Assessment of Solar Powered Drip Irrigation Project Implemented by Ministry of Agriculture - Phase 1

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Research Report No: 148 October 2012

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First Published: 2012

ISBN: 978-955-612-138-4

Suggested citation: Aheeyar, M.M.M., Bandara, M.A.C.S. and Padmajani, M.T. (2012). Assessment of Solar Powered Drip Irrigation Project Implemented by Ministry of Agriculture- Phase 1. HARTI Research Report No: 148, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo, Sri Lanka.

FOREWORD

The government of Sri Lanka has made various attempts to promote drip irrigation technology in the past to increase water use efficiency and enhance the income levels of farmers in the water scarce areas. Provision of Solar Powered Drip Irrigation (SPDI) Systems is one such effort. As the SPDI system is an environmental friendly advance water saving technology, it is considered as one of the adaptation strategies to minimize the climate change impacts on water and food sector.

The present study has endeavored to analyze the performance of the SPDI systems distributed under the phase-1 of the project implemented by the Ministry of Agriculture. The approach adopted, strategies used, impacts and lessons learnt from the project are important for future promotion of the technology. The use of drip irrigation technology has multiple benefits viz; water and labour saving, efficient use of fertilizer, less weeds growth, and reduced environmental pollution. The technology has the ability to produce high quality yields and higher income due to both ability of off season cultivation and higher production.

Enhancing the water use efficiency in agriculture sector is a vital requirement with the increasing demand for water for human and environmental needs. Various technologies and management tools were adopted to reduce the agricultural water demand, but drip irrigation technology has been proven all over the world as one of the effective technologies to reduce the agricultural water consumption. I am sure this study would add new knowledge in this area and guide the policy makers and implementers for successful future project implementations.

Lalith Kantha Jayasekara
Director

ACKNOWLEDGEMENTS

At the outset it is our duty to thank Sustainable Agriculture Water Management Project (SAWMP) of the Ministry of Agriculture for its assistance and generous cooperation extended in conducting this study. Our sincere thanks go to the district level field coordinators of the project for their valuable assistance provided in field data collection. The research team is very grateful to all grass root level officers namely, Divisional Officers (DOs), Agricultural Instructors (AI), Samurdhi Managers, and Agricultural Research and Production Assistants (ARPAs) of all selected areas for their kind cooperation extended to conduct the study.

We would like to thank, Mr. Lalith Kantha Jayasekara, Director, Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI), for providing support to conduct this study and publishing the report. Dr. L.P. Rupasena, Additional Director of HARTI also provided his constant support and guidance to complete this study on time. A special word of thanks to Prof. W.I. Siriweera for the expert editorial assistance provided.

We are also indebted to Mr. A Ratnasiri, Statistical Assistant of HARTI for his commitment and dedication shown in field data collection and analysis. The service rendered by the support staff of EWRM Division namely, Ms. Niluka Priyadarshani de Silva, and Ms. Indra Devendra in type setting the report and typing the research questionnaire respectively and the support staff of Publication Unit namely, Ms. Dilanthi Hewavitharana, and Ms. Udeni Karunartna in final page setting of the report and designing the cover page respectively are highly appreciated. Our thanks are also due to Mr. C.U. Senanayaka, Acting Head, Publication Unit and the printing staff of HARTI for their excellent handling of the publication. Finally, we warmly acknowledge the co-operation extended by the solar powered drip irrigation beneficiaries of the selected study areas.

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October 2012

ABSTRACT

Solar powered drip irrigation project (SPDI) was implemented by the "Sustainable Agriculture Water Management Project (SAWMP)" operated under the Ministry of Agriculture with the partnership of BP Solar (PVT) Ltd of Australia. The project has supplied and installed 5000 units of 150W SPDI in selected areas of the dry zone and some parts of wet zone throughout the country under the phase one of the project. The SPDI systems are provided to farmers under a loan scheme. The total value of the each drip irrigation system is Rs.300,000 at the time of delivery. The selected beneficiaries have to pay an initial down payment of Rs.5000 at the Samurdhi bank or Govijana bank. The remaining cost has to be settled within 10 years making biannual payments in 20 installments paid after one year grace period. Agreement between beneficiary farmers and the Ministry of Agriculture was signed to legally ensure cost recovery. Farmers have to look after the routine maintenance of the system using the training offered and user manual provided by the company. All the repair works of the systems was the responsibility of the BP Solar Company during the warranty period of first three years. SAWMP has to undertake creating awareness among farmers, select suitable farmers, identify the suitable locations, identify the feasibility of available water source, sign the agreement with farmers with initial installment, monitor the establishment of drip irrigation system, ensure the supply of inputs to implement agricultural programme among drip irrigation farmers and collect loan installments on time and credit them to the treasury accounts.

SPDI technology is a new experience for the Sri Lankan farmers. The major objective of this evaluation is to assess the achievements of the aims of providing SPDI systems and fulfilling roles and responsibilities of different stakeholders of the project and the initial impacts to formulate the strategies for the similar future projects.

According to the findings of the study, only 20% of the beneficiaries have paid any installment after paying the initial down payment, but none of them make regular payments of installment. Farmers do not value the product for the given amount. Moreover, only five percent of the farmers use complete set of SPDI, while seven percent are using the drip system without fertigation unit. The non use of drippers by 88% of the farmers indicates the failure of the project in achieving its objectives such as water saving, labour saving, enhancing productivity, and environmental conservation. The proper targeting of beneficiaries is a vital requirement to introduce advance technologies. The main reasons for the non usage of drippers are, blocking of drippers, difficulties in cleaning of drippers, lack of knowledge on drip system, damage caused to drip lateral pipes by rodents, insufficient water supply from the drippers to crops, small land size and non existence of water scarcity to use drip irrigation. Only 10% of farmers have utilized the drip irrigation for some kind of cultivation during *yala* 2010, while it was limited to 4% of farmers in *maha* 2009/10 Therefore it is necessary to conduct pilot studies before promotion of new technologies. Awareness on O&M of the system and the appropriate cultivation using drip system is lacking among farmers. The project should have adequate component to enhance the capacities of the beneficiary farmers and ground level officers.

The solar power company had rendered poor after sales services and had violated the agreement on many occasions which indicates the necessity for suitable terms and conditions with well established post monitoring mechanism in working with private sector. The project has failed in recovering the loan and the same trend is continuing in the second phase. Farmers do not value the product for the amount that has to be paid though they had signed the agreement with or without knowing the content. This is an indication of lack of transparency in the project implementation.

As the degree of use of SPDI system for the given purpose is very poor and as majority of the farmers do not make any payments other than initial down payments, it is not recommended to continue this project in this form. The selection of beneficiaries should be undertaken by the line agency officers as the loan recovery and monitoring of the project are their responsibility. Farmers should be convinced about the benefits in adopting the technology and there should be appropriate water sources (quantity and quality). There should also be water scarcity at least during some periods of the year. The inbuilt nozzles and poor quality drip laterals need to be changed to make them user friendly and durable. The major lesson of the project is that, the introduction of new technologies should be undertaken by targeting most suitable beneficiaries and institutionalizing proper backup and after sales supports. The technology should be easily operated and maintained by the rural farmers.

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LIST OF ABBREVIATIONS

ADC - Agrarian Development Centers
AI - Agriculture Instructors
ASC - Agrarian Services Centers
DOA - Department of Agriculture
DO - Divisional Officers
O&M - Operation and maintenance
SPDI - Solar Powered Drip Irrigation
SAWMP - Sustainable Agriculture Water Management Project

CHAPTER ONE

Introduction

1.1 Background

About 66% of total land area of the country is demarcated as dry zone which receives less than 1000mm of annual rainfall. According to the land use map released by the Survey Department, the total cultivated extent in Sri Lanka is estimated at 2.86 million ha of which approximately 632,000 ha are irrigated (Meegastenne, 2005). In other words, only about 22% of total cultivated land is irrigated. The availability of sparsely used land for highland cultivation is around 1 million ha. Only 7% of this land area is cultivated by the farmers at present. The precipitation is mainly limited to the period between April and September and drought condition mostly prevails during the rest of the period. The income levels of the farmers in the dry zone area is comparatively low due to less cropping intensity and non cultivation of high value crops because of unreliable supply of water. Farmers had to utilize groundwater using high cost water pumps to irrigate the field by means of water hoses for long hours results in the increase of the cost of production (cost of pump and fuel cost for lifting water) and waste of limited groundwater. Excess pumping of water also trigger the growth of weeds. Increasing fuel prices is the critical problem faced by farmers who depend on the existing technologies. The use of fuel pumps causes environmental pollution through spills of fuels and emission of CO_2. The access to grid electricity for the farmlands in rural areas is not feasible for most of the farmers.

Meeting the increasing food demand for the growing population in the context of diminishing natural resources will require less expensive technologies, and less harmful to the environment. One of the methods available to improve efficiency of water usage is the adoption of micro irrigation technologies. Drip irrigation system preciously delivers water directly to plant root system and is considered as a most efficient method of irrigation. Research findings show that drip irrigation has resulted in yield gains up to 100%, water savings up to 40-80% and associated pesticide, fertilizer and labour savings compared to conventional irrigation systems (Sivanappan, 1994). The solar power drip irrigation (SPDI) system is considered as an environmentally friendly technology and has the ability to reduce fuel costs. SPDI systems used solar powered water pumps, drip irrigation tubing and emitters to provide water supply to the plant. The system runs automatically on solar power. The system requires minimal manpower due to the fact that fertilizer is automatically mixed with water before being pumped in to the crops' roots through carefully measured drip pipes. The research findings from many countries show that solar powered drip irrigation projects have improved the agricultural productivity and rural livelihoods. Burney (2010) has found that solar-powered drip irrigation systems significantly enhanced household incomes and nutritional intake of villagers in arid sub-Saharan Africa within one year period of the project implementation.

Therefore an agreement was signed between then Ministry of Agriculture, Livestock, Lands and Irrigation and BP Solar (PVT) Ltd of Australia in December 2004 to supply and install 5000 units of 150W SPDI to the farmers in selected areas of the dry

zone throughout the country under the phase one of the project. The novel features of the BP Solar system are ability to operate without batteries and low light conditions. It was expected to generate 250KWh electricity per system per year. The approximate project value of the phase 1 is Aus$ 1.2 million. The SPDI systems are provided to farmers under a loan scheme repayable within a period up to ten years. As the system has produced good results in other parts of the world and in pilot test conducted in local conditions, it was expected that there won't be a problem in repayment. The company had to provide service for maintenance of the system through their technical staff and train the farmers on operation and maintenance (O&M) of the system. The company had to provide training for the district officers and Agricultural Instructors on O&M and improved method of agriculture. It was agreed to provide another 5000 units in the second phase of the project after successful completion of first phase.

1.2 Sustainable Agriculture Water Management Project (SAWMP)

The SPDI project was implemented by the "Sustainable Agriculture Water Management Project (SAWMP)" operated under the Ministry of Agriculture. The project was initially planned to implement throughout the dry zone and some parts of wet zone covering Puttalam, Kurunegala, Polonnaruwa, Anuradhapura, Vavuniya, Hambantota, Badulla, Moneragala, Matalae, Nuwara-eliya, Kandy, Mullaitivu, Kilinochchi, Mannar, Jaffna, Trincomalee, Batticoloa and Ampara Districts, but, the project was not implemented in Northern Districts and Batticoloa district in the eastern province. The aims of the project were to enhance farm productivity, farmers' income and livelihood of the beneficiary farmers. Another objective of the project was to demonstrate the viability of using renewable energy with drip irrigation systems among rural farmers. The use of irrigation system expected saving in water, fuel and fertilizer and improving crop yield and the quality of harvest. The anticipated outcomes of the project are summarized in table 1.1.

Table 1.1: Expected Outcome of SAWMP

Outcome	Impact
Agriculture	• Increased cropping intensity • Improved crop yield • Increased farm income due to high value crops • Improved quality of outputs • Increase water use efficiency • Reduce cost of production (Less input, labour and fuel cost)
Socio-Economic	• Increased family income • Improved family welfare • Increased employment opportunities
Gender	• Increased leisure time • Reduced difficulties in work
Human Health and Environmental	• Improved water management • Reduced soil erosion • Protect groundwater • Effective application of fertilizer • Reduced health risk exposure (Toxic fumes etc)

Source: SAWMP, 2006

1.2.1 Solar Powered Drip Irrigation System

Solar powered drip irrigation system provided by the project has following components to serve up to half an acre of land.

i) Solar Panel- Solar panel is to generate energy to run the water pump. The panel has 25years limited warranty. Quarterly manual checkup of solar module is recommended to remove dust and other such substance to ensure maximum power from the module.
ii) Water pump- This is a specially designed pump to operate at even very low light intensity. In a normal day the pump has the capacity to deliver 6500-7000 litre of water /day during eight hour period.
iii) Maximum Power Point Tracker (MPPT) - The Unit adjusts the variation of voltage on the solar array to maximize power generation.
iv) Filters- A disk filter is installed between the pump and the irrigation pipes to remove the solids in the water to prevent the drippers getting clogged. The filter is easy to clean and does not require replacement cartridges.
v) Fertigator Tank- Fertigator tank consists of five litre steel tank to dispense fertilizers/chemicals through the drip to the crops.
vi) Drip System- Each system was provided with 4000 drip points. Drippers are placed at 30cm intervals. The drip line also consisted of self cleaning devise to prevent clogging of drippers.

In addition to the above major components, each system is equipped with mounting structures for solar array, and water pump, water pump enclosures, 12m long suction line, 1.25" plastic foot valve, steel support structures for fertigator tank and filter and concrete base for pole mount structures of solar panel, solar water pump, fertigator tank and filter.

The provided system is designed to irrigate ¼ to ½ ac block of land typically for 6 hours per day.

1.3 Method of Implementation

1.3.1 Selection Criteria of Beneficiaries

SAWMP should select suitable beneficiaries for the project based on following criteria;

a) Full time farmer
b) Resident in target area, but no access to grid electricity to the farm
c) Owns over 0.5 acres of land
d) Own an agro well able to provide 6000-7000 liters of water per day

The total value of the drip irrigation system is Rs.300,000. The selected beneficiaries have to pay a down payment of Rs.5,000 at the Samurdhi bank or Govijana bank. The remaining cost has to be paid after one year grace period within 10 years making biannual payments in 20 installments. Agreement between farmers and the Ministry

of Agriculture was signed for the cost recovery arrangement. Farmers have to do the routine maintenance of the system using the training offered and user manuals provided by the company.

