Annals of the Sri Lanka Department of Agriculture 2010. 12: 257-266.

REPORT

ADOPTION OF SOLAR-POWERED DRIP IRRIGATION: A CASE STUDY OF THE SUSTAINABLE AGRICULTURE WATER MANAGEMENT PROJECT IN POLONNARUWA DISTRICT

P. SISIRA KUMARA
Office of the Deputy Director of Agriculture (Inter Provincial) Office, Polonnaruwa, Sri Lanka.

SUMMARY

The modern agricultural technologies are essential to upgrade agricultural production of Sri Lanka. The Sustainable Agriculture Water Management project (SAWMP) promotes drip irrigation technology among dry zone farmers to improve productivity and water use efficiency. An investigation was conducted in Polonnaruwa District of Sri Lanka to evaluate the adoption levels of solar-powered drip irrigation systems that were distributed to selected farmers in the dry zone under a subsidized loan scheme, and constraints faced by the recipient farmers. A sample of 40 farmers (vegetable, other field crops and fruits growers) who received solar-powered drip irrigation systems and a sample of 30 officers (AI, DO and RDAs) were used in the questionnaire survey. The results indicated that 60 % of farmers are utilizing the drip irrigation system for agriculture purposes (irrigation users) while the remaining 40 % are using the system for other purposes (non-users). The estimated Adoption Index was 78% for irrigation users and 53% for non-users. The inadequate capacity to supply the water requirements and clogged drippers were the major reasons for abandoning the system for irrigation. The operating efficiency of the system is directly related with the level of education and farming experience with drip irrigation. The repayment rate of the loan was not satisfactory, which was below 10 %. The results confirmed that the adoption of solar-powered drip irrigation system is not satisfactory among the SAWMP farmers and that the capacity building of farmers is imperative for successful adoption of this modern technology.

KEYWORDS: Solar-powered drip irrigation, Water management, Adoption

INTRODUCTION

Increasing agricultural productivity and income of the majority of farmers in developing countries is a relatively huge challenge (IDE, 2002). Low agricultural productivity is associated with a number of underlying factors including low levels of new technology adoption (Wirasinghe, 1997). The modern agricultural technologies such as drip irrigation could reduce farmer's workload, improve productivity and family food and nutritional intake as well (Upadhyay *et al.*, 2005). The choice of drip irrigation was originally intended provide water conservation, however later was used for yield improvement in crops as growers become more experienced with the technology (Shrestha and Gopalakrishnan, 1993). The knowledge and experiences are important factors for the adoption of drip irrigation systems by farmers (Skaggs, 2001).

The Sustainable Agriculture Water Management Project (SAWMP) - phase I of the Ministry of Agriculture Development and Agrarian Services, which launched in 2005, has designed and delivered solar-powered drip irrigation systems to farmers in the dry zone of Sri Lanka to help them better manage their irrigation techniques, boost productivity and reduce CO_2 emissions. The 5085 solar-powered drip systems distributed were installed in farmer fields in 16 dry zone districts. The farmers who received the solar-powered drip irrigation facilities were selected by the officers of the Agrarian Service department (ASD) under a loan scheme repayable up to a ten-year period. Even though the government has invested a substantial amount of public funds in this project, no in-depth analysis has been done to find the impact of the project interventions. The objective of this study was to understand the system performance and adoption of solar-powered drip irrigation systems distributed among the farmers in Polonnaruwa district by the SAWMP in order to plan of future programmes in the popularization of solar-powered drip irrigation systems among farmers.

MATERIALS AND METHODS

SAWMP solar-powered drip irrigation system

The drip irrigation system was designed to efficiently irrigate small extents of cash crops using solar power, and consisted of six key parts namely, solar module (150 modules per system) and the frame, the DC motor pump and support frame, suction pipe, SAWMP maximum power point trackers (MPPT) to adjust voltage to suit the motor demand, drip irrigation kit, and the fertigation system. The pump operates with its maximum capacity over the whole day and even during cloudy conditions. The maximum vertical suction height and static discharge head was 6 m and 10 m, respectively.

