given to the farmers and 92 percent had obtained the subsidy while the rest had constructed the structure with their own money as they were unable to avail themselves of the subsidy. The main reason was that these farmers had not paid the Rs. 25,000 initial down payment to the DOA.

The recommended size of the rain shelter by the DOA was 1000sq. ft. structure and the majority of farmers (73%) owned rain shelters of the same size though the sizes slightly varied from farmer to farmer (Figure 4.3). Initially a large number of rain shelters were constructed by Hayley's but with time the company provided the farmer the materials whereby the farmers altered the sizes. The initial intention was that the rain shelters be used for other crops once the onion seeds are harvested, but only ten percent farmers had used them for the cultivation of vegetables (beet and tomato) since they found it is more convenient. The rest have the required land to cultivate these crops in the open field. Onion growers in the Matale district used their own bulbs/seeds and once produced gave back to the DOA as per the agreement.

Rain Shelters for Seed Onion Production

The majority of farmers (91%) had only one structure. One farmer who was a large scale farmer having as many as 4 rain shelters had proved the economic viability of onion seed production to be profitable. He had utilized his own money to construct additional structures which were of varying sizes. According to the data in the Figure 4.3, the majority of farmers had a structure of 1000sq.ft.

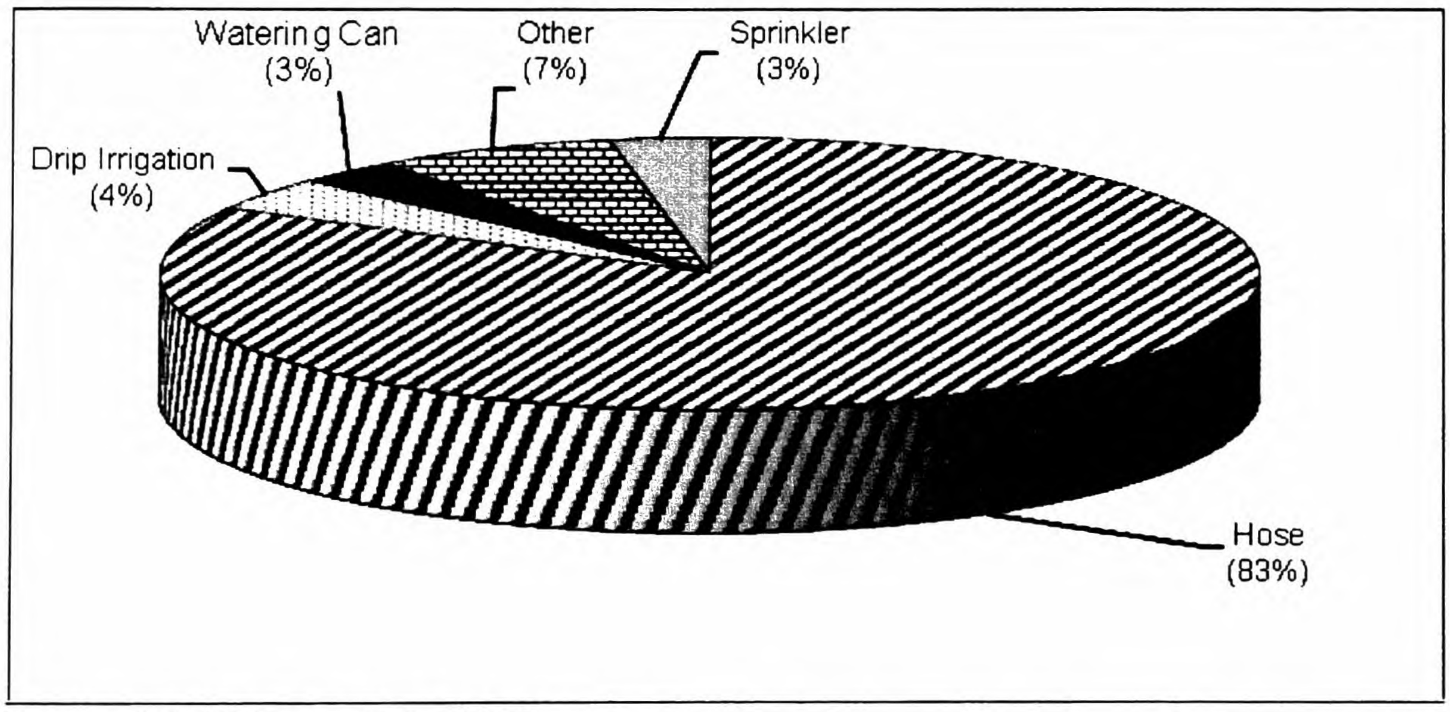


Source: HARTI Survey Data, 2012

Figure 4.3: Distribution of Rain Shelters by Size

4.3 Irrigation in Rain Shelters

The large majority of farmers had irrigated the crops manually using the hose, watering can or other implements (Figure 4.4). Use of advanced technology for irrigation such as drip and sprinkler irrigation was at a very low level (7% farmers). The main source of growth medium was a mixture of compost and soil for planting mother bulbs which produced the onion seeds. Mother bulbs required for onion seed production were mainly obtained from the DOA. Farmers mainly used Murate of Potash (MOP) and urea and a basal dressing with minority using a variety of other fertilizer.



Source: HARTI Survey Data, 2012

Figure 4.4: Percentage Distribution of Farmers by Irrigation Method Used

4. 4 Harvesting and Marketing of Onion Seeds

There is a huge demand for locally produced onion seeds as farmers claimed and relied on the quality of the local seeds which they claimed supersedes the imported seeds. Within 100 days of planting the mother bulbs onion seeds are harvested. Mother bulbs are planted in January and the seeds are obtained in mid-April (*Maha* season) and if planted in May the harvest is reaped in August (*Yala* Season). The seed yield is stored and used in the appropriate season for planting. Marketing of onion seeds was not found to be a problem for seed producers.

However, around one third of the farmers did not sell their harvest as they had retained it to use as planting material. A certain quantity had been given back to the ASC and a small percentage had been sold by some farmers. Data showed that only 22 percent of farmers had sold over 75 percent of their harvest (Table 4.2) while a larger percentage (54%) had sold over 50 percent as planting material.

Table 4.2: Percentage Distribution of Farmers by Quantity of Onion Seeds Sold

Percentage of Harvest Sold	Distribution of Farmers	
	No	%
Not sold	22	31
< 25	1	1
25 to 49	9	13
50 to 74	23	32
75 to 99	8	11
100	8	11
Total	71	100

Source: HARTI Survey Data, 2012.

According to the Table 4.3, onion seed production is a profitable enterprise where farmers mainly use family labour for most operations and this was reflected in the total cost of cultivation being high with family labour.

Annually over 30,000kg of big onion seeds are needed for planting in Sri Lanka, according to the statistics of the Ministry of Agriculture. With the successful launch of a programme in the Matale district by the Agriculture Department in which 1,000 farmers in the district cultivated 100,000 kilograms of vernalised union bulbs, targeting 10,000 kilograms of onion seeds under the tunnel system (9th February 2014, Sunday Observer). By 2012 according the Ministry of Agriculture, 25000 kg of seeds had been produced and the country has a shortfall of 5000kg of onion seed.

As shown in the Table 4.3, a 1000sq ft rain shelter produces 11kg of seeds and therefore, to produce the 5000 kg, 450 farmers are required. At the rate of Rs. 100,000 per complete tunnel kit the government needs further Rs 45 million of investment to meet the production target of seed onions. The farmers who were members of various organizations sought help in marketing of produce, easier procurement of seeds and fertilizer and the provision of training programmes. The two main parties of the agreement were the Matale onion growers and the DOA. Accordingly, each farmer had to supply 2 kg of onion seed to the DOA as a repayment of assistance they received. Data in the Table 4.3 proves that true seed production of onion in rain shelters in the Matale district is a highly viable agro-enterprise.