1.3.2 Roles & Responsibilities of Solar Power Company

The following responsibilities had to be fulfilled by the BP Solar Company.

a) Technical staff of the company installs the system and instructs farmers on operation and maintenance of the system. The customers have to be provided maintenance manual in local languages.
b) All maintenance activities are to be done by the company for the first 03 years after installation.
c) Local service centers for the project need to be setup and trained by the company to ensure proper maintenance supports and the availability of spare parts at local level.
d) Train the Divisional Officers (DOs) and Agricultural Instructors (AIs) on Technical aspects and O&M of the system and improved crop production techniques.

1.3.3 Roles & Responsibilities of SAWMP

According to the agreement signed between the Ministry of Agriculture Development and Agrarian Services and the Ministry of Finance and Policy Planning on 06th August 2007, the Ministry of Agriculture Development and Agrarian Services has agreed to take several measures for the successful implantation of solar powered drip irrigation project- awareness creation among farmers, selection of suitable farmers, identifying the suitability of locations, identifying the feasibility of water source, signing the agreement with farmers with initial installment, monitoring the establishment of drip irrigation system, ensuring the supply of inputs to implement agricultural programme among drip irrigation farmers and collecting loan installments on time and, crediting them to the treasury accounts. In order to ensure the smooth implementation of the above activities, following conditions have been agreed by the Ministry of Agriculture;

a) Create awareness among the all relevant officers on the policy framework, methodology, limitation and conditions set by the Ministry of Agriculture to implement the project
b) Plan and implement the farmer awareness programme with the support of partner organizations
c) Identify the feasibility of land and water sources and thereby select the suitable beneficiaries with the support of partner organizations
d) Approve selected beneficiaries from the heads of district level organization
e) Collection of initial down payment and depositing in the relevant bank and maintaining the financial records
f) Signing an agreement between the ministry and the selected farmer base on the policy framework, methodology, limitation and conditions setup by the Ministry of Agriculture

g) Monitoring the installment of solar power drip system in the selected farmers field by the company
h) Setup an insurance scheme for the provided drip systems
i) Provide crop recommendation for the drip irrigation farmers from the Department of Agriculture/Provincial Department of Agriculture
j) Establish a programme to ensure the supply of quality seeds and planting material and other necessary inputs on time for the selected farmers
k) Facilitate the forward purchasing agreement for the marketing of products of drip irrigation farmers
l) Make a work plan to monitor the progress of the project at divisional, district and the ministry level

1.4 Relevance of the Study

SPDI system is a new technology for Sri Lankan farmers. The government of Sri Lanka has invested about US$ 28 million for this project under the loan scheme provided by Australian EFIC funding. The project is in place since 2005 and phase-1 project was completed by 2008. Therefore it is important to assess the performance of SPDI systems and the impacts of the project on agricultural productivity, farm income and other socio and environmental conditions to make recommendations for future such projects.

1.5 Objectives of the Study

The major objective of this study is to assess the achievements of the aims of providing solar powered drip irrigation systems and the initial impacts of the project to formulate strategies for the future similar projects. The specific objectives of the study are;

i) Study the approach of intervention adopted in selecting the beneficiary and delivering and monitoring the progress
ii) Examine the socio-economic conditions of the beneficiary farmers
iii) Find out the effectiveness of institutional mechanism adopted and the capacity building
iv) Assess the performance of fulfilling roles and responsibilities of different stakeholders of the project
v) Examine the performance of solar powered irrigation systems provided
vi) Estimate the level of usage of solar powered micro irrigation systems
vii) Identify the prospects and problems in using micro irrigation systems
viii) Assess the impacts of micro irrigation systems in improving crop cultivation, crop yield, quality of harvest, reducing cost of production and enhancing family income and welfare
ix) Make policy recommendations for the future promotion of solar powered micro irrigation systems

CHAPTER TWO

Methodology

2.1 Site Selection and Sample Size

All the districts of phase 1 (Puttalam, Kurunegala, Polonnaruwa, Anuradhapura, Hambantota, Badulla, Moneragala, and Ampara Districts) except Nuwara eliya, Kandy and Trincomalee were selected for the study. The districts not selected for the study consisted few numbers of beneficiaries. The study sites were selected from divisions which had the higher number of beneficiaries considering the logistics of data collection from the selected districts. There are 5137 total numbers of beneficiaries in the selected districts including 4704 beneficiaries under the Govijana bank and 433 beneficiaries under the Samurdhi bank. The suitable sample size was selected using following formula at 95% confidence levels. The selected sites and the sample size are given in table 2.1.

$$\text{Sample size} = \frac{z^2 * (p) * (1-p)}{c^2}$$

Where:
Z = Z value
p = percentage picking a choice, expressed as decimal
(0.5 used for sample size needed)
c = confidence interval, expressed as decimal

According to the formula the sample size chosen was 368. The sample was proportionately allocated among Govijana bank and Samurdhi bank beneficiaries as 342 and 26 respectively. These numbers were proportionately allocated to selected districts based on total number of beneficiaries in each district under the two different categories. The sample size of the selected district was proportionately allocated based on the beneficiary population of the selected district. The district sample was then proportionately allotted to the selected Agrarian Development Centers (ADC) in the respective districts. The distribution of sample size in the selected ADC divisions is given in table 2.1.

Table 2.1: Distribution of Sample

District	Agrarian Development Centre Division	No. of Beneficiaries	No. of Sample Farmers
Ampara	Irrakkamam	48	11
	Uhana	42	14
	Weranketagoda	12	3
Anuradhapura	Galenbindunu wewa	124	35
	Katiyawa	68	16
	Kawarankulama	10	3
	Padaviya Parakramapura	121	29
Badulla	Rideemaliyadda	94	8
Hambanatota	Ambalantota	156	37
	Hakuruwela	13	4
	Meegahajandura	186	30
Kurunegala	Ehatuwewa	101	11
	Rambe	697	57
Matale	Dambulla	334	51
	Galewela	109	16
Moneragala	Buttala	83	16
	Makulla	40	6
Polonnaruwa	Gal-Amuna	59	17
Puttalam	Puttalam	24	5
Total		**2204**	**369**

Source: Authors' Survey Data, 2011

2.2 Data Collection Methods

The study employed multiple methods to gather necessary information and data for the evaluation namely, key informant interview, focus group discussion, case studies and questionnaire survey. Field survey was conducted during the period of January to April 2011.

Key informants such as officials of SAWMP, BP Solar Company, district and divisional officers, farmer leaders, pilot farmers, and village level officers were interviewed to understand the progress, prospects and problems of the drip irrigation project and also the effectiveness of the approach and the institutional arrangements made. Focus group discussions were conducted in selected areas where large numbers of drip irrigation systems had been provided targeting women and men groups to gather qualitative information on benefits and impacts of the project.

Sample survey was planned using the beneficiary list available in the SAWMP. Random sample was selected based on the table No. 2 covering both the beneficiaries under Samurdhi and Govijana bank. Questionnaire was prepared to achieve the objectives listed in section 5. The indicators were developed to assess the impacts of

drip irrigation systems on agriculture production, productivity, quality of products, cropping pattern, cost of cultivation, marketing of produce, income and welfare change, usefulness of drip irrigation systems, problems in using drip irrigation systems provided, repayment of loan, capacity built among farmers, and other environmental and social impacts. Case studies were conducted in selected locations to explore more detail information about the performance.

2.3 Data Analysis

Data collected was analysed using SPSS software package. Both descriptive and tabular analysis was conducted.

CHAPTER THREE

Approach of the Intervention and Achievements

3.1 Demographic Characteristics of Beneficiaries

3.1.1 Family Size Distribution

Average family size of the sample population is around 4.46 and district wise family size distribution is shown in table 3.1. Depending on the number of members in the families, sample families in each district are categorized into three groups, namely families with 1-3 members, 4-5 members and more than 6 members. About 65 percent of the total families have 4-5 members.

Table 3.1: Family Size Distribution by District

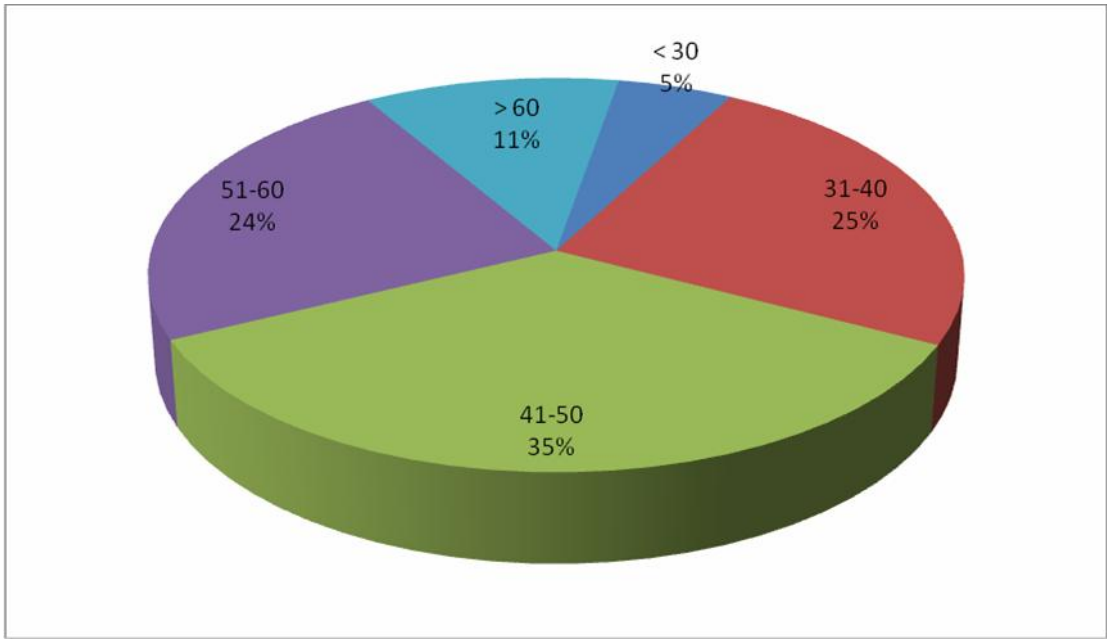
District	Average family size	Family size group (% of total families)		
		1-3 members	4-5 members	>6 members
Ampara	4.96	17.9	57.1	25.0
Anuradhapura	4.20	22.9	69.9	7.2
Badulla	3.75	25.0	75.0	0.0
Hambantota	4.52	21.1	60.6	18.3
Kurunegala	4.06	29.4	64.7	5.9
Matale	4.25	16.4	74.6	9.0
Moneragala	4.14	36.4	40.9	22.7
Puttalam	5.80	0.0	60.0	40.0
Polonnaruwa	4.47	17.6	70.6	11.8

Source: Authors' Survey Data, 2011

3.1.2 Age Distribution

As indicated in Figure 3.1, majority of the SPDI system owners belong to the age category of 40-50 years. About 25 percent of the sample population in the study area is between 31-40 age groups and 24 percent of the population is in the age group of 51-60. Beneficiaries who are below the age of 30 years are only 5 percent. The findings indicate that, the majority of the farmers are relatively young farmers and have the ability to adopt new technologies, subject to correct intervention approach.

Figure 3.1: Age Distribution of Beneficiaries (% of total beneficiaries)



Source: Authors' Survey Data, 2011

The details analysis of age structure is given in tale 3.2. As shown in the table, 83 percent of the beneficiaries in the total sample population belong to the age group of 30 to 60 (work force) years. Distribution of the beneficiaries among different age groups is more or less similar in all study districts.

Table 3.2: Age Distribution of Farmers by District (% of total beneficiaries)

District	< 30 years	31-40 years	41-50 years	51-60 years	> 60 years
Ampara	7.14	25.00	25.00	32.14	10.71
Anuradhapura	7.23	26.51	37.35	19.28	9.64
Badulla	12.50	12.50	50.00	12.50	12.50
Hambanthota	1.41	29.58	35.21	25.35	8.45
Kurunegala	7.35	30.88	20.59	25.00	16.18
Matale	4.48	20.90	44.78	17.91	11.94
Moneragala	4.55	22.73	31.82	22.73	18.18
Puttalam	0.00	0.00	40.00	60.00	0.00
Polonnaruwa	0.00	0.00	58.82	35.29	5.88
Total	**5.15**	**24.66**	**35.23**	**23.58**	**11.38**

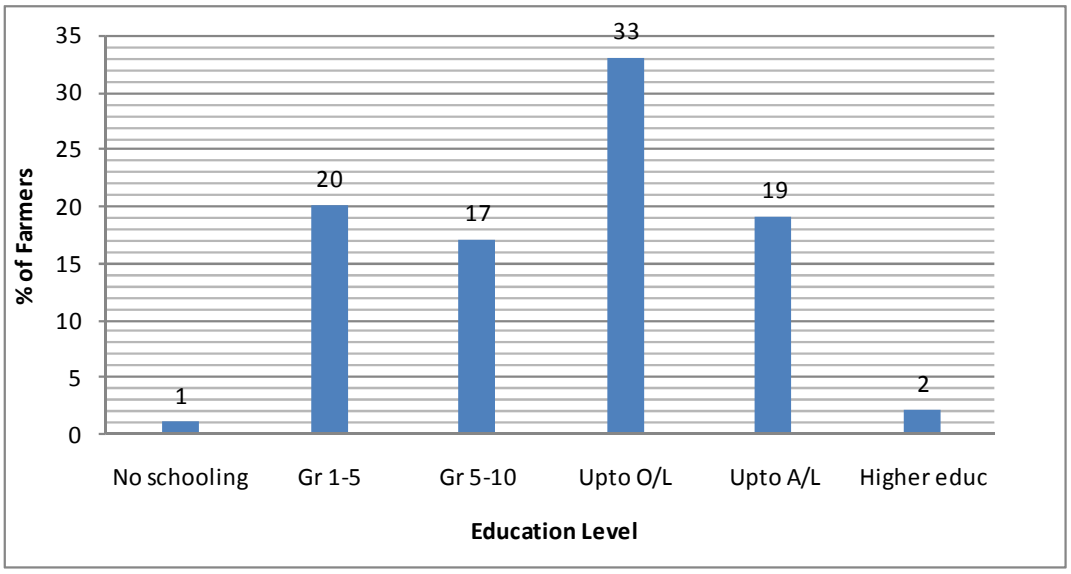
Source: Authors' Survey Data, 2011

3.1.3 Education Level of the Beneficiaries

As indicated in Figure 3.2, 33 percent of the beneficiaries have achieved education up to GCE ordinary level. Farmers who had never been to school is less than 1 percent

of the study population and on the other hand around 2 percent had received higher education.

Figure 3.2: Educational Level of Sample Beneficiaries



Source: Authors' Survey Data, 2011

Table 3.3 represents the education level of sample beneficiaries as reported by sample households. Non-schooling beneficiaries were reported only from Kurunegala and Polonnaruwa, but numbers are very low. The number of farmers who had education up to GCE (Ordinary Level) and above accounted approximately 53% of total beneficiaries. Therefore, the sample farmers have some educational background to understand the SPDI concepts.