The drip kit carried water from the pump to the field. The pumped water was filtered by disc filters with 120 micron discs. The system provided water to two separate 2000 m^2 irrigation blocks but only one block could be watered at any given time. The drip lines had drippers built into the tube at intervals of 30 cm with a flow rate of 1 liter per hour (LPH). The pump was able to irrigate a maximum of 600 m of drip line at any given time on a flat ground.

Study area and data collection

The study was conducted in Polonnaruwa district that had 191 SAWMP sponsored solar-powered drip irrigation systems distributed among farmers. The SAWMP farmers were stratified into major Agrarian Service Center's (ASC) and 40 farmers were selected for data collection based on proportionate random sampling method (Table 1). Data were also collected from 30 field officers (20 from Department of Agriculture – DOA, and 10 from ASD) involved in the project. A pre-tested questionnaire used to gather information from SAWMP farmers in this study consisted of four parts namely, (1) to collect general information, (2) to collect information of adoption, (3) for gathering information on condition of field establishment of the system, and (4) to collect information on effectiveness of extension.

Table 1. Number of SAWMP farmers and number of farmers selected from different agrarian service centers for the study.

ASCs	*SAWMP farmers*	*Selected farmers*
Manampitiya	22	4
Higurakgoda	13	3
Giritale	16	3
Bakamuna	12	3
Newtown	21	5
Sewagama	31	7
Pulastigama	2	0
Medirigiriya	35	7
Galamuna	38	8
Total	191	40

Ranking and mean percent score (MPS) were used for the statistical analysis of system utilization. The MPS was obtained by dividing the total score by the maximum obtainable score under each aspect and multiplying by hundred. The knowledge, attitude, skill and practice of SAWMP farmers were used to develop an adoption index (Sriram, 1997) as shown in Equation 1;

$$AI = (RTS/MPS) x\ 100 \qquad \text{Eq. 1}$$

where, AI - adoption index; RTS - Respondent total scores; MPS - maximum possible scores.

Based on the initial observations, the sample was divided into two distinct categories; farmers who do use system for irrigation (users) and farmers who do not use for irrigation or system that are not operational (non-users). The efficiency of extension workers was measured by the amount of fieldwork done by the officers during the previous year. All officers were then categorized into three categories as highly efficient, moderate and poor and marks allocated as 5, 3, and 1 respectively for each of the major functions performed and the maximum possible marks were considered as the potential.

Descriptive analysis and chi square, 't' test, and regression analysis were used to analyze the data, using SAS software package.

RESULTS AND DISCUSSION

Socioeconomic background of the farmers

About, 43 % of non-users were reported (farmers who did not use the drip system for irrigation or system is not working) and most of these farmers used their drip system for non-agricultural purposes. Two farmers used the drip system for animal husbandry and ornamental fish cultivation. As shown in Table 2, the majority of the farmers are middle-aged males, with employment based on agriculture or other activities.

Table 2. Socioeconomics condition of the farmers participated in the study

Indicators	*Number of farmers*		*X^2 Statistics*
	Users	*Non-Users*	
Gender			
Male	21 (62%)	13 (38%)	Ns
Female	2 (33%)	4 (67%)	
Age			
Below 30 years	8 (67%)	4 (33%)	Ns
30- 50 years	9(53%)	8 (47%)	
> 50 years	6 (46 %)	7 (54%)	
Nature of farming (%)			
Full time	18 (78%)	5 (12%)	$X^2 = 9.5$, df=1; P=0.00[illegible]
Part time	5 (29%)	12 (71%)	
Experience of farming			
< 5years	5 (62%)	3 (38%)	Ns
5- 10 years	4 (67 %)	2 (33%)	
10- 20 years	6 (43%)	8 (57 %)	
>20 years	8 (67%)	4 (33 %)	
Duration of farming with Drip irrigation			
< 2 years	9 (43 %)	12 (57%)	$X^2 = 4.18$, df=1;P = 0.0[illegible]
> 2 years	14 (74%)	5 (26%)	
Average number of years	3.8	2.6	
Level of education			
Lower than GCE O/L	6 (35%)	11 (65%)	$X^2 = 5.96$, df= 1;P 0.01[illegible]
GCE O/L or higher	17 (74%)	6 (26%)	