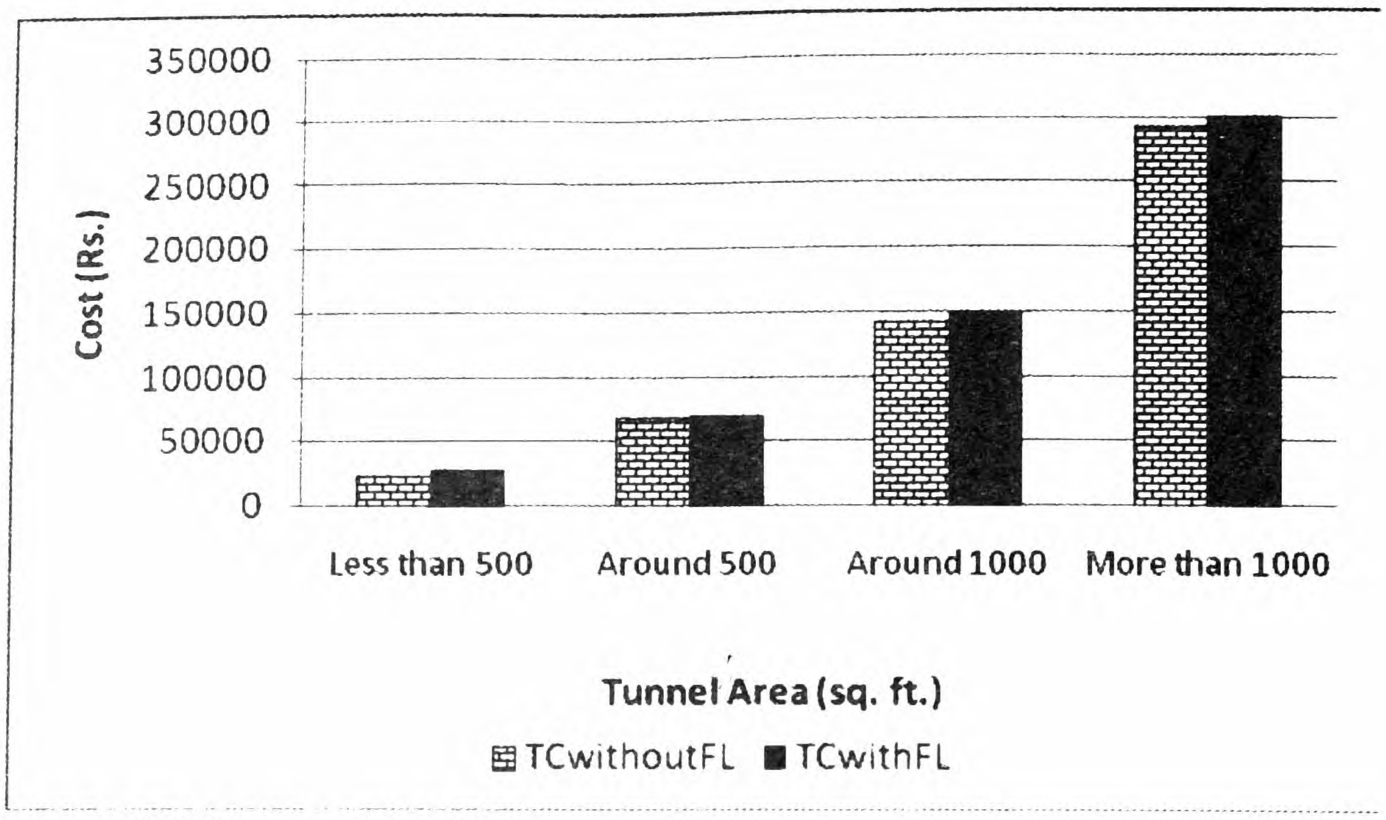
Table 4.3: Costs and Returns for True Seed Production of Onion in a 1000sq ft Rain Shelter

Activities/Costs/Returns	Value (Rs)
Potting Media	3493
Seeds	11,708
Crop Hanging Materials	1618
Fertilizer	1521
Agro Chemical	4027
Water Management	3245
Harvesting Materials	389
Other Materials	2707
Total Material Cost	28,707
Hired Labour Cost	837
Family Labour Cost	12,358
Total Labour Cost	13,195
Total Cost with Family Labour*	41,902
Total Cost without Family Labour*	29,544
Average Total Harvest (kg)	11
Average Quantity Sold (kg)	8
Average Selling Price (Rs./kg)	11,451
Value of the Total Harvest	125,961
Revenue	91,608
Profit (Without Family Labour Cost)	61,228
Profit (With Family Labour Cost)	48,870
Benefit Cost Ratio (With Family Labour)	3.07
Benefit Cost Ratio (Without Family Labour)	2.17

*Excluding the initial fixed costs
Source: HARTI Survey Data, 2012

4.5 Constraints in Onion Seed Production in Rain Shelters

As in the case of poly-tunnel the key constraint for operating rain shelters is the high initial cost which is not affordable to small scale operators (Figure 4.5). True seed production of onion in rain shelters is a profitable venture for farmers and with rain shelters farmers have been able to avoid the key constraints in onion seed production in open field farming which is the dependence on the vagaries of weather. Therefore the key constraint presently faced by the farmers is the high initial construction cost of rain shelters. In addition, 49 percent farmers have stated marketing difficulties due to the lack of a fixed marketing channel and a fixed price.



Source: HARTI Survey Data, 2012

Figure 4.5: Cost of Construction of Rain Shelters by Size

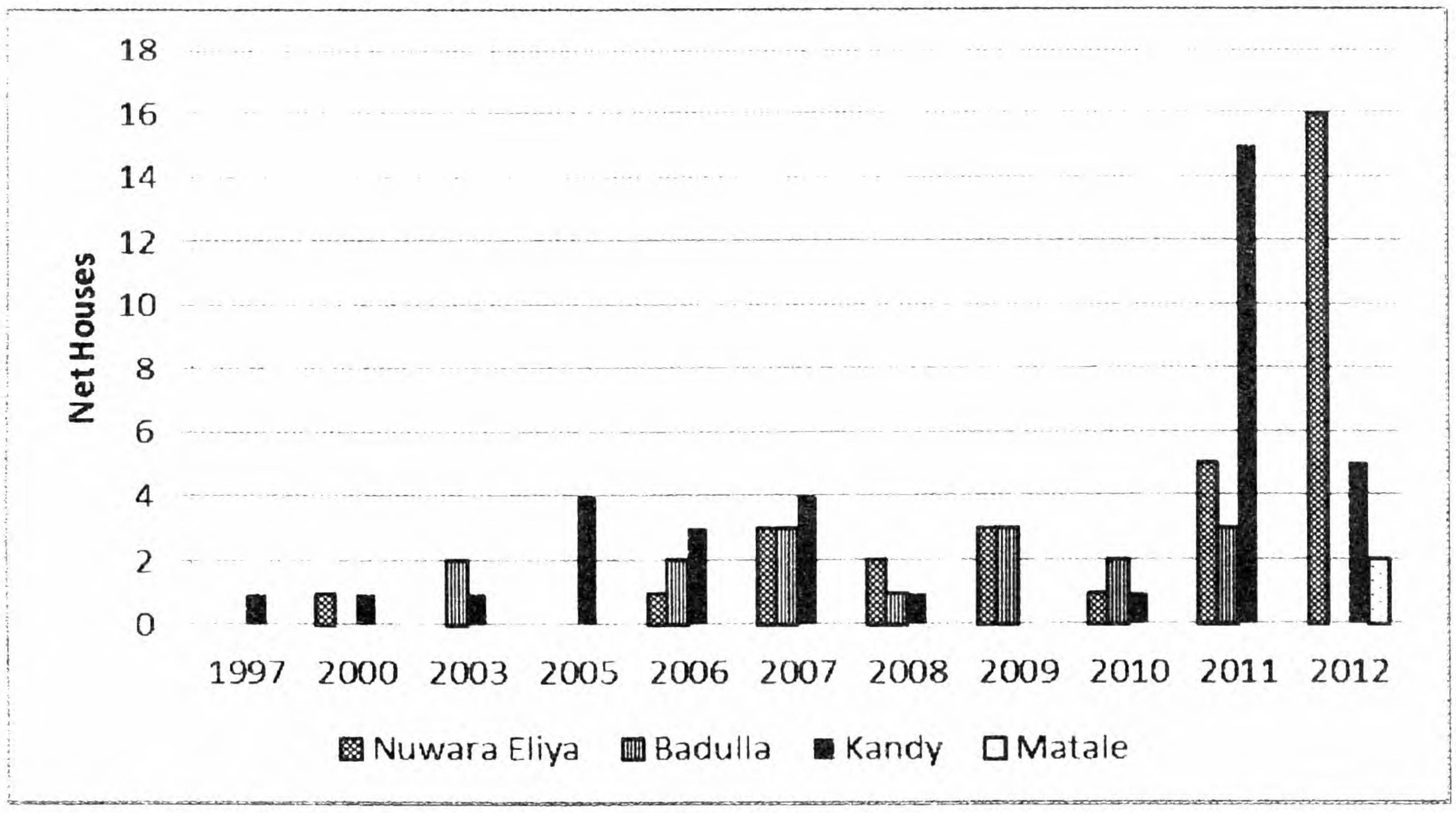
Among the environmental constraints are destruction of both tunnels and the crop due heavy winds and (73%), damage to flowers and pollens due to high temperature (13%), spread of pests and diseases with heavy rains (9%) and damages from wild animals such as peacocks are prominent.