Table 3.3: Level of Education by District (% of Beneficiaries)

District	No schooling	Grade 1-5	Grade 5-10	Up to O/L	Up to A/L	Higher education
Ampara	0.00	32.14	14.29	25.00	25.00	3.57
Anuradhapura	0.00	14.46	32.53	36.14	15.66	1.20
Badulla	0.00	0.00	25.00	37.50	25.00	12.50
Hambanthota	0.00	26.76	30.99	26.76	14.08	1.41
Kurunegala	1.47	30.88	25.00	27.94	14.71	0.00
Matale	0.00	8.96	22.39	43.28	23.88	1.49
Moneragala	0.00	9.09	36.36	27.27	22.73	4.55
Puttalam	0.00	20.00	40.00	20.00	20.00	0.00
Polonnaruwa	5.88	11.76	11.76	41.18	29.41	0.00
Total	**0.54**	**19.51**	**26.83**	**32.79**	**18.70**	**1.63**

Source: Authors' Survey Data, 2011

3.1.4 Employment

Out of the total number of beneficiaries in the sample area, around 83 percent involved in the agriculture as primary employment and rest are part time farmers. Only 24 percent of the beneficiaries had involved in secondary employment (Table 3.4). Other prominent employments of the study population are state or private sector jobs (8%) and self-employment (5%).

Table 3.4: Employment Pattern in Sample Area

Type of employment	Primary Employment		Secondary employment	
	No.	%	No.	%
Agriculture	307	83.20	44	11.92
Government/ private sector employment	31	8.40	0	0
Non permanent employment	2	0.54	1	0.27
Business/ Self-employment	19	5.15	29	7.86
Agricultural labourer	0	0.00	6	1.63
Off farm labourer	1	0.27	1	0.27
Skilled labourer	9	2.44	4	1.08
Fisheries/ Animal husbandry	0	0.00	5	1.36
Total	369	100	90	24.40

Source: Authors' Survey Data, 2011

3.1.5 Land Availability and Land Use Pattern

Land is the most important and limited factor in Agriculture. About 47 percent of the total land area of the beneficiaries are belongs to lowland and 53 percent is highland. Almost 97 percent of the land parcels are located within the village. Distribution of land extent according to size class is described in Table 3.5.

Table 3.5: Distribution of Land Extents According to Size

Range of land extent(ac)	Lowland		Highland	
	Total extent (ac)	% of total lowland	Total extent (ac)	% of total highland
<0.25	0.45	0.06	3.15	0.42
0.25-0.5	15.00	2.03	17.00	2.28
0.5-1	92.60	12.53	115.50	15.46
1-2	194.75	26.36	247.00	33.07
2-5	330.50	44.73	277.25	37.12
>5	105.50	14.28	87.00	11.65
Total	738.80	100.00	746.90	100.00

Source: Authors' Survey Data, 2011

In study areas, 45 percent of the lowlands of the beneficiaries are 2-5 ac in extent while 37 percent of the highlands belong to the category of 2-5ac. When considering the highlands and lowlands together, almost all beneficiaries are holding more than 0.5 ac of land extent. Single owner owns more than 68 percent of the lowland plots and rest are operating their lowland under some kind of tenurial arrangements including share tenancy, mortgage and encroachment (Table 3.5). About 78 percent of the highlands are under single ownership while, 11 percent are operated by encroachers. Distribution of land according to ownership categories is in Table 3.6.

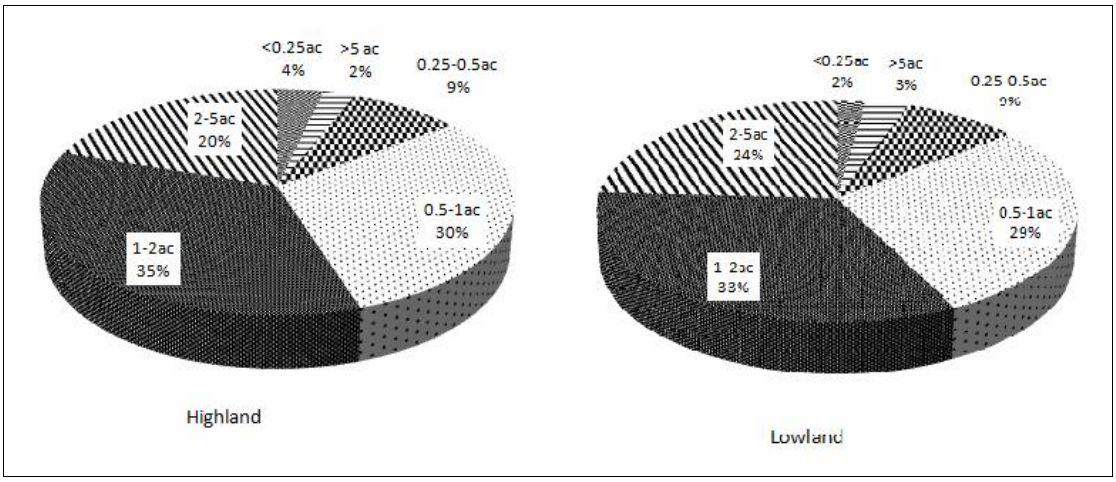
Table 3.6: Distribution of Land by Ownership in Sample Area

Type of ownership	Lowland		Highland	
	Extent (ac)	%	Extent (ac)	%
Single owner	503.30	68.17	580.65	77.74
Tenancy	119.50	16.19	13.00	1.74
Lease/mortgage in	33.00	4.47	7.75	1.04
Lease/mortgage out	14.00	1.90	3.25	0.44
Encroached land	34.00	4.61	83.25	11.15
Permit holder	20.00	2.71	31.00	4.15
Nindagam land	10.00	1.35	20.00	2.68
By kingship	4.50	0.61	8.00	1.07
Total	738.30	100.00	746.90	100.00

Source: Authors' Survey Data, 2011

Figure 3.3 illustrates the percentages of land holdings (based on number of holdings) under different land sizes. Nearly 11 percent of lowland and 13 percent of highland holdings are in the category of less than 0.5 ac, while 27 percent of lowland and 22 percent of highlands are in the land size class of over 2 ac extent.

Figure 3.3: Land Distribution Based on Number of Land Holdings



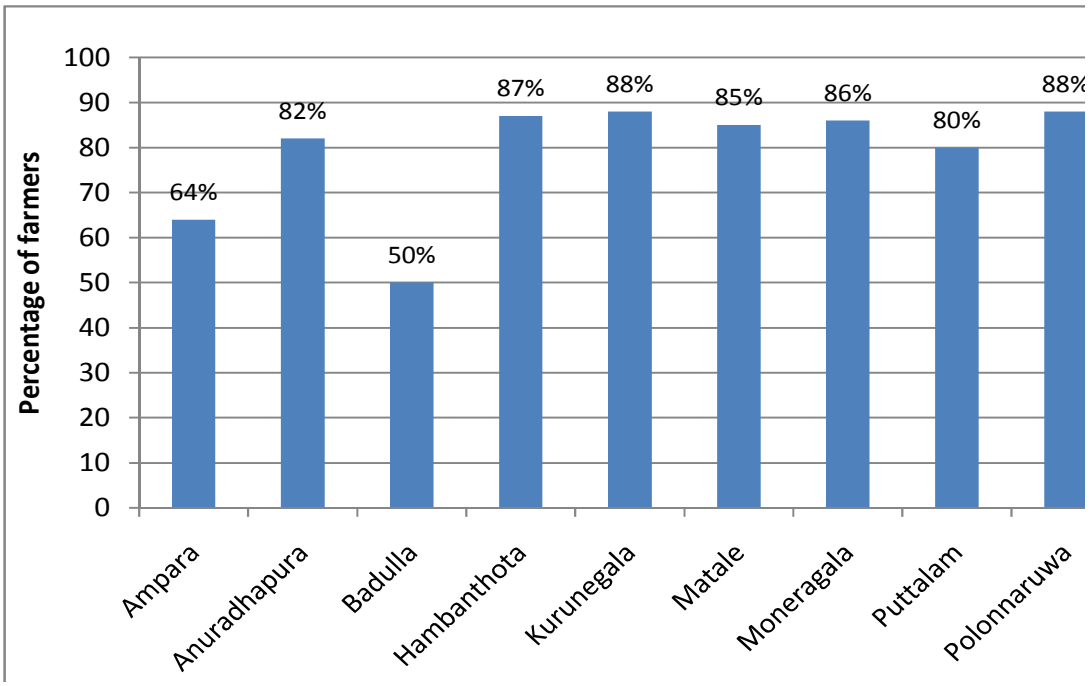
Source: Authors' Survey Data, 2011

3.2 Accomplishment of Proposed Criteria in the Selection of Beneficiaries

According to the project proposal, the eligibility of a farmer to own a solar power drip irrigation system will be decided by the Ministry of Agriculture based on the following selection criteria; a) Fulltime involvement in farming b) resident in the target area c) Owns more than 0.5 ac of land d) Owns an agro-well built that can deliver 6000 to 7000 litres of water per day. The achievement of these requirements at the field level is discussed in following section.

According to the above mentioned beneficiary selection criteria, a drip system receiver should be a full time farmer. Survey results (Figure 3.4) shows that, more that 80 percent of the system receivers are full time farmers except in Ampara and Badulla districts. The rest of the beneficiaries are mainly government sector employees or involved in self employment/ business related activities as their primary employment.

Figure 3.4: Percentage of Full Time Farmers in the Sample Area



Source: Authors' Survey Data, 2011

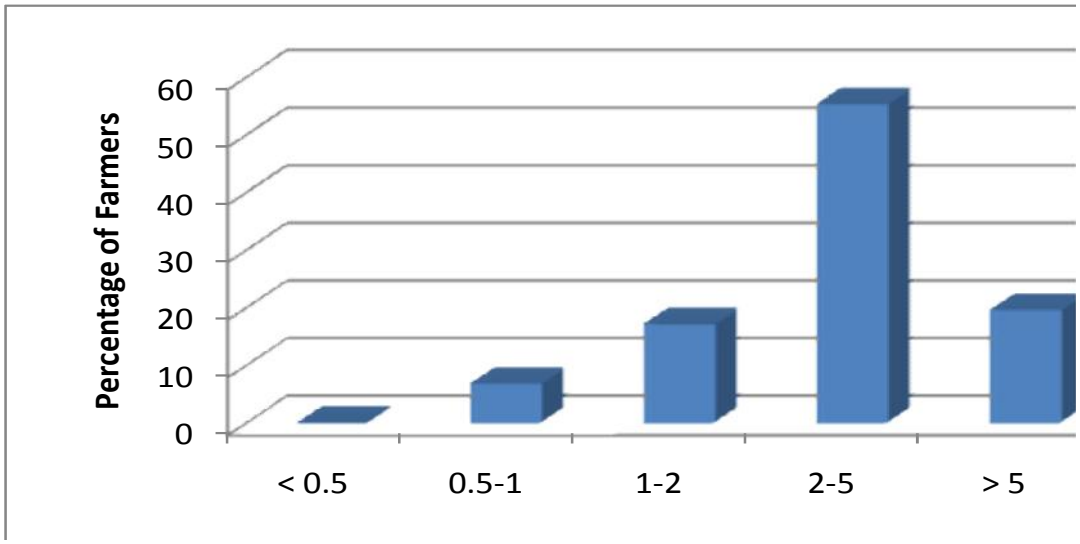
Another requirement to qualify to be a solar drip irrigation system beneficiary is that farmer should be a permanent resident in target area. The finding of the study shows that almost all the farmers in project areas have met this criterion.

Another basic criteria proposed in selecting beneficiaries for the solar powered drip irrigation project was having own land. A farmer should own not less than 0.5 ac extent of cultivable land to be eligible to receive a drip irrigation system. However, the findings show that about 87 percent of the total farmers have more than 0.5 ac of

lowlands and more than 95 percent farmers have more than 0.5 ac highland extent. Land distribution among beneficiaries is illustrated in the Figure 3.5.

More than 55 percent of the beneficiaries had 2-5 ac of land (lowland and highland together). Of the total sample there is only one person, who owned less than 0.5 ac of land.

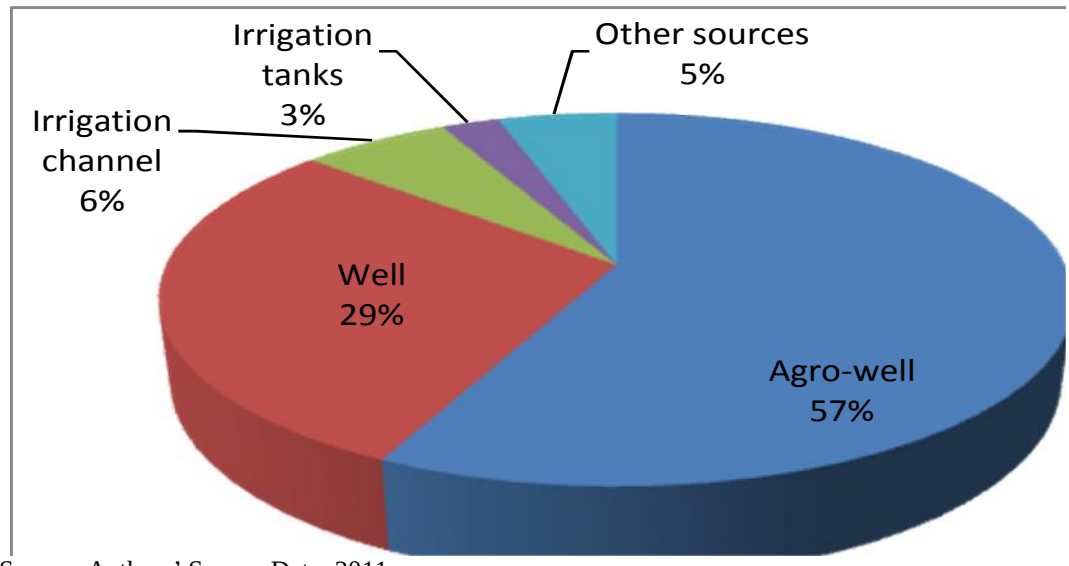
Figure 3.5: Land Distribution among Beneficiaries



Source: Authors' Survey Data, 2011

The source of water for drip irrigation system used in the study area is presented in Figure 3.6. Only 57 percent of the drip system holders own agro-well for the use of drip system. Another 29 percent used their domestic wells to supply water for the system.