Ns- Not significant at p=0.05

A significant difference ($p<0.05$) between users and non-users was observed in their education level, involvement in farming and farming experiences with drip irrigation. However, age, gender or farming experience did not affect the effective utilization of the system. Among the users, the majority (74 %) had an education up to GCE O/L or above. In the non-user group, about 65 % of farmers had an education lower than GCE O/L, thus indicating that the education level relates with absorptive capacity to understand new agricultural technologies. Farming experience with crop cultivation did not show any significant effect ($p>0.05$) on adoption of solar-powered drip irrigation. The duration of farming experience with drip irrigation among the users, prior to the introduction of SAWMP, was higher (3.8 years) than that of the non-users (2.6 years) suggesting that previous experience with drip irrigation techniques have an impact on the adoption of the system. The majority (78%) of users of the technology were full time farmers while only 12 % of non-users were full time farmers.

Utilization of SAWMP solar drip irrigation system

Insufficient water for crops, clogged drippers due to salt and algae and incomplete installation of system are the main reasons (ranked 1st, 2nd and 3rd, respectively) for not using the system (Table 3). About 82 % (14 out of 17 farmers) reported that water supplied through the drip was not adequate for the growth of crops, especially during dry season. Clogging of dippers is mainly due salt water, algae and fertilizer, which inject though the fertigation unit. About 52 % of farmers did not know how to clean drip lines. In addition, incomplete installation of the system has affected them because at the installation time, the farmers had little knowledge on proper installation of the system.

Table 3. Reasons for failure of drip irrigation system among non users

Criteria	*Frequency*	*MPS*	*Rank*
Insufficient water for crop growth	*14*	36.8	*1*
Clogging drippers by salt and algae	*9*	23.8	*2*
Incomplete installation	*5*	13.2	*3*
Broken laterals	*4*	10.5	*4*
Pump not working/instrument fault	*4*	10.5	*4*
Shortage of irrigation well water	*2*	5.2	*6*

The level of difficulties was estimated by obtaining the perception about the difficulties faced by farmers with the irrigation system. Clogging drippers by salt and algae, lack of uniformity in distribution of water and damage to laterals by animals were the major difficulties among the SAWMP farmers who use the system for irrigation (Table 4). The low-density polyethylene laterals (tapes) has easily got damaged by animals while they seek water during the dry season. The findings of the survey were also supported by the results of the interviews conducted with extension officers of DAS and DOA. Almost all the officers expressed similar views on the reasons for not using the system and difficulties faced by farmers.

Table 4. Difficulties faced by farmers when using the solar-powered drip systems

Criteria	*Frequency*	*MPS*	*Rank*
No uniformity in water distribution	*11*	17.5	*2*
Clogging drippers by salt and algae	*18*	28.5	*1*
Damage laterals by animals	*8*	12.7	*3*
Shortage of irrigation well water	*8*	12.7	*3*
System leakage	*7*	11.1	*5*
Water not enough to crops	*6*	9.5	*6*
Difficulties with maintenance	*5*	8.0	*7*

Adaptability of solar-powered drip irrigation system

The Adoption Index (AI) calculated using knowledge, attitude, skills and practice of the farmers, revealed that majority of the farmers (52.5 %) had a medium level of adoption followed by a low level (32.5%) of adoption and high level (15%) of adoption of solar-powered drip irrigation technology in crop cultivation (Table 5).

Table 5. Distribution of solar-powered drip irrigation technology according to adoption index (n=40)

Category	*Score range*	*Frequency*	*Percentage %*
Low	<30	13	32.5
Medium	30-60	21	52.5
High	>60	6	15
Mean=41.3; SD=18.6			

The chi-square value indicates that there is an association between AI level and utilization of drip system in the fields (Table 6). About 78 % of "user" farmers have medium to high-level AI compared to 48 % in "non user" farmers.