CHAPTER FIVE

Crop Production in Net Houses

5.1 Nature and Scale of Operating Net Houses

The cultivation of vegetables in poly-net houses was initiated after heavy rain in 2010 affecting most of the crops island wide. This led to a scarcity of vegetables in the market with a sharp increase in prices. From the latter part of 2011 under the *Divi Neguma* programme subsidies were granted to farmers to construct net houses mainly for the propagation of nurseries and cultivation of vegetables during the rainy seasons. This saw an increase in the number (Figure 5.1) of net houses. Under this programme farmers were given subsidies by the Department of Up-country Peasantry Rehabilitation and the *Samurdhi* Authority. The farmer had to initially construct a tunnel with his/her own money, after which he/she was entitled to half the cost of the tunnel.



Source: HARTI Survey Data, 2012

Figure 5.1: Percentage Distribution of Net Houses by District

In 2011 the Kandy district and in 2012 the Nuwara Eliya district saw a sharp increase in the number of net houses mainly due to the subsidy given by the *Samurdhi* Authority under the auspices of the *Divi Neguma* programme. Net house operations are observed in the Matale district only in 2012.

5.2 Socio-demographic Features of Net House Operators

Table 5.1: Socio-demographic Features of Net House Operators

Socio-Demographic Characteristics	Nuwara Eliya	Badulla	Kandy	Overall
Sex				
Female	41	25	14	27
Male	59	75	86	73
Total	**100**	**100**	**100**	**100**
Age				
20 - 40 Years	16	19	56	30
40 - 60 Years	66	81	36	61
More than 60 Years	19	-	8	9
Total	**100**	**100**	**100**	**100**
Level of Education				
Primary Education	3	-	-	1
Secondary Education	13	13	3	10
O/L Passed	53	44	33	43
A/L Passed	28	44	50	41
Degree/Diploma	3	-	14	6
Total	**100**	**100**	**100**	**100**
Degree of Involvement in Farming				
Full Time	88	63	50	67
Part Time	13	38	50	34
Total	**101**	**101**	**100**	**101**
Experience in PA				
Recently Started	50	-	14	21
1 - 5 Years	44	75	58	59
6 - 10 Years	3	25	22	17
More than 10 Years	3	-	6	3
Total	**100**	**100**	**100**	**100**
Training				
Received	66	50	83	66
Not Received	34	50	17	34
Total	**100**	**100**	**100**	**100**

Source: HARTI Survey Data, 2012

Data on socio-demographic features of net house operators are presented in the Table 5.1. A significant point with regard to net house farming was that the involvement of more females from Nuwara Eliya (41%) and Badulla (25%) districts, compared to Kandy district (14%), showing a nearly significant variation in sex ratio, across districts (χ^2 =7.080; P = 0.069). Age wise, a younger crowd is found from the Kandy district (56%) among the net house operators with a significant variation in the age distribution of farmers across districts (χ^2 =18.479; P = 0.005). The large majority of respondents from all districts were educated up to O/L or A/L, however, the salient feature was that there were 7 percent (six) graduates among the respondents: five from the Kandy district and one from the Nuwara Eliya district.

Again, the Kandy district is predominated by 50-50 participation by full time and part time farmers. Overall, one third of the respondents were involved in net house farming as part-time farmers. Among the females the majority (86%) is full time farmers but among the males the majority (59%) is part time farmers. This establishes that in general, net house farming is a venture in which women entrepreneurs are involved in full time than that of men with significant variations in terms of the degree of involvement by respondents across districts (χ^2 =11.056; P = 0.011). It should also be noted that net houses are relatively new to the Nuwara Eliya district where the majority (50%) of net houses had begun operations recently. Overall 80 percent of net houses had started within one to over ten years with significant variations in the number started across districts (χ^2 =26.742; P = 0.002). Once again, the data shows that two third of the respondents had undergone training on net house operation for cultivation of crops at AS centers alongside the construction of net house.

Table 5.2: Percentage Distribution of Farmers by Number of Net Houses

No. of Net Houses	Nuwara Eliya		Badulla		Kandy		Matale		Overall	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	29	91	15	94	35	97	2	100	81	94
2	2	6	1	6	1	3	-	-	4	5
4	1	3	-	-	-	-	-	-	1	1
Total	32	100	16	100%	36	100%	2	100%	86	100

Source: HARTI Survey Data, 2012

The majority of farmers in the three districts owned one net house with three percent farmers in the Nuwara Eliya district (Table 5.2) having four net houses. The predominance of net houses in the Kandy district was due to the initiation of cash programmes in Matale, Kandy and Nuwara Eliya districts (Sunday Observer, August 2011) for cultivation of vegetables for which subsidies were granted and farmers in this district availed themselves of loans to set up net houses.

5.3 Institutional Assistance to Popularize Net House Farming

Net house farmers had received support from various agencies to build their net houses. Overall 77 percent of net houses had been built with funding assistance including 88 percent from Nuwara Eliya, 25 percent from Badulla and 89 percent from Kandy.

Nursery in a Net House

Vegetables grown in a Net House

Table 5.3: **Percentage Distribution of Farmers by Size of Net Houses**

Sizes (Sq. ft.)	Percentage of Farmers by District			Overall
	Nuwara Eliya	Badulla	Kandy	
< 500	35	-	6	16
Around 500	27	-	78	43
Around 750	3	-	-	1
Around 1000	29	75	8	29
> 1000	6	25	8	11
Total	100	100	100	100

Source: HARTI Survey Data, 2012

There was a size variation of net houses across the districts with a majority of farmers in the Nuwara Eliya district (35%) owning smaller net houses (Table 5.3), whereas in the Kandy district 78 percent of farmers owned 500 square feet net houses, the reasons being that subsidies were granted under the *Divi Neguma* programme for these sizes of net houses. In the Badulla district the number of net houses found was less (16) but they were larger in size.