Figure 3.6: Water Source for Solar Powered Drip Irrigation System

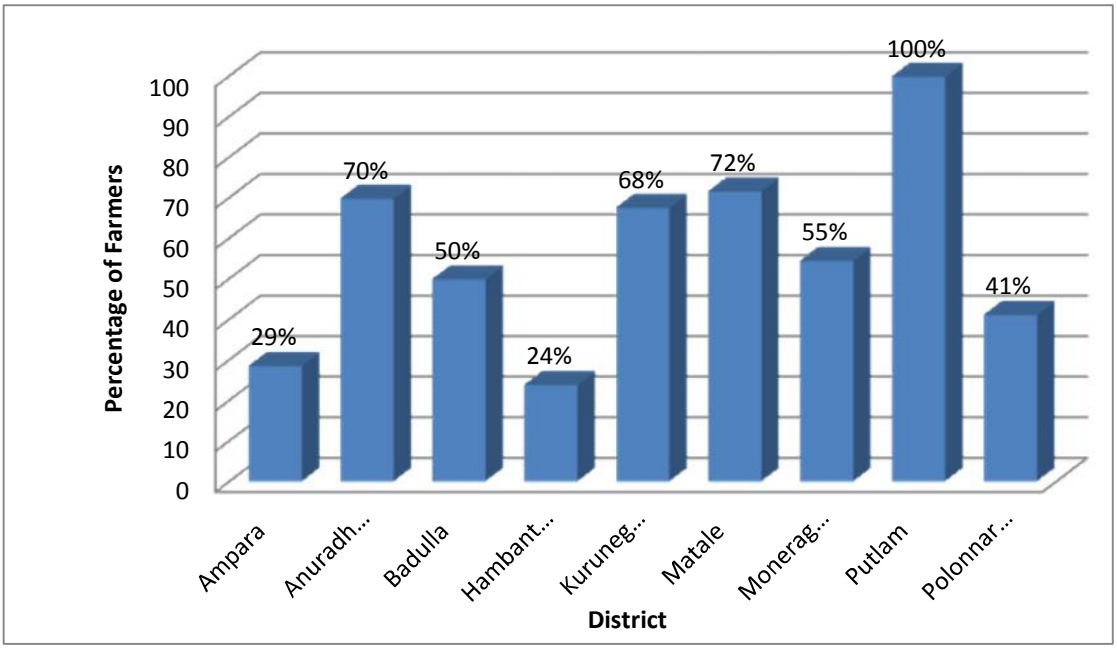


Source: Authors' Survey Data, 2011

Out of the total agro-well holders, 70 percent said that they have sufficient water to pump throughout the year and 28 percent said that they experienced water scarcities during certain period of the year. About 58 percent of the domestic well users expressed that they have enough water around the year to use for drip systems.

Another condition set by the project to qualify to receive SPDI system by a beneficiary is non- availability of grid electricity in the agriculture field. The findings show that abut 60 percent of the sample population had no accessibility to grid electricity at the time of project intervention and 72 percent of the beneficiaries have used or are using kerosene or other fuel to lift groundwater.

Figure 3.7: District wise Distribution of the Agro-wells



Source: Authors' Survey Data, 2011

3.3 Accomplishment of Roles and Responsibilities of the Project by Stakeholders

This section assesses the achievement of different roles and responsibilities entrusted to the three main stakeholders of the project; Ministry of Agriculture, BP Solar Company and the beneficiaries.

3.3.1 BP Solar Company

One of the responsibilities of the company is field installation of SPDI systems by appointing suitable technical staff who can instruct farmers on operation and maintenance of the system. The company also needs to provide maintenance manual in the local language of the respective beneficiary. Survey findings show that 96 percent of the drip systems have been established in the field by the technical staff of

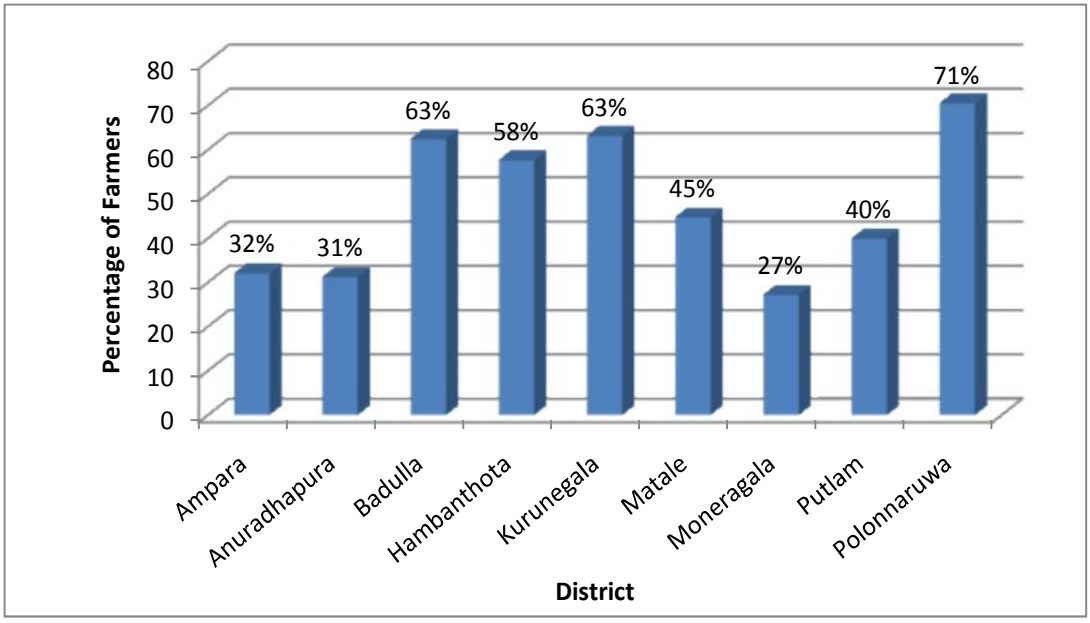
the BP Solar Company, 3 percent are installed by farmers themselves and one percent of the systems are yet to be installed even after seven years of project implementation.

This drip irrigation system being a new technology to farmers, initial awareness was needed. About 88 percent of the sample beneficiaries were given basic instructions about usage and operation and maintenance of the system. More than 98 percent of the farmers obtained instructions from the BP Solar company officials and others acquired awareness from AI and officers in the ASC.

Regarding the provision of instructions to farmers on O&M, only 27 percent of the beneficiaries had received the maintenance manual in their native language. Out of the total number of manual receivers, 81 percent had read the manual and 94 percent had expressed that manual was useful to them giving some knowledge on designing the spacing between two crops and selecting suitable crops and maintenance of the system.

According to the agreement signed between the Ministry and the company, all maintenance activities in the first three years after the installation is the responsibility of the BP Solar Company free of charge. Out of 369 total sample, 136 drip irrigation systems had to be repaired within the three year warranty period. 94 percent of the farmers who needed some repair during the first 3 years, had informed the maintenance requirements to the BP Solar technical officers and more than 75 percent of them had get the service from the BP Solar technical officers within one week after the company was informed. According to the agreement all maintenance activities should be attended free of charge within 3 years warranty period, but 24 percent of the farmers had paid maintenance fee during that period.

Figure 3.8: Percentage of Farmers who were Aware of the Service Centre



Source: Authors' Survey Data, 2011

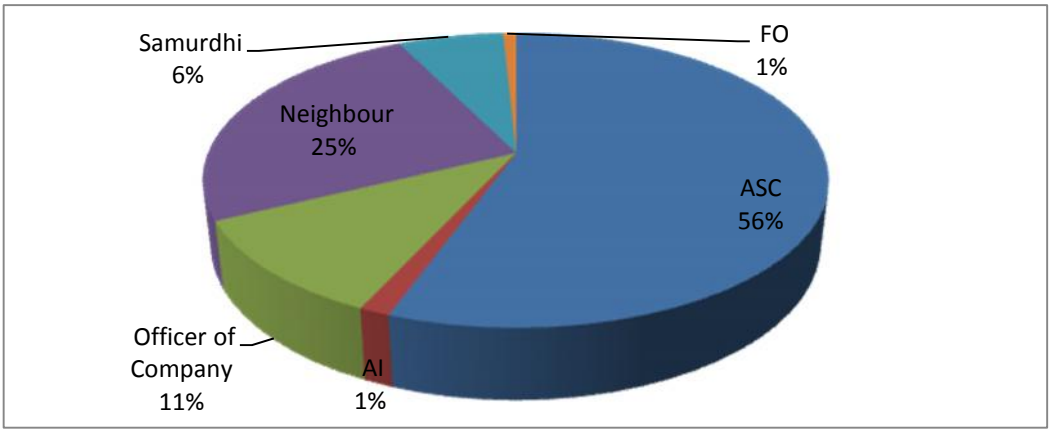
As mentioned in the section 1.3.2, the company has to ensure proper maintenance support and availability of spare parts at local level by setting up of local level service centers. It was reported in the field that the number of service centers established was not sufficient to provide convenient services to the beneficiaries. For example, one service centre functioned in Bibile area in Moneragala district to cover the beneficiaries in Moneragala, Badulla and Ampara districts. Some of the service centers established reported to have not regularly functioned and not accessible over the phone to make inquiries by the farmers. Figure 3.8 illustrated the percentage of beneficiaries who had any awareness about the availability of local level service centre. On average 47 percent of the sample population had awareness about the existence of local service centre. Most of the farmers, (more than 90 percent) were aware of the availability of technicians and spare parts in the service centre.

3.3.2 SAWMP or Ministry of Agriculture

Ministry of Agriculture Development and Agrarian Services has agreed to take several measures for the successful implementation of solar powered drip irrigation project which are discussed in section 1.3.3.

One of the tasks of the Ministry is to create awareness on project among the farmers. Figure 3.9 present the mode of awareness of the sample farmers. More than half of the total beneficiaries had gained awareness through the officers attached to Agrarian Services Centers (ASC) in the relevant area, which is the local level institution of the Ministry of Agriculture Development and Agrarian Services. Another 25 percent of the farmers had come to know about the project from the neighbouring farmer who had benefitted from the project. It should be noted that, about 51 percent farmers in Matale and 37 percent of the farmers in Kurunegala district had received information on this project through neighbours, indicating the low level of participation of the line agency in promoting the project. Sales agents of BP Solar Company had promoted solar powered drip irrigation system and selected the beneficiaries without considering set criterion in some project areas especially in the districts of Ampara, Moneragala and Polonnaruwa, though it is not their job.

Figure 3.9: Mode of Awareness about the Project



Source: Authors' Survey Data, 2011

At the initial stage, Ministry or other authorized line agency officers have the responsibility of providing knowledge on cost of the system, mode of payment, size of the initial down payment and the installment and other conditions of the project to the farmers. About 40 percent of the beneficiaries were aware that down payment was Rs.5000 and remaining cost had to be repaid through biannual payments in 20 installments after six months grace period. However, about 24 percent of the farmers were informed by BP Solar Company that, the size of initial down payment was Rs.1000 and remaining amount had to be paid on installments. About 9 percent of the sample population had informed that the condition of buying drip system was that they had to pay only Rs.5000. About 7 percent beneficiaries perceived that they were informed that the payment was only Rs.1000 for the system and nothing was mentioned about installments. The results indicate the dilemma of external interventions by some other parties (politicians and BP Solar Company) in promoting SPDI systems other than relevant government officials. The impact of these kinds of attitudes is continuously reflecting in phase 2 of the project as well and seriously hampering the recovery of the installments.

Selection of suitable beneficiaries is the most important component of the project as it determines the success level of the project. Apart from the criterion to be followed in selecting beneficiaries as describe in previous selection, there are other requirements to be fulfilled by the officials of the line agency in beneficiary selection. The officers have to make a field inspection of the beneficiary farmers to identify the feasibility of the location to adopt drip irrigation technology and the feasibility of the water source available for the lift irrigation.

According to the study findings, land and water source feasibility was not strictly followed by the ministry or line agency. About 51 percent of the farmers responded that the suitability of water source was not assessed prior to selecting the beneficiary farmer. In Hambanthota district, only 10 percent of the field sites had been inspected to find out the feasibility of the available water source.

The Ministry of Agriculture has agreed to provide crop recommendations for the drip irrigation farmers through the DOA, introduce a programme to ensure the provision of timely and quality supply of seeds and planting materials and other necessary inputs to selected farmers. Only 15 percent of the farmers had received training or guidance and recommendations from the related government officers regarding cultivation of crop under drip irrigation. Seeds and planting materials from the DOA have been received only by 8 percent of the beneficiaries. These results indicate that the particular roles and responsibilities entrusted to the Ministry of Agriculture have not been fulfilled.

The task of preparing a work plan to monitor the progress of the project at divisional, district and the ministry level by the Ministry of Agriculture has not been realized. Another agreed responsibility by the Ministry to facilitate the forward purchasing agreement for the marketing of products of drip irrigation farmers and setup an insurance scheme for the provided drip systems also have not been executed.

3.3.3 Beneficiary Farmers

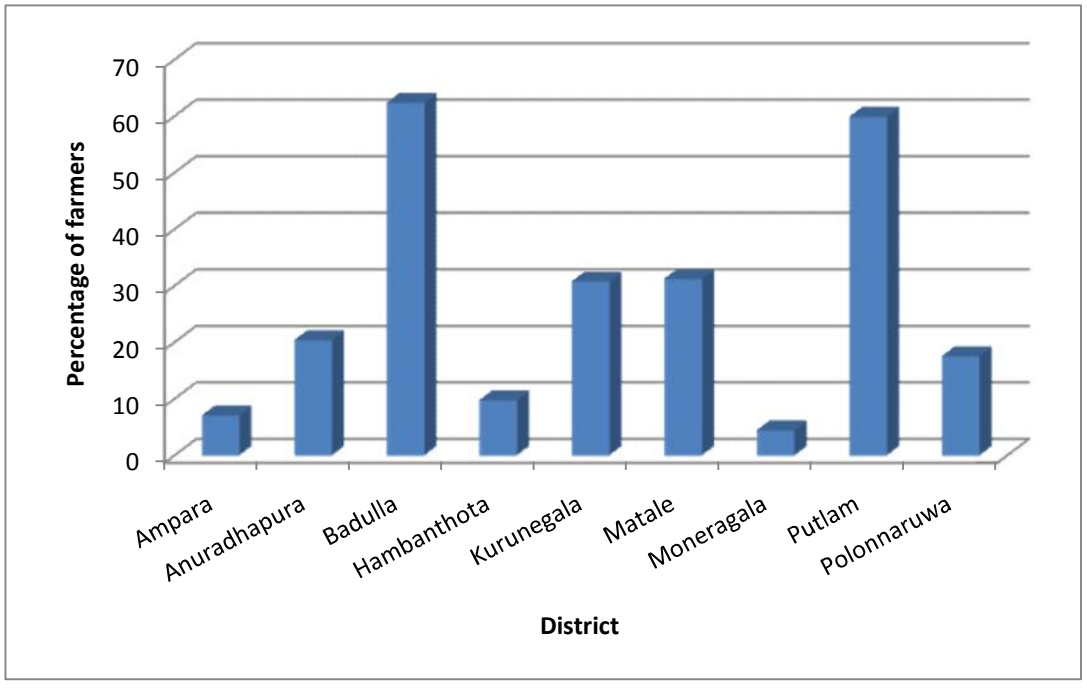
Beneficiary farmers are the other key stakeholders of the project. Agreement between farmers and the Ministry of Agriculture was signed for the cost recovery arrangements.