Table 6. Frequency of farmers with either low or medium to high Adoption Index in users and non-user categories

Adoption Index		*Frequency in "user" farmers*	*Frequency in" not users"*
Low (<40)		5 (22%)	9 (52%)
Medium to High (> 40)		18 (78%)	8 (48%)
Mean AI=41.3	SD=18.6	$X^2 = 4.18$ df=1	P< 0.041

Farmer field observations and reasons for failures

The performance of solar-powered drip system was affected significantly by the field condition (Table 7). The farmers were of the view that functioning of main control unit, which included water pump, filters, fertigation unit and valves, are at moderate level (45 %). Ninety per cent of the farmers did not use the fertigation unit at all. The major fraction of farmers stated that they did not know how to use the unit for fertigation. These, farmers did not use anti- clogging chemicals to clean the drip system. About 42.5 % of systems were not maintained at satisfactory level and about 90 % of farmers were not aware of the methods of flushing the system to clean clogged lines and laterals (Table 7). About 52.5 % of the farmers were not satisfied with the field installation of solar panel, main lines and laterals of drip systems. The field installation done by the private company has not completed the installation during their first visit due to the unprepared or improper field conditions and never returned to complete the installation. Only 10 % of farmers knew about the recommended crop establishment techniques to be practiced under drip irrigation. However, a higher percentage of farmers (80 %) had selected suitable crops for the drip system (Table 7).

Table 7. Field condition of SAWMP solar-powered drip irrigation

Criteria	*Satisfied %*	*Moderate %*	*Not satisfied %*	*Respondents*
Main control unit	40	45	15	40
Field installation	12.5	35	52.5	40
Maintenance of system	10	47.5	42.5	40
Irrigated field condition	50	27.5	22.5	40
Selection of crops	80	15	5	40
Knowledge on crop establishment for drip irrigation	10	10	80	40

X^2 statistics; df=10, X^2=80.44, P=0.001

Service efficiency of extension workers

The solar-powered drip irrigation is a new advanced technology intended for rural community development. Agriculture extension and training efforts have contributed much to technology adoption. In the SAWMP, several government and private sector officers have been involved in extension and training aspects to promote the adoption of new technology (Table 8).

Table 8. Extension officers visits related to SAWMP

Farmers' response	*AI*	*ARPA*	*Private officers*
Yes	25	10	7
No	15	30	33
Total respondents	40	40	40

AI – Agriculture Instructors; ARPA – Agriculture research and Production Assistants

The field information revealed that the Agriculture Instructors have visited the fields more often than the Agriculture Research and Production Assistants (ARPAs). However, the main purpose of their visits was not for extension activities related to solar-powered drip irrigation system but on other extension activities.

As shown in Table 9, there is no significant difference between service efficiency of AIs and ARPAs for training. The service efficiency of private sector extension worker was much greater than AIs and ARPAs. Although few visits have been reported for providing instructions to farmers, the private sector extension workers have the ability to provide better farmer support service as they are rich in knowledge, skills and practice of drip irrigation to disseminate information on the drip irrigation technology. Efficiency level of DOA staff was always high compared with DAS officers but, both groups had lower capability/efficiency level for field inspection and advisory services. This is mainly due to the lack of practical knowledge on the drip systems. Information provided by the extension workers is mostly theoretical and not practice-oriented (ICID, 2006).

Table 9. Service efficiency of extension workers on SAWMP

Functions	*Efficiency level (% of potential)*		
	AI	*ARPA*	*Private sector officer*
Training	60	50	80
Field inspection	40	30	90
Advisory service	30	20	70
Providing part of drip system	30	Not applicable	90

AI – Agriculture Instructors; ARPA – Agriculture Research and Production Assistant

Repayment of loan

Although farmers were in a position to re-pay the loan installments while continuing their farming operations, many farmers in study area had not done the repayment accordingly. From the phase I of the project, Rs 205 million was expected to be repaid by farmers to the government. However, only 16.5 million has been paid so far. The progress of repayment was less than 10 % in all ASC divisions (Table 10).