5.4 Crops Grown in Net Houses

The crops grown in net houses varied from the type of vegetables which were frequently cultivated in poly-tunnels. The most frequently cultivated in all three districts were different varieties of tomatoes such as *Thilina, Padma* and beef tomatoes (Table 5.4). Most farmers preferred to grow tomato as there was a greater opportunity for sale of this produce unlike in other vegetables. In addition farmers preferred net houses to open fields for the cultivation of tomatoes due to the vagaries of weather. The table further provides data on the crops grown in each district. In addition to the specified crops leeks and *gotukola* were found to be cultivated in the Nuwara Eliya district. In the Badulla district Japanese cucumber was grown by one farmer. Carrot and cabbage are the other crops grown in the Kandy district.

Table 5.4: Percentage Distribution of Farmers who Cultivated Different Crops

Crops	Percentage of Farmers by District		
	Nuwara Eliya	Badulla	Kandy
Tomatoes	38	63	15
Radish	18	-	6
Naimiris	6	-	18
Beans	15	-	6
Green chilli	6	-	9
B' Onion seed production	3	-	9
Nursery	9		6
Bell pepper	6	25	-
Capsicum	6	6	6
Beet	12	-	6
Knoh -khol	6	6	-
Seed potato	9	-	-
Brinjal	3	-	6
Other crops	9	6	9

Source: HARTI Survey Data, 2012

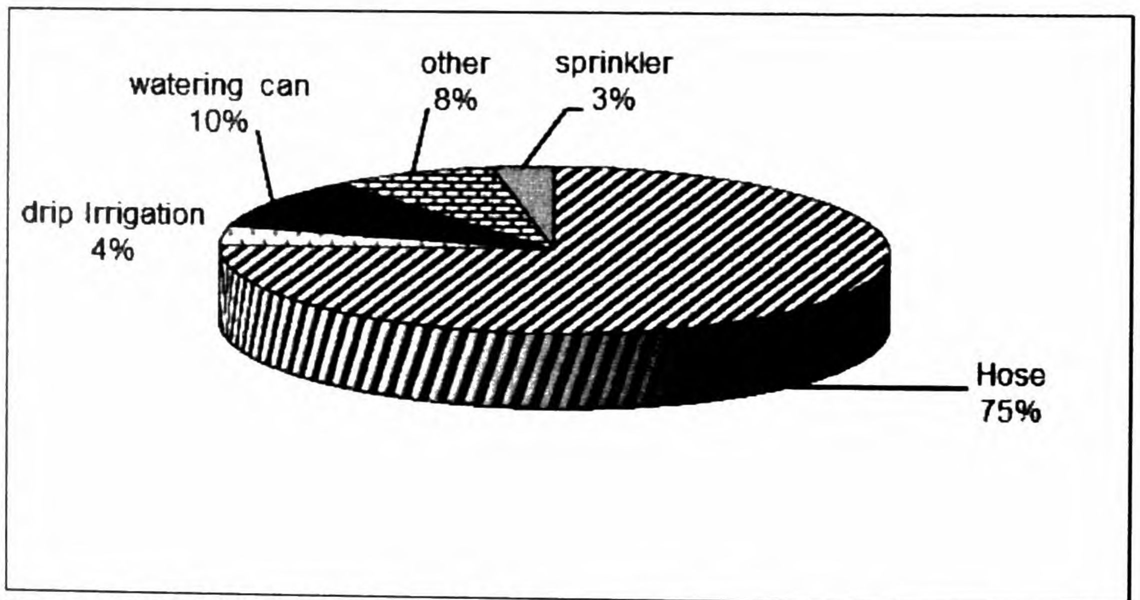
In net houses nursery plants were mainly grown in small polythene covers while the black grow bags were used for other plants such as tomatoes and *Naimiris* (c.annum) with a mixture of compost and soil as the growth medium. Most of the farmers purchased seeds from agro-chemical dealers or obtained from the *Divi Neguma* programme. In net houses like in poly-tunnels use of fertilizer depends on the value of the crop e.g.: some farmers used Albert solution and Murate of potash (MOP) for tomatoes while the other farmers' used urea and a mixture of fertilizers.

Table 5.5: Duration of Crops Grown in Net Houses

Common Name	Scientific Name	Duration	Harvesting Period Begins At
Beans	*Phaseolus vulgaris*	2-3 months	50-65 days
Local tomatoes	*Lycopersicon esculentum*	5-6 months	2.5 months
Capsicum	*Capsicum annum*	150 days	10-15 weeks
Carrot	*Daucuscarota*	75-90 days	75-90 days
Beet	*Beta vulgaris*	75-90 days	75-90 days
Naimiris	*Capsicum frutescens*	110-120 days	3 months
Local Cucumber	*Cucumis sativus*	55-70days	60 days
Gotukola	*Centellaa siatica*	2-4 years	6 months
Raddish	*Raphanus sativas*	35-40 days	35-40 days
Spinach	*Basella alba*	70 -80 days	6-8 weeks
Lime	*Citrus aurantifolia*	April-July	9-15 months
Ginger Nursery	*Zingiber officinale*	8-10 months	8-10 months

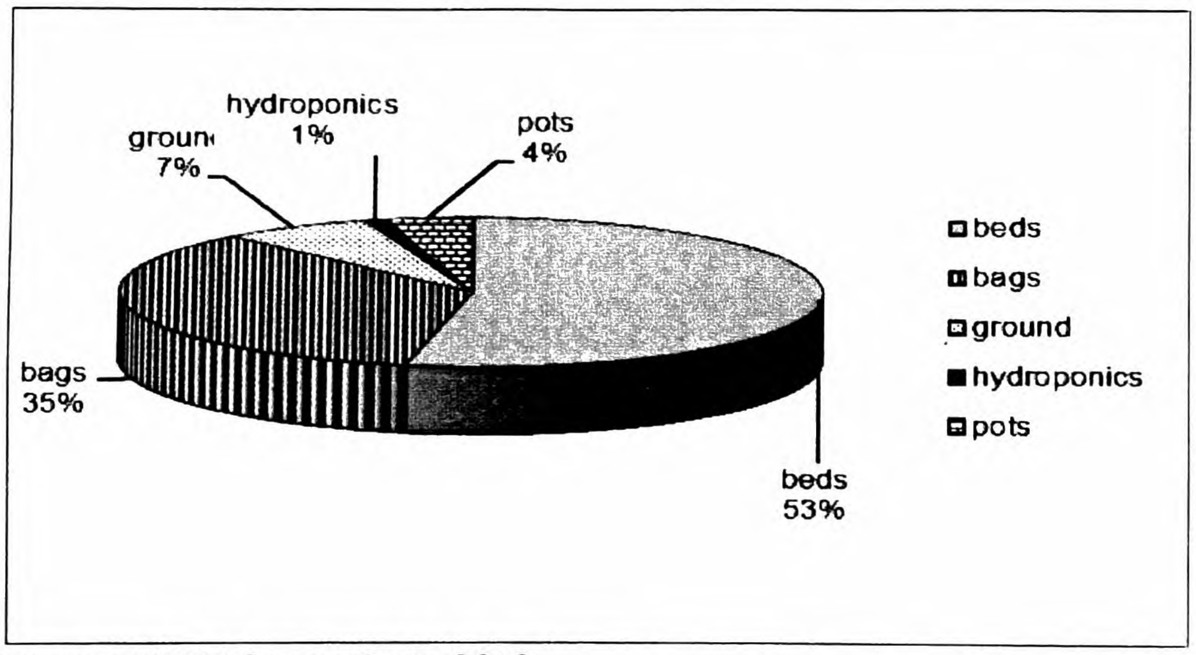
Source: Department of Agriculture (2010/2009/2006/2003/2002)

In net houses, the majority of farmers had used manual methods for watering of crops (Figure 5.2) using the hose, watering can and other domestic vessels and implements. Use of growing media was also not of a required standard where most farmers had used raised beds (Figure5.3) prepared on the ground or the plants had been grown directly in the ground.