3.3.3.1 Repayment of Loan

Research findings provide evidence that 78 percent of the sample population had been aware of the conditions stipulated in the agreement before signing it. In the interviews with the farmers, they said that they did not read the agreement before signing as it was a bulky document and no enough time was given to read it.

Even though farmers were aware of the repayment conditions at the time of receiving it, cost recovery percentage of the project was very poor. Only 80 out of 369 beneficiaries (21 percent) paid any installment or part of the installment after the down payment. Figure 3.10 illustrate the percentage of sample farmers who had paid an installment other than the down payment. Except in Badulla and Puttalam districts, payment of installments in other districts was very poor.

Figure 3.10: Percentage of Sample Farmers Who Paid an Installment



Source: Authors' Survey Data, 2011

Relationships between the farmers' knowhow about the repayment conditions and the actual payment made by the beneficiary are shown in Table 3.7.

Table 3.7: Farmers Knowhow about the Repayment Conditions and the Payments Made

Repayment condition informed to the beneficiary	Total	Stay behind the informed condition (Number of Beneficiaries)	
		Yes	No
Initial payment Rs.5000 and the balance in twenty equal installments	126	32	94
Payment of Rs.5000 only as initial down payment	34	2	32
Payment of Rs 5000 with initial payment of Rs.1000 and remaining Rs.4000 by installments convenient to beneficiaries	47	11	36
Initial down payment Rs1000 and remaining total amount in installments convenient to beneficiaries	127	23	104
Payment of Rs.1000 only as the initial down payment	26	2	24
Other	9	4	5
Total	**369**	**74**	**295**

Source: Authors' Survey Data, 2011

Even though 126 farmers had the knowhow about the actual repayment terms, only 32 had paid any installment. Out of these 32 farmers, 23 farmers had paid total amount of Rs.1000-5000 as total installments at the time of survey. Repayment trend was poor among the farmers who had informed the repayment term as they had to pay only the initial down payment of Rs.5000 (Table 3.8)

Table 3.8: Number of Farmers Who Adhered the Informed Repayment Conditions and the Total Amount of Installments Paid Until 2010

Repayment condition informed to the beneficiary	Total value of installments paid during 2005-2010				Total farmers
	< 1000	1000 - 5000	5000 - 10000	10000 < 100000	
Initial payment Rs.5000 and the balance in twenty equal installments	3	23	3	3	32
Payment of Rs.5000 only as initial down payment	1	1	0	0	2
Payment of Rs 5000 with initial payment of Rs.1000 and remaining Rs.4000 by installments convenient to the beneficiary	2	9	0	0	11
Initial down payment Rs1000 and remaining total amount in installments convenient to beneficiaries	0	22	1	0	23
Payment of Rs.1000 only as the initial down payment	0	2	0	0	2
Other	0	4	0	0	4
Total	**6**	**61**	**4**	**3**	**74**

Source: Authors' Survey Data, 2011

Table 3.9: Repayment Pattern of Loan Installments by Districts (Number of Beneficiaries

District	Total value of installments paid during 2005-2010				Total Number of paid beneficiaries	Total number of beneficiaries
	Rs <1000	Rs.1000 - 5000	Rs.5000-10000	Rs. 10,000 <100000		
Ampara				1	1	28
Anuradhapura	1	15			16	83
Badulla		5			5	8
Hambanthota		5		1	6	71
Kurunegala	1	17	2		20	68
Matale	4	17	0		21	67
Moneragala		1	0		1	22
Puttalam		1	1	1	2	5
Polonnaruwa		1	1		2	17
Total	**6**	**67**	**4**	**3**	**74**	**369**

Source: Authors' Survey Data, 2011

3.3.3.2 Reasons for Nonpayment

Table 3.9 shows the repayment pattern in study districts. Pattern of repayment shows that, over 95 percent of the beneficiaries who had paid an installment have paid between Rs.1000-5000. The number of beneficiaries who paid any installment did not exceed 20% of the total beneficiaries. Continuous repayment was not reported in any locations.

During the last 4 to 5 years of the project implementation, not a single farmer in the sample population had continued the payment of installments. Farmers have many explanations to justify their strand of non payment of installments.

i. Full drip irrigation system is used up to date by only 5 percent of the sample farmers, hence expected level of success cannot be achieved without using the full system.
ii. Although the famers had experienced increase in farm income due to adoption of SPDI system, the additional income generated from the drip irrigation system was not sufficient to pay the huge capital cost.
iii. About 26 percent of the farmers declare that they do not want to pay the installment because others are not paying. It was observed in the field that the beneficiaries have some kind of understanding and harmony for nonpayment of the installments.
iv. Paying over Rs. 350,000 for SPDI system is not worth at all compared to other farm machinery cost such as two wheel tractors, farm thresher, water pump etc.

Most of the farmers think or assume that there is no real need of repaying the total cost due to various reasons. About 17 percent of the beneficiaries believe this is a project implemented by the government as they did in the past to uplift the livelihoods of the rural people. Therefore, this is a welfare investment and there is no need of repayment. Another 12.5 percent of the farmers were misguided by some local level politicians that this project is a grant from the Australian government for the poor Sri Lankan farmers and therefore repayment is not necessary. Some other farmers expect that although this project is given on repayment basis, after a certain period of time government will write-off this loan as the past governments did for agricultural loan. Further, some local politicians also instruct the people not to pay the installments to gain cheap popularity and people think that they are not committed to repay the cost.

The other explanation for the non payment is that, only around 8 percent of the farmers had decided to obtain systems understanding of the actual use of SPDI systems. About 40 percent obtained the systems because of the small initial down payment and possibility of paying reset on installment basis. Other 24 percent decided to get solar power drip systems because the government and BP Solar company officer convinced them that the SPDI system is a very effective and useful technology. Most of the reason described in this section indicates that there was no real need of system among farmers and therefore they were not willing to repay the cost.

According to the agreement signed between the Ministry and the farmer, if a farmer failed to pay the installments regularly, the line agency officers have the authority to withdraw the system provided. Most of the farmers were not keen in observing conditions in this clause as the system have failed to give expected benefited to them. The officers were also not interested on removing the system from farmers' field as they did not have the facilities to transport the system and there was no space in the office to store the system. The second hand value of the removed system was also low. Therefore non payment of installment is not an issue for the farmers.

CHAPTER FOUR

Performance of Utilizing Drip Irrigation Systems

4.1 Degree of Use of Full Set of Drip Irrigation Systems

The Solar Powered Drip Irrigation (SPDI) system comprised of several parts; solar panel, solar powered water pump, maximum power point tracker (MPPT), fertigation unit, main pipe line and laterals with in-line drippers. The research findings show that, the SPDI systems are being used by the beneficiaries in several ways from full utilization to zero level of utilization. The important function of this system is generation of power by solar panel and supplied to water pump to lift water from groundwater source and distribute the water to a low-pressure drip irrigation system. As there is no rechargeable battery included in the system provided, the water pump runs only during the sunshine hours of the day. Table 4.1 indicates the current status of usage of the SPDI system distributed under phase I of the project. According to the table 4.1 more than 71 percent of farmers have used the SPDI system up to date. However, the usage of complete system for agricultural activities under drip irrigation is marginal (Table 4.2).

Table 4.1: Present Status of Usage of SPDI System

Status	No of farmers (N=369)	% of farmers
Use until to date	263	71.27
Used only during first few seasons	73	19.78
Used until recent past, but not used now	25	6.78
Never used	8	2.17

Source: Authors' Survey Data, 2011

Although, more than 71 percent of farmers used the SPDI system up to date, only 5 percent had used the complete system for agriculture activities. The rest of the users have been utilizing SPDI systems without one or more component.

Table 4.2: Types of Usage of SPDI System

Types of use	No of farmers (N=369)*	% of respondents
Full system is being used	19	5
Full system without fertigation kit is being used	26	7
System is used without drip irrigation components	208	56
Water pump and the pipe system is used to pump water for domestic water needs	72	20
Solar panel is used to generate household electricity	2	1
Not used now for any activities	98	27
Never used	8	2

***** Multiple answers make the total percentage more than 100

Source: Authors' Survey Data, 2011

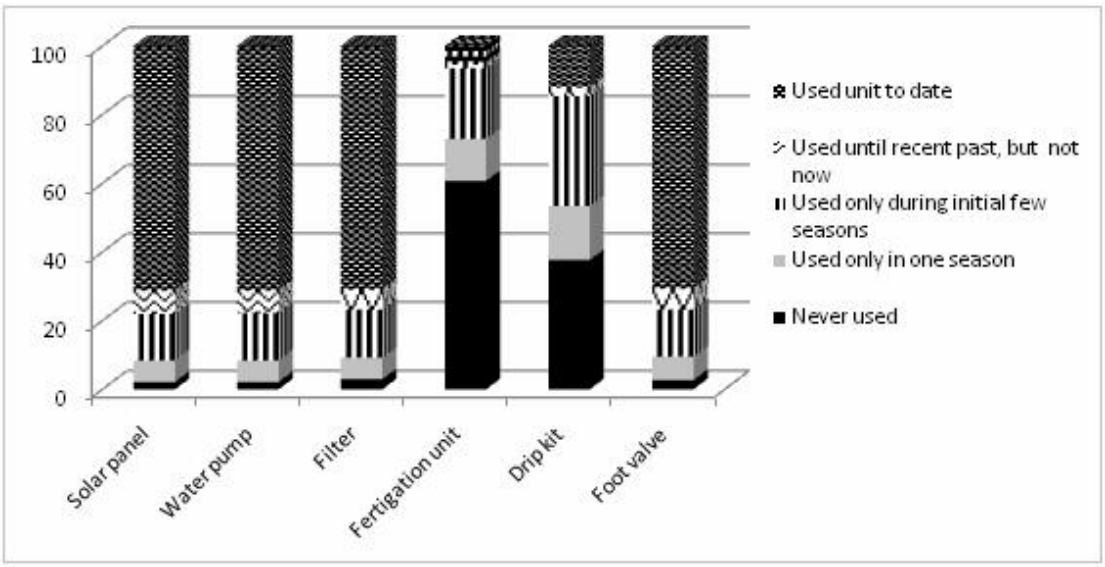
The findings given in the table 4.2 indicates that 80 percent of the SPDI system has been used without drippers until to date, which is beyond the scope of the project. The findings indicate that about 30 percent of the beneficiaries had not used the systems for any agriculture related activities or not used the system at all.

4.2 Use of Different Components of Drip Irrigation Systems

The levels of usage of different components of SPDI system are illustrated in figure 4.1. The findings show that more than 60 percent of the fertigation units supplied with SPDI systems have never been used. Only about 5 percent of the beneficiaries are using the fertigation units provided at the time of survey.

Drip systems with lateral pipes were used only by 12 percent. About 38 percent of the drips with lateral pipes had not been used on any day. The findings indicate the ineffectiveness of the project in achieving its primary objectives by minimizing the water use while increasing cultivable land extent and agricultural productivity. To increases the cultivable land extent and productivity with the available water and other inputs, drippers and fertigation kits should essentially be used.

Figure 4.1: SPDI System Status and Usage (% Percentage of Beneficiaries)



Source: Authors' Survey Data, 2011

4.3 Farmers Awareness on the Use of Drip Irrigation Systems and Training Needs

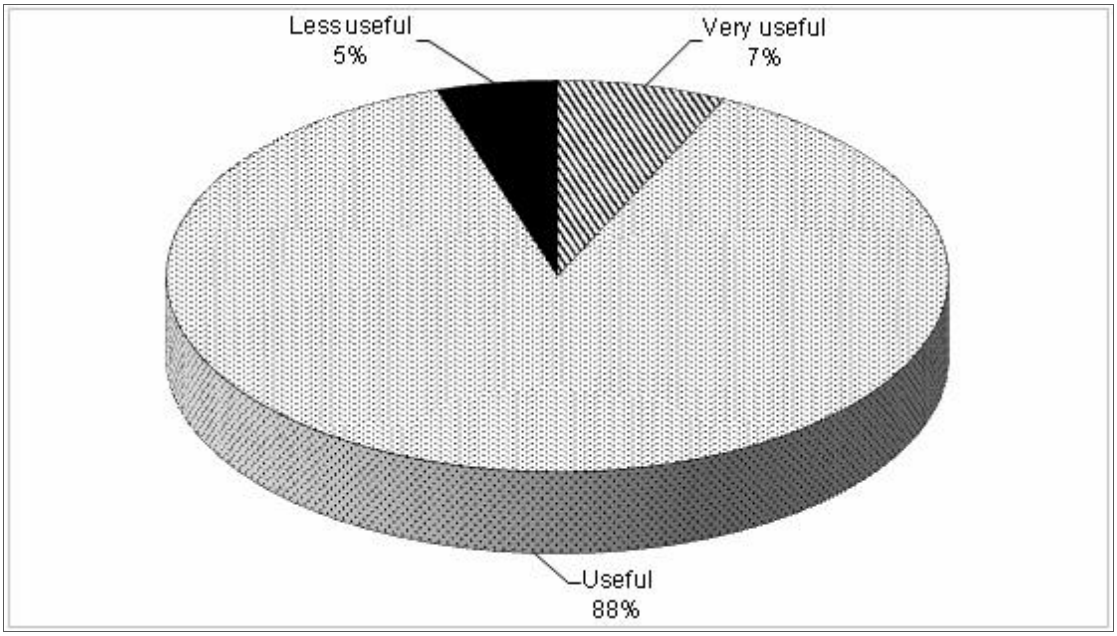
The SPDI package and the components provided to beneficiaries are mostly novel to Sri Lankan farmers. According to the information given by the beneficiaries, the components that are included in the package were delivered, but, the awareness on operation and maintenance (O&M) was lacking.

Nearly 22 and 11 percent of the beneficiaries were unaware of the operation and maintenance of the fertigation unit and drippers respectively. The purpose of given advance irrigation technologies is worthless if the beneficiaries do not understand the mechanism and operations. However, during the survey 88 percent of the beneficiaries stated that they had obtained some guidance and knowledge for the usage, operations and maintenance of SPDI systems from the BP Solar company field officials.