The failure in repayment indicates that farmers could not use this system effectively for additional crops, increasing yields and earning more money. These results have proved that adoption of solar-powered drip irrigation system is at very low level among all farmers. Similar observations have been made in many other countries and ICID (2006) indicated that though farmers are aware of drip irrigation technology, the adoption rate was very poor.

Table 10. Repayment of loan installments by SAWMP farmers

ASC	*Total amount of installments (Rs)*	*Total amount of repayments (Rs)*	*Percentage*
Manumpitiya	1735410.25	154750.00	8.9
Higurakgoda	976445.00	96470.75	9.8
Giritale	1340832.25	117500.00	0.87
Bakamoona	895491.25	7000.00	0.78
New Town	1431595.25	149500.00	10.4
Sewagama	1962699.25	179100.00	9.1
Pulastigama	222670.50	10000.00	4.5
Medirigiriya	2286514.25	190935.75	8.3
Galamuna	2240751.25	209099.00	9.33

Source : ASD, 2010

CONCLUSIONS AND RECOMMENDATION

For the better performance of this SAWMP, farmer selection criteria should be established to select capable farmers and capacity-building programmes should be conducted for farmers. Extension workers need to deliver good quality technical and practical extension services. In addition to providing the technology, an effective and efficient sale services and inspection of the system by private suppliers is needed. Special efforts are needed to remove the impediments and to promote further adoption of solar-powered drip irrigation technology. Therefore, more demonstration sites, technical visits, group discussions are recommended. For sustainable use of this technology, an integrated and holistic approach should be adopted. A complete package of cultivation practices for appropriate crops under solar-powered drip irrigation system should be developed and explained to growers/farmers and to extension staffs to facilitate successful adoption of the technology. Frequent assessment of the project objective needs to be conducted to achieve a better outcome from the project.

ACKNOWLEDGEMENTS

Field staff of Deputy Director of Agriculture (Inter Provincial) Office, Polonnaruwa and Agrarian Service Department, Polonnaruwa, are acknowledged for the help given in field sampling. The author wishes to express his gratitude to Mr. Shantha Emitiyagoda, Additional Secretary, Ministry of Agriculture and Dr. Kamal Karunagoda, Economist, Socio Economic Planning Centre, Department of Agriculture, Peradeniya, Sri Lanka for the help offered and valuable suggestions made during the period of study and preparation of the manuscript.

REFERENCES

Department of Agrarian Service. 2010, Monthly report of SAWMP, Polonnaruwa, Department of Agrarian Service, Polonnaruwa, Sri Lanka.

Foltz, D.J. 2003. The economics of water conserving technology adoption in Tunisia: An empirical estimation of farmer technology choice. EDCC 51 (2). USA: University of Chicago.

IDE (International Development Enterprise). 2002, scaling up plan of appropriate micro irrigation technique with complementary small farm intensification and micro enterprise deployment, New Delhi.

ICID. 2006. 7th international Micro irrigation Congress, Kuala Lumpur. International Commission on Irrigation and Drainage.

Sarkar, N.A. and S.J. Hanamashetti. 2002. Financial viability of drip-irrigation system for sugarcane and grape cultivation in Maharashtra. Asia-Pacific Journal of Rural Development XII: 1-31.

Shrestha, R.B. and C. Gopalakrishnan. 1993. Adoption and Diffusion of Drip Irrigation:An Econoometric Analysis Economic Development and Cultural Change. 41(2): 407-418.

Skaggs, R.K. 2001 Predicting drip irrigation use and adoption in a desert region. Agricultural Water Management. 51(2)125-142.

Sriram, N. 1997. Eco-friendly agriculture practices in cotton cultivation, farmers awareness, attitude and adoption. M.Sc. (Ag.) thesis, Tamil Nadu Agricultural University, Coimbatore. 1991p.

Upadhyay, B., M. Samad and M. Giordano. 2005. Livelihoods and Gender roles in drip Irrigation thchnology: a Case of Nepal, working paper 87, International Water management institute, Colombo, Sri Lanka.

Wirasinghe, S. 1997, Agriculture information needs, mode, mechanism and information flow in SAARC countries, SAIC, Bangladesh. 143-149.