Source: HARTI Survey Data, 2012

Figure 5.2: Percentage Distribution of Farmers by Irrigation Method



Source: HARTI Survey Data, 2012

Figure 5.3: Percentage Distribution of Farmers by Growth Medium

Plants for nurseries were mainly grown in small polythene covers while the black grow bags were used for other plants such as tomatoes and *naimiris*. Only one percent farmers used advanced techniques such as hydroponics and 40 percent used grow bags and pots and used a mixture of compost and soil as the growth medium.

5.5 Harvesting Packaging and Marketing of Vegetables

Some crops grown in net houses such as tomatoes, chilli and *gotukola* were continuously harvested. At the time of the survey, 31 percent (Table 5.6) of the farmers had not harvested their crops as these farmers had begun cultivation only in the last quarter of the year (around November/December) since crops can be grown irrespective of the season. Therefore, 69 percent of farmers had harvested their crops once or more for the year 2012.

Table 5.6: Harvesting of Crops Cultivated in 2012

No. of Times Harvested	No. of Farmers	Percentage of Farmers
Not Harvested	23	31
1	35	47
2	13	16
3	2	3
5	2	3
Total	75	100

Source: HARTI Survey Data, 2012

Over 36 percent of farmers cultivating vegetables in net houses (Table 5.7) found it difficult to sell more than 50 percent of their produce. Falling into this category were 15 percent of farmers who owned nurseries while the rest were farmers who had grown an assortment of vegetables. The farmers having set up nurseries on the request of *Divi Neguma* officials had finally found that the sale of plants as promised had not materialized. Other farmers who had also begun cultivation of vegetables at the same time as in open field found the sale of vegetables difficult as there was generally open - field harvest also in the market, which then did not return the farmer a higher price.

Table 5.7: Distribution of Percentage of Farmers by Quantity of Harvest Sold by Districts

Percentage of Harvest Sold	Percentage of Farmers by District			Overall
	Nuwara Eliya	Badulla	Kandy	
less than 25	44	-	43	34
25 to 49	6	-	-	2
50 to 74	6	-	-	2
75 to 99	11	31	14	16
100	33	69	43	46
Total	100	100	100	100

Source: HARTI Survey Data, 2012

Data showed the crops with less than 25 percent of the amount sold (Table 5.8) were mainly found in the Nuwara Eliya District which had a larger percentage of farmers who had not been able to sell most of their harvest. The main reason for this lies in the fact that farmers had grown the vegetables in net houses during the same period as in open field, thus at the time of harvest when there is a glut there is a difficulty in selling the produce.

Table 5.8: Percentage of Farmers Selling Less than 25 percent of Harvest by District

Crops	Percentage of Farmers by District	
	Nuwara Eliya	Kandy
Beans	25	11
Tomatoes	24	33
Capsicum	12	11
Carrot	nil	11
Brinjal	nil	11
Cabbage	nil	11
Radish	25	nil
Spinach	12	nil

Source: HARTI Survey Data, 2012

Data established a relationship between the amount of harvest sold and the size of the net house (p = 0.381: P=0.002) where it was observed that larger the net houses more the percentage of harvest sold. Data in the Table 5.9 further elaborates the above relationship. This can be explained in the terms that farmers having invested a larger amount of cash both in the construction of the net houses and in planting of the crops were involved in net house cultivation with commercial orientation.

Table 5.9: Percentage Distribution of Farmers by Quantity of Harvest Sold and Tunnel Size

Quantity	Tunnel Size Category					Total
	<500	500- 600	600-800	800-1200	>1200	
<25	9	5	5	1	1	21
25 to 49	1	0	0	0	0	1
50 to 74	1	0	0	0	0	1
75 to 99	0	3	1	3	3	10
100	3	9	3	11	2	28
Total	14	17	9	15	6	61

Source: HARTI Survey Data, 2012

5.6 Costs and Returns from Net House Operation

Table 5.10: Costs and Returns for the Cultivation of Crops in Net Houses

Activities/Costs/Returns (Rs.)	Size of Net Houses and Sample Size	
	Around 500 (N=16)	Around 1000 (N=13)
Potting Media	3,971	6,204
Seeds	480	2,030
Crop Hanging	513	1,126
Fertilizer	919	9,491
Agro Chemical	1,251	3,699
Harvesting Materials	412	856
Other Materials	1,810	1,715
Total Material Cost	9,357	25,121
Hired Labour Cost	1,609	465
Family Labour Cost	8,506	17,378
Total Labour Cost	10,115	17,843
Total Cost with Family Labour*	19,472	42,964
Total Cost without Family Labour*	10,965	25,586
Average Total Harvest (kg)	523	1,370
Average Quantity Sold (kg)	485	1,321
Average Selling Price (Rs./kg)	53	86
Value of the Total Harvest	27,719	117,820
Revenue	25,705	113,606
Profit (Without Family Labour Cost)	14,740	88,020
Profit (With Family Labour Cost)	6234	70,642
Benefit Cost Ratio (Without Family Labour)	2.34	4.44
Benefit Cost Ratio (With Family Labour)	1.32	2.64