Beneficiary perceptions were obtained on their training needs during the survey. About 43 percent of farmers expressed their training needs. Among the required training, 62 percent requested training on O&M activities of the SPDI system and the rest was interested on crop cultivation using SPDI system.

During the installation period, the company was responsible to provide an O&M manual with the SPDI system to give some awareness on the usage of SPDI system. According to the farmer responses, only 26 percent had received the manual in their own language and 80 percent of them had read it. Usefulness of the manual as perceived by the manual users is shown in figure 4.2.

Figure 4.2: Usefulness of Training Manual Given (Percentage of Manual users)



Source: Authors' Survey Data, 2011

4.4 Operation and Maintenance

Maintenance requirements had arisen for 54% of the farmers in which 72% were within the warranty period. Whenever maintenance requirements encountered, it was farmer's duty to inform the problem directly to BP Solar service centre or relevant officer attached to the ADC or coordinating officer appointed by the Ministry. Table 4.3 shows the mode of complaint and the person informed on maintenance requirement.

Table 4.3: Ways of Informing Maintenance Requirements of the SPDI System

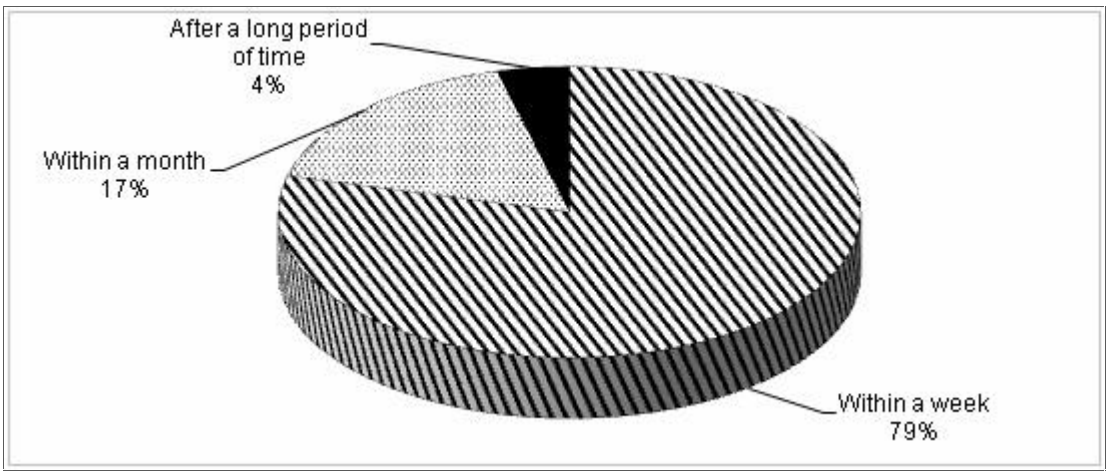
Responses	No of farmers required maintenance or repair (N=195)	% of respondents
Verbally to ADC officials	10	5
To the company field officers or centers verbally or using telephone	173	89
Written complain made to the company	2	1
Not informed to anybody but repaired by farmer himself or neighbour farmer	7	3.5
Not made complain	3	1.5

Source: Authors' Survey Data, 2011

According to the table 4.3, about 95 percent of the relevant beneficiaries had made formal complaints to the company regarding the maintenance/repair requirement, but only 74 percent had received some kind of service from the company though it was an entrusted responsibility of the company under the agreement signed between BP Solar and Ministry of Agriculture. According to the agreement, BP Solar was responsible for any maintenance requirement of SPDI system even after the warranty period as well. This is one of the issues highlighted during the survey which discourage the farmers to accept this kind of new technologies. Therefore, new technologies should be introduced with proper plan, suitable awareness campaign and appropriate backup services.

Figure 4.3 illustrates the time taken to rectify the reported problems of SPDI systems requested by the farmers. Almost one fifth of the farmers stated that time taken to attend the maintenance was quite long which was nearly one month or more. About 22 percent of the farmers declared that they paid for maintenance service even within the warranty period though it was the responsibility of the company. Nearly 50 percent of beneficiaries were not aware of the location and/or contact details of BP Solar service center. The knowledge on the location of service centre, contact person and contact telephone number are important to ensuring proper backup service.

Figure 4.3: Time Taken to Attend the Maintenance Works

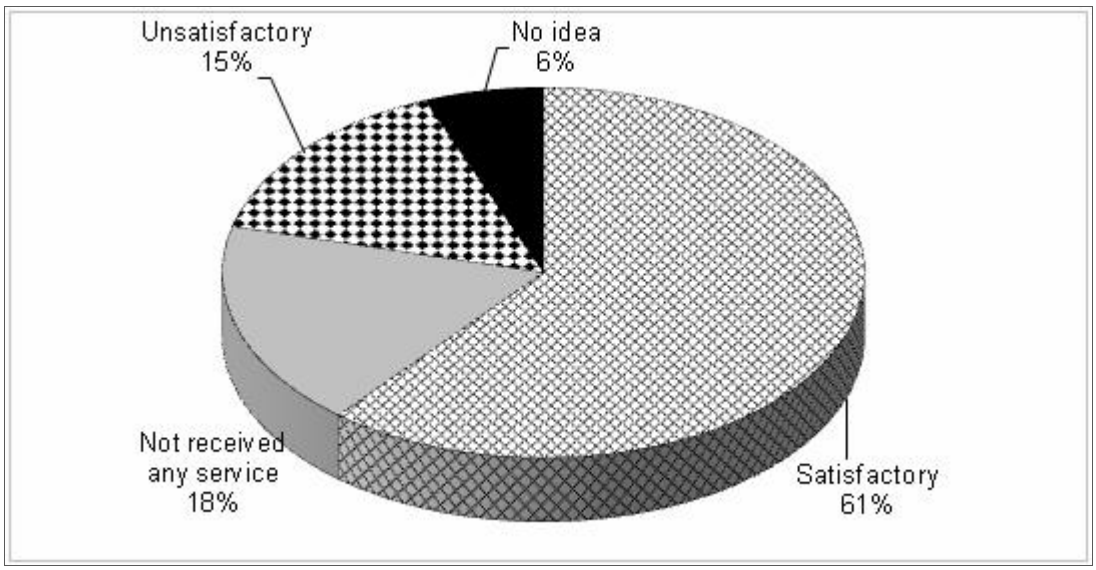


Source: Authors' Survey Data, 2011

It is the duty of the BP Solar Company to provide after sales services and supply necessary spare parts. It has been recorded that the poor after sales services and unavailability of spare parts was one of the reasons for the failure of past interventions made in promoting micro irrigation systems (Aheeyar *et al*, 2005).

Figure 4.4 illustrates the level of maintenance done by the company. About 40% of the beneficiaries had not received satisfactory service or any service during the warranty period from the company though several requests had been made.

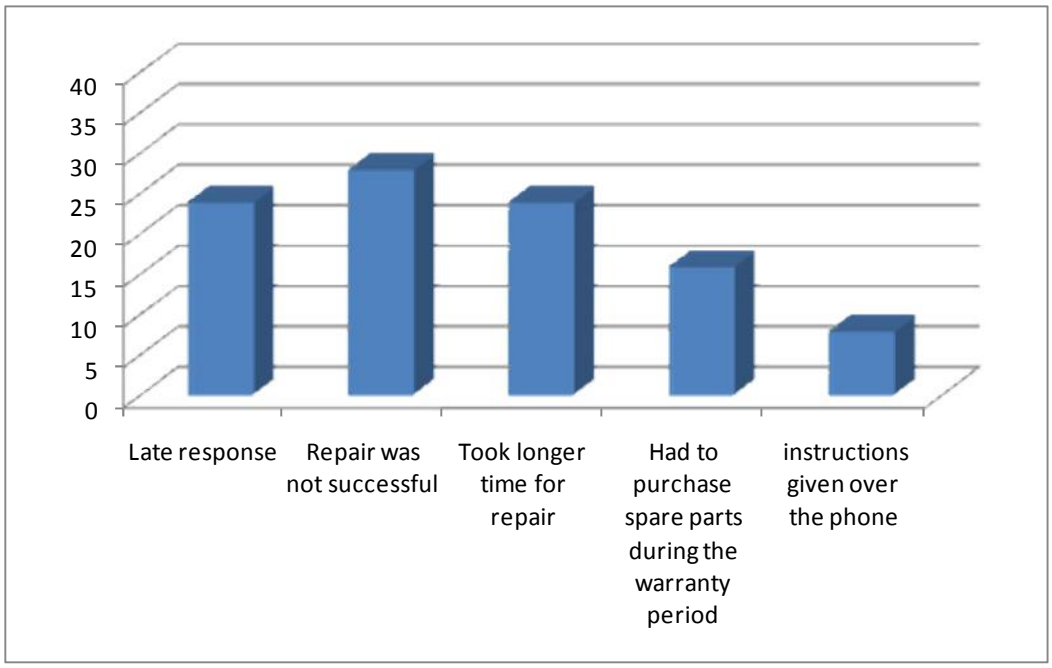
Figure 4.4: Level of Satisfaction about the Maintenance Offered by the Company



Source: Authors' Survey Data, 2011

The reasons for unsatisfactory services of the company as perceived by the beneficiaries are illustrated in Figure 4.5. The experience related to rectification of problems repeatedly by 28 percent farmers raised the question of technical capability of the technician or quality of spare parts.

Figure 4.5: Reasons for Unsatisfactory Services from the BP Solar Company



Source: Authors' Survey Data, 2011

4.5 Reasons for Non Use and Partial Use of Drip Irrigation Systems

Although, SPDI systems contained solar panel, pump, filters, fertigation unit, main line and laterals with inline drippers, most of the farmers used the SPDI system without laterals with inline drippers and fertigation unit. This has been discussed previously in sections 4.1 and 4.2.

Table 4.4: Use of SPDI System Without Drip Set

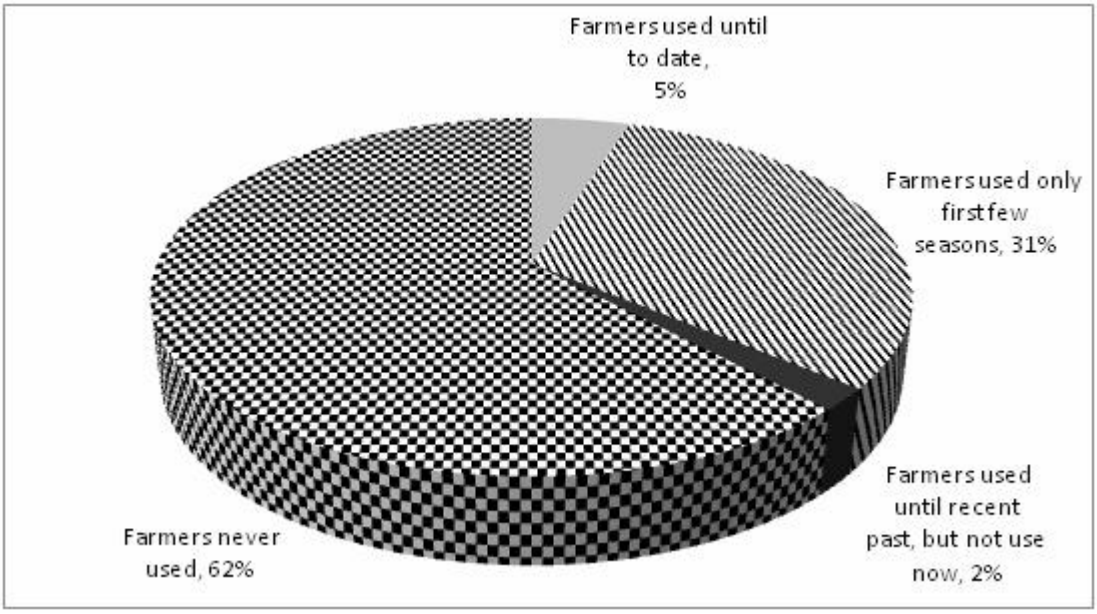
Responses	No of farmers (N=208)**	% of respondents*
Land size is smaller than half acre	37	18
Blocking of drippers	100	48
Difficulties of cleaning the drippers	56	27
Damage of drippers and pipes by animals	29	14
Water supply through drippers is not sufficient for crop	43	21
Drip system in the field is a barrier to perform other agronomic activities	6	3
No water scarcity to use drip system	29	14
Lack of availability of spare parts for the drip system	8	4
Lack of knowledge to use drip system	67	32

*Multiple answers make the total percentage more than 100
**N=208 Farmer's who used SPDI system without drip set
Source: Authors' Survey Data, 2011

The beneficiary, who had obtained the SPDI system under subsidy package, and did not use drippers containing laterals, indicates the non achievement of main objective of the project. Drippers are the element that control the discharge rate in the irrigation and help to save water and enhance the water use efficiency. The table 4.4 shows the reasons for not using drippers and the related accessories.

The major reason for the non use of drippers by 48 percent of beneficiaries was the blocking of drippers. The non use of fertigation unit was other aspect in utilizing SPDI system. About 31 percent (Figure 4.6) of the beneficiaries said they used the fertigation unit only in the first few seasons. More than 62 percent had never used the fertigation unit.

Figure 4.6: Usage of Fertigation Unit



Source: Authors' Survey Data, 2011

Reasons for non use of fertigation unit are given in Table 4.5. About 24 percent of the farmers believed that fertilizer application through fertigation unit was accelerating the blocking or clogging of drippers. It is perceived that the fertigation units are appropriate for liquid type of fertilizer application, but Sri Lankan farmers mostly use solid fertilizers.

Table 4.5: Reasons for Non Use of Fertigation Unit

Status	No. of farmers (N=369)	% of farmers
Clogging of drippers	87	24
Low effectiveness in fertilizers applied through fertigation units	30	8
Not convinced about the application mechanism	64	17
Lack of awareness on methodology of using fertigation unit	30	8
No any special benefit of using the unit	6	2
As drippers are not used, use of fertigation units is not applicable	127	35
Technical difficulties (Some of essential parts are missing)	28	8
Some parts are physically damaged or stolen	3	1
Not received fertigation unit	6	2

* Multiple answers make the total percentage more than 100
Source: Authors' Survey Data, 2011

Most of the fertilizers used by the farmers are granular in form. If it is injected to the irrigation lines, it should be dissolved in the water. Even though the urea and KCl (MOP) are water-soluble compounds, the concentration of those will limit the solubility. According to the literature, only 1g of urea can be dissolved in 1ml of water (Pickering, 1987).