*Excluding the initial costs

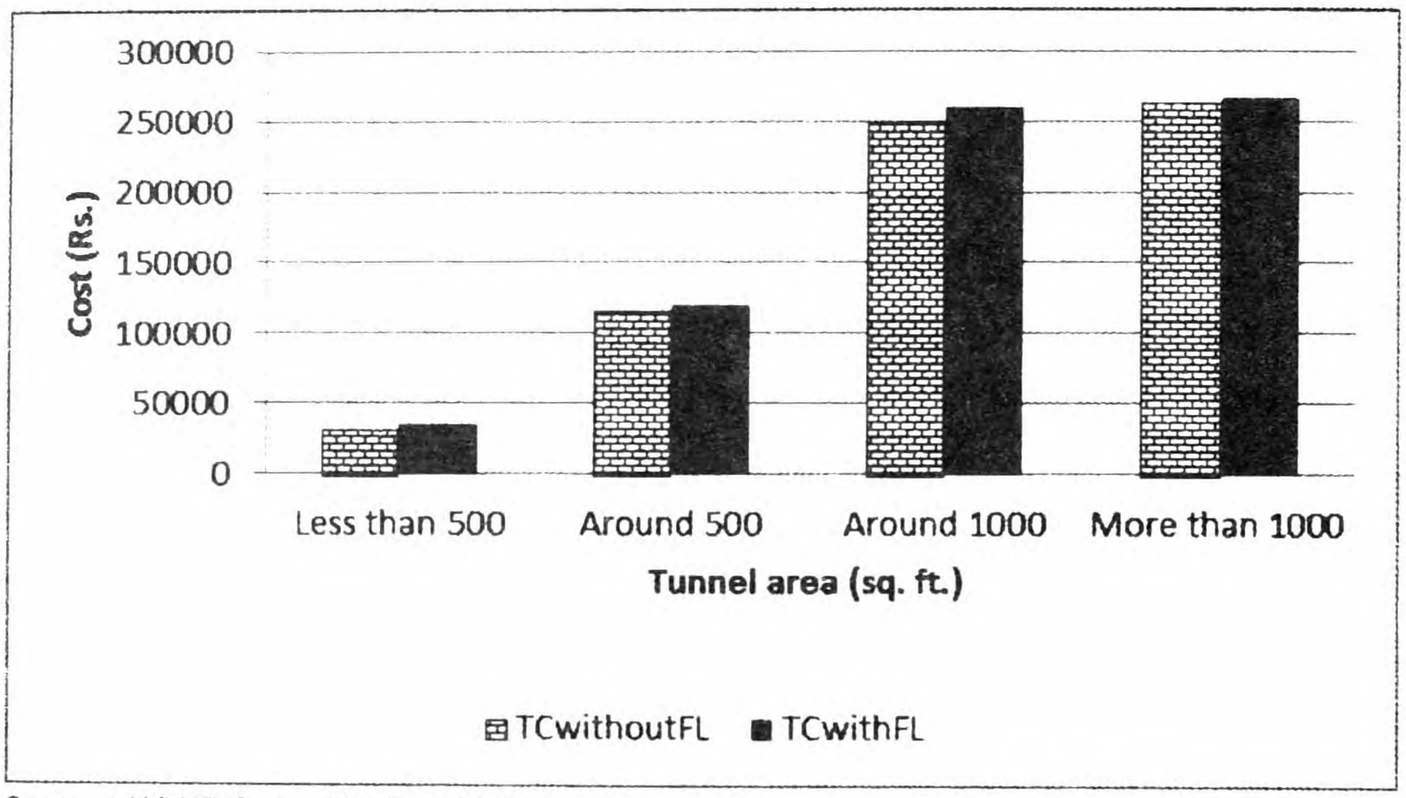
Source: HARTI Survey Data, 2012

The above data shows that local tomatoes are profitable in net houses (Table 5.10) and labour was the most expensive cost component. According to this analysis, production of other crops in net houses was not profitable.

5.7 Constraints of Crop Production in Net Houses

5.7.1 High Initial Cost for Construction of Net Houses

The main capital requirement for net houses was in the initial cost of setting up of the structure. Overall the capital required for construction is high with the increasing size of the tunnel and the materials used for construction (Figure 5.4). Therefore most farmers sought subsidies or outright grants for the construction of net houses.



Source: HARTI Survey Data, 2012

Figure 5.4: Construction Cost of Net Houses

5.7.2 Marketing of Products

Marketing of products was also a key constraint (Table 5.11) for net house operators. The production of *Naimiris* was at a loss and only local tomatoes returned profits. Choice of what products to be grown was governed by the market demand. As most of the net houses were granted under the subsidy scheme of *Divi Neguma* programme, the type of seeds was predetermined (given via the programme). However, the most advisable is to develop a market intelligence system for farmers whereby they may be able to decide their crops for the season. Directing farmers for off-season vegetable production is a must to derive better results from net houses.

Table 5.11: Significant Marketing Problems of Net House Operators

Marketing Problems	Distribution of Respondents	
	No	%
Price Fluctuation	36	42
Lack of Fixed Markets(agreements)	35	41
High Quality Standards Expected	4	5
High Transportation cost	4	5
Increased Involvement by Middlemen	2	2
Failing to Meet Demand	1	1

Source: HARTI Survey Data, 2012

5.7.3 Environmental Constraints

Among the respondents 42 percent did not mention that they faced any problems relating to environmental factors but the rest accounting for the majority (58%) were faced with one or more environment factors that hindered the net house production in one way or the other (Table 5.12).

Table 5.12: Environmental Problems of Net House Operators

Environmental Constraints	Distribution of Respondents	
	No	%
Damages of Net Houses due to Rain and Wind	27	49
Spread of Pests and Diseases during Rainy Season	9	16
Shedding Flowers and Fruits due to High Temperature	8	14
Low Yield due Overcast Conditions(Rain/Mist/Frost)	8	13
Water Scarcity during Dry Period	9	10
Scorching of Crops due to Strong Sun Light	1	2

Source: HARTI Survey Data, 2012

5.7.4 Other Problems

Technical and economic issues too affect net house operation though at a lesser scale. Damage due to wild animals such as deer, rabbit, wild boar and rats is one of the barriers that cause a reduction in yield. Among other problems: inadequate practical knowledge on net house operation, lack of an organized advisory service, maintenance difficulties due to height of net houses, shortage of chemicals required for removing algae grown on roof and scarcity of high yielding seeds can be cited. It was also revealed that a considerable percentage of farmers (28%) from all the study locations do not use safety measures with the highest percentage of respondents from Nuwara Eliya (35%), and 13 percent from Badulla and 28 percent from Kandy.

Irrespective of the study location ambitions of net house operators vary. The expectation of the most operators is to construct another net house with further subsidies and continue cultivation of crops. Cultivating new crops and varieties, supplying products to the export market, using advanced technologies such as drip irrigation, starting sales outlets, producing organic vegetables, shifting to hanging bag system and hydroponics and production for consumption are some other innovative expectations of net house operators. Respondents are of the view that there is a strong need for them to be equipped of new and advanced technologies appropriate for net house farming.

CHAPTER SIX

Summary of Findings, Conclusions and Recommendations

6.1 Vegetable Cultivation in Poly-tunnels

Summary of Findings

1. The study shows that females had shown an increased interest in poly-tunnel farming irrespective of the location where they operate (χ^2= 5.564; P=0.062) and a relatively younger farmers below 40 years of age (32%) had taken up this innovative practice. Altogether 90 percent operators had received education beyond O/L there is no significant variations among respondents in terms of educational attainment (χ^2 = 8.705; P = 0.368) χ^2 = 5.714; P = 0.222) across districts. Around one third of farmers were involved in poly tunnel farming on a part time basis.

2. Poly-tunnel farming has been chosen by 30 percent farmers as an additional source of income and the majority (63%) had undergone training on poly-tunnel farming. No significant variations were found in terms of exposure to training by respondents across districts (χ^2 =5.111; P = 0.078).

3. The majority of operators (67%) had constructed poly tunnels utilizing own funds whereas a few operators (7%) had received a partial grant while the rest 26 percent received full grants. Assistance extended by various organizations and institutions to construct tunnels has been a great support for the small farmers to start poly-tunnel cultivation.

4. Most of the open field farmers (65%) who had some knowledge on poly tunnel farming had shown an interest to commence poly tunnel operations but had not received any grants or subsidy.

5. The majority (62%) of farmers from all three districts had only one tunnel while the Badulla district had 28 percent farmers who owned two tunnels and the Kandy district had 20 percent farmers with three tunnels. In the Nuwara Eliya district (20%) there are farmers who owned as many as 23 poly-tunnels. The most prominent tunnel size was around 1000sq. ft which was found among fifty five percent of the farmers.

6. Around 50 percent farmers who self-financed their structures had utilized formal loans from banks ranging from Rs.50,000-240,000 at a varying interest rate ranging from 8-15 percent.

7. The number of crops grown in poly-tunnels was limited and had shown a variation across districts. A majority had grown bell pepper (40%) and Japanese cucumber (19%). Local tomatoes were popular in Badulla and Kandy districts. Beef tomatoes, zucchini and herbs were only grown in Nuwara Eliya. In a smaller extent beef tomato and cherry tomatoes were cultivated in Nuwara Eliya and Kandy districts on the request of buyers.

8. Around 90 percent operators used to practice a mono cropping system, however, among the districts Kandy predominated in multiple cropping (18%). A very few farmers who had a regular and assured buyers had started cultivation of salad leaves in hydroponics culture while other farmers still cultivate different varieties of salad leaves in soil medium.

9. Due to lack of local varieties imported seeds were used for the crops commonly grown in poly-tunnels and there were several varieties of each crop at varying prices.

10. Irrigation systems varied; drip, sprinkler, and mist and watering of plants by hose and using small utensils or other implements. Only 14 percent used drip and sprinkler systems whereas the majority practiced manual irrigation using the ordinary hose, the cheapest and the most convenient method.

11. Grow bags were mostly used in poly-tunnels whereas hydroponics was used for cultivation of salad leaves mainly in the Nuwara Eliya district but at a lesser extent. Most of the poly-tunnel farmers used the recommended potting medium of coir dust, top soil and sand in a 2:1:1 ratio. In certain instances some poly-tunnel farmers used compost, cow dung, goat manure, tea refuse and saw dust as the potting media depending on the availability. The main fertilizer used by almost all the farmers was Albert's solution.

12. The crops were largely harvested based on market demand. Lettuce is harvested once a week with specialty lettuce such as Romaine or Iceberg once for the season. The general trend was weekly 2-3 times for bell pepper, cucumber and tomatoes.

13. The quantity of vegetables sold varied; 61 percent sold the entire harvest; 30 percent sold more than 75 percent of the harvest; 12 percent had difficulty in selling more than half the harvest.

14. In general, the larger the tunnel size the greater the quantity of harvest that had been sold by the farmers (Y=0.717; P=0.136) owing to higher investment on large tunnels that encouraged farmers to find assured buyers.

15. The avenues open for the sale of the harvest were of three types; specialty markets (super markets and hotels), export market and local market. PAEA in Kandy, few farmer associations instituted by EDB and few individual farmers from Badulla and Nuwara Eliya districts were involved in export of vegetables. Local markets including dedicated economic centers, manning market, neighbors, and collectors/middlemen too played a role in marketing of vegetables produced in poly tunnels. In Badulla and Nuwara Eliya local markets predominated whereas it was PAEA in the Kandy district.

16. Post-harvest grading had been carried out in two stages; before sale by the farmer and after sale by the buyer. Grading was essential for the specialty market products such as bell pepper, tomatoes, japanese cucumber and zucchini which were graded based on maturity of the crop, size, color, variety, shape and texture.

17. The price variation of the major poly tunnel crop, bell pepper, was not significant between districts ($F = 1.918$; $P = 0.171$) nor markets ($F = 2.127$; $P = 0.145$) suggesting that farmers had been unable to derive exceptional benefits either through cultivation in different locations or supplying to different markets.

18. Family labour predominated in poly tunnel cultivation irrespective of scale of operation, though the labour use efficiency of family labour was less when compared to that of hired labour. Hired labour use had shown an increase with the increase in scale of operation.

19. Costs and returns estimated for bell pepper grown in medium (1000sq. ft.) and large (1865sq. ft.) poly tunnels with the use of grow bags or pots in recommended potting media established that economies of scale in the cultivation of bell pepper existed. Cost benefit analysis confirmed that the production of bell pepper in larger tunnels seems to be the most viable option in poly-tunnel farming.

20. Cost Benefit analysis of japanese cucumber cultivation in poly tunnels too demonstrated both viable and increased returns to scale.

21. Among the drawbacks for promotion of poly tunnel farming are high initial construction cost, unavailability of certain varieties which were used to cultivate by farmers and reluctance to grow new varieties, the lack of a fixed markets and prices, lack of sufficient quantities required to meet the demand of export markets, destruction of tunnels and pest problems due to wind and rain, rather overuse of agrochemicals, inadequate technical knowledge on operation of poly tunnels owing to lack of adequate training.

Conclusions and Recommendations

Vegetable production under protective covers received an impetus in Sri Lanka for four main reasons:

- ensure sustained supply of vegetables against seasonality of production,
- avoid decrease in farmer income that fluctuates due to erratic weather conditions and pest problems,
- Circumvent land and labour scarcity in agricultural production
- As a means of crop diversification to attract youth to the sector through promoting modern technology.

Though it was not the purpose of this study to assess the extent to which these objectives have been achieved, this study too reveals some relevant information pertaining to the achievement of the said objectives in introducing protective agriculture techniques to the country. Poly tunnel farming first commenced in the Nuwara Eliya district largely by well-off farmers as an alternative business enterprise to ensure sustained supply of exotic vegetables that cannot be achieved under open field conditions. Over time, poly tunnel farming spread within the district at a varying scale and then beyond the district to Badulla and Kandy districts. Despite high initial cost of construction of poly tunnels small farmers also ventured into poly tunnel farming with the funding assistance from various organizations.

As evident from this survey, vegetable production in poly tunnels does not largely differ from open field farming with respect to labour intensive manual operations, indiscriminate use of agro-chemicals and marketing problems. Thus the present way of vegetable production in poly tunnels with substandard structures would hardly be recognized by the younger generation as a sophisticated automated system that would support to realize their expectations to become a successful entrepreneur in agriculture. The high initial cost of structures and considerable maintenance cost arising due to heavy wind and rains are also key constraints for continuation of operations in poly tunnels. The most severe problem is the marketing of products which are produced at a huge capital and recurrent cost. Frequent occurrence of pest and diseases owing to sub-standard structures and adverse weather conditions that encourage the same incurs a high cost and causes quality degradation and thereby discourages some farmers in continuing and newcomers to self-finance this venture. Yet, the production of some vegetables in poly tunnels is profitable, the key reasons for the present level of vegetable production in poly tunnels are due to increased dependence of family labour and funding assistance for the structures.

Despite the huge potential which exists for these exotic vegetables at the export markets poly tunnel farming has failed to achieve its objectives for which it was introduced due to inadequate marketing opportunities and production constraints from poor application of modern technologies, pest problems, low quality planting material and environmental constraints. Thus from the production point of view, there needs to be a shift in the cultivation systems from the construction of standard structures to employing advanced cultural practices that would ensure an increased production of vegetables of high quality in required quantities, that fetches a high income to the farmers. From the marketing perspective, such quality products should be able to be sold at higher prices with no significant reduction in income to the farmers occurring due to failed marketing. Therefore, the following recommendations are made in order to attract successful entrepreneurs to poly tunnel farming.

a. Promotion of local organizations/individuals for export of exotic vegetables through strengthening of supply chains in order to increase the market share of exotic vegetables produced in poly tunnels.

b. Make marketing options compulsory in funding assistance programmes provided for the construction of poly tunnels. Develop value chains encouraging quality production and assured purchasing with respect to local sales.

c. Standardization of poly tunnel structures and provide concessions for high quality raw material.

d. Restructure training programmes for poly tunnel operators, hence, their technical knowledge on proper construction and maintenance of poly tunnels are ensured.

e. Improve market intelligence of potential exporters both individuals and associations on export markets for diversified products especially for non-toxic labeling pest free tunnel operation.

f. Research into low cost automated systems (for fertigation and temperature regulation) of poly tunnel farming in order to attract young entrepreneurs and women.

g. Farmer training programmes i.e. on proper construction and maintenance and employing proper cultural practices.

h. Ensure access to credit facilities especially for those who wish to establish automated systems of poly tunnel operation.

i. Involvement of DOA to ensure the availability of high quality planting material.

6.2 Onion True Seed Production in Rain Shelters

Summary of Findings

1. Among the 72 respondents from the Matale district 62 percent were the recipients of the DOA scheme to provide assistance to construct rain shelters at an estimated cost of Rs 100,000 and the majority (79%) had initiated cultivation under rain shelters in 2011. Among the other organizations that provided assistance were *Divi Neguma* programme, *Mahaweli* authority and provincial council. The aim was to meet 50 percent of the local big onion seed requirement.

2. The recommended size of rain shelters was 1000sq. ft. structure and the majority of farmers (74%) owned rain shelters of the same size though the sizes slightly varied from farmer to farmer.

3. Some of the salient characteristics of the majority of respondents were; almost all the respondents were male farmers (100%), a relatively younger crowd less than 40 years of age (53%), majority was engaged in full time farming (93%), having 1-5 years of experience in onion seed production (92%) and with no training on cultivation under rain shelters (61%). Training was also not seen as compulsory for them as they had been producing onion seeds prior to installation of the present structures.

4. The initial intention was that the rain shelters be used for other crops once the onion seeds are harvested, but only ten percent farmers had used them for the cultivation of beet and tomato since they found it is more convenient.