Therefore, the urea solubility decreases when it reaches to the maximum permissible limit of the solubility. In addition, the granular form of fertilizer compounds contain considerable amount of inert materials. Some of the inert materials are deposited as insoluble within the irrigation lines and keep blocking the holes of inline drippers. This problem has to be solved through continuous washing by opening the end caps of the all laterals.

Table 4.6 describes the current status of usage and the reasons for none use of SPDI systems. Over 60% of the farmers who used the SPDI systems in the initial few seasons only, have stop usage mainly due to damage or broken condition of SPDI units or parts. Among the never used category, 32 percent of them had not installed the system yet.

Table 4.6: Status of Usage of SPDI System Vs Reasons for Non Use

Responses	Only first few seasons (N=73)	Used until recent past (N=25)	Never used (N=8)
Handed over to neighbour	0	4	0
Excess water	7	4	0
Difficulties of use	11	0	25
Advantages are not considerable	9	16	25
Parts of the SPDI system were stolen	4	16	0
unawareness of use	0	0	12
Parts of the SPDI systems are malfunctioning or broken	61	56	0
Parts of the SPDI system had been damage by wild animals	5	4	0
No time	3	0	0
SPDI system not installed in the field yet	0	0	38

*N= Status of use of SPDI system
Source: Authors' Survey Data, 2011

According to the findings given in table 4.1 and 4.2, more than 28 percent of the SPDI systems are not being used now. Further, 56 percent of SPDI systems are being used without drippers due to various reasons. The problems and constrains of using SPDI systems are listed in table 4.7.

Table 4.7: Problems and Constrains in the Use of SPDI System

Problems experienced	No. of farmers (N=361)**	% of respondents*
Water discharge rate is not enough during crop growth period	36	10
Water pump pressure is not enough	57	16
Pump is not working during cloudy days/periods	248	69
Clogging of drippers	192	53
Difficulties in field operations	16	4
Need to change the distance between drippers for different crops	12	3
Damage caused by the rodents and other animals	101	28
SPDI system is stolen	12	3
Drippers are unable to wet crop leaves	3	1
Need more time and labour to clean the clogged drippers	35	10
Possibility of crop damage during bright sunshine hours due to high discharge of water	11	3
No any constrains	8	2

*Multiple answers make the total percentage more than 100
**N=Number of farmers used SPDI system without drip set
Source: Authors' Survey Data, 2011

69 percent of beneficiaries had perceived that inability of water pump operations during cloudy days is a constraint in supplying sufficient irrigation for the crops cultivated. Some of the farmers believed that the discharge amount from drippers is not enough during harvesting period for the crops like Papaya, Guava and crop growth period of most of the crops.

Other important problem experienced by the farmers was clogging or blocking of drippers in almost all the locations. Farmers and experts have tried several techniques and chemicals in the past to rectify the problem but without much success. In the dry zone conditions, especially during dry periods, water for animals become as a serious issue. Therefore, the rodents and other domestic animals try to damage the lateral pipe system to access water. Some of the farmers use their traditional knowledge to overcome these types of problem such as keeping water in coconut shells in several places in the cultivation land as a source of water for rodents and other animals.

As the drippers are inline and cannot change the position, there are difficulties experienced by farmers in using drip system of changing the distance between two drippers for different crops. Farmers prefer to have drip system with removable drippers, which are easy to manipulate for spacing and cleaning.

CHAPTER FIVE

Effects and Impacts of the Solar Powered Drip Irrigation Projects

5.1 Impacts of SPDI Project

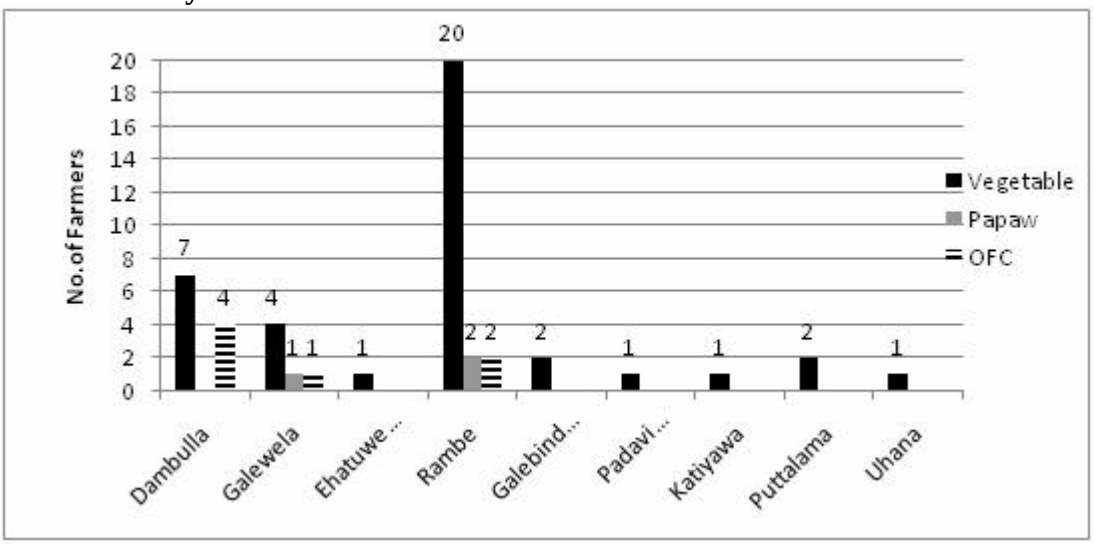
Theoretically the SPDI project is supposed to increase the crop productivity through providing proper irrigation to crops, increase cropping intensity and improve the cropping system. Farmer income is expected to increase through reduced cost of production via saving of labour time, reduced energy cost, fertilizer cost and herbicide cost and utilization of saved labour time for income generating activities.

5.1.1 Cropping System

Out of 369 farmers only 46 (12%) are using drip component for cultivation with or without fertigator. During *yala* 2010 only 39 farmers had utilized the drip irrigation for some kind of cultivation while it was limited to 13 farmers in *maha* 2009/10. Therefore most of the anticipated positive impacts such as water saving, energy saving, labour saving, increased extent of cultivation and productivity of SPDI project are very low. Except Rambe ADC division in Kurunegala District and Dambulla ADC division in Matale district, the number of farmers involved in drip irrigated crop cultivation was very minimal (Figure 5.1 and 5.2). In the divisions of Irakkamam, Weranketagoda, Kawarankulama, Rideemaliyadda, Ambalantota, Meegahajandura, Hakuruwela, Buttala, Makulla and Gal-Amuna, not a single farmer had utized drip component.

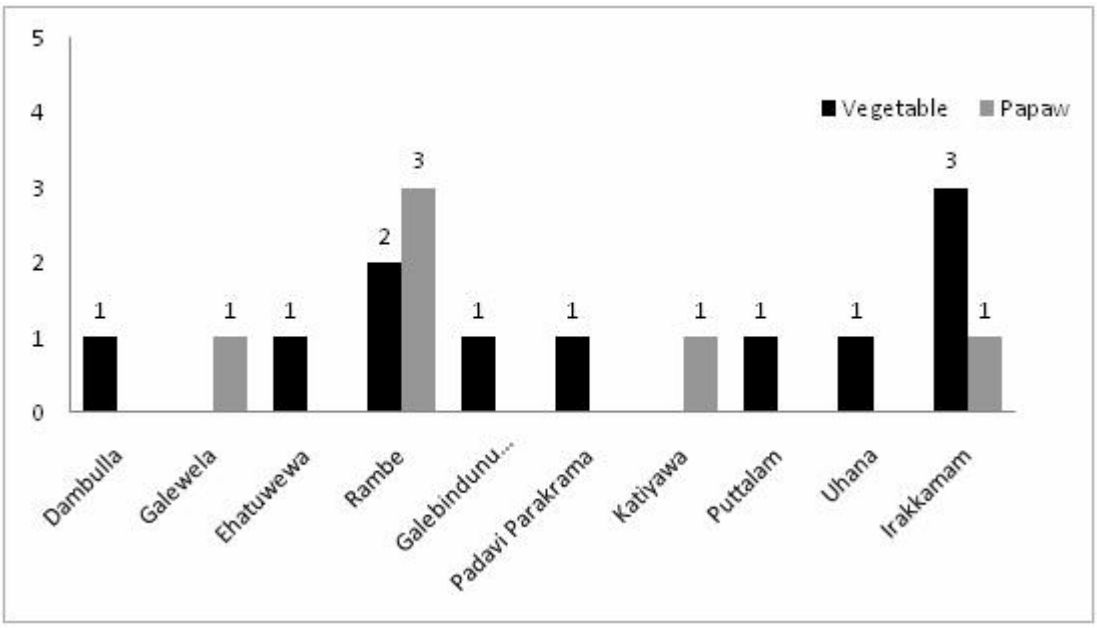
Majority of the drip users had cultivated vegetables followed by Other Field Crops (OFC) and Papaya. One farmer in Galewela was using drip irrigation for coconut and banana cultivation for about 0.25ac extent each.

Figure 5.1: Number of Farmers Undertook Crop Cultivation Using Drip System–*Yala* 2010



Source: Authors' Survey Data, 2011

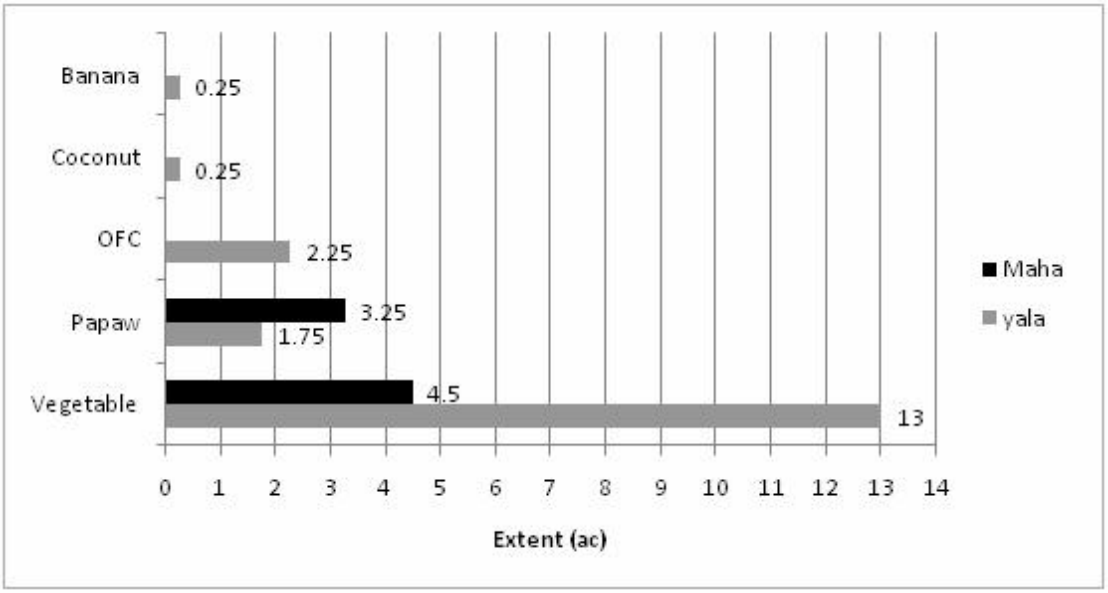
Figure 5.2: Number of Farmers who Undertook Crop Cultivation Using Drip System–Maha 2009/10



Source: Authors' Survey Data, 2011

The total extent cultivated using drip irrigation in *yala* 2010 and *maha* 2009/10 were 7.75 ac and 4.5 ac respectively, but theoretically farmers should have cultivated 184ac in a season if all the sample farmers had cultivated half acre each. Therefore actual cultivated extent was merely 4% of the target area.

Figure 5.3: Total Extent Cultivated by Sample Farmers Using Drip System (In acres)



Source: Authors' Survey Data, 2011

5.1.2 Socio Economic Impacts

Majority of the beneficiaries are not utilizing drip irrigation component of the provided system, but, about 58% of the beneficiaries take advantage of the system for lift irrigation without drips utilizing the water pump and water hose provided (Table 5.1). About 20% of the beneficiaries are making use of the water pump provided to meet the domestic water needs. There is couple of sample farmers using the SPDI system to generate electricity for the household use. However about 25% of the beneficiaries were not using the system for any purpose at the time of survey.

Table 5.1: Types of Usage of SPDI Systems (%of Beneficiary Farmers)

Types of Use	No. of Farmers (N= 369)	% of Respondents
Full system is being used	20	5
Full system without fertigation kit is being used	26	7
System is used without drip irrigation component	216	58.5
Water pump and the pipe system is used to meet domestic water needs	73	20
Solar panel is used to generate household electricity	2	0.5
Not used for any activities at the moment	86	23
Never used	08	2

*Multiple answers make the total percentage more than 100
Source: Authors' Survey Data, 2011

Although the current pattern of utilization of SPDI systems is not within the scope of the project, it has an impact on increasing household income and family welfare by numerous ways as reported by 60% of sample users. Table 5.2 describes the method of income increase by using SPDI system. Reduced cost of production due to less labour time, fuel saving and reduced chemical cost is the most prominent reasons for increased household income. The average amount of money saved due to reduced fuel /electricity use is from Rs. 3300 to 4000 for different type of uses and the average value of labour saving is of Rs. 580 to 618, but for a small percentage of users (Table 5.2 and 5.3). However, about 50% system users with or without the use of drippers have not realized any fuel saving except domestic water users. About 14% of the users have utilized their saved time for income generating activities while another 6% have used the saved time to devote family welfare activities (Table 5.4)

Table 5.2: Value of Energy Saving by SPDI System

Type of User	Average value (Rs)	Minimum	Maximum	SD	No. of people received zero saving
Full system is being used **(N=19)**	3322	300	4,800	1505	10
Full system without fertigation kit is being used **(N=12)**	3495	300	5,000	1560	10
System is used without drip irrigation component **(N= 114)**	3960	300	7,000	1025	62
Water pump and the pipe system is used to meet domestic water needs **(N= 46)**	3585	300	5,000	1404	5

Source: Authors' Survey Data, 2011

Table 5.3: Value of Labour Saving by SPDI System

Type of User	Average value (Rs)	Minimum (Rs)	Maximum	SD	No. of users received zero saving
Full system is being used **(N=02)**	600	600	600	0	16
Full system without fertigation kit is being used **(N=02)**	600	600	600	0	20
System is used without drip irrigation component **(N= 25)**	584	600	700	125.76	150
Water pump and the pipe system is used to meet domestic needs **(N= 11)**	618	600	700	40.45	41

Source: Authors' Survey Data, 2011

Table 5.4: How Household Income Increased by Solar Powered Drip Irrigation Systems? (% of Beneficiary Perception)

Reasons	No. of farmers (N=358)	Percentage of farmers
No income change	147	41
Reduced cost of production	133	37
Increase in yield	77	21
Use of saved time for income earning activities	50	14
Shifting to high income crop	5	1
Increase of extent cultivated	4	1
Increase in quality of the product	2	0.5

* Multiple answers make total percentage of responses more than 100
Source: Authors' Survey Data, 2011

5.1.3 Environmental Impacts

Use of complete drip system was expected to provide numerous environmental benefits namely improved water management, reduced soil erosion, protect groundwater, effective application of fertilizer and reduced health risk exposure (Toxic fumes etc). However, as only 5% and 12% of the users have adopted fertigation kits and drip system respectively, the anticipated environmental impacts are negligible other than reduced use of fossil fuels and hydro electricity for water lifting (Table 5.2). Another environmental impact of the project is reduced use of fertilizers and agrochemicals by 17% of the users (Table 5.5).