5. The majority of farmers (91%) had only one structure while a large scale farmer had as many as 4 rain shelters.

6. The crops had been irrigated manually with the use of hose, watering can or other utensils and the use of advanced technologies (drip and sprinkler) was at a very low level (7%); the main source of growth medium was a mixture of compost and soil for planting mother bulbs, obtained mainly from the DOA.

7. The demand for locally produced onion seeds was high as farmers claimed that the quality of the local seeds supersedes the imported seeds therefore selling of onion seeds had not been a big problem for seed producers.

8. Most of the farmers had not sold their entire harvest while a larger percentage had retained more than 50 percent as planting material for their own fields. A certain quantity had been given back to the ASC. Only 23 percent of farmers had sold over 75 percent of their harvest.

9. Onion seed production is a profitable enterprise. On average, a 1000sq ft rain shelter produces 11 kg of onion seeds and therefore around 450 farmers having the rain shelters of the same size are capable of producing the balance 5000kg of onion seeds required for the country per annum at an additional cost of Rs.45 mn to the government at a cost of Rs. 100,000/tunnel of 1000sq ft.

10. The key constraint of operating rain shelters for onion true seed production is the high initial cost which is not affordable for small scale operators. Around 49 percent farmers have stated marketing difficulties due to lack of fixed buyers and a fixed price.

Conclusions and Recommendations

True seed production of onion in rain shelters which was recently introduced to onion growers in the Matale district is a highly efficient and viable option. A 1000sq ft rain shelter produces around 11 kg of seeds demonstrating a cost benefit ratio of 3.07 excluding the cost of family labour. This fetches an income around Rs. 126000 to the farmer. About one third of operators had entirely used the harvest as planting material whereas over half of the respondents had sold over 50 percent of the harvest. Thus true seed production of onion operates both at subsistence and commercial scales. Whilst this has been a profitable alternative for the farmers to generate an income during the off season it has also been a better option that makes small farmers self-sufficient in planting material with high quality at a low cost of around Rs. 3800/kg.

Annually, over 30,000kg of big onion seeds are needed for planting in Sri Lanka, according to the statistics of the Ministry of Agriculture. Therefore, learning lessons from the successful programme launched in the Matale district the Agriculture Department needs to ensure the necessary conditions and initiate appropriate steps to promote both small scale and commercial scale onion seed production programme in the country to fulfill the local seed requirement. High initial cost of construction of rain shelters is the key impediment for small farmers to venture into this enterprise. The following recommendations may attract small scale farmers:

a. Provision of subsidies to construct rain shelters in order to capture the full potential of onion seed production in the country.

b. Production planning in order to maintain the balance between production and supply of onion seeds and avoid any marketing problems.

6.3 Crop Production in Net Houses

Summary of Findings

1. Scarcity of vegetables in the market with a sharp increase in prices after a heavy rain in 2010 led to cultivation of vegetables in poly-net houses. In the latter part of 2011 under the *Divi Neguma* programme, subsidies were granted to farmers to construct net houses mainly for the propagation of nurseries and cultivation of vegetables during the rainy seasons.

2. Participation of more females from Nuwara Eliya (41%) and Badulla (25%) districts and a younger crowd from the Kandy district (56%) and a comparatively educated group of farmers were a few prominent features of net house operators. Overall one third of the respondents were part- time farmers, however, the majority of females (86%)were full time farmers but the males were engaged in part time basis with significant variation in terms of the degree of involvement of the respondents across the districts (χ^2 =11.056; P = 0.011).

3. Overall 80 percent of net houses had started cultivation in net houses within a time span of one to over ten years with significant variations in the initial number of net houses across the districts (χ^2 =26.742; P = 0.002). Once again data shows that two third of respondents had undergone training on net house operation for cultivation of crops at Agrarian Services Centers alongside the construction of net house.

4. The majority of farmers in the three districts owned one net house with three percent farmers in the Kandy district having six net houses.

5. Overall 77 percent net houses had been built with funding assistance: 88 percent from Nuwara Eliya, 25 percent from Badulla and 89 percent from Kandy.

6. The most frequently cultivated crops in all three districts were the different varieties of tomatoes such as *Thilina*, *Padma* and beef tomatoes. Most farmers preferred tomato as there was a greater opportunity for sale due to the vagaries of weather.

7. Plants for nurseries were mainly grown in small polythene covers while the black grow bags were used for other plants such as tomatoes and *naimiris*. However, the most used beds prepared on the ground. They had used a mixture of compost and soil as the growth medium. Majority had used manual methods for watering of crops. Only one percent farmers used advanced techniques such as hydroponics.

8. Over 36 percent of farmers found it difficult to sell more than 50 percent of their produce. Falling into this category were 15 percent of farmers who had set up nurseries on the request of *Divi Neguma* officials and they finally found that the sale of plants as promised had not materialized. Others who had grown vegetables had been unable to sell the produce due to the competition from the open field production.

9. Data established a relationship between the amount of harvest sold and the size of the net house (ρ = 0.381; p = 0.002) that, larger the net houses, higher the percentage of harvest sold. Farmers having invested more in the construction of net houses had operated enthusiastically, with commercial orientation.

10. The study revealed that the production of tomatoes in net houses is a viable agro enterprise.

11. Among the constraints of vegetable cultivation in net houses, high initial cost of construction that is unaffordable to small farmers, difficulties in marketing of vegetables due to lack of direction to farmers to grow vegetables in off-seasons and adverse environmental factors that affect net house structures and pest and disease incidence associated with adverse weather conditions.

Conclusions and Recommendations

Vegetable cultivation in net houses is not that viable as poly-tunnel operations and true seed production of onion under rain shelters. More females had ventured into these net house operations on a full time basis with funding assistance. However, due to technical constraints and severe marketing problems most of them had been unable to make a profit from net house operation except for tomato cultivation. Nevertheless, high initial cost of construction of net houses farmers have discouraged net house operations in the absence of proper direction and assistance for the production and marketing of vegetables during the off season. However, as per the success case of tomato production, vegetable production in net houses cannot be disqualified as non-viable. Therefore, provision of subsidies for net houses with direction for farmers to operate them for off season vegetable production is suggested.

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Appendices

Appendix 1: Sample Distribution by DSDs and ASCs

District	DS Division	Number of Agrarian Service Centers	Number of GN Divisions	Number of operators
Nuwara Eliya	Nuwara Eliya	7	15	47
	Walapane	3	3	8
	Kotagala	2	2	2
	Ginigathhena	2	1	8
	Ambagamuwa	3	4	6
	Kothmale	3	4	4
Badulla	Bandarawela	2	9	21
	UwaParanagama	2	5	27
	Welimada	4	6	23
	Ella	3	2	4
Kandy	YatiNuwara	3	6	6
	PahathaHewaheta	3	5	6
	Ganga Ihala	4	7	10
	Udapalatha	1	1	7
	Delpitiya	1	1	1
	Doragala	1	2	3
	Thalathuoya	2	2	2
	Thaladuwa	1	1	1
	Kurunduwatta	1	1	1
	Harispaththuwa	2	2	2
	Gampola	2	2	2
	UduNuwara	3	4	4
	Pilimathalawa	1	1	1
	Pahatha Dumbara	2	4	4
	Nawalapitiya	3	3	4
	Dolawa	3	3	3
	Pasbagekorale	1	3	3
	Wewegoda	1	3	3
Matale	Walapane	1	1	1
	Galewela	5	9	34
	Naula	3	3	14
	Dambulla	2	11	26

Source: HARTI Survey Data, 2012

VIABILITY OF CONTROLLED ENVIRONMENTAL AGRICULTURE FOR VEGETABLE FARMERS IN SRI LANKA

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