5.1.4 Gender Impacts

About 75% of beneficiaries are utilizing the SPDI system for one or more purposes related with water and irrigation. Use of the system for irrigation with or without drippers has an impact on women's time spent in the field. The use of the system to supply domestic water needs by 20% of the beneficiaries has a direct impact on women and child welfare and leisure time because in most of the families they are the main water carriers. Use of drip system has made reduced involvement of women in weeding, fertilizer application and other agricultural involvement. Some of the women have used the saved time for income earning activities, leisure, child welfare and social activities.

5.2 Benefits of Solar Powered Drip Irrigation Project

The major benefit of the project as expressed by 81% of the beneficiaries is reduced energy cost of pumping water as a result of the use of solar energy. Availability of water pump also helped to reduce the labour time requirement for irrigation. Although only 12% of the beneficiaries are using drip component, 23% of the beneficiaries accept that use of drip system help to save water. A similar trend of higher beneficiary perception for various benefits of SPDI was recorded than the number of current actual users. This is mainly due to reduced number of beneficiaries over the time with

difficulties experienced in using SPDI system, breakdowns, and maintenance issues and various other drawbacks discussed in the following section. A detail description of the benefits experienced by the beneficiaries is listed in table 5.5.

Table 5.5: Advantages of Using SPDI Systems (%of Currently Using or Earlier Used Farmers)

Advantages	No. of Farmers (N= 361)	% of Respondents*
Reduced energy cost (fuel/electricity expenditure)	291	81
Reduced labour time	224	62
Water saving	82	23
Increase of crop yield	69	19
Increased household income	63	17
Low requirement of fertilizers/agro chemicals	61	17
Supply of domestic water	62	17
Increase quality of yield	40	11
Use of the Main water hose to irrigate remaining area after fulfilling the water needs of dripped area	44	12
Cultivation of cash crops	28	8
Enhanced family welfare	20	6
Brick making	7	2
No impact	7	2
Supply of water to upland paddy field	4	1
Supply of water for livestock	3	1

*Multiple answers make the total percentage more than 100
Source: Authors' Survey Data, 2011

5.3 Drawbacks of Solar Powered Drip Irrigation Project

Although the major barrier of using SPDI systems as perceived by farmers is under performance or nonfunctioning of water pump during the cloudy period/days due to insufficient solar power, the main issue we observed in the field related to use of drip system is poor quality of drip pipes and nozzles provided by the project compared to the entire system. The nozzles are fixed type and difficult to clean. A chemical to clean the blockage in nozzles was introduced only in 2010, but it is also reported to be not effective and difficult to practice. Rubber based drip pipes are easily damaged by rodent animals and giant ants. This is one of the major reasons discouraging beneficiaries not to use the drip pipes and use the system to supply irrigation through the main hose without drippers. About 15% of the beneficiaries believe that water supplied by drip system is not sufficient at plant growth stage, though it is not scientific.

Table 5.6: Barriers in Using Solar Powered Drip Irrigation Systems (% of Farmer Perception)

Barriers	No. of farmers (N=353)	Percentage of farmers*
Improper functioning of the system on cloudy days	246	70
Blockages occurring in drippers	187	53
Damages caused for the drip system by rodents and other animals	85	24
Insufficient power of the water pump for irrigation	60	17
Insufficient supply of water during crop growth phase	48	14
Need more labour time to clean the drip nozzles	18	5
Difficulties in land preparation/weed control	13	4
Need to adjust the distance between nozzles for different crops	8	2
Problem of theft of the system installed in the field	7	2
No wetting of crop leaves	3	1
Possibility of harming crops due to supply of more water during high intensity sunshine	5	1

* Multiple answers make total percentage of responses more than 100
Source: Authors' Survey Data, 2011

Various reasons expressed by farmers for not using the system at the time of survey is indicated in table 5.7. Around 60% of the non users are having incomplete SPDI system due to lack or non working condition of some of the components. Another 7% of non users have lost their system or parts of the system in the field by theft. Non availability of spare parts and poor post project support services are the main causes for the situation. The answers like not enough advantages using drip system, no need to use drips as sufficient water is available, system is given to a neighbor farmer, no time to use the system and the system is not yet fixed in the field are invariably highlighting the problems associated with selection of suitable beneficiaries.

Table 5.7: Reasons for Not Using Solar Powered Drip Irrigation Systems (% of Farmer Perception)

Reasons	No. of farmers (N=103)	Percentage of farmers*
Some components of the system are broken/ not in working order	59	57
No enough advantages using drip system	14	14
Use of drip system is a difficult task	9	9
Some components of the system were stolen	7	7
No need to use drips as sufficient water is available	6	6
Some parts of the system are damaged by wild animals	5	5
System is given to a neighbor farmer	1	1
Lack of awareness on use of drip system	1	1
No time to use the system	2	2
System is not yet fixed in the field	3	3

* Multiple answers make total percentage of responses more than 100
Source: Authors' Survey Data, 2011

CHAPTER SIX

Conclusion and Recommendations

6.1 Major Findings

1. Socio economic features: About 70% of the targeted beneficiaries belong to the age group of over 40 years. Average family size of the 65% of the beneficiaries was 4-5 members. The educational achievement of 54% of the beneficiaries was up to GCE (O/L) and above.

2. Fulfillment of criteria in the selection of beneficiaries: - Among the farmers only 83 percent had involved in the agriculture as primary employment and the rest were involved in agriculture on part time basis and were not eligible to be beneficiaries. Almost all the farmers were residing in the project area and therefore had met the project criteria. About 57 percent of the drip system beneficiaries owned agro-wells to use for drip system. Another 29 percent used their domestic wells to supply water for the system. Out of the total agro-well holders 70 percent stated that they had sufficient water to lift througout the year while only 58 percent of the domstic well users expressed that they had enough water around the year to use for drip systems.

3. Achievement of roles & responsibilities of solar power company- About 96% of the systems provided have been installed in the field by the company technical staff. Although, the supply of user manuals in local language is the responsibility of the company, only 27% of the farmers had received it in their native languge. Majority of the manual recievers had read the manual and expressed that the manual was useful. About 37% of systems had undergone some kind of repairs within the warranty period, but only 75% of them had received timely service from technical offciers within one week of reported time. Another 25% had paid a fee to the company for their maintenance during the warranty period though it was a violation of the agreement. Service centres established had to cover two to three districts creating diffciulties of access. Further, most of the time the centres were not accessible to farmers even over the phone. Only 47% of the beneficiaries had a know how on the avialablity of a service centre. Capacity builiding of the field level offciers on technical aspects of SPDI system and improved crop production techniques by the company had also not materialised satisfactorily in any areas. About 88% of beneficiaries had received guidance from solar power company officials on how to operate and maintain the SPDI system..

4. Achievement of roles & responsibilities of SAWMP- The message and awareness of the SPDI project had reached to majority of the farmers from the Ministry of Agriculture and its line agencies. However, 44% of the beneficiaries had received had got to know about the project through the neighbour farmers, officials attached to BP Solar company and other sources. The company has reported to be actively involved in promoting and giving false information about the programme bypassing the government authorities in many places. About 24% of the

beneficiaries were informed by the company officials that they had to pay only Rs. 1000 as initial down payment and the rest to be paid on installment basis at their own convenience. Another 7% and 10% of the beneficiaries had been advised to pay Rs. 1000 and Rs 5000 respectively and nothing had been mentioned about installments. Although the ministry or the line agency had to assess the feasibility of land and water resources of the beneficiary farmers, this was not strictly followed. Little more than half of the beneficiaries expressed that their water source was not inspected by the officials prior to delivering SPDI systems. The role of providing quality and timely supply of seeds and other planting materials and other technical advices for drip irrigation by the ministry had also not reached to more than 90% of farmers. The non use of drip system was the major barrier in providing these services.

5. Repayment of Loan - Only about 20% of the beneficiaries had paid any installments after paying the initial down payment, but none of the beneficiaries were making regular payment of installment. The main reasons for the non payment of the installment are; not using the whole SPDI system by 88% of the beneficiaries, failure to generate sufficient income, high capital cost of the system, lack of awareness about the repayment requirements at the time of system delivery, non payment of installments by other farmers, expectation of loan write off from government as the government did for agricultural credits in the past, local political influences for non payment and some other misconceptions.

6. Utilization of SPDI system- Only five percent of the farmers were using complete set of SPDI, while another seven percentage were using the drip system, but without fertigation kit. However 56% of the users were using the solar system without drip component, which is not the scope of the project. About 29%of the beneficiaries were not using the provided system at the time of survey.

7. Nearly 22% and 11% of the beneficiaries lacked awareness of O&M of the system and maintenance of fertigation unit and drippers respectively. About 62% of the farmers requested training on O&M of the SPDI system and method of cultivation using drip irrigation.

8. Operation and maintenance- Maintenance requirements had arisen for 64% of the users, in which three quarters of the requirements were within the warranty period of the product. Majority of the farmers had informed the maintenance problem verbally to either ACS officials or field officers of the company. However only 75% of the beneficiaries had received some kind of service form the company though it was the responsibility of the company within the warranty period and afterwards. About 20% of the service receivers had to wait for more than one month to rectify the problem, while another 21% of the service receivers had paid money for the service within the warranty period. The quality of service provided by the company was not satisfactory for the 40% of users who requested service form the company due to late response, poor quality of the service, longer time taken for the repair, payment for spare parts during warranty period and providing instructions over the phone without visiting to the site. Nearly half of the

beneficiaries were not aware of the location of the local service centre and their contact details.

9. Reasons for the non use or partial use of the SPDI System- The main reasons for the non use of drippers are, blocking of drippers, difficulties in cleaning of drippers, lack of knowledge to drip system, damaged caused to drip lateral pipes by rodents, insufficient water supply from the drippers to crops, small land size and no water scarcity to use drip irrigation.

   The reasons for the non use of fertigation unit are ineffectiveness of drippers, lack of faith on ferigation mechanism, and lack of awareness on the methodlogy.

   The major constraints in using SPDI system as a whole are, non working of pumps during cloudy days/time, clogging of drippers, damages caused by rodents, lack of water pump pressure, difficulties in adjusting drippers space for different crops and insufficient water supply to crops during crop growth periods.

10. Impact on cropping system- Out of 369 farmers only 39 farmers had utilized the drip irrigation for some kind of cultivation during *yala* 2010, while it was limited to 13 farmers in *maha* 2009/10. Therefore most of the anticipated positive impacts such as water saving, energy saving, labour saving, increased extent of cultivation and productivity of SPDI project were very low. The actual cultivated extent under drip irrigation was merely 4% of the total potential area of the all beneficiaries.

11. Socio-economic impact- The using of solar panel and water pump for lift irrigation and domestic water supply and using solar panel for electricity generation are not within the scope of the project. However, these practices have an impact on increasing household income and family welfare by reduced labour time, fuel saving and reduced chemical cost as reported by 60% of sample users. About 14% of the users had utilized their saved labour time for income generating activities.

12. Gender impacts- Use of the system for irrigation with or without drippers has an impact on women's time spent in the field due to less engagement of women in various cultivation practices such as weeding, fertilizer application and other cultural practices. The use of the system to supply domestic water needs by 20% of the beneficiaries had a direct impact on welfare and leisure time of women and children as in most of the families they are the main water carriers.

6.2 Conclusion

1. The non use of drippers by 88% of the farmers indicates the failure of the project in achieving its objectives of water saving, labour saving, enhancing productivity, and environmental conservation. The proper targeting of beneficiaries is a vital requirement to introduce these kinds of advance technologies.

2. The blocking of drippers is the most common constraint and difficulties of cleaning the drippers due to non removable inbuilt nature of the outlet. The quality of the lateral pipes is also reported to be poor in quality compared to the rest of the system. Therefore it is necessary to conduct pilot studies before promotion of new technologies.
3. The solar power company had rendered poor after sales services and had violated the agreement in many occasions which indicates the requirement of suitable terms and condition with well established post monitoring mechanism in working with private sector.
4. Awareness on O&M of the system and the appropriate cultivation using drip system is lacking among farmers. The project should have adequate component to enhance the capacities of the beneficiary farmers and ground level officers.
5. The project has failed in recovering the loan and the similar trend is continuing in the second phase as well. Farmers do not consider the product for the amount that has to be paid though they had signed the agreement with or without knowing the content. This is an indication of lack of transparency in the project implementation.

6.3 Recommendations

1. As the degree of use of SPDI system for the given purpose is very poor and majority of the farmers are not making any payments other than initial down payments, it is not recommended to continue this project without fulfilling following recommendations.
    - i Selection of beneficiaries should be done by the field level officers of the DAD with the supervision of DO and AI. The BP Solar Company should be completely withdrawn from the selection or identification of the beneficiaries, if the field level officers of the SAWMP are responsible for monitoring of the project and recovery of loan
    - ii Alternatively BP Solar company could be responsible for both beneficiary selection and the recovery of loan
    - iii Capacity building of farmers and field level officers should be undertaken by the relevant parties as agreed in the agreement.
    - iv. Farmers should be convinced about the benefits in adopting the technology and there should be appropriate water sources (quantity and quality) and there should also be water scarcity at least during some periods of the year.
    - v. The clause in the agreement signed between the beneficiary famer and the DAD regarding non payment of installments is not strong enough to motivate the famers to honour the agreement. The agreement should be strengthened to make collateral arrangements necessary for the loan granted and provisions to take legal actions against violators.

vi As the blocking of nozzles is very common in most of the areas, there should be some technology for easy cleaning of the nozzles. The inbuilt nozzles and poor quality drip laterals need to be changed to make them user friendly and durable.

2. The introduction of new technologies should be under taken by targeting most suitable beneficiaries and institutionalizing proper backup and after sales supports. The technology should be easily operated and maintained by the rural farmers.
3. A mechanism is needed to monitor the performance of roles and responsibilities of stakeholders in relation to the project implementation.